

SECTION 23 05 48

MECHANICAL VIBRATION ISOLATION AND SEISMIC RESTRAINT SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. It is the objective of this Specification to provide the necessary design requirements for the 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. It is also the objective of this specification to provide the design criteria for seismic restraints for all isolated and non-isolated equipment.
- B. Work in this section includes the providing of labor, materials, equipment and services necessary for a complete and safe installation in of vibration isolation systems and seismic restraints for every mechanical system including piping and ductwork within and on the roof of the building, complete, as shown and specified per the contract documents and all applicable codes and authorities having jurisdiction.
- C. The work of this section includes, but is not limited to the following:
 - 1. Vibration isolation elements for piping and equipment.
 - 2. Equipment isolation bases.
 - 3. Piping flexible connections.
 - 4. Seismic restraints for isolated and non-isolated piping, tanks, stacks, ductwork, VAV boxes, and equipment.
- D. Related Sections:
 - 1. All Division 23000 Sections as issued for this project.
- E. Seismic restraints:
 - 1. All equipment, piping and ductwork shall be adequately restrained to resist seismic forces. This specification is in addition to the specified vibration isolation for this project. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest issue of the state and local codes and other authorities having jurisdiction.

2. Anchor bolt calculations, signed and stamped by a registered Professional Engineer, shall be submitted showing adequacy of the bolt sizing and type. Calculations shall include anchor embedment, minimum edge distance and minimum center distance. The design lateral forces shall be distributed in proportion to the mass distribution of the equipment. Calculations shall be furnished for anchors on restraint devices, cables, isolators and on rigid mounted equipment. The seismic designer must perform final jobsite inspection to verify anchor installation.
 3. Contractor shall supply all supplemental steel required for all equipment, ductwork and piping including roof mounted equipment.
 4. All isolators and equipment shall meet OSHPD requirements and contain approval from OSHPD.
- F. This specification shall be supplemented by all local codes and ordinance which shall take precedence in the event of the existence of any conflict between same and this specification. Where methods or materials specified are equivalent to the code requirements specified, comply with the specified requirements.
- G. Seismic-Restraint Loading:
1. Site Class as Defined in the IBC: D
 2. Assigned Seismic Use Group or Building Design Category as Defined in the IBC: C
 - a. Component Importance Factor: 1.50
 - b. Component Response Modification Factor: 6.0
 - c. Component Amplification Factor: 2.5
 3. Design Spectral Response Acceleration at Short Periods (0.123 Second): 0.327
 4. Design Spectral Response Acceleration at 1-Second Period: 0.077

1.3 SUBMITTALS

- A. In addition to the requirements of the section on Mechanical General Provisions, the submittal material shall include descriptive data for all products and materials including, but not limited to, the following:
1. Descriptive Data:
 - a. Catalog cuts and data sheets on specific vibration isolators and seismic restraints to be utilized showing compliance with the specifications.
 - b. An itemized list showing the items of equipment or piping to be isolated, the isolator type and model number selected, isolator loading and deflection, and reference to specific drawings showing seismic restraints, base and construction where applicable.

- c. An itemized list of non-isolated equipment, piping, and ductwork to be seismically restrained.
 - d. Seismic restraint calculations.
 - e. Riser supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
 - f. Structural or civil engineer's stamp verifying design and calculations for seismic restraining systems used.
2. Shop Drawings:
- a. Drawings showing equipment base constructions for each machine, including dimensions, structural member sizes and support point locations.
 - b. Drawings showing methods of suspension, support guides for piping and ductwork.
 - c. Drawings showing methods for isolation of pipes and ductwork piercing walls and slabs.
 - d. Concrete and steel details for bases, including anchor bolt locations.
 - e. Number and location of seismic restraints and anchors for each piece of equipment and of ductwork and piping.
 - f. Specific details of restraints, including anchor bolts for mounting and maximum loading at each location for each piece of equipment and lengths of ductwork and piping.

1.4 CODE AND REFERENCE STANDARD REQUIREMENTS

- A. All equipment supplied under this specification shall conform in all respects to the rules and regulations of:
- 1. SMACNA "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems." 1982
 - 2. 2003 ASHRAE GUIDE, Chapter 47, and Chapter 54
 - 3. All applicable state and local codes and authorities having jurisdiction.
 - 4. American Society for Testing and Materials:
 - a. ASTM A 36/a 36M-96: Specification for Carbon Structural Steel.

