

Section 23 05 48

**Bltn 3** VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
1. Isolation pads.
  2. Isolation mounts.
  3. Freestanding and restrained spring isolators.
  4. Housed spring mounts.
  5. Elastomeric hangers.
  6. Spring hangers.
  7. Spring hangers with vertical-limit stops.
  8. Pipe riser resilient supports.
  9. Resilient pipe guides.
  10. Restraining braces and cables.
  11. Steel and inertia, vibration isolation equipment bases.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

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B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including

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anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

**B.C.** Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
  - a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
2. 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.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

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4. Seismic Restraint Details:
  - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
  - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
  - c. Coordinate seismic restraint and vibration isolation details with wind restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
  - d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

## 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

- B. Qualification Data: For professional engineer and testing agency.
- C. Welding certificates.
- D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.
- E. Field quality-control test reports.

#### 1.6 CLOSEOUT SUBMITTALS

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- A. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.
  - B. Submit under provision of General Conditions and Division 1 as applicable.
  - C. Maintenance Data: Include adjustment instructions.
  - A.D. Submit manufacturer's installation instructions.

#### 1.7 QUALITY ASSURANCE

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- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
  - ~~B. Comply with seismic restraint requirements in the IBC unless requirements in this Section are more stringent.~~
  - B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
  - C. Reference Standards:
    - 1. SMACNA - Sheet Metal and Air Conditioning Contractors National Association. "Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems"
    - 2. Codes and Standards for Noise Control:
      - a. ADC 1062R-4 Air Diffusion Council: Certification Rating and Test Manual
      - b. ANSI S1.13 American National Standards Institute: Measurement of Sound Pressure Levels
      - c. ARI 575 American Refrigeration Institute: Measurement of Sound in Equipment Rooms
      - d. ARI 443 American Refrigeration Institute: Standard of Sound Rating of Fan Coil Air Conditioners
      - e. ASHRAE 36-72 American Society of Heating, Refrigeration and Air

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Conditioning Engineers: Determination of Ventilating Equipment Sound Power.

- f. AMCA 300 Air Moving and Control Association: Determination of Fan Sound Power Levels
- g. ASTM E477 American Society for Testing and Materials: Test of Duct Lining and Silencer Performance
- h. ASTM C423 American Society for Testing and Materials: Method for Measuring Sound Absorption
- i. ASTM E90 American Society of Testing and Materials: Method for Measuring Sound Transmission Loss
- j. ASTM E413 American Society of Testing and Materials: Determination of Sound Transmission Class
- k. SMACNA Sheet Metal and Air Conditioning Contractors National Association

~~D. Seismic restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic restraint designs must be signed and sealed by a qualified professional engineer.~~

## 1.8 SUSTAINABLE DESIGN INTENT

- A. Comply with project requirements intended to achieve sustainable design, measured and documented. Refer to Sections 018113, SUSTAINABLE DESIGN REQUIREMENTS and 018125 LIMITS FOR VOC CONTENT for additional requirements.

## PART 2 - PRODUCTS

### 2.1 VIBRATION ISOLATORS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Ace Mountings Co., Inc.
  - 2. Amber/Booth Company, Inc.
  - 3. California Dynamics Corporation.
  - 4. Isolation Technology, Inc.
  - 5. Kinetics Noise Control.
  - 6. Mason Industries.
  - 7. Vibration Eliminator Co., Inc.
  - 8. Vibration Isolation.

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9. Vibration Mountings & Controls, Inc.
  10. Or approved equal
- B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
1. Resilient Material: Oil- and water-resistant neoprene.
- C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
  2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- D. Restrained Mounts: All-directional mountings with seismic restraint.
1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
  2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
  6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
  3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- G. **Housed Spring Mounts:** Housed spring isolator with integral seismic snubbers.
1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
  2. Base: Factory drilled for bolting to structure.
  3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch-travel up or down before contacting a resilient collar.
- H. **Elastomeric Hangers:** Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
- I. **Spring Hangers:** Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
  2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
  7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
- J. **Spring Hangers with Vertical-Limit Stop:** Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
  2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  3. Minimum Additional Travel: 50 percent of the required deflection at

- rated load.
  - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
  - 7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
  - 8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
- K. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.
- L. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

## 2.2 VIBRATION ISOLATION EQUIPMENT BASES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
- 1. Amber/Booth Company, Inc.
  - 2. California Dynamics Corporation.
  - 3. Isolation Technology, Inc.
  - 4. Kinetics Noise Control.
  - 5. Mason Industries.
  - 6. Vibration Eliminator Co., Inc.
  - 7. Vibration Isolation.
  - 8. Vibration Mountings & Controls, Inc.
  - 9. Or Approved Equal.
- D. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
- 1. Design Requirements: Lowest possible mounting height with not less

- than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
- a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
  3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- E. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
    - a. Include supports for suction and discharge elbows for pumps.
  2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
  3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
  4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

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~~2.3 SEISMIC RESTRAINT DEVICES~~

