

SECTION 23 05 48**VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT****PART 1 - DESIGN DIRECTIVES****1.1 RELATED DOCUMENTS**

- A. This section shall be considered as a part of each DC Standards, Division 23.

1.2 QUALITY ASSURANCE

- A. Manufacturer's qualifications, firms regularly engaged in manufacture of seismic restraint products, of type, size and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. 2015 International Building Code, or New Hampshire latest adopted version of the IBC
 - 2. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) Seismic Restraint Manual Guidelines for Mechanical Systems, latest edition.
 - 3. ASHRAE HVAC Applications Handbook, Seismic Restraint Design, latest edition.

1.3 DESIGN CRITERIA

- A. The designer is responsible to coordinate with the architect determine if seismic restraint is required for the building. If required, state in the specifications the parameter of seismic restraint that is required for the project.
- B. The designer is responsible in determining and stating in the specifications the Seismic Hazard Level (SHL) requirements as published by SMACNA.
- C. The designer is responsible for specifying each vibration device to insure suitability for the intended service. The selections for equipment shall be clearly defined in the drawing schedules.
- D. Seismic protection of water pipes for fire protection systems shall be installed in strict accordance with the provisions of NFPA 13 and Appendix A thereto as specified in, "FIRE PROTECTION".

1.4 SUBMITTALS

- A. Mechanical Systems and Equipment Seismic Restraint Shop Drawings: detail drawings of manufacturer's products, calculations, SMACNA Guidelines, NFPA 13 guidelines, and/or additional installation details for the seismic restraints required shall be submitted. Submittals shall be complete in detail; shall indicated thickness, type, grade, class of metal, dimensions, and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction. Provide a plan indicating the locations and types of seismic restraints and references to drawing detail types and shall bear the stamp of a New Hampshire licensed professional structural engineer.

PART 2 - PRODUCTS**2.1 ACCEPTABLE MANUFACTURERS**

- A. Manufacturer: subject to compliance with requirements, provide vibration control products of one of the following:
1. Amber/Booth Co.
 2. Kinectics Noise Control
 3. Korfund Dynamics Corp
 4. Mason Industries, Inc.
 5. Sound Seal, United Process, Inc.
 6. Vibration Mountings and Controls, Inc.

2.2 SEISMIC RESTRAINT MATERIALS AND EQUIPMENT

- A. Materials and equipment shall conform to the respective specifications and other requirements specified below:
1. Cold-formed angles shall conform to the material and identification requirements of the latest "Specifications for the Design of Cold-Formed Steel Structural Members" of the American Iron and Steel Institute with a minimum $F_y = 33$ ksi and a minimum $F_u = 38$ ksi.
 2. The uncoated minimum steel thickness of the cold-formed product as delivered to the job site shall not at any location be less than 95% of the thickness indicated. The thickness may be less at bends after cold forming.

Gage	Standard Uncoated Thickness (inches)	Galvanized Thickness (inches)
12	.1046	.1084
14	.0747	.0785
16	.0598	.0635

3. Hot-rolled shapes and plates shall conform to ASTM A36. Pipes used as braces shall be Standard Steel Pipes ASTM A120 or A53.
4. Cables shall be wire-core with a minimum breaking strength as specified. Cable shall be zinc-coated to a minimum of 0.4 ounces/square foot or stainless steel per ASTM A304. Tighten cable only to remove excessive slack.

Size (inches)	Breaking Strength (lbs.)
1/4	4,940
3/8	10,980
1/2	19,260

5. Bolts shall conform to ASTM A325. Bolt holes shall be 1/16" larger than the bolt diameter unless noted otherwise.
6. Expansion anchors shall have values equal to or greater than both the shear and tension capacities listed. Cast-in-place concrete inserts may replace expansion

anchors where the approved loads are equal to greater than the values for the specified expansion anchors.

Expansion Anchor Size(inches)	Shear Capacity (lbs.)	Tension Capacity (lbs.)
3/8	675	615
1/2	1,130	1,040
5/8	1,580	1,535
3/4	2,270	2,020
7/8	5,060	3,705

7. Welding shall conform to AWS D1.1 and shall use either the shielded or submerged arc methods.
8. Where neoprene is used in any seismic device only bridge grade neoprene is allowed.