- b. ASTM E 488-96: Test Methods for Strength of Anchors in Concrete and Masonry Elements.
5. American Welding Society:
- a. ASW D1.1-98: Structural Welding Code – Steel.

1.5 QUALITY ASSURANCE

- A. All vibration isolation and seismic restraint devices shall be the product of a single manufacturer. Products of other manufacturer's are acceptable provided that their systems comply with the design intent for system performance, static deflection and structural design of the base manufacturer.
- B. Vibration isolation firms having a minimum ten years experience designing and supervising the installation of vibration isolation and seismic restraint systems shall be qualified to provide the materials and installation required by this section. Project listings shall be provided including geographical location and a reference contact.
- C. The installation of all vibration isolation units, and associated seismic restraints, hangers and bases, shall be under the direct supervision of the vibration isolation manufacturer's representative. The isolation manufacturer is to send a letter stating that they have inspected all of the vibration isolation units installed and they are installed properly and operating.
- D. Substitution of internally isolated mechanical equipment in lieu of the specified isolation of this Section must be approved for individual equipment units and is acceptable only if above acceleration loads are certified in writing by the equipment manufacturer and stamped and sealed by a licensed civil or structural engineer.
- E. Purchased and/or fabricated equipment must be designed to safely accept external forces of 1.0 g load in any direction for all rigidly and resiliently supported equipment, piping and ductwork without failure and permanent displacement of the equipment. Life safety equipment such as fire pumps, smoke exhaust fans, emergency generators and other life safety designated equipment must be capable of accepting external forces of up to 1.5 g in any direction without permanent displacement or failure of the equipment.
- F. Standards: If any item in this specification as furnished by the contractor is manufactured in a location which does not certify the referenced standards as defined in paragraph 1.4 of this specification, the contractor is to pay the owner for all expenses incurred by the owner for an outside testing company to confirm such compliances.
- G. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver each item as a factory-assembled unit with protective crating and covering.

- B. Store in a dry location.
- C. Provide disassembly and re-assembly as required to accommodate rigging and shipping.
- D. Comply with the manufacturer's written rigging and installation instructions for unloading, transporting and setting in final location.
- E. All equipment with shaft bearings (pump, fans, etc..) must have the shaft rotated every 2 weeks and the equipment must be stored inside.

1.7 SUBSTITUTIONS

- A. Any proposed substitution must be submitted at the time the bid is submitted. No substitute material or manufacturer of equipment shall be permitted without a formal written submittal to the engineer which includes all dimensional, performance and material specifications and is approved in writing by the engineer. Any changes in layout or design brought about by the use of a substitution shall be submitted to the engineer fully designed for review in conjunction with the submittal of the alternate. Any substitutions must be submitted with an explanation why a substitution is being proposed. If the substitute is being proposed for financial reasons the associated credit must be simultaneously submitted.
- B. Final acceptance or rejection of any substitution is subject to the Owner's review.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Coordinate with the architect and structural engineer for concrete, reinforcement, and formwork requirements.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The following are approved manufacturers, provided their systems strictly comply with the design intent for performance, deflection and structural capacity of this specification.
 - 1. Mason Industries, Inc., Hauppauge, NY
 - 2. Vibration Mountings & Controls, Inc., Bloomingdale, NJ
 - 3. Kinetics Noise Control, Dublin, OH
 - 4. Vibration Eliminator Co., Inc., Capiague, NY

5. Amber Booth, Houston, TX

2.2 DESCRIPTION

- A. All 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.
- B. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50% above the design deflection.
- C. Where spring isolation systems are described in the following specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 0.8 of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the springs remain parallel. The minimum deflection from loaded operating height to spring solid height shall be 50% of the rated static deflection of the spring.
- D. Where neoprene-in-shear isolation systems are described in the following specifications, the mounting assemblies shall utilize bare neoprene elements with unit type design molded in oil resistant neoprene. The neoprene shall be compounded to meet the following:
 1. Shore hardness of 35 to 65 \pm 5, after minimum aging of 20 days or corresponding oven-aging.
 2. Minimum tensile strength of 2000 PSI.
 3. Minimum elongation of 300 %.
 4. Maximum compression at 25 % of original deflection.
- E. The isolator ratio of lateral to vertical stiffness shall not be less than 0.9 nor more than 1.5.
- F. 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 \pm 10%.
- G. All mounting systems, including seismic restraints, exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) to be hot dip galvanized. Springs shall be powder coated and neoprene coated. Nuts and bolts shall be cadmium plated.
- H. All roof-mounted isolators shall be bolted or welded to building steel and anchored to the structure to resist 110 mph wind loads.

