

SECTION 22 05 48.00 20

MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL
04/06

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

- ARI 370 (2001) Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
- ARI 575 (1994) Method of Measuring Machinery Sound Within an Equipment Space

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

- AISC 350 (1999) Load and Resistance Factor Design (LRFD) Specification for Structural Steel Buildings

AMERICAN WELDING SOCIETY (AWS)

- AWS D1.1/D1.1M (2006) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

- ASTM A 123/A 123M (2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A 36/A 36M (2005) Carbon Structural Steel
- ASTM C 94 (1994) Ready-Mixed Concrete
- ASTM D 2240 (2005) Rubber Property - Durometer Hardness
- ASTM D 471 (1998e1) Rubber Property - Effect of Liquids
- ASTM E 84 (2005) Surface Burning Characteristics of Building Materials

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

- SMACNA HVAC Duct Const Stds (1995, 2nd Ed) HVAC Duct Construction

Standards - Metal and Flexible

SMACNA Seismic Restraint Mnl (1998, 2nd Ed) Seismic Restraint Manual:
Guidelines for Mechanical Systems

1.2 RELATED REQUIREMENTS

The provisions of Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS apply to this section.

1.3 DEFINITIONS

1.3.1 Decibels dB

Measure of sound level. Decibels are referenced to either 20 uPa for sound pressure levels or one pW for sound power levels. dBA is the overall "A" weighted sound level.

1.3.2 Machinery

The vibration or noise producing equipment that must be isolated.

1.3.3 Manufacturer

The fabricator or supplier of vibration-isolation or seismic-protection materials and equipment. For mechanical equipment and machinery the term machinery manufacturer will be used.

1.3.4 Micropascal uPa

10 to the minus 6 power newtons per square meter.

1.3.5 Picowatt pW

10 to the minus 12 power watts.

1.4 SYSTEM DESCRIPTION

1.4.1 Spring Isolator Data

For each type and size of spring isolator, submit the spring outside diameter, deflection, operating spring height, unloaded spring height, solid spring height, the ratio of the outside diameter to the operating spring height, the load to deflection ratio of the springs, and weight and sizes of structural steel members.

1.4.2 Machinery Manufacturer's Sound Data

For each piece of indicated machinery to be vibration isolated, the calculated sound power test data or sound pressure test data as levels in dB in the eight octave bands between 63 and 8,000 Hz. Refer sound power levels to one pW and sound pressure levels to 20 uPa. Submit the overall "A" weighted scale sound pressure level in dB. Submit the standard test procedure used to obtain the sound power or pressure data for the

applicable vibration isolation equipment size.

1.4.3 Machinery

For each item of machinery, compare spring static deflections with the specified minimum static deflection, to show that the calculated spring static deflections are not less than the minimum static deflections specified. Rated spring static deflections are not acceptable in lieu of calculated spring static deflections. When seismic protection is required, substantiating calculations are required.

1.4.4 Machinery Over 300 Pounds

For machinery items over 300 pounds, provide calculations for shear, pull-up, primary overturning, and secondary overturning.

1.4.5 Machinery Vibration Criteria

TABLE 1A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
<u>Equipment</u>	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
Centrifugal Chillers or Heat Pumps						
Hermetic Type	SV-B	1.75	SV-B	2.5	SV-B	3.5
Open Type	SV-1	1.75	SV-I	2.5	SV-I	3.5
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
Reciprocating Chillers or Heat Pumps						
500 to 750 rpm	SV-R	1.75	SV-R	2.5	SV-R	3.5
751 rpm and up	SV-R	1.5	SV-R	2.5	SV-R	3.5

TABLE 1A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	(Note (1))		(Note (1))		(Note (1))	
Packaged Boilers	SV	1.0	SV	2.5	SV-R	3.5
Closed Coupled Pumps						
Up to 7-1/2 hp	S-I	1.0	S-I	1.0	S-I	1.0
Over 7-1/2 hp	S-I	1.5	S-I	2.5	S-I	2.5
Base Mounted Pumps						
Up to 20 hp	S-I	1.5	S-I	2.5	S-I	2.5
20 to 75 hp	S-I	1.5	S-I	2.5	S-I	3.5
Over 75 hp	S-I	2.5	S-I	3.5	S-I	3.5
Cooling Towers and Evaporative Condensers	SV with deflections specified for centrifugal blowers when springs are supported on beams. Use selection listed for column supported floors with up to 30 foot column spacing when springs are located on columns or bearing walls					
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))						
Suspended Units						
Up to 5 hp	H	1.0	H	1.0	H	1.0
Over 5 hp						
Up to 400 rpm	H	1.75	H	1.75	H	1.75
Over 401 rpm	H	1.0	H	1.5	H	2.5
Floor Mounted						