2.3 VIBRATION CONTROL MATERIALS AND SUPPORTS UNITS

- A. The references to type refer to the descriptions noted in the ASHRAE Applications Handbook, chapter 46, notes to table 45.
- B. Fiberglass Pads and Shapes (type 1): glass fiber of not more than 0.18 mil diameter, produced by multiple-frame attenuation process, molded with manufacturer's standard fillers and binders through 10 compression cycles at 3 times rated load bearing capacity, to achieve natural frequency of not more than 12 Hertz, in thicknesses and shapes required for use in vibration isolation units.
- C. Neoprene Pads (type 1): oil-resistant neoprene sheets, 40 – 60 durometer stiffness, cross-ribbed or waffled pattern.
- D. Neoprene Mountings (type 2): provide neoprene mountings consisting of neoprene element bonded between 2 steel plates that are neoprene-covered to prevent corrosion. Provide minimum rated deflection of 0.35". Provide threaded hole in upper plate and 2 holes in base plate for securing to equipment and to substrate.
- E. Vibration Isolation Springs: wound-steel compression springs, or high-strength spring alloy steel; with spring diameter not less than 0.8 of compressed height of spring at rated loads. Provide minimum additional travel to solid, equal to 50% of rated deflection. Provide spring wire with elastic limit stress exceeding at solid deflection.
 1. Spring Isolators, Free-Standing (type 3): provide vibration isolation spring between top and bottom loading plates, and with pad-type isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with lock nuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated. Include holes in bottom plate for bolting unit to substrate as indicated.
 2. Spring Isolators, Housed (type 4): provide vibration isolation spring between telescoping steel housings with top and bottom loading plates, and with pad type isolator bonded to bottom of loading plate. Include resilient inserts to separate and guide telescoping housings.

- a. Equip top loading plate with equipment anchorages as indicated or as required for support and attachment.
 - b. Include pad type isolator bonded to top of top loading plate, except on units with leveling bolts.
 - c. Include holes in bottom plate for bolting unit to substrate.
 3. Spring Isolators, Vertically-Restrained (type 4): provide spring isolators in housing that include vertical limit stops. Design housing to act as blocking during erection, and with installed height and operating height being equal. Maintain 1/2" minimum clearance around restraining bolts, and between housing and springs. Design so limit stops are out of contact during normal operation.
 4. Spring Isolators, Earthquake-Restrained: Provide spring isolator assembly which will resist horizontal and vertical forces.
- F. Seismic Snubbers: provide seismic snubbers, separate from spring isolators, for limiting equipment movement, designed to provide seismic restraint in all modes. Provide snubbers designed to have no contact during normal operation and have minimum clearances of 1/4" in all directions.
- G. Thrust Restraints (type 5): provide horizontal thrust restraints consisting of spring element in series with neoprene pad. Select spring deflection same as for equipment loading. Design so thrust restraints can be preset and adjusted in field. Attach horizontal restraints at centerline of thrust and symmetrically on either side of unit.
- H. Equipment Rails (type B): provide steel beams complying with ASTM A36, with minimum depth of 6" or 10% of the beam span between isolators (whichever is greater). Provide welded bracket at each end of beams and anchor each end to spring isolator unit. Provide bolt holes in beams matching anchor bolt holes in equipment. Provide beams of section modulus indicated or, if not indicated, selected for normal-weight equipment loading to limit static load stress to 16,000 psi.
- I. Fabricated Equipment Bases (type B): provide welded rectangular unit, fabricated of structural steel shapes, plates and bars complying with ASTM A36. Provide welded support brackets at points indicated, and anchor base to spring isolator units. Arrange brackets to result in lowest possible mounting height for equipment but provide a minimum clearance of 1". Provide bolt holes in base matching anchor bolt holes in equipment.
1. Where indicated, provide for auxiliary motor slide base under motor or motor slide rails for adjusting belt tension. Design primary base for bolting of rails or slide base in position.
 2. Fabricate base with depth of structure not less than 10% of the longest span of base, rigidly braced to support equipment without deflections or distortions that would be detrimental to equipment or equipment performance.
- J. Inertia Base Frames (type C): where inertia bases are indicated for use with isolation units to support equipment, provide rectangular structural beam channel, or complete sheet metal box concrete forms for floating foundations, with materials complying with ASTM A36. Frame unit with a minimum depth of 10% of the longest dimension of base, but not less than 6" deep. Size so that the weight of frame plus concrete fill will be greater than operating weight of equipment supported. Provide steel reinforcing both ways with

both ends of reinforcing butt-welded to base framing. Provide welded support brackets for connection to spring isolator units.