2.3 MANUFACTURER RESPONSIBILITIES

- A. Manufacturer of vibration isolation and seismic restraint equipment shall have the following responsibilities:
 - 1. Determine vibration isolation and seismic restraint sizes and locations.
 - 2. Provide piping and equipment isolation systems and seismic restraints as scheduled or specified.
 - 3. Guarantee specified isolation system deflection.
 - 4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.

2.4 VIBRATION ISOLATORS

- A. Type A: Bare spring isolators shall incorporate the following:
 - 1. Minimum 1/4" (6 mm) thick neoprene acoustical base pad on underside, unless designated otherwise.
 - 2. Non-resonant with equipment forcing frequencies or support structure natural frequencies.
 - 3. Requires seismic restraint type II
 - 4. Spring isolators to be Mason Type SLF, or as approved.
- B. Type B: Spring isolators shall be same as Type A, except:
 - 1. Provide built-in vertical limit stops with minimum 1/4" clearance under normal operation.
 - 2. Tapped holes in top plate for bolting to equipment. All hot dipped galvanized for outdoor installation such as at the air cooled chiller and centrifugal exhaust fans.
 - 3. Capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
 - 4. Shall incorporate snubbing restraint in all directions. Cast or aluminum housings are unacceptable. System to be field bolted or welded to deck with ability to resist forces of 1.5 g acceleration.
 - 5. Mason Type SLR, or as approved.
- C. Type C: Spring hanger rod isolators shall incorporate the following:
 - 1. Spring element seated on a steel washer within a neoprene cup incorporating a rod isolation bushing.
 - 2. Steel retainer box encasing the spring and neoprene cup.

3. Provide sufficient clearance between retainer box and spring hanger rod to permit minimum 15 degree allowable rod misalignment in any direction, total 30 degrees.
 4. Requires seismic restraint type III
 5. Mason Type TPC-30N, or as approved.
 6. 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.
- D. Type D: Elastomer Mounting Types/Elastomer Isolators, shall incorporate the following:
1. Bolt holes for bolting to equipment base.
 2. Bottom steel plates for bolting or welding to sub-base as required.
 3. Unit type design molded in oil-resistant neoprene.
 4. Encased in ductile steel or iron casing and capable of withstanding external forces of up to 1.5 g. System to be field bolted or welded to deck with ability to resist forces of 1.5 g.
 5. Mason Type ND isolation BR, RBA or as approved.
- E. Type E: Elastomer hanger rod isolators shall incorporate the following:
1. Molded unit type neoprene element with projecting bushing lining rod clearance hole.
 2. Neoprene element to be minimum 1 3/4" thick.
 3. Steel retainer box encasing neoprene mounting.
 4. Clearance between mounting hanger rod and neoprene bushing shall be minimum 1/8".
 5. Requires seismic restraint type III.
 6. Mason Type HD, or as approved.
- F. Type F: Combination spring/elastomer hanger rod isolators to incorporate the following:
1. Spring and neoprene isolator elements in a steel box retainer.
 2. Other characteristics of steel box retainer and hanger rod swing as described for Type C isolators.
 3. Requires seismic restraint type III

4. Mason Type TPC-30N, or as approved.
- G. Type G: Pad type elastomer mountings to incorporate the following:
1. 0.750" minimum thickness.
 2. 50 psi maximum loading.
 3. Ribbed or waffled design.
 4. 0.10" deflection per pad thickness.
 5. 1/16" galvanized steel plate between multiple layers of pad thickness.
 6. Suitable bearing plate to distribute load.
 7. Requires seismic restraint type II or III as installation requires.
 8. Mason Type Super W, or as approved.
- H. Type H: Pad type elastomer mountings to incorporate the following:
1. Laminated canvas duck and neoprene.
 2. Maximum loading 1000 psi.
 3. Suitable bearing plate to distribute load.
 4. Minimum thickness, 2".
 5. Requires seismic restraint type II or III as installation requires.
 6. Mason Type HL, or as approved.
- I. Type I: Air Mounts: Freestanding, single or multiple, compressed-air bellows.
1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.
 2. Maximum Natural Frequency: 3 Hz.
 3. Operating Pressure Range: 25 to 100 psig.
 4. Burst Pressure: At least three times the manufacturer's published maximum operating pressure.
 5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch.
 6. Requires seismic restraint type II
- J. Restrained Air Mounts: Housed compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.
2. Maximum Natural Frequency: 3 Hz.
3. Operating Pressure Range: 25 to 100 psig.
4. Burst Pressure: At least three times the manufacturer's published maximum operating pressure.
5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch.
6. Requires seismic restraint type II

2.5 EQUIPMENT BASES

A. Integral Structural Steel Base, Type B-1

1. Reinforced, as required, to prevent base flexure at start-up and misalignment of drive and driven units. Centrifugal fan bases complete with motor slide base with double adjustment bolts.. Drilled for drive and driven unit mounting template.
2. Mason Type M, WF, or as approved.