TABLE 1A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	(Note (1))		(Note (1))		(Note (1))	
Units						
Up to 5 hp	S	1.0	S	1.0	S	1.0
Over 5 hp						
Up to 400 rpm	S-R	1.75	S-R	1.75	S-R	2.5
Over 401 rpm	S-R	1.0	S-R	1.5	S-R	2.5
Centrifugal Blowers						
175 - 224 rpm	S-B	4.75	S-B	4.75	S-B	4.75
225 - 299 rpm	S-B	3.75	S-B	4.75	S-B	4.75
300 - 374 rpm	S-B	2.75	S-B	4.5	S-B	4.75
375 - 499 rpm	S-B	2.5	S-B	3.5	S-B	4.5
Over 500 rpm	S-B	1.75	S-B	2.5	S-B	3.5
Tubular Centrifugal and Axial Fans (Note (2))						
Suspended	H with deflection specified for centrifugal blowers					
Floor Mounted Arrangements 1 & 9	S-B with deflections specified for centrifugal blowers					
Utility Fans (Note (2))						
Suspended	H with deflections specified for centrifugal blowers but not to exceed 2.75 inches					
Floor-Mounted	S-R with deflections not specified for centrifugal blowers but not to exceed 2.75 inches					
High Pressure Fans (Over 6 Inch Water-Column Static Pressure) and Other	HR recommended for minimizing undesirable thrust effects					

TABLE 1A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
<u>Machineries</u> Producing Thrust (Note (2))						
Internal Combustion Engines and Engine Driven Equip						
750 rpm and over	S	1.5	S	2.5	S	3.5
Dimmer Banks and Transformers						
Up to 1000 lbs.	NM	0.35	NM	0.35	S	3.5
Over 1000 lbs.	SV	1.0	SV	1.0	SV	1.0

NOTES: (1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)

- B - Welded structural steel bases.
- H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.
- HR - Thrust restraints
- I - Concrete inertia bases with steel forms.
- NM - Neoprene mounts.
- NP - Neoprene pads.
- R - Structural steel rail for equipment mounts.
- S - Freestanding spring isolators (floor-mounted equipment).
- SV - Freestanding spring isolators (floor-mounted equipment).

TABLE 1A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
SX	- Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment). Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.					

(2) Fans

- a. When fan motors are 75 hp or larger, use the deflection requirements for the next wider column spacing. Except for building slab on grade a minimum of 2.5 inches should be used unless larger deflections are specified in the centrifugal blower table.
- b. Provide sway brace isolators for tubular centrifugal and axial fans when the fan pressure exceeds 4 inches water column.
- c. Provide inertia bases for all fans in lieu of structural steel bases or rails specified above when the fan pressure exceeds 4 inches water column.
- d. With attaching brackets, suspension spring isolators bridge between the structure and the thrust-producing machinery such as high-pressure fan. Both types H and HR normally provide reaction in tension, while types S, SV, and SX normally provide reaction in compression. Thrust restraints are low-cost and effective components available from manufacturers. Use thrust restraints to eliminate the need for or reduce the magnitude of inertia mass when the mass is only used to reduce the displacement effects of the thrust.

1.4.6 Machinery Airborne Sound Level Criteria

TABLE 2A
Sound Data Schedule

Equipment	Maximum Sound Power Level (dB)							
	Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Air Handling Unit	94	90	89	89	89	84	82	79
Make-Up Air Fan	91	91	80	84	82	76	71	65
Air Conditioning Unit	100	96	90	89	86	80	75	72
Boiler	75	72	72	75	76	63	55	50
Chiller	98	98	96	95	93	94	88	81
Cooling Tower	110	110	105	102	98	95	92	87
Air Compressor	90	89	92	93	92	92	90	81
Pump	85	80	82	82	80	77	74	72
Fan	55	50	48	47	48	46	42	37

1.4.6.1 Basic Criteria

For each piece of machinery in the human work environment, do not exceed the maximum airborne sound levels 84 dB A-weighted scale, continuous or intermittent, or 140 dB peak sound pressure-level, impact or impulse, noise.

1.4.6.2 Sound Data Schedule

TABLE 2A
Sound Data Schedule

Equipment	Maximum Sound Power Level (dB)							
	Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Air Handling Unit	94	90	89	89	89	84	82	79
Make-Up Air Fan	91	91	80	84	82	76	71	65
Air Conditioning Unit	100	96	90	89	86	80	75	72
Boiler	75	72	72	75	76	63	55	50
Chiller	98	98	96	95	93	94	88	81

TABLE 2A
Sound Data Schedule

Equipment	Maximum Sound Power Level (dB)							
	Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Cooling Tower	110	110	105	102	98	95	92	87
Air Compressor	90	89	92	93	92	92	90	81
Pump	85	80	82	82	80	77	74	72
Fan	55	50	48	47	48	46	42	37

1.4.7 Seismic Protection Criteria

Use a Horizontal Force Factor minimum 60 percent of the machinery weight considered passing through the machinery center of gravity in any horizontal direction, *as indicated*. Unless vibration isolation is required to protect machinery against unacceptable structure transmitted noise or vibration, protect the structure or machinery from earthquakes by rigid structurally sound attachment to the load-supporting structure. Protect each piece of vibration-isolated machinery with protected spring isolators or separate seismic restraint devices. Determine by calculations the number and size of seismic restraints needed for each machinery. Verify seismic restraint vendor's calculations by a registered professional engineer. Provide seismic snubbers and protected spring isolators rated in three principle axes. Verify ratings by independent laboratory testing, by analysis of an independent licensed structural engineer.

