SECTION 23 05 48
VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 – GENERAL

1.01 WORK INCLUDED

A. The work of this Section shall include, but is not limited to, the following:

1. Selection and design of vibration isolation elements for mechanical piping, ductwork and rotating equipment
2. Equipment isolation bases
3. Flexible connectors
4. Seismic restraint and anchorage calculations
5. Seismic restraints for isolated and non-isolated equipment, piping and ductwork
6. Supervision and inspection of installed vibration isolators, seismic restraints, anchorage and associated hardware

1.02 RELATED DOCUMENTS

A. Section 23 05 01 – HVAC General Provisions

B. Section 23 05 29 – Hangers and Supports for HVAC

C. Section 23 05 14 – Variable Frequency Drives for HVAC

D. Section 23 21 13 – Hydronic Piping

E. Section 23 21 23 – Hydronic Pumps

F. Section 23 23 00 – Refrigerant Piping and Accessories

G. Section 23 31 00 – HVAC Ducts and Casings

H. Section 23 34 00 – HVAC Fans

I. Section 23 36 00 – Air Terminal Units

J. Section 23 51 00 – Breechings, Chimneys and Stacks

K. Section 23 52 16 – Condensing Boilers

L. Section 23 64 29 – Air Cooled Chillers

M. Section 23 81 26 – Split-System Air-Conditioners

N. Section 23 81 46 – Water-Source Unitary Heat Pumps

O. Section 23 82 19 – Fan Coil Units

1.03 REFERENCE STANDARDS

Published specifications standards, tests or recommended methods of trade, industry or

governmental organizations apply to work in this Section where cited below:

A. ASCE – American Society of Civil Engineers

1. ASCE 7-05 Minimum Design Loads for Buildings and Other Structures

1.04 QUALITY ASSURANCE

A. Provide control of excessive noise and vibration in the buildings due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork or conduit. Install vibration isolation units and associated hangers and bases under the direct supervision of the vibration isolation manufacturer's engineer.

1. Vibration isolators shall have either known undeflected heights or calibration markings so that after adjustment, when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.
2. Isolators shall operate in the linear portion of their load versus deflection curve. Furnish load versus deflection curves that are linear over a deflection range of not less than 50 percent greater than the design deflection.
3. The ratio of lateral to vertical stiffness shall be neither less than 0.9 nor greater than 1.5.
4. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness shall not differ from the design objectives for the equipment as a whole by more than plus or minus 10 percent.
5. All neoprene mountings and components shall be oil resistant and have:

a. Shore durometer hardness of 40 to 65, after minimum aging of 20 days or corresponding oven-aging
b. Minimum tensile strength of 2,000 pounds per square inch
c. Minimum elongation of 300 percent
d. Maximum compression set at 25 percent

B. Mounting systems or components shall not be resonant with any of the supported equipment forcing frequencies.

C. Isolators shall be selected on the basis of the static and dynamic loads actually supported. Dynamic loads include those due to: wind, fluid flow, thrust and rotational inertia. Select each isolator independently for proper load distribution on each piece of equipment, duct and pipe support, or base.

D. Vibration isolation hardware shall not be concealed until reviewed by the Architect.

E. Verify specified clearances, plumb installation of hanger rods and lack of interference – no contact permitted with gypsum board, framing, ceiling wires, light fixtures, conduit, ducts and piping.

F. Verify that the space below inertia bases is clean and clear of construction debris and obstructions.

G. Verify proper vibration isolator loading and deflection.

H. Vibration isolation field inspection engineer shall provide a punchlist report for the Architect's review.

I. Vibration isolation and seismic restraint field inspection engineer shall submit a close-out letter stating that the installation is complete and meets the requirements of the specification and the manufacturer's installation instructions, and all deficiencies noted have been corrected.