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 transfer into equipment. The base shall be complete with motor slide base with double adjustment bolts , pump base elbow supports, and complete with height saving brackets, reinforcing, equipment bolting provisions and isolators.
2. Minimum thickness of the inertia base shall be according to the following tabulation:

Motor Size		Minimum Thickness	
(hp)	(kw)	(in.)	(mm)
5-15	(4-11)	6	(150)
20-50	(15-37)	8	(200)
60-75	(45-55)	10	(250)
100-250	(75-190)	12	(300)
300-500	(220-375)	18	(350)

3. Mason Type K, BMK, or as approved.

C. Curb Mounted Base, Type B-3

1. Rooftop equipment, such as the air cooled chiller, shall be mounted on steel dunnage that is part of the structure and roof construction and are flashed and incorporated into roof's membrane waterproofing system.
2. All spring isolators shall have Type G continuous Super W elastomer mounting pads between the equipment and the isolator plate and bolted through.
3. Curb and equipment shall be capable of withstanding 110mph wind and 1.5 g seismic loads.

D. Type B-4 (Flashable Roof Rail System)

1. Rooftop fans, condensing units, air handlers, etc. shall be mounted on continuous support piers that combines equipment support and isolation into (1) assembly.
2. Rails shall incorporate Type A isolators which are adjustable, removable and interchangeable after equipment has been installed.
3. The system shall maintain the same installed and operating height with or without the equipment load.
4. The system shall have full plywood nailers on all (4) sides, designed to accept membrane waterproofing and shall be dry galvanized or plastic coated.
5. Unit to be supplied with flashing.
6. Roof rail shall be similar to Mason Industries Type R-7000 having a minimum 3" rated static deflection.

E. Type B-6 (Non-Isolated Roof Curb)

1. Non-isolated, curb mounted rooftop equipment shall be mounted on structural curbs that meet the acceleration criteria hereinbefore defined.
2. Curbs shall accept standard 2" roof insulation furnished and installed by the roofing contractor.
3. Non-isolated curbs shall be similar to Mason Industries Type B-6000.

2.6 FLEXIBLE CONNECTORS

A. Elastomer Type FC-1

1. Manufactured of nylon tire cord and EPDM, both molded and cured with hydraulic presses.
2. Straight connectors to have two spheres reinforced with a molded-in external ductile iron ring between spheres.
3. Elbow shall be long radius reducing type.

4. Rated 250 psi. at 170°F. Dropping in a straight line to 170 psi. at 250°F for sizes 1-1/2" to 12", elbows. Elbows shall be rated no less than 90% of straight connections.
 5. Sizes 10" and 12" to employ control cables with neoprene end fittings isolated from anchor plates by means of 2" bridge bearing neoprene bushings.
 6. Minimum safety factor of 4 to 1 at maximum pressure ratings.
 7. Submittals to include test reports, projected life, replacement interval, compression and elongation limits.
 8. Mason Types SuperFlex MFNEC, MFLRR, MFTFU, MFTNC, MFTCR, or as approved.
- B. Flexible Stainless Hose, Type FC-2
1. Braided flexible metal hose.
 2. 2" pipe size and smaller with male nipple fittings.
 3. 2-1/2" and larger pipe size with fixed steel flanges.
 4. Suitable for operating pressure with 4 to 1 minimum safety factor.
 5. Length as shown on drawings.
 6. Mason Type BSS, or as approved.
- C. Unbraided Exhaust Hose, Type FC-3
1. Low pressure stainless steel angularly corrugated.
 2. Fitted with flanged ends.
 3. Maximum temperature 1500°F.
 4. Mason Type SDL-RF, or as approved.