1.4.8 Welding

AWS D1.1/D1.1M.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section *01 33 00* SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Inertia bases

Machinery bases

Platforms

Rails

Saddles

SD-03 Product Data

Isolators
Flexible connectors
Flexible duct connectors
Pipe guides
Seismic snubbers
Vertical stops
Thrust restraints
Inertia bases
Machinery bases
Machinery foundations and subbases
Platforms
Rails
Saddles
Machinery manufacturer's sound data

SD-05 Design Data

Inertia bases
Machinery bases
Platforms
Rails
Saddles
Each item of machinery
Each item of machinery over 300 pounds

Submit design calculations for inertia bases, machinery bases, platforms, rails, and saddles, either by the machinery manufacturer for the recommended machinery mounting or by the vibration-isolation equipment manufacturer.

SD-06 Test Reports

Seismic snubbers

Equipment vibration tests

Equipment sound level tests

Protected spring isolators

Submit seismic protection rating in three principal axes certified by an independent laboratory or analyzed by an independent licensed structural engineer.

SD-08 Manufacturer's Instructions

Vibration and noise isolation components

Seismic protection components

1.6 QUALITY ASSURANCE

1.6.1 Vibration Isolator Procurement

For each piece of machinery to be isolated from vibration, supply **all** the materials and equipment as a coordinated package by a single manufacturer or by the machinery manufacturer. Select isolators that provide uniform deflection even when machinery weight is not evenly distributed. This requirement does not include the flexible connectors or the hangers for the associated piping and ductwork.

1.6.2 Unitized Machinery Assemblies

Mounting of unitized assemblies directly on vibration isolation springs is acceptable if machinery manufacturer certifies that the end supports of the assemblies have been designed for such installation.

PART 2 PRODUCTS

2.1 CORROSION PROTECTION FOR STEEL PARTS

ASTM A 123/A 123M hot-dipped galvanized, or equivalent manufacturer standard coatings. Where steel parts are exposed to the weather, provide galvanized coating of at least **2 ounces** of zinc per square **foot** of surface. Coat springs with neoprene.

2.2 NEOPRENE

ASTM D 471 and **ASTM D 2240**, Grade Durometer 40, 50, or 60, and oil resistant.

2.3 FLOOR-MOUNTED ISOLATORS

2.3.1 Neoprene Isolation Pads

Provide pads at least **1/4 inch** thick with cross-ribbed or waffle design. For concentrated loads, provide steel bearing plates bonded or cold

cemented to the pads.

2.3.2 Neoprene Isolators

Provide molded neoprene isolators having steel base plates with mounting holes and, at the top, steel mounting plates with mounting holes or threaded inserts. Provide elements of type and size coded with molded letters or color-coded for capacity identification. Embed metal parts completely in neoprene.

2.4 SPRING ISOLATORS AND PROTECTED SPRING ISOLATORS

Provide spring isolators or protected spring isolators that are adjustable and laterally stable with free-standing springs of horizontal stiffness at minimum 80 percent of the vertical (axial) stiffness. For machine-attached and floor-attached restraining elements, separate from metal-to-metal contact by neoprene cushions 1/8 inch thick minimum. Provide neoprene acoustic friction pads at least 1/4 inch thick.

2.4.1 Springs

Provide springs with base and compression plates, to keep spring ends parallel during and after deflection to operating height. Provide outside coil diameters at least 0.8 of the operating height. At operating height, springs shall have additional travel to complete (solid) compression equal to at least 50 percent of the operating deflection.

2.4.2 Mounting and Adjustment

Provide base and compression plates with mounting holes or threaded fittings. Bolt leveling adjustment bolts to machinery or base.

2.5 SUSPENSION ISOLATORS

Provide hangers with suspension isolators encased in open steel brackets. Isolate hanger rods from isolator steel brackets with neoprene-lined opening.

2.5.1 Suspension Neoprene Isolators

Provide double-deflection elements with minimum 3/8 inch deflection.

2.5.2 Suspension Spring Isolators

Provide hangers with springs and molded neoprene elements in series. Provide isolators with adjustable spring-preloading devices where required to maintain constant pipe elevations during installation and when pipe operational loads are transferred to the springs.