J. Cooperate with Owner's Special Inspector.

1.05 SUBMITTALS

A. Manufacturer's Data:

1. Catalog cuts and data sheets on specific vibration isolators to be utilized showing compliance with the specifications.
2. An itemized list showing the items of equipment and piping to be isolated, the isolator type and model number selected, isolator loading and deflection, and reference to specific drawings.
3. Written approval of the base design shall be obtained from the equipment manufacturer.

B. Shop Drawings: Concrete reinforcing details and templates for all foundations, bases, supports, inertia blocks, hanger bolts, etc.; support frame details, pipe support details; vibration isolation mountings for equipment and piping including equipment weight, center of gravity and operating speed, location and installation details. Include in the vibration isolation equipment submittal drawing the following information based on equipment submittals released for construction:

1. Isolation mounting deflections.
2. Spring diameters, compressed spring heights at rated load and solid spring heights where steel spring isolation mountings are used.
3. Equipment operating speed.

4. Seismic restraint calculations stamped by a **Utah State** licensed structural or civil engineer, confirming compliance with ASCE 7-05 and the building code.

5. Product data and provide calculations to demonstrate compliance with the requirements of regulatory agencies.
6. Note compliance with seismic code regulations and the project specification on the submittals.
7. Number and location of seismic restraints and anchors for each piece of equipment including but not limited to bolted or welded connections between cooling tower and support beams, vertical pipe risers, bolt sizing and embedment depth, and seismic cable strength and diameters.
8. Drawings showing methods of isolation of pipes and ductwork piercing walls and floor slabs.
9. Provide installation instructions, drawings and field supervision to assure proper installation and performance.

10. Certificate of compliance for each component mounting system and anchorage as required by **IBC** Section 1705.12.
11. Written statement of responsibility as required by **IBC**Section 1704.4.

C. Submit close-out letter and reports as described in Paragraphs 1.04I, 3.06A and 3.06C.

D. Submit seismic restraint calculations as described in Paragraph 2.05A.

1.06 MANUFACTURER RESPONSIBILITIES

A. Manufacturer of vibration isolation equipment shall have the following responsibilities:

1. Certificate of compliance.
2. Determine vibration isolation and seismic restraint sizes and required locations.
3. Provide piping, ductwork and equipment isolation systems and seismic restraints as scheduled or specified.
4. Guarantee specified isolation system deflection.
5. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
6. Seismic restraints and anchorage shall be designed for the lateral and vertical forces required by the Building Code for the specific project type and site. Confirm lateral and vertical forces and site-specific design criteria with the project Structural Engineer.

1.07 DEFINITIONS

A. Life Safety Systems:

1. All components involved with fire protection including fans, etc. System restraints shall be designed with an Importance Factor of 1.5.

B. Positive Attachment:

1. A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double-sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided “C” type beam clamps for support rods of overhead piping, ductwork, components involved with fire protection or any other equipment are not acceptable as seismic anchor points.

1.08 SPECIAL INSPECTIONS

A. The Owner shall retain a Special Inspector to perform periodic inspections of the following systems:

1. Vibration isolation systems where the clearance between equipment support frame and seismic restraints is ¼ inch or less.
2. Piping and attached equipment containing flammable, combustible or highly toxic materials. Importance Factor 1.5.
3. Ductwork and attached equipment containing hazardous substances. Importance Factor 1.5.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Vibration Isolation: Mason Industries (MII), Vibration Mountings & Control (VMC), Vibration Eliminator (VEC), Vibrex Vibration Control Systems (VVC), ISAT

B. Piping and Duct Seismic Bracing: B-Line, Super Strut, Mason Industries, ISAT

2.02 MATERIALS

A. All vibration isolation devices shall be the products of a single manufacturer.

B. Where exposed to the atmosphere, all steel shall be hot-dipped galvanized; hardware shall be cadmium plated; springs shall be powder coated.