- K. Roof Curb Isolators (type D): fabricated frame units sized to match roof curbs, formed with isolation springs between extruded aluminum upper and lower sections, which are shaped and positioned to prevent metal to metal contact. Provide continuous airtight and waterproof seal between upper and lower extrusions. Include provisions for anchorage of frame unit to roof curb, and for anchorage of equipment to unit.
- L. Spring Isolation Hangers (type 3): angle units formed with brackets and including manufacturer's standard compression isolators. Design brackets for 3 times rated loading of units. Fabricate units to accept misalignment of 30° off center in any direction before contacting hanger box, and for use with rod type members, and including acoustical neoprene washers to prevent metal at the top of the hanger box and under the spring.
- M. Flexible Pipe Connectors:
 - 1. For non-ferrous piping, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose.
 - 2. For ferrous piping, provide stainless steel hose covered with stainless steel wire braid with NPT steel nipples or 150 psi ANSI flanges, welded to hose.
 - 3. Flexible Pipe Connectors: Provide neoprene or EDPM construction consisting of multiple plies of nylon tire cord fabric and elastomer molded and cured in hydraulic rubber presses. Provide straight or elbow connector as indicated, rated at 125 psi at 220°F.

PART 3 - EXECUTION

3.1 SEISMIC MECHANICAL SYSTEMS BRACING

- A. All required ductwork and piping shall be provided with seismic restraint in accordance with the approved submittal.

3.2 SEISMIC EQUIPMENT BRACING

- A. Braces shall consist of angles, rods, bars, or pipes secured at both ends with not less than ½-inch bolts. Bracing shall be provided in two planes of directions, 90° apart, for each piece of equipment. Sufficient braces shall be provided for equipment to resist horizontal forces without exceeding safe working stress of bracing components. In lieu of bracing with vertical supports, these items may be supported with hangers included at 45° directed up and radially away from equipment and oriented symmetrically in 90° intervals on the horizontal plane, bisecting the angle of each corner of the equipment, provided that supporting members are properly sized to support operating weight of equipment when hangers are included at a 45° angle.

3.3 PERFORMANCE OF VIBRATION ISOLATORS

- A. Comply with minimum static deflections recommended by ASHRAE, for selection and application of vibration isolation materials and units as indicated.

- B. Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units.

3.4 APPLICATIONS

- A. Select vibration control products in accordance with the ASHRAE Applications Handbook, Chapter 46 "Sound and Vibration Control", Tables 45 & 46. Where more than one type of product is offered, selection is Designer's option and shall be submitted for review. Amend Table 45 as follows:

1. Tank mounted air compressors and vacuum pumps ≤ 10 HP, located on other than slab on grade, shall be mounted on type 'C' base.
2. Close coupled, end suction, and split case pumps on grade shall be as recommended by the manufacturer.
3. Package roof top equipment, up to 20 tons, and up to 20' structure span, shall be mounted on type 'A' mountings. Larger equipment and/or greater spans shall be type 'D' mounting.

- B. For piping connected to equipment mounted on vibration control products, install pipe isolation hangers for first points according to the following schedule:

Isolated Pipe Hanger Requirements	
Pipe Size	Qty. of Isolated Supports
$\leq 4"$	3
5" \rightarrow 8"	4
$\geq 10"$	6

- C. Pipe Isolation

1. All chilled water, hot water, steam, steam condensate, refrigerant, drain and equipment exhaust piping that is connected to vibration-isolated equipment, shall be isolated from the building structure within mechanical rooms, 50 ft total pipe length of connected vibration-isolated equipment (chillers, pumps, air handling units, etc.), and at every support point for piping that is greater than 4 inches in diameter.
2. Piping shall be isolated from the building structure by means of vibration isolators, resilient lateral supports, and resilient penetration sleeve/seals.