2.6 MACHINERY BASES , PLATFORMS , RAILS SADDLES

ASTM A 36/A 36M and AISC 350.

2.7 INERTIA BASES

ASTM A 36/A 36M steel, ASTM C 94 3,000 psi) concrete.

2.8 FLEXIBLE CONNECTORS FOR PIPING

Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.

2.8.1 Elastomeric Flexible Connectors

Fabricated of multiple plies of tire cord fabric and elastomeric materials with integral reinforced elastomeric flanges with galvanized malleable iron back up rings.

2.8.2 Metal Flexible Connectors

Fabricated of Grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover.

2.9 FLEXIBLE DUCT CONNECTORS

Provide flexible duct connectors fabricated in accordance with SMACNA HVAC Duct Const Stds.

2.10 SEISMIC SNUBBERS FOR EQUIPMENT

Factory-fabricated, omni-directional with factory set air gaps between 1/8 inch minimum and 1/4 inch maximum. Load capacity of each snubber at 50 percent neoprene element deflection shall be 1.0g minimum. Provide replaceable neoprene elements 3/4 inch minimum thickness.

2.11 PIPE GUIDES

Factory-fabricated. Weld steel bar guides to the pipe at a maximum radial spacing of 60 degrees. The outside diameter around the guide bars shall be smaller than the inside diameter of the guide sleeve in accordance with standard field construction practice. For pipe temperatures below 60 degrees F, provide metal sleeve, minimum one pound per cubic foot density insulation.

2.12 THRUST RESTRAINTS

Adjustable spring thrust restraints, able to resist the thrust force with at least 25 percent unused capacity. The operating spring deflection shall be not less than 50 percent of the static deflection of the isolation supporting the machinery.

2.13 SEISMIC PROTECTION COMPONENTS FOR PIPING AND DUCTWORK

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS.

SMACNA Seismic Restraint Mnl.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Vibration and Noise Isolation Components

Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

3.1.2 Suspension Vibration Isolators

Provide suspension isolation hangers for piping, suspended equipment, and suspended equipment platforms in mechanical equipment rooms, as indicated and as specified. For operating load static deflections of $1/4$ inch or less, provide neoprene pads or single deflection neoprene isolators. For operating load static deflections over $5/16$ to $3/8$ inch, provide double-deflection neoprene element isolators. For operating load static deflections over $3/8$ inch, provide isolators with spring and neoprene elements in series.

3.1.3 Vertical Stops

For machinery affected by wind pressure or having an operational weight different from installed weight, provide resilient vertical limit stops which prevent spring extension when weight is removed. Provide vertical stops for machinery containing liquid, such as water chillers, evaporative coolers, boilers, and cooling towers. Spring isolated or protected spring isolated machinery must rock and move freely within limits of stops or seismic restraint devices.

3.1.4 Thrust Restraints

Where required, provide pairs of thrust restraints, symmetrically installed on both sides of the steady state line of thrust.

3.1.5 Flexible Pipe and Duct Connectors

Install flexible connectors in accordance with the manufacturer's instructions. When liquid pulsation dampening is required, flexible connectors with spherical configuration may be used. Provide restraints for pipe connectors at pumps to prevent connector failure upon pump startup.

3.1.6 Seismic Snubbers

Provide snubbers as close as possible to each vibration isolator as indicated. After installing and leveling of the machinery, adjust snubbers in accordance with the snubber manufacturer's instructions.

3.1.7 Machinery

Provide vibration isolators, flexible connectors and seismic snubbers in accordance with manufacturer's recommendations. Machinery with spring isolators or protected spring isolators shall rock or move freely within

limits of stops or seismic snubber restraints.

3.1.7.1 Stability

Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.

3.1.7.2 Lateral Motion

The installed vibration isolation system for each piece of floor or ceiling mounted machinery shall have a maximum lateral motion under machinery start up and shut down conditions of not more than 1/4 inch. Restrain motions in excess by approved spring mountings.

3.1.7.3 Unbalanced Machinery

Provide foundation suspension systems specifically designed to resist horizontal forces for machinery with large unbalanced horizontal forces. Vibration isolator systems shall conform to the machinery manufacturer's recommendations.

3.1.7.4 Nonrotating Machinery

Mount nonrotating machinery in systems which includes rotating or vibrating machinery on isolators having the same deflection as the hangers and supports for the pipe connected to.