2.03 VIBRATION ISOLATORS

A. Refer to these specifications and drawings for vibration isolator types to be used:

1. Type “A” spring isolators shall incorporate the following:

a. Minimum diameter of 0.8 of the loaded operating height and horizontal spring stiffness 1.1 times rated vertical spring stiffness.
b. Reserve deflection, from loaded to solid height, of 50 percent of rated deflection with leveling device.
c. Minimum ½-inch thick neoprene acoustical base pad on underside, unless designated otherwise. Neoprene elements shall be as specified.
d. Designed and installed so that ends of springs remain parallel.

Type SLF..... MII
Type OSK.....VEC
Type RMS VVC

2. Type “B” spring isolators shall be similar to Type “A”, except inherently restrained:

a. Provide built-in resilient vertical limit stops with neoprene grommets.
b. Tapped holes in base plate for bolting isolator to base, housekeeping pad or structural support. Tapped holes in top plate for bolting to equipment.
c. Capable of supporting equipment at fixed elevation during equipment erection.

Type SLR Series 100..... MII
Type KW .....VEC
Type RMLS-EQ.....VVC

3. Type “C1” pre-compressed spring hanger rod isolators shall incorporate the following:

a. Spring element seated on a steel washer in series with a deflected neoprene element as specified.
b. Steel retainer box encasing the spring and neoprene washer. Ensure no metal-to-metal contact.
c. Minimum ½-inch clearance between retainer box and spring hanger rod. Provide neoprene grommet.
d. Where operating weight differs from installed weight provide built-in adjustable limit stops to prevent equipment rising when weight is removed. Stops shall not be in contact during normal operation. Clearly indicate deflection with scale on isolator.

e. Maximum 30-degree allowable rod misalignment from centerline axis.

Type PC30N..... MII
Type PCSR .....VEC
Type HXA-PC.....VVC
Type HRSA-PR..... VMC

4. Type “D” elastomer inherently restrained isolators shall incorporate the following:

a. Bolt holes for bolting to equipment base.
b. Bottom steel plates for bolting to sub-base as required.
c. Molded unit type neoprene element as specified.

Type BR ..... MII
Type 368 S/368 TD .....VEC
Type FUD-EQ VVC
Type RDC ..... VMC

5. Type “E” elastomer hanger rod isolators shall incorporate the following:

a. Molded unit type neoprene element as specified.
b. Steel retainer box encasing neoprene mounting.
c. Clearance between mounting hanger rod and steel retainer box. Provide neoprene grommet.

Type HD ..... MII
Type CD .....VEC
Type HSS-VLS.....VVC
Type HR ..... VMC

6. Type “F” pad type elastomer mountings shall incorporate the following:

a. 5/16-inch minimum thickness neoprene elements as specified. Verify thickness will not degrade or derate the isolator performance.
b. Sized for 50 pounds per square inch maximum loading. Provide suitable bearing plate to distribute load.
c. Ribbed or waffled design.
d. ⅙-inch deflection per pad thickness.
e. 16 gauge galvanized steel plate between multiple layers of pad thickness.

Type Super MWSW ..... MII
Type EVAPG-EQ VVC
Type MAXI FLEX ..... VMC

7. Type “G” pad type elastomer mountings shall incorporate the following:

a. Neoprene impregnated canvas duck material.
b. Maximum loading 1,000 pounds per square inch. Provide suitable bearing plate to distribute load.
c. Minimum thickness, 2-inch.

Type HL..... MII
Type Fabri-Flex..... VMC

8. Type “H”: Rooftop equipment spring isolation curb shall incorporate the following:

a. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. All directional neoprene snubber bushings shall be a minimum of ¼-inch thick. Steel springs shall be laterally stable and rest on ¼-inch thick neoprene acoustical pads.

b. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2-inch thick insulation.

2.04 EQUIPMENT BASES

A. Structural Steel Base, Type “B-1”:

1. Reinforce base as required to prevent flexure at start-up and misalignment of drive and driven units. Provide centrifugal fan bases complete with motor slide rails, drilled or slotted for drive and driven unit mounting template with height-saving brackets and equipment-bolting provisions.
2. A minimum operating clearance of 2 inches shall exist between the inertia base and the housekeeping pad.