2.7 SEISMIC RESTRAINTS

- A. All seismic restraints for mechanical equipment shall be capable of safely accepting 1.0 g (1.5 g for designated life safety equipment) external forces without failure, and shall maintain equipment, piping, duct and pressure reducing boxes in a captive position. Seismic restraints shall not short circuit isolation systems or transmit objectionable vibration or noise, and shall be Provided on all equipment as scheduled on drawings.
- B. Submit calculations by a licensed Structural or Civil Engineer substantiating that all equipment mountings and foundations and their seismic restraints can safely accept external forces of 1.0 g load for all rigidly and resiliently supported equipment, piping, and ductwork (1.5 g load for all life safety equipment) without failure and

permanent displacement. Restrain all resiliently mounted piping and ductwork with cable sway bracing by Mason Industries, or approved equal.

C. Seismic Restraint Types

1. Seismic Restraint, Type I

- a. Shall comply with general characteristics of spring isolators.
- b. Shall have vertical restraints and are capable of supporting equipment at fixed elevation during equipment erection.
- c. Shall incorporate seismic snubbing restraint in all directions at specified acceleration loadings.
- d. System to be field bolted to structure with minimum capability to withstand external forces of 1.5 g.
- e. Mason Type SSLR, or as approved.

2. Seismic Restraint, Type II

- a. Each corner or side seismic restraint shall incorporate minimum 5/8" thick pad limit stops. Restraints shall be made of plate, structural members or square metal tubing in a welded assembly, incorporating resilient pads. Angle bumpers are not acceptable. System to be field bolted to deck with 1.5 g acceleration capacity.
- b. Seismic spring mountings as described above are an acceptable alternative providing all seismic loading requirements are met.
- c. Mason Industries Type Z-1011, Type Z-1225, or as approved.

3. Seismic Restraint, Type III

- a. Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable fastening to equipment and structure. System to be field bolted to deck or overhead structural members or deck with aircraft cable and clamps as per SMACNA guidelines.

PART 3 - EXECUTION

3.1 GENERAL VIBRATION ISOLATION REQUIREMENTS

- A. Install in accordance with manufacturer's written instructions. Vibration isolators must not cause any change of position of equipment or piping resulting in piping stresses or misalignment.
- B. Mechanical equipment shall be isolated from the building structure by means of noise and vibration isolators as scheduled on the drawings or within these specifications.

- C. No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation systems herein specified.
- D. Electrical circuit connections to isolated equipment shall be looped to allow free motion of isolated equipment.
- E. The contractor shall not install any equipment, piping or conduit which makes rigid contact with the "building" unless permitted in this Specification. Building includes, but is not limited to, slabs, beams, columns, studs and walls.
- F. Isolation mounting deflection shall be (minimum) as specified or scheduled on drawings.
- G. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.
- H. 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 shall be at the responsible contractor's expense.
- I. Bring to the Architect's attention any discrepancies between the specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the contractor's expense.
- J. Obtain inspection and approval of any installation to be covered or enclosed, prior to such closure.
- K. Correct, at no additional cost, all installations which are deemed defective in workmanship or materials.

3.2 EQUIPMENT ISOLATION

- A. Mount floor mounted equipment on 4" high concrete housekeeping pads over complete floor area of equipment. Mount vibration isolating devices and related inertia blocks on concrete pad. Key housekeeping pads with hair pins, as required, to be integral with structural slab. Provide approved seismic restraint anchor plates flush with top of housekeeping pad. Concrete work specified in Division 3.

3.3 EQUIPMENT BASES

- A. Fill concrete inertia bases, after installing base frame, with concrete; trowel to a smooth finish.
- B. Concrete Bases: Anchor equipment to concrete base according to supported equipment manufacturer's written instructions for seismic codes at Project site.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch(450-mm) centers around the full perimeter of the base.
 2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 6. Cast-in-place concrete materials and placement requirements are specified in Division 3.
- C. Each fan and motor assembly shall be supported on a single structural steel frame. Flexible duct connections shall be provided at inlet and discharge of fan.
- D. The machine to be isolated shall be supported by a structural steel frame or concrete inertia base.
- E. Brackets shall be provided to accommodate the isolator. The vertical position and size of the bracket shall be specified by the isolator manufacturer.
- F. The minimum operating clearance between the equipment frame or rigid steel base frame and the housekeeping pad or floor shall be 1". Minimum operating clearance between concrete inertia and base and housekeeping pad or floor shall be 2".
- G. The equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.
- H. The isolators shall be installed without raising the machine and frame assembly.
- I. After the entire installation is complete and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. When all isolators are properly adjusted, the blocks or shims shall be barely free and shall be removed.
- J. Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators or seismic restraints.
- K. Verify that all installed isolator and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to 1/4".
- L. Provide flexible connections between all fans and ductwork. Refer to duct accessories section.