3.1.7.5 Unitized Machinery Assemblies

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
<u>Equipment</u>	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
Centrifugal Chillers or Heat Pumps						
Hermetic Type	SV-B	1.75	SV-B	2.5	SV-B	3.5
Open Type	SV-1	1.75	SV-I	2.5	SV-I	3.5
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5

TABLE 3A

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Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	(Note (1))		(Note (1))		(Note (1))	
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
Reciprocating Chillers or Heat Pumps						
500 to 750 rpm	SV-R	1.75	SV-R	2.5	SV-R	3.5
751 rpm and up	SV-R	1.5	SV-R	2.5	SV-R	3.5
Packaged Boilers	SV	1.0	SV	2.5	SV-R	3.5
Closed Coupled Pumps						
Up to 7 1/2 hp	S-I	1.0	S-I	1.0	S-I	1.0
Over 7 1/2 hp	S-I	1.5	S-I	2.5	S-I	2.5
Base Mounted Pumps						
Up to 20 hp	S-I	1.5	S-I	2.5	S-I	2.5
20 to 75 hp	S-I	1.5	S-I	2.5	S-I	3.5
Over 75 hp	S-I	2.5	S-I	3.5	S-I	3.5
Cooling Towers and Evaporative Condensers	SV with deflections specified for centrifugal blowers when springs are supported on beams. Use deflection listed for column supported floors with up to 30 foot column spacing when springs are located on columns or bearing walls					
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))						

TABLE 3A

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Equipment	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
Suspended Units						
Up to 5 hp	H	1.0	H	1.0	H	1.0
Over 5 hp						
Up to 400 rpm	H	1.75	H	1.75	H	1.75
Over 401 rpm	H	1.0	H	1.5	H	2.5
Floor Mounted Units						
Up to 5 hp	S	1.0	S	1.0	S	1.0
Over 5 hp						
Up to 400 rpm	S-R	1.75	S-R	1.75	S-R	2.5
Over 401 rpm	S-R	1.0	S-R	1.5	S-R	2.5
Centrifugal Blowers						
175 - 224 rpm	S-B	4.75	S-B	4.75	S-B	4.75
225 - 299 rpm	S-B	3.75	S-B	4.75	S-B	4.75
300 - 374 rpm	S-B	2.75	S-B	4.5	S-B	4.75
375 - 499 rpm	S-B	2.5	S-B	3.5	S-B	4.5
Over 500 rpm	S-B	1.75	S-B	2.5	S-B	3.5
Tubular Centrifugal and Axial Fans (Note (2))						
Suspended	H with deflection specified for centrifugal blowers					
Floor Mounted Arrangements 1 & 9	S-B with deflections specified for centrifugal blowers					
Utility Fans (Note (2))						
Suspended	H with deflections specified for					

TABLE 3A

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Equipment	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
			centrifugal blowers but not to exceed 2.75 inches			
Floor-Mounted			S-R with deflections not specified for centrifugal blowers but not to exceed 2.75 inches			
High Pressure Fans (Over 6 Inch Water-Column Static Pressure) and Other Machineries Producing Thrust (Note (2))			HR recommended for minimizing undesirable thrust effects			
Internal Combustion Engines and Engine Driven Equip						
750 rpm and over	S	1.5	S	2.5	S	3.5
Dimmer Banks and Transformers						
Up to 1000 lbs.	NM	0.35	NM	0.35	S	3.5
Over 1000 lbs.	SV	1.0	SV	1.0	SV	1.0

NOTES: (1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)

- B - Welded structural steel bases.
- H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.
- HR - Thrust restraints

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
<u>Equipment</u>	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
I	- Concrete inertia bases with steel forms.					
NM	- Neoprene mounts.					
NP	- Neoprene pads.					
R	- Structural steel rail for equipment mounts.					
S	- Freestanding spring isolators (floor-mounted equipment).					
SV	- Freestanding spring isolators (floor-mounted equipment).					
SX	- Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment). Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.					

(2) Fans

- a. When fan motors are 75 hp or larger, use the deflection requirements for the next wider column spacing. Except for building slab on grade a minimum of 2.5 inches should be used unless larger deflections are specified in the centrifugal blower table.
- b. Provide sway brace isolators for tubular centrifugal and axial fans when the fan pressure exceeds 4 inches water column.
- c. Provide inertia bases for all fans in lieu of structural steel bases or rails specified above when the fan pressure exceeds 4 inches water column.
- d. With attaching brackets, suspension spring isolators bridge between the structure and the thrust-producing machinery such as high-pressure fan. Both types H and HR normally provide reaction in tension, while types S, SV, and SX normally provide reaction in compression. Thrust restraints are low-cost and effective components available from manufacturers. Use thrust restraints to eliminate the need for or reduce the magnitude of inertia mass when the mass is only used to reduce the

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
displacement effects of the thrust.						

Unitized assemblies such as chillers with evaporator and condenser, and top mounted centrifugal compressor or unitized absorption refrigeration machines, structurally designed with end supports, may be mounted on steel rails and springs in lieu of steel bases and springs. Where the slab or deck is less than 4 inches thick, provide spring isolation units with the deflection double that of the vibration isolation schedule, up to a maximum static deflection of 5 inches.