- ~~A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:~~
- ~~B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:~~
- ~~C. Basis of Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:~~
- ~~1. Amber/Booth Company, Inc.~~
  - ~~2. California Dynamics Corporation.~~
  - ~~3. Cooper B-Line, Inc.; a division of Cooper Industries.~~
  - ~~4. Hilti, Inc.~~
  - ~~5. Kinetics Noise Control.~~
  - ~~6. Loos & Co.; Cableware Division.~~
  - ~~7. Mason Industries.~~
  - ~~8. TOLCO Incorporated; a brand of NIBCO INC.~~
  - ~~9. Unistrut; Tyco International, Ltd.~~
  - ~~10. Or Approved Equal.~~



- ~~D.— General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES.~~
- ~~1.— Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.~~
- ~~E.— Snubbers: Factory fabricated using welded structural steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.~~
- ~~1.— Anchor bolts for attaching to concrete shall be seismic-rated, drill in, and stud wedge or female wedge type.~~
  - ~~2.— Resilient Isolation Washers and Bushings: Oil and water resistant neoprene.~~
  - ~~3.— Maximum 1/4-inch air gap, and minimum 1/4-inch thick resilient cushion.~~
- ~~F.— Channel Support System: MFMA 3, shop or field fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion resistant coating; and rated in tension, compression, and torsion forces.~~
- ~~G.— Restraint Cables: ASTM A 603 galvanized steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.~~
- ~~H.— Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.~~
- ~~I.— Bushings for Floor Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.~~
- ~~J.— Bushing Assemblies for Wall Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.~~
- ~~K.— Resilient Isolation Washers and Bushings: One piece, molded, oil and water resistant neoprene, with a flat washer face.~~
- ~~L.— Mechanical Anchor Bolts: Drilled in and stud wedge or female wedge type in zinc coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.~~
- ~~M.— Adhesive Anchor Bolts: Drilled in and capsule anchor system containing polyvinyl or urethane methacrylate based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc coated steel for interior applications and stainless steel for exterior~~

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~~applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.~~

### 2.4.2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard paint applied to factory-assembled and - tested equipment before shipping.
  - 1. Powder coating on springs and housings.
  - 2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
  - 3. Baked enamel or powder coat for metal components on isolators for interior use.
  - 4. Color-code or otherwise mark vibration isolation and seismic control devices to indicate capacity range.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

**Bltm 3** B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

### 3.3 INSTALLATION

#### A. GENERAL:

- 1. Install vibration isolation equipment in full accordance with the manufacturer's instructions.
- 2. Suspend the vibration isolators supporting piping ductwork and

- equipment from structural members.
3. Provide a minimum of 1 inch clearance between the building structure and vibration isolated supports, ducts, pipes, and equipment.
  4. Provide 2 inch minimum clearance between the top of the housekeeping pad or floor and the underside of concrete inertial pads and/or steel equipment support frames.
  5. Fasten all vibration isolators to the structure, not to floor diaphragms or lightweight components. Use bolts where holes are provided in the mounting flanges; otherwise, adhere using structural adhesive. Where mounting flanges are steel, use neoprene grommets and washers under anchor bolts. Where vibrating elements are to be fastened to structural elements provide connection details for review by Architect.
  6. Do not use vibration isolation components to straighten or connect misaligned sections of piping or ductwork.
  7. Align spring isolation hanger rods to clear the hanger box under all operating conditions.
  8. Any bracing or supports for mechanical ductwork, piping, and equipment shall not bridge or reduce the effectiveness of vibration isolators.
  9. Level vibration isolated equipment under rated design operating conditions while maintaining the isolation criteria. Isolators shall be plumb and aligned to preclude misalignment or undesired contact during operation

B. Vibration Isolation Schedule:

<u>Equipment</u>	<u>Deflection</u>	<u>Isolator Class</u>
<u>Air handling unit fans (internal isolation)</u>	<u>2.0"</u>	<u>USM</u>
<u>Air handling units (typical external isolation)</u>	<u>0.125"</u>	<u>NP</u>
<u>Fans</u>	<u>2.0"</u>	<u>SH or USM</u>
<u>Base-mounted pumps and compressors, 5 hp and larger (provide inertia base)</u>	<u>2.0"</u>	<u>IB</u>
<u>Base-mounted pumps and compressors less than 5 hp</u>	<u>0.25"</u>	<u>NM</u>
<u>Other small pumps and motors (incl. inline pumps)</u>	<u>0.25</u>	<u>NM</u>
<u>Wall and exhaust fans less than ¼ hp</u>	<u>0.25"</u>	<u>NH or NM</u>
<u>All process and passive equipment attached to pump systems</u>	<u>0.25"</u>	<u>NM, SF</u>
<u>All mechanical room piping within the first 50-ft from rotating and reciprocating equipment</u>	<u>Same as attached equipment</u>	
<u>Piping Risers</u>		<u>RG</u>
<u>Transformers</u>	<u>0.25"</u>	<u>NM</u>
<u>Skid mounted equipment – Energy recover skid etc.</u>	<u>0.35"</u>	<u>NM</u>
<u>Dust Collector</u>	<u>0.3"</u>	<u>NM</u>
<u>Unit Heaters and FCU's</u>	<u>0.75"</u>	<u>SH</u>

<u>Water heaters</u>	<u>0.35"</u>	<u>FN</u>
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\* Double layer NP isolation such as Mason Industry type WSW (or similar) with resilient hold-down assembly.