Type WF or M ..... MII

B. Concrete Inertia Base, Type “B-2”:

1. Concrete inertia bases shall be formed in a structural steel perimeter base, reinforced as required to prevent flexure, misalignment of drive and driven unit or stress transferal into equipment. The base shall be complete with pump or piping base elbow support anchors and complete with height-saving brackets, reinforcing, equipment-bolting provisions.
2. Each pump with its driving motor shall be bolted and grouted to a spring-supported concrete inertia base reinforced as required. Provide a minimum of four spring vibration isolators as specified and/or shown on the Drawings.
3. Each rectangular concrete base shall include supports and base elbows for pump suction and discharge connections. Base elbows shall be bolted and grouted to the concrete foundation.
4. The suction and discharge pipe elbows of horizontal and/or vertical inline pumps shall be provided with welded vertical support stanchions of adequate strength and rigidity. These support stanchions along with the pump supports shall be bolted and grouted to a concrete inertia base, which in turn shall be supported on steel spring isolators. A minimum operating clearance of 2 inches shall exist between the inertia base and the housekeeping pad.
5. Minimum thickness of the inertia base shall be as follows:

Motor Size (Horsepower)	Minimum Thickness (Inches)
5-15	6

2.05 SEISMIC RESTRAINTS

A. General:

1. Provide restraints capable of safely accepting forces specified in PART 1 of this Section, without failure, to maintain equipment, piping, and ductwork in a captive position. Restraints must not short circuit vibration isolation systems or transmit objectionable vibration or noise. Submit calculations by a structural or civil engineer licensed and registered in the **Utah** to verify seismic restraint and cable capacities.

   a. Seismic Restraint, Type I: All directional seismic snubbers shall consist of interlocking steel members restrained by molded neoprene bushing compounded to bridge bearing specifications. Bushing shall be replaceable and a minimum of ¼-inch thick. Rated loadings shall not exceed 1,000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than ⅛ inch or more than ¼ inch. Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at ⅜-inch deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to ½-inch deflection in the X-, Y- and Z-planes.

      Type Z-1225-1 ..... MII

   b. Seismic Restraint, Type II: Cable type with approved end fastening devices (minimum of two per end) to equipment and structure. Cable to comply with Federal Specification MIL-DTL-83420 military grade 7 by 19 galvanized steel.

      Type SCBH ..... MII

PART 3 – EXECUTION

3.01 GENERAL

A. Install in accordance with manufacturer's recommendations and written instructions. Vibration isolators must not cause any change of position of equipment or piping resulting in piping stresses or misalignment.

B. Isolate mechanical equipment from the building structure by means of vibration isolators as specified and scheduled on the Drawings.

C. Vibration isolated piping and ductwork shall pass freely through walls and floors without rigid connections. Maintain ¾-inch to 1¼-inch concentric clearance around outside surfaces of piping or ductwork at penetration points. Pack this clearance space tightly with fiberglass, and caulk airtight after installation of piping or ductwork, or provide resilient firestopping as required. Provide supports 6 to 8 inches from walls or partitions on both sides of penetrations.

D. Do not make rigid connections between equipment and building structure that degrades or short circuits the vibration isolation system specified herein.

E. Loop electrical circuit connections to isolated equipment to allow free motion. Include at least one slack 90-degree bend.

F. Bring to the Architect's attention prior to installation any conflicts with other trades, which will result in unavoidable rigid contact with equipment or piping as, described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation will be at the Contractor's expense.

G. Support vertical piping loads, including water strainers, and valves between pump base elbow supports and the suction and discharge header piping by means of the pump base spring isolators without stress or strain to the pump housing.

H. Provide a flanged steel pipe spool piece between suction and discharge valves and pumps to permit future installation of flexible connectors.

I. Level vibration isolated equipment under rated design operating conditions while maintaining the isolation criteria. Isolators shall be plumb and aligned during operation.