3.1.7.6 Roof and Upper Floor Mounted Machinery

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
Centrifugal Chillers or Heat Pumps						
Hermetic Type	SV-B	1.75	SV-B	2.5	SV-B	3.5
Open Type	SV-1	1.75	SV-I	2.5	SV-I	3.5
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
Reciprocating Chillers or Heat Pumps						

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	(Note (1))		(Note (1))		(Note (1))	
500 to 750 rpm	SV-R	1.75	SV-R	2.5	SV-R	3.5
751 rpm and up	SV-R	1.5	SV-R	2.5	SV-R	3.5
Packaged Boilers	SV	1.0	SV	2.5	SV-R	3.5
Closed Coupled Pumps						
Up to 7 1/2 hp	S-I	1.0	S-I	1.0	S-I	1.0
Over 7 1/2 hp	S-I	1.5	S-I	2.5	S-I	2.5
Base Mounted Pumps						
Up to 20 hp	S-I	1.5	S-I	2.5	S-I	2.5
20 to 75 hp	S-I	1.5	S-I	2.5	S-I	3.5
Over 75 hp	S-I	2.5	S-I	3.5	S-I	3.5
Cooling Towers and Evaporative Condensers	SV with deflections specified for centrifugal blowers when springs are supported on beams. Use deflection listed for column supported floors with up to 30 foot column spacing when springs are located on columns or bearing walls					
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))						
Suspended Units						
Up to 5 hp	H	1.0	H	1.0	H	1.0
Over 5 hp						

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD (Note (1))	Type	MSD (Note (1))	Type	MSD (Note (1))
Up to 400 rpm	H	1.75	H	1.75	H	1.75
Over 401 rpm	H	1.0	H	1.5	H	2.5
Floor Mounted Units						
Up to 5 hp	S	1.0	S	1.0	S	1.0
Over 5 hp						
Up to 400 rpm	S-R	1.75	S-R	1.75	S-R	2.5
Over 401 rpm	S-R	1.0	S-R	1.5	S-R	2.5
Centrifugal Blowers						
175 - 224 rpm	S-B	4.75	S-B	4.75	S-B	4.75
225 - 299 rpm	S-B	3.75	S-B	4.75	S-B	4.75
300 - 374 rpm	S-B	2.75	S-B	4.5	S-B	4.75
375 - 499 rpm	S-B	2.5	S-B	3.5	S-B	4.5
Over 500 rpm	S-B	1.75	S-B	2.5	S-B	3.5
Tubular Centrifugal and Axial Fans (Note (2))						
Suspended		H with deflection specified for centrifugal blowers				
Floor Mounted Arrangements 1 & 9		S-B with deflections specified for centrifugal blowers				
Utility Fans (Note (2))						
Suspended		H with deflections specified for centrifugal blowers but not to exceed 2.75 inches				
Floor-Mounted		S-R with deflections not specified for centrifugal blowers but not to exceed 2.75 inches				

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type	MSD	Type	MSD	Type	MSD
	(Note (1))		(Note (1))		(Note (1))	
High Pressure Fans (Over 6 Inch Water-Column Static Pressure) and Other Machineries Producing Thrust (Note (2))		HR recommended		for minimizing		undesirable
		thrust effects				
Internal Combustion Engines and Engine Driven Equip						
750 rpm and over	S	1.5	S	2.5	S	3.5
Dimmer Banks and Transformers						
Up to 1000 lbs.	NM	0.35	NM	0.35	S	3.5
Over 1000 lbs.	SV	1.0	SV	1.0	SV	1.0

NOTES: (1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)

- B - Welded structural steel bases.
- H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.
- HR - Thrust restraints
- I - Concrete inertia bases with steel forms.
- NM - Neoprene mounts.
- NP - Neoprene pads.

TABLE 3A

Vibration Isolator Types and Minimum Static Deflection (MSD, inches) for 4-8 inch slab on grade and column supported.

Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
<u>Equipment</u>	Type	MSD	Type	MSD	Type	MSD
	<u>(Note (1))</u>		<u>(Note (1))</u>		<u>(Note (1))</u>	
R	- Structural steel rail for equipment mounts.					
S	- Freestanding spring isolators (floor-mounted equipment).					
SV	- Freestanding spring isolators (floor-mounted equipment).					
SX	- Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment). Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.					

(2) Fans

- a. When fan motors are 75 hp or larger, use the deflection requirements for the next wider column spacing. Except for building slab on grade a minimum of 2.5 inches should be used unless larger deflections are specified in the centrifugal blower table.
- b. Provide sway brace isolators for tubular centrifugal and axial fans when the fan pressure exceeds 4 inches water column.
- c. Provide inertia bases for all fans in lieu of structural steel bases or rails specified above when the fan pressure exceeds 4 inches water column.
- d. With attaching brackets, suspension spring isolators bridge between the structure and the thrust-producing machinery such as high-pressure fan. Both types H and HR normally provide reaction in tension, while types S, SV, and SX normally provide reaction in compression. Thrust restraints are low-cost and effective components available from manufacturers. Use thrust restraints to eliminate the need for or reduce the magnitude of inertia mass when the mass is only used to reduce the displacement effects of the thrust.