C. Miscellaneous Mechanical Equipment Isolation

1. Miscellaneous pieces of mechanical equipment, such as converters, pressure reducing stations, dryers, strainers, storage tanks, condensate receiver tanks, and expansion tanks, which are connected to isolated piping systems, shall be vibration-isolated from the building structure by Type NP or Type HN isolators (selected for 0.1" static deflection), unless their position in the piping system requires a higher degree of isolation as called for under Pipe Isolation.

D. Piping and Ductwork:

1. All piping within mechanical room connected to rotating and reciprocating equipment within 50 linear feet, shall be vibration isolated. Isolation devices shall be equivalent to that scheduled for the associated equipment.
2. Use trapezes for vertical support to horizontal piping only. Brace trapeze with an OSHPD pre-approved bracing system, or provide calculations demonstrating compliance with regulatory requirements.
3. No electrical conduit, fixture, ceiling suspension wires or other elements of the building construction attached to or abutted against the duct and piping systems.
4. Where ducts or piping penetrate walls, ceilings and floors of the occupied spaces, or ceiling void partitions or acoustically rated elements whether shown on the drawings or not, acoustically seal the penetration. See detail specified herein.
5. Contain rough-in of piping within stud wall cavities no less than 1/4-inch from the plane of the studs and 1 inch from gypsum board or other wall sheathing.
6. Install flexible connections at all connections to vibration isolated equipment, rotating, reciprocating and other vibrating equipment, and all pumps, whether isolated or not and at all air handlers whether internally isolated or not.
7. Vibration isolate all pipes except vents, gas and fire protection lines. Do not allow piping, plumbing or vent stacks to contact gypsum board.
8. Do not suspend plumbing or piping from ducts, conduits or related supports.
9. Provide flexible connectors in inlet and discharge piping systems for pumps having concrete inertial bases and where indicated on the Drawings.
10. Sheet metal band supports are not permitted on ducts suspended on vibration isolators. Use threaded rods, or other indicated support.
11. Do not suspend ducts from piping, plumbing, conduits or related supports.
12. Incorporate flexible connections in ductwork adjacent to all air moving units.
13. When equipment is in full operational condition, adjust the mounts to

ensure that the equipment is free floating, level and stable.

14. All equipment mounted on anti vibration mounts shall be connected to the adjacent ductwork or pipework system via a flexible connection positioned to avoid a direct connection between equipment and mounting surface.

~~B.~~15. Flanged equipment shall be directly connected to neoprene elbows in the size range 2-1/2" through 12" if the piping makes a 90° turn at the equipment. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure, 12" and larger sizes operating above 100 psi shall employ control cables with end fittings isolated by means of 1/2" thick bridge bearing neoprene washer bushings designed for maximum of 1000 psi.

~~C. Strength of Support and Seismic Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.~~

### ~~3.3 VIBRATION CONTROL AND SEISMIC RESTRAINT DEVICE INSTALLATION~~

~~A. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.~~

~~B. Equipment Restraints:~~

- ~~1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.~~
- ~~2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.~~
- ~~3. Install seismic restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.~~

~~C. Piping Restraints:~~

- ~~1. Comply with requirements in MSS-SP-127.~~
- ~~2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.~~
- ~~3. Brace a change of direction longer than 12 feet.~~

~~D. Install cables so they do not bend across edges of adjacent equipment or building structure.~~

~~E. Install seismic restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.~~

~~F. Install bushing assemblies for anchor bolts for floor mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.~~

- ~~G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.~~
- ~~H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.~~
- ~~I. Drilled-in Anchors:~~
- ~~1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.~~
  - ~~2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.~~
  - ~~3. 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.~~
  - ~~4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.~~
  - ~~5. Set anchors to manufacturer's recommended torque, using a torque wrench.~~
  - ~~6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.~~

#### ~~3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION~~

- ~~A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.~~

#### ~~3.5.4 FIELD QUALITY CONTROL~~

- ~~A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.~~
- ~~B. Perform tests and inspections.~~

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- C. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
  2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
  3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
  4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
  5. Test to 90 percent of rated proof load of device.
  6. Measure isolator restraint clearance.
  7. Measure isolator deflection.
  8. Verify snubber minimum clearances.
  9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
  11. Test and adjust air-mounting system controls and safeties.
  12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

### ~~3.6~~3.5 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust air-spring leveling mechanism.
- D. Adjust active height of spring isolators.
- E. Adjust restraints to permit free movement of equipment within normal mode of operation.

### ~~3.7~~3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Section 017900 "Demonstration and Training."

End of Section