3.02 EQUIPMENT ISOLATORS

A. Mount vibration isolating devices and related inertia blocks on concrete housekeeping pads.

B. Support each fan and motor assembly on a single structural steel frame. Provide flexible duct connections at inlet and discharge of heat pumps, air-conditioning units, fan coils and fans, including plug fan assemblies inside factory-assembled air-handling units unless prohibited by codes or local Authorities Having Jurisdiction. Refer to Section 23 31 00, HVAC Ducts and Casings.

C. If the equipment to be mounted is not furnished with integral structural frames and external mounting lugs (both of suitable strength and rigidity), install approved structural sub-base in the field which will support the equipment to be hung and to which will be attached the hangers.

D. Additional Requirements:

1. Provide brackets to accommodate the isolator. Manufacturer shall indicate bolt hole sizes and locations, welds required, and specify the vertical position and size of the bracket.
2. Maintain a minimum operating balance between the equipment frame on rigid steel base frame and the concrete housekeeping pad of 1 inch. Maintain a minimum operating clearance between concrete inertia and base and concrete housekeeping pad or floor of 2 inches.
3. Temporarily support the structural steel or concrete inertia base with blocks or shims, as appropriate, prior to the installation of the equipment or isolators.
4. Install the isolators without raising the equipment and frame assembly.
5. Adjust the isolators after the entire installation is complete and under full operational load so that the load is transferred from the blocks to the isolator. When all isolators are properly adjusted, the blocks or shims will be barely free and shall be removed.
6. Verify that all insulated isolator and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit equipment start-up lateral motion to ½-inch.
7. Prior to start-up, clean out all foreign matter between bases and equipment and under inertia bases. Verify that there are no isolation short circuits in the base or isolators.

3.03 PIPING ISOLATORS

A. Isolate piping as follows:

1. Piping in mechanical rooms, fan rooms, plumbing equipment rooms or boiler rooms.
2. Piping within 50 feet (or 100 diameters if greater) from connected rotating equipment and pressure-reducing stations.
3. As additionally specified in the following clauses.

B. Install isolators with the isolator hanger box attached to, or hung as close as possible to, the structure. Provide outrigger supports where required for clearance to equipment and to maintain minimum clearance of equipment to structure above.

C. Suspend isolators from substantial structural members, not from slab unless specifically permitted. Attachments to fireproofed structural members shall be re-fireproofed as required.

D. Align hanger rods to clear the hanger box. Replace bent rods.

E. Support pipe for the first three pipe hangers from any rotating equipment with isolator Type “C1” with a minimum 1½-inch static deflection.

F. Support pipe larger than 2 inches by isolator Type “C” with a minimum 1½-inch static deflection. Support horizontal pipe 2 inches and smaller by means of Type “E” isolator with a minimum of ¼-inch deflection.

G. HVAC piping, one-inch diameter and less, shall be isolated using Acousto-Plumb or equal resilient attachments or shall be provided with thermal insulation with shields at support points.

H. Grouped pipes shall be isolated by using Type “C” vibration isolators supporting trapeze hangers and selected to provide a static deflection of 1.0 inches. Grouped floor-supported pipes shall be isolated using Type “D” isolators selected to provide a static deflection of 0.15 inches.

I. Mount floor-supported horizontal pipe at slab using Type “A” isolator with a minimum static deflection of 1-inch or same deflection as isolated equipment to which pipe connects, whichever is greater.

J. Mount all isolators between building structure and supplementary steel.

K. Suspend isolators from rigid and massive support points.

L. Supplementary steel to be sized for a maximum deflection of 0.08 inches at center of span.

M. Support water piping not subject to thermal expansion with riser floor supports with Type “F” isolators (2 layers) or Type “G” pad depending on piping loads and support point space conditions within shafts.

N. Vibration isolation components shall not be used to correct misaligned sections of pipe.

O. Vertical piping subject to thermal expansion shall have pipe riser guides, anchors and supports located so that there will be no direct metal contact of the piping with the building structure.