3.1.8 Piping and High Pressure Ductwork

Provide vibration isolation for piping and high pressure ductwork with over 6 inches water column. The isolator deflections shall be equal to or greater than the static deflection of the vibration isolators provided for the connected machinery as follows:

3.1.8.1 High Pressure Ductwork

For a distance of 50 feet from fans, exhausters and blowers.

3.1.8.2 Piping Connected to Vibration Isolated Machinery

For a distance of 50 feet or 50 pipe diameters, whichever is greater.

3.1.8.3 Steam Pressure Reducing Valves

Connected piping for a distance of 50 feet or 50 pipe diameters, whichever is greater.

3.1.8.4 Condenser Water

For the full length of the piping.

3.1.8.5 Chilled, Hot, and Dual Temperature Piping

For risers from pumps and for the first 20 feet of the branch connection of the main supply and return piping at each floor.

3.1.9 Water and Steam Distribution Piping Application

Resiliently support piping with combination spring and neoprene isolation hangers. Provide spring elements with 5/8 inch static deflection; install the hanger with spacing so that the first harmonic natural frequency is not less than 360 Hz. Provide double-deflection neoprene elements. For the first two isolation hangers from the rotating equipment of 3 1/2 inch and smaller piping systems, ensure a deflection equal to the equipment-isolation static deflection. For the first four piping isolation hanger supports from rotating equipment of 4 inch and larger piping systems, use resilient hanger-rod isolators at a fixed elevation regardless of load changes. Incorporate an adjustable preloading device to transfer the load to the spring element within the hanger mounting after the piping system has been filled with water.

3.1.10 Pipe Hanger and Support Installation

3.1.10.1 Pipe Hangers

Provide eye-bolts or swivel joints for pipe hangers to permit pipe thermal or mechanical movement without angular misalignment of hanger vibration isolator.

3.1.10.2 High Temperatures

Where neoprene elements of vibration isolator may be subjected to high pipe temperatures, above 160 degrees F, provide metal heat shields or thermal isolators.

3.1.10.3 Valves

Provide vibration isolation hangers and supports at modulating, pressure reducing, or control valves which will induce fluid pulsations. When required or indicated, isolate valves with flexible connectors.

3.1.10.4 Machinery Without Flexible Connections

When piping is not connected to vibrating machinery with flexible connectors, provide the first four hangers with isolation elements designed for deflections equal to equipment vibration isolator deflections (including static, operating, and start-up).

3.1.10.5 Twelve Inch and Larger Pipe

Suspend 12 inch and larger pipe vibration hangers from resilient hanger rod isolators. Resilient hanger rod isolators shall be capable of supporting pipe during installation at a fixed elevation regardless of load changes. Provide an adjustable preloading device to transfer the load to isolation element after operational load is applied. Provide 12 inch and larger pipe supports with unrestrained stable springs for one inch deflection and with built-in leveling device and resilient vertical limit stops to prevent spring elongation when partial load is removed. Provide isolators capable of providing rigid anchoring during erection of piping so that it can be erected at a fixed elevation.

3.1.10.6 Pipe Risers

Provide pipe riser supports with bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with 1/4 inch steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.

3.1.10.7 Supports at Base of Pipe Risers

Piping isolation supports at the base of risers shall be two layers of 1/2 inch thick heavy-duty neoprene pad separated by 1/4 inch thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.

3.1.10.8 Pipe Anchors

Attach each end of the pipe anchor to an omni-directional pipe isolator which in turn shall be rigidly fastened to the steel framing or structural concrete. Provide a telescoping pipe isolator of two sizes of steel tubing separated by a minimum 1/2 inch thick pad of heavy-duty neoprene or heavy-duty neoprene and canvas. Provide vertical restraints by similar material to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.1.11 High Pressure Ductwork Hanger and Support Installation

Provide ductwork with vibration isolation hangers and supports where required or indicated. Connect ductwork to equipment with flexible duct connectors. Segment ductwork with flexible duct connectors.

3.1.11.1 Duct Risers

Provide duct riser supports within shafts with suitable bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with 1/4 inch steel plate.

3.1.11.2 Supports at Base of Duct Risers

For duct isolation supports at the base of risers, provide two layers of 1/2 inch thick heavy-duty neoprene pad separated by 1/4 inch thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the duct and isolation support to the pipe, and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support ducts, provide a maximum deflection of 1/4 inch at the midspan of this steel under the supported load. Rigidly support duct from the supplementary steel and the supplementary steel isolators.