- M. When operating weight differs from installed weight, provide built-in limit stops to prevent equipment from rising when weight is removed. Stops shall not be in contact during normal operation.
- N. Additional Requirements
 - 1. Diagonal thrust restraint shall be as described for Type C hanger with the same deflection as specified for the spring mountings. The spring element shall be designed so it can be pre-set for thrust and adjusted to allow for a maximum of 1/4" movement at start and stop. Thrust restraints shall be attached at the centerline of thrust. Restraint shall be Mason Type WB, or as approved.
 - 2. All piping and ductwork to be isolated shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork, and maintain 3/4" to 1 1/4" clearance around the outside surfaces. This clearance space shall be tightly packed with fiberglass (except in cases of fire smoke dampers in ducts), and caulked airtight after installation of piping or ductwork.
 - 3. HVAC piping vertical risers larger than 2" in diameter shall be isolated from the building structure by means of noise and vibration isolation guides and supports.
 - 4. Isolators shall be installed with the isolator hanger box attached to, or hung as close as possible to, the structure. Hanger rods shall be aligned to clear the hanger box.
 - 5. Isolators shall be suspended from substantial structural members, not from slab diaphragm unless specifically permitted.
 - 6. Structural steel for cooling tower or other equipment must support the equipment without excessive deflection of the steel. The structural steel support shall not be resonant with the isolation system resonant frequencies or the driving frequencies of the supported equipment.

3.4 PIPING AND BOILER BREECHING ISOLATORS

- A. All piping and boiler breeching, except fire standpipe systems, are included under this Section.
- B. Installation:
 - 1. Isolate piping, generator stacks/breeching, muffler, domestic hot water breeching and boiler breeching outside of shafts as follows:
 - a. All water, steam and glycol piping and breeching in the boiler room and machine rooms.
 - b. Piping where exposed on roof.
 - c. Water piping, stacks, all mufflers and all boiler breeching within 50 ft, or 100 diameters, which ever is greater, from connected equipment.

- d. All other piping shall be rigidly supported and provided with approved seismic restraints to maintain the piping in a captive position without excessive motion.
 - e. Do not use neoprene components on emergency generator exhaust.
 - f. All emergency generator fuel oil piping and pumps.
2. All piping 2" and over located in mechanical equipment rooms, and for a minimum of fifty (50) feet or 100 pipe diameters, whichever is greater, from connection to vibrating mechanical or electrical equipment, shall be isolated from the building structure by means of noise and vibration isolation hangers, Type F.
 3. Horizontal suspended pipe 2" and smaller and all steam piping shall be suspended by Type E isolator with a minimum 3/8" deflection. Water pipe larger than 2" shall be supported by Type F isolator with a minimum 1", or same static deflection as isolated equipment to which pipe connects, whichever is greater.
 4. Horizontal pipe floor supported at slab shall be supported via Type B, with a minimum static deflection of 1" or same deflection as isolated equipment to which pipe connects, whichever is the greater.
 5. Vertical riser pipe supports shall utilize Type H.
 6. Vertical riser guides, if required, shall avoid direct contact of piping with building.
 7. Pipe anchors, where required, shall utilize resilient pipe anchors, Mason Industries Type ADA, or equivalent, to avoid direct contact of piping with building.
 8. Pipe sway braces, where required, shall utilize two (2) neoprene elements (Type G or H to accommodate tension and compression forces).
 9. Pipe extension and alignment connectors: Provide connectors at riser takeoffs, cooling and heating coils, and elsewhere as required, to accommodate thermal expansion and misalignment.
 10. Adjust, as required, all isolators to eliminate all contact of the isolated rod with the hanger rod box retainer or short circuiting of the spring.
- C. Domestic Water System Isolation :
1. Support all domestic water piping in horizontal and vertical runs with a resilient wrapping or clamp system employing a resilient element of wool, felt, neoprene, or other suitable material; "Trisolators" by Semco or P.R. Isolators by Potter-Roemer, or as approved.
 2. All domestic water piping, size 2" and larger within the building shall be isolated as follows:

- a. Provide Type F hanger rod isolators with a minimum static deflection of 1" (25 mm) or as scheduled.
 - b. Provide Type B isolators with 1" static deflection, or as scheduled.
 - c. Support water piping in shafts and floor supports` entering shaft with Type G isolators or Type H pad to prevent direct contact of piping with building structure.
 - d. Guide and anchor piping in shafts, as required, with approved mounting designs incorporating Type H pad to prevent direct contact of pipe with building structure.
- D. Isolator Position:
1. Close to building structure.
 2. Between building structure and supplementary steel if required.
 3. Suspend isolators from rigid and massive support points.
 4. All supplementary steel to be sized for a maximum deflection of 0.08 inches (2 mm) at center span.