1. Weld steel guide bars to the pipe at a maximum spacing of 60 feet. The outside diameter of the opposing guide bars shall be smaller than the inside diameter of the pipe riser clamp in accordance with standard field construction practice. Each end of the pipe riser clamp shall be rigidly attached to an all-directional pipe anchor isolation mounting, which in turn shall be rigidly fastened to the supplementary steel framing within the shaft.
2. The all-directional pipe anchor shall consist of a telescoping arrangement of 2 sizes of steel tubing separated by a minimum of ½-inch thick heavy duty neoprene and canvas duck isolation pad. Provide vertical restraints by similar material arranged to prevent vertical travel in either direction. The allowable load on the isolation material shall not exceed 500 pounds per square inch. Anchors shall be Mason Industries Type ADA or equal.
3. Construct piping guides for insulated piping with a 10-gauge metal sleeve around the piping. Provide the thermal insulation requirements for the piping between the piping and the sleeve. The metal sleeve outside diameter shall be smaller than the pipe riser clamp inside diameter. The pipe riser clamp shall be rigidly attached to the pipe guide, which shall be rigidly attached to the steel framing within the shaft. Guides shall be Mason Industries Type VSG or equal.
4. The pipe anchor mountings shall be capable of safely supporting loads, expansion, and thrusts developed by the installed piping.

P. Provide flexible piping connections for connections to rotating equipment as specified and where shown on the Drawings.

Q. Provide flexible piping connections and four-elbow offsets for all piping that crosses building seismic or expansion joints unless more stringent flexible all-directional joints have been specified elsewhere.

3.04 SEISMIC RESTRAINTS

A. General:

1. Cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or ductwork. Cable restraints shall be installed taut on non-isolated systems. Seismic solid brace restraints may be used in lieu of cables on non-isolated rigidly attached systems only.
2. Where cable or solid brace restraints are located, the equipment, ductwork or piping support rods shall be angle braced for compression loads.
3. At all locations where cable or solid brace restraints are attached to pipe clevises, the clevis cross bolt shall be reinforced with cross braces or a pipe spacer placed over the clevis bolt.
4. Provide drill-in concrete anchors for ceiling and wall installation and female wedge type for floor-mounted equipment.

B. Seismic Restraint of Piping:

1. Transverse piping restraints shall be at 40-foot maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
2. Longitudinal restraints shall be at 80-foot maximum spacing for all pipe sizes,

except where lesser spacing is required to limit anchorage loads.

3. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
4. PVC piping transverse restraints must be at 20-foot maximum and longitudinal restraints at 40-foot maximum spacing.
5. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within **[a specified distance]** (based on engineered data) of the elbow or tee or combined stresses are within allowable limits at longer distances.
6. Hold-down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.
7. Branch lines may not be used to restrain main lines.

C. Seismic Restraint of Ductwork:

1. Transverse restraints shall occur at 30-foot intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.
2. Longitudinal restraints shall occur at 60-foot intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4 feet of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.
3. The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.
4. A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
5. Walls, including gypsum board non-bearing partitions, which have ducts running through them, may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

D. Seismic Restraint of Equipment:

1. All mechanical equipment shall be vibration isolated and seismically restrained as scheduled using either inherently restrained vibration isolators or separate all-directional seismic snubbers as specified. Suspended equipment shall be restrained by cable restraints.

E. Seismic Restraint Exclusions (Flexible connectors are required between pipe or duct and equipment):

1. Piping:

   a. For I_p = 1.5 projects or systems, all piping 1-inch nominal diameter and smaller, except PVC piping of allsizes.
   b. For I_p = 1.0 projects, all steel and copper piping 3-inch diameter and smaller, except PVC piping of all sizes.

c. All piping suspended by individual hangers 12 inches or less as measured from the top of the pipe to the bottom of the support where the hanger is attached provided the hanger rod connection to the structure will not develop a moment. However, if the 12-inch limit is exceeded by any hanger in the run, seismic bracing is required for the run.

d. The 12-inch exemption applies for trapeze supported systems if the top of each item supported by the trapeze qualifies.