3.1.11.3 Duct Anchors

Attach each end of the duct anchor to an omni-directional isolator which in turn shall be rigidly fastened to the steel framing or structural concrete as indicated. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.1.12 Equipment Room Sound Isolation

Do not allow direct contact between pipe or ducts and walls, floor slabs, roofs, ceilings or partitions of equipment rooms.

3.1.12.1 Pipe Penetrations

Provide galvanized Schedule 40 pipe sleeves and tightly pack annular space between sleeves and pipe with insulation having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E 84, maximum effective temperature 1000 degrees F, bulk density 6 pounds/cu. ft. minimum. Provide uninsulated pipe with a one

inch thick mineral fiber sleeve the full length of the penetration and seal each end with an interior or exterior and weather resistant non-hardening compound. Provide sealant and mineral-fiber sleeve of a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E 84.

3.1.12.2 Duct Penetrations

Pack openings around ducts with mineral fiber insulation the full length of the penetration having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E 84.

At each end of duct opening provide sealing collars and seal with an interior or exterior and weather resistant non-hardening compound.

3.1.12.3 Ducts Passing Through Equipment Rooms

Provide with sound insulation equal to the sound attenuation value of the wall, floor, or ceiling penetrated.

3.1.13 Machinery Foundations and Subbases

Provide cast in place anchor bolts as recommended by the machinery manufacturer.

3.1.13.1 Machinery Subbases

Provide concrete subbases at least 4 inches high for floor mounted equipment except elevators. Rest subbases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both ends. Provide at least 2 inch clearance between subbases and inertia bases, steel bases, and steel saddles with machinery in operation.

3.1.13.2 Common Machinery Foundations

Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.

3.1.13.3 Foundation and Subbase Concrete

Cast concrete foundations and subbases of ASTM C 94 3,000 psi concrete reinforced with steel bars as indicated or recommended by machinery manufacturer.

3.1.13.4 Anchor Bolts and Grout

Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.

3.1.14 Inertia Bases

Install inertia bases in accordance with the recommendations of the machinery manufacturer or inertia base manufacturer, as applicable.

3.1.15 Seismic Restraints for Piping and Ductwork

Provide seismic restraints in accordance with [SMACNA Seismic Restraint Mnl.](#)

3.1.16 Suspended Machinery Platforms

Provide with vibration-isolation hangers.

3.1.17 Electrical Connections

Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit minimum displacement in any direction without damage.

3.1.18 Systems Not To Be Vibration Isolated

Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

3.2 FIELD QUALITY CONTROL

Provide equipment and apparatus required for performing inspections and tests. Notify Contracting Officer 14 days prior to machinery testing. Rebalance, adjust, or replace machinery with noise or vibration levels in excess of those given in the machinery specifications, or machinery manufacturer's data.

3.2.1 Field Inspections

Prior to initial operation, inspect the vibration isolators and seismic snubbers for conformance to drawings, specifications, and manufacturer's data and instructions. Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Check connector alignment before and after filling of system and during operation. Correct misalignment without damage to connector and in accordance with manufacturer's recommendations.

3.2.2 Spring Isolator Inspection

After installation of spring isolators or protected spring isolators, and seismic restraint devices, the machinery shall rock freely on its spring isolators within limits of stops or seismic restraint devices. Eliminate or correct interferences.

3.2.3 Tests

Adjust, repair, or replace isolators as required to reduce vibration and

noise transmissions to specified levels.

3.2.3.1 Equipment Vibration Tests

Perform vibration tests to determine conformance with vibration isolation schedule specified .

3.2.3.2 Equipment Sound Level Tests

Measure continuous or intermittent steady state noise with a sound level meter set for low response. Measure impact or impulse noise as dB peak sound pressure level (20 uPa) with an impact noise analyzer. Measure work distance from person to machinery noise center. Perform sound level tests to determine conformance with sound level schedule specified.

a. Interior Machinery Sound

In accordance with [ARI 575](#), measure the sound data for air conditioning and refrigeration machinery, such as fans, boilers, valves, engines, turbines, or transformers. Measure the sound pressure levels around mechanical and electrical machinery located in equipment spaces, [3 feet](#) horizontally from the edge closest to the acoustical center of the machinery at points [3 feet](#) and [5.5 feet](#) above floor. Take measurements at the center of each side of the machinery. Locate the microphone at least [3 feet](#) from the observer and measuring instruments. Observer shall not be between the machinery and the measuring instrument.

b. Exterior Machinery Sound

Measure sound data in accordance with [ARI 370](#) for machinery radiating noise outside the building in such applications as grade installations, area-ways, wall and roof installations for cooling towers, refrigerant condensers, engine driven generator sets, fans, air conditioning machinery, heat pumps, evaporative coolers, exhaust silencers, and air intakes.

-- End of Section --