3.5 GENERAL SEISMIC RESTRAINT REQUIREMENT

- A. All equipment whether isolated or not shall be bolted to structure to allow for minimum 1.0 g of acceleration (1.5 g for life safety equipment). Bolt points and diameter of inserts shall be submitted and verified as part of the contractor's submission for each piece of equipment and stamped and sealed by a civil or structural engineer.
- B. Position all corner or side seismic restraints with equipment at operating weight for proper operation clearance and weld or bolt seismic restraint to seismic anchor plates in housekeeping pad. Install equipment with flexibility in wiring connection. Verify all installed isolators and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit startup equipment lateral motion to 1/4 inch. Prior to startup, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators or seismic restraints.
- C. All suspended equipment, whether isolated or not, shall be seismically restrained at four points with Type III cable restraints.
- D. Install seismic restraining system Type III taut for overhead suspended unisolated equipment, piping or ductwork, and slack with 2" cable deflection for isolated systems.
- E. Seismically restrain all piping and ductwork with center bracing or Type III restraining system in accordance with SMACNA guidelines to comply as outlined below:

1. All schedule 10, 20, or 40 piping shall be welded or laterally braced at 40 foot intervals and at turns of more than 4 feet. Longitudinally bracing shall be supplied at 80 foot intervals. No-hub piping shall be braced at 10 foot intervals or at 40 foot intervals if 1.5 g rated couplings are used.
 2. Ductwork to be braced every 30 feet and at every turn and duct run ends. Longitudinal bracing to be provided at 60 foot intervals.
- F. Seismic restraints are not required for the following:
1. Gas piping less than 1" internal diameter.
 2. Piping in boiler and MER room that is less than 1 1/4" internal diameter. Less than 1 inch for fuel oil piping.
 3. All other piping and electrical conduit less than 2" internal diameter.
 4. All rectangular ducts less than 6 sq. ft. (0.56 m²) in cross sectional area.
 5. All round ducts less than 28" in diameter.
 6. All piping suspended by individual hangers 12" in length or less from the top of the pipe to the bottom of the support for the hanger.
 7. All ducts suspended by hangers 12" (305 mm) or less in length from the point of the attachment to the duct to the bottom of the support for the hanger.
- G. Chimneys, breeching and stacks passing through floors are to be bolted at each floor level or secured above and below each floor with riser clamps or approved vibration isolation systems with seismic restraints.
- H. Chimneys and stacks running horizontally to be braced every 30 ft with Type III restraining system.
- I. Where base anchoring is insufficient to resist seismic forces, supplementary restraining such as seismic restraint system Type III shall be used above system's center of gravity to suitably resist "g" force levels. Vertically mounted tanks may require this additional restraint.
- J. For overhead supported equipment, overstress of the building structure must not occur. Bracing may occur from:
1. upper flanges of structural beams;
 2. upper truss chords in bar joist construction at the panel points;
 3. cast-in-place inserts or drilled and shielded inserts in concrete structures suitably located away from edges.
- K. Each seismic restraint and snubbing device shall be installed after equipment is installed and fully operational. Each isolation mounting incorporating seismic restraint shall be adjusted to provide the minimum operating clearance in all directions to permit the operation of the equipment without objectionable noise or vibration to any part of the building structure. The operating clearance for

equipment seismic restraints shall not be greater than 1/4" (6 mm). Seismic restraints must not result in short-circuiting of isolated equipment.

- L. Pipe risers through cored holes in structure require no additional seismic bracing. (Cored hole diameter to be a maximum of 2 inches larger than pipe outer diameter).

3.6 INSPECTION

- A. On completion of installation of all vibration isolation and seismic restraint devices herein specified, the local representative of the isolation materials manufacturer shall inspect the completed system and report in writing any installation errors, improperly selected isolation or restraint devices, or other faults that could affect the performance of the system. Contractor shall submit a report to the Architect, including the manufacturer's representatives final report, indicating all isolation reported as properly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the isolation work.