2. Ductwork (for Importance Factor 1.0):

a. Rectangular and Square Ducts that are less than 6 square feet in cross-sectional area.

b. Oval ducts that are less than 6 square feet in cross-sectional area based on nominal size.

c. Round duct less than 34 inches in diameter.

d. All duct suspended by hangers 12 inches or less in length as measured from the top of the duct to the point of attachment to the structure. Hangers must be attached within 2 inches of the top of the duct with a minimum of two #10 sheet metal screws. If the 12-inch limit is exceeded by any hanger in the run, seismic bracing is required for the run.

3. Suspended Equipment:

a. VAV boxes and fan-powered equipment weighing less than 75 pounds and rigidly connected to the supply side of the duct system and supported with a minimum of 4 hanger rods.

3.05 VIBRATION ISOLATION AND SEISMIC RESTRAINTS SCHEDULE

A. Unless otherwise scheduled on the Drawings provide the following Equipment Vibration Isolation and Seismic Restraints (General Equipment):

General Equipment		**Deflection (Inches)**	**Isolator Type**	**Restraint Type**
Chillers		2.0	“B”	–
Boilers		0.15	“F”	I
Roof-mounted fans ½ hp or greater		1.0	“B”	–
Roof-mounted fans less than ½ hp		0.15	“G”	–
Wall-mounted fans		0.15	“G”	–
Suspended fans		1.0	“C1”	II
Fan Arrays (external isolation)		0.15	“F”	–
Indoor and outdoor air-handling units:	internal isolation	2.0	“A”	I
Heat pumps and air conditioning units		1.0	“C1”	II
Fan coil units		0.35	“E”	II
Fan powered terminal units		0.35	“E”	II
Floor-mounted heat pumps and fan coils		1.0	“A”	I

General Equipment	Deflection (Inches)	Isolator Type	Restraint Type
Base-mounted pumps – inertia base required	2.0	"A"	I
Other suspended small pumps and motor driven equipment	1.0	"C1"	II
Split-system or VRF air-cooled condensers	2	"B"	–
Wall- or floor-mounted VFD's	0.15	"G"	–
Diesel engine and fire pump silencers, mufflers, precipitators (horizontal)	1.0	"C1"	II
Diesel engine/fire pump/boiler flue/exhaust pipes (vertical at floor supports)	⅙	F	I

B. (Specific Equipment)

General Equipment	Deflection (Inches)	Isolator Type
AHU-B1-1	1"	"A"
AHU-B1-2	1"	"A"
AHU-A-1-1	1"	"A"
AHU-A-1-X	1"	"A"
AHU-L-1-1	1"	"A"
AHU-B-B-1	1"	"A"
AHU-B-P1-1	1"	"A"
AHU-C-1-1	1"	"A"
UH	0.25"	"E"
ASHP	2"	"B"
GEF	0.1"	"F"
EF	1"	"C1"
TX, DX, KX	1"	"H"
BEF	1"	"C1"
SPF	1"	"H"
MUA	1"	"C1"
PCHWP	1"	"A"
SHWP	1"	"A"
SMBP	1"	"A"
BP	0.1"	"F"
GPS	0.1"	"F"
Boilers	0.25"	"D"
FCU	1"	"C1"
FPT ≤600 cfm	0.25"	"E"
FPT >600 cfm	1"	"C1"

3.06 INSPECTION

A. On completion of installation of all vibration isolation devices specified herein, the local representative of the isolation manufacturer, the manufacturer's engineer shall inspect the completed system and submit a report to the Architect indicating the adequacy of the

installation and listing any corrective action required.

B. Replace any component found to be visibly deflected with more substantial components.

C. Review Special Inspections reports prepared by the Owner's Agent and make corrections to deficiencies as noted. Provide written response to deficiency and document corrective actions.

END OF SECTION 23 05 48

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