- D. Major Equipment Isolation

1. All floor mounted major equipment shall be set on housekeeping concrete pads, structurally designed for the weight, and use of equipment. Architect to coordinate.
2. Flexible duct connections shall be installed at all fan unit intakes, fan unit discharges, and as required throughout the spaces. Design to specifically show this.
3. Thrust restraints shall be installed on all suspended fans and on all floor-mounted fans developing 4" or more of static pressure, unless the horizontal component of the thrust force can be demonstrated to be less than 10% of the equipment weight.
4. Electrical connections to vibration-isolated equipment shall be flexible, coordinate with Division 26.

- E. Duct Isolation

1. All sheet metal ducts and air plenums that are within mechanical rooms or within a distance of 50 ft total duct length of connected vibration-isolated equipment (whichever is longer) shall be isolated from the building structure by Type FN or HN isolators. All isolators shall achieve 0.1" minimum static deflection.
2. Ducts within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
3. Flexible duct connections shall be provided as called for under Major Equipment and as required throughout the spaces. Design to specifically show this.

F. Miscellaneous Equipment Isolation

1. Miscellaneous mechanical equipment, converters, pressure reducing stations, dryers, strainers, storage tanks, condensate receiver tanks, expansion tanks, which are connected to isolated piping systems, shall be vibration-isolated from the building structure, unless their position in the piping system requires a higher degree of isolation.

3.5 INSTALLATION

- A. Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.
- B. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.
- C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.
- D. Install inertia base frames on isolator units as indicated, so that minimum of 1" clearance below base will result when frame is filled with concrete and supported equipment has been installed and loaded for operation.
- E. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft.
- F. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
- G. Hanger rods for vibration-isolated support shall be connected to major structural members, not the floor slab between major structural members. Provide suitable intermediate support members as necessary.
- H. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly but not in contact with the building structure or other objects.
- I. Parallel running pipes may hang together on a trapeze that is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze.
- J. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.

- K. All equipment shall be adjusted through leveling bolts and hanger rod bolts to be level and in proper alignment.
- L. For air handling equipment, install thrust restraints as indicated, and also wherever thrust exceeds 10% of equipment weight.
- M. Thrust restraints shall be attached on each side of the fan parallel to the thrust force. The body of the thrust restraint shall not come in contact with the connected elements and be adjusted to constrain equipment movement to a specified limit.
- N. Locate isolation hangers as near overhead support structure as possible.
- O. Weld riser isolator units in place as required to prevent displacement from loading and operations.
- P. Install flexible pipe connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible.
- Q. Grommets, when required to hold down bolts of isolators, bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized.
- R. Resilient Penetration Sleeve/Seals – maintain airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.
- S. Drilled-in Anchors
 - 1. Wedge Anchors: protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 2. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.6 ADJUSTING AND CLEANING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operation height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment during normal mode of operation.
- E. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.7 HVAC VIBRATION-CONTROL DEVICE SCHEDULE

- A. Vibration isolation shall be provided on mechanical equipment. Isolation and restraint device types and minimum deflection shall be as follows:

SUSPENDED EQUIPMENT VIBRATION ISOLATION SCHEDULE		
Suspended Equipment	Isolator Type	Minimum Static Deflection
Generator exhaust/silencer	3ON	1.5"
In-line pumps	ND	0.30"
In-line exhaust fans	SLF	1.5"
Fan coil unit or cabinet unit heater	30N	0.75"
VAV boxes with flexible duct connections	NA	NA
Miscellaneous equipment	HD	0.1"
Diffusers in ceilings not seismically restrained	NA	NA

B

SUSPENDED EQUIPMENT VIBRATION ISOLATION SCHEDULE		
Suspended Equipment	Isolator Type	Minimum Static Deflection
Wall-mounted non-isolated equipment, if not specified elsewhere	NA	NA
Non-isolated equipment suspended from structure, if not specified elsewhere	NA	NA

BASE-MOUNTED EQUIPMENT VIBRATION ISOLATION SCHEDULE		
Base-Mounted Equipment	Isolator Type	Minimum Static Deflection
Circulating pumps	SLF	1.5"
Air handling unit fans	SLF	1.5"
Chiller	SLRS	0.75"
Exhaust fans	SLF	1.5"
Floor-mounted non-isolated equipment, if not specified elsewhere	N/A	N/A
Air handling units	SLF	0.75"
Miscellaneous equipment	ND	0.1"

- B. Each floor mounted pump shall be bolted and grouted to reinforced concrete inertia base. Support concrete base by isolators.

END OF SECTION 23 05 48