3.7 VIBRATION TESTING

- A. Owner reserves the right to require vibration testing for all new rotating pieces of equipment installed under this contract including pumps and fans. Vibration testing will be performed after the equipment is installed, aligned, dynamically balanced and commissioned. The mechanical contractor shall correct any deficiencies found with the new equipment as identified in the vibration analysis report. The vibration testing shall be as follows:
 1. Equipment Vibration testing shall be performed by a certified vibration consultant. A report shall be provided indicating all of the pieces of equipment tested, the results of the tests and any deficiencies found.
 2. Vibration allowances shall be as per the latest ASHRAE standard for rotating equipment (ASHRAE 2000 Systems and Equipment), as defined here:
 3. Vibration shall not exceed 0.20 inches per second (0.20 in/sec), peak value throughout the operating range of the piece of rotating equipment. (If connected to a VFD.)
 4. Measurements for all equipment, at each point shall be taken at each axis (3 axis) throughout the entire operating range of the equipment. (If connected to a VFD.)
 5. The test for equipment connected and driven by a Variable Frequency Drive shall include natural (critical) speed testing. Measurements shall be taken throughout the operating range of the equipment starting from a complete stop, ramping slowly up to maximum speed, and pausing briefly at the natural frequencies of the equipment/VFD (15, 30, 45 and 60 Hz) during the test.
 6. Tests for any piece of equipment not driven by a VFD shall be at their normal operating speed, under normal operating conditions.

3.8 CLEANING

- A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 23 Section HVAC General Provisions or to Division 1 Section "Closeout Procedures and Demonstration and Training."

3.10 VIBRATION ISOLATION SCHEDULE

Equipment Type	Horsepower and Other	RPM	Base Type	Isolator Type	Min. Defl., in.
Chillers			–	B	
Rotary, screw	All	All	–	B	1.50
Air Compressors and vacuum pumping					
Tank-mounted horizontal	Up to 10	All	–	A or C	1.50
	15 & up	All	B-2	A or C	1.50
Tank-mounted vertical	All	All	B-2	A or C	1.50
Base-mounted	All	All	B-2	A or C	1.50
Large reciprocating	All	All	B-2	A or C	1.50
Pumps					
Close-coupled	Up to 7.5	All	B-2	A or C	.75
	10 & up	All	B-2	A or C	1.50
Large in-line	5 to 25	All	–	A or C	1.50
	30 & up	All	–	A or C	1.50
End suction and split case	Up to 40	All	B-2	A or C	1.50
	50 to 125	All	B-2	A or C	1.50
	150 & up	All	B-2	A or C	2.50
Boilers	All	All	B-1	B	1.50
Fans and Fan Sections					
Up to 22 in. diameter	All	All	-	A or C	.75
24 in. diameter	Up to 2 in. s.p.	Up to 300	B-2	A or C	3.50
		300 to 500	C	A or C	2.50
		501 & up	B	A or C	1.50
	2.1 in s.p and up	Up to 300	B-2	A or C	3.50
		300 to 500	C	A or C	2.50
		501 & up	B	A or C	1.50
Centrifugal Fans					
Up to 22 in. diameter	All	All	B-1	A or C	.75

24 in. diameter and up		Up to 40	Up to 300	B-1	A or C	3.50
			300 to 500	B-1	A or C	2.50
			501 & up	B-1	A or C	1.5
		50 and up	Up to 300	B-2	A or C	3.50
			300 to 500	B-2	A or C	2.50
Propeller Fans			501 & up	B-2	A or C	1.50
Wall-mounted		All	All	–	G	0.25
Air Cooled Chillers		On Roof	All	All	–	A
Packaged AHU						
All		Up to 10	All	–	A	1.0
		15 and up to 4 in. s.p.	Up to 300	–	A	3.50
			301 to 500	–	A	2.50
			501 & up	–	A	1.50
		15 and up, 4 in. s.p. & up	Up to 300	B-2	A	3.50
			301 to 500	B-2	A	2.50
			501 & up	B-2	A	1.50
Packaged Rooftop Equipment		All	All	B-3	G	2.50
Ducted Rotating Equipment						
Small fans, fan-powered boxes		Up to 600 cfm	All	–	A	0.50
		601 cfm & up	All	–	A	

Curb-Mounted Equipment	All	All	B-6	–	–
Engine-Driven Generators & Muffler	All	All	–	A	2.50

1. Pumps mounted at grade do not require inertia bases. Provide Type A isolators.

END OF SECTION