

SECTION 23 05 41
NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

Noise criteria, vibration tolerance and vibration isolation for HVAC and plumbing work.

1.2 RELATED WORK

- A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete inertia bases.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING: Requirements for flexible pipe connectors to reciprocating and rotating mechanical equipment.
- D. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS: Requirements for optional Air Handling Unit internal vibration isolation.
- E. Section 23 31 00, HVAC DUCTS AND CASINGS: requirements for flexible duct connectors, sound attenuators and sound absorbing duct lining.
- F. SECTION 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: requirements for sound and vibration tests.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Noise Criteria:
 - 1. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed following NC levels:

| TYPE OF ROOM | NC LEVEL |
|--------------------------------------|----------|
| Bathrooms and Toilet Rooms | 40 |
| Conference Rooms | 35 |
| Corridors (Nurse Stations) | 40 |
| Corridors(Public) | 40 |
| Dining Rooms, Food Services/ Serving | 35 |
| Kitchens | 50 |
| Recreation Rooms | 50 |

2. For equipment which has no sound power ratings scheduled on the plans, the contractor shall select equipment such that the foregoing noise criteria, local ordinance noise levels, and OSHA requirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Fundamentals Handbook, Chapter 7, Sound and Vibration.
 3. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
 4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.
- C. Allowable Vibration Tolerances for Rotating, Non-reciprocating Equipment: Not to exceed a self-excited vibration maximum velocity of 5 mm per second (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. Measurements for internally isolated fans and motors may be made at the mounting feet.

1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
 1. Vibration isolators:
 - a. Floor mountings
 - b. Hangers
 - c. Thrust restraints
 2. Bases.
 3. Acoustical enclosures.
- C. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
2005.....Fundamentals Handbook, Chapter 7, Sound and Vibration
- C. American Society for Testing and Materials (ASTM):
A123/A123M-02.....Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A307-04.....Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
D2240-05.....Standard Test Method for Rubber Property - Durometer Hardness
- D. Manufacturers Standardization (MSS):
SP-58-02.....Pipe Hangers and Supports-Materials, Design and Manufacture
- E. Occupational Safety and Health Administration (OSHA):
29 CFR 1910.95.....Occupational Noise Exposure

PART 2 - PRODUCTS**2.1 GENERAL REQUIREMENTS**

- A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein and in the schedule on the drawings.
- B. Elastometric Isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.
- C. Exposure to weather: Isolators, including springs, exposed to weather shall be hot dip galvanized after fabrication. Hot-dip zinc coating shall not be less than 609 grams per square meter (two ounces per square foot) by weight complying with ASTM A123. In addition provide limit stops to resist wind velocity.
- D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.
- E. Color code isolators by type and size for easy identification of capacity.

2.2 VIBRATION ISOLATORS

A. Floor Mountings:

1. Double Deflection Neoprene (Type N): Shall include neoprene covered steel support plated (top and bottom), friction pads, and necessary bolt holes.
2. Spring Isolators (Type S): Shall be free-standing, laterally stable and include acoustical friction pads and leveling bolts. Isolators shall have a minimum ratio of spring diameter-to-operating spring height of 1.0 and an additional travel to solid equal to 50 percent of rated deflection.
3. Spring Isolators with Vertical Limit Stops (Type SP): Similar to spring isolators noted above, except include a vertical limit stop to limit upward travel if weight is removed and also to reduce movement and spring extension due to wind loads. Provide clearance around restraining bolts to prevent mechanical short circuiting.
4. Pads (Type D), Washers (Type W), and Bushings (Type L): Pads shall be felt, cork, neoprene waffle, neoprene and cork sandwich, neoprene and fiberglass, neoprene and steel waffle, or reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).

B. Hangers: Shall be combination neoprene and springs unless otherwise noted and shall allow for expansion of pipe.

1. Combination Neoprene and Spring (Type H): Vibration hanger shall contain a spring and double deflection neoprene element in series. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
2. Spring Position Hanger (Type HP): Similar to combination neoprene and spring hanger except hanger shall hold piping at a fixed elevation during installation and include a secondary adjustment feature to transfer load to spring while maintaining same position.
3. Neoprene (Type HN): Vibration hanger shall contain a double deflection type neoprene isolation element. Hanger rod shall be separated from contact with hanger bracket by a neoprene grommet.

4. Spring (Type HS): Vibration hanger shall contain a coiled steel spring in series with a neoprene grommet. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
 5. Hanger supports for piping 50 mm (2 inches) and larger shall have a pointer and scale deflection indicator.
- C. Thrust Restraints (Type THR): Restraints shall provide a spring element contained in a steel frame with neoprene pads at each end attachment. Restraints shall have factory preset thrust and be field adjustable to allow a maximum movement of 6 mm (1/4 inch) when the fan starts and stops. Restraint assemblies shall include rods, angle brackets and other hardware for field installation.

2.3 BASES

- A. Rails (Type R): Design rails with isolator brackets to reduce mounting height of equipment and cradle machines having legs or bases that do not require a complete supplementary base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension but not less than 100 mm (4 inches). Where rails are used with neoprene mounts for small fans or close coupled pumps, extend rails to compensate overhang of housing.
- B. Integral Structural Steel Base (Type B): Design base with isolator brackets to reduce mounting height of equipment which require a complete supplementary rigid base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension, but not less than 100 mm (four inches).
- C. Inertia Base (Type I): Base shall be a reinforced concrete inertia base. Pour concrete into a welded steel channel frame, incorporating prelocated equipment anchor bolts and pipe sleeves. Level the concrete to provide a smooth uniform bearing surface for equipment mounting. Provide grout under uneven supports. Channel depth shall be a minimum of 1/12 of longest dimension of base but not less than 150 mm (six inches). Form shall include 13-mm (1/2-inch) reinforcing bars welded in place on minimum of 203 mm (eight inch) centers running both ways in a layer 40 mm (1-1/2 inches) above bottom. Use height saving brackets in all mounting locations. Weight of inertia base shall be equal to or

greater than weight of equipment supported to provide a maximum peak-to-peak displacement of 2 mm (1/16 inch).

- D. Curb Mounted Isolation Base (Type CB): Fabricate from aluminum to fit on top of standard curb with overlap to allow water run-off and have wind and water seals which shall not interfere with spring action. Provide resilient snubbers with 6 mm (1/4 inch) clearance for wind resistance. Top and bottom bearing surfaces shall have sponge type weather seals. Integral spring isolators shall comply with Spring Isolator (Type S) requirements.

2.4 SOUND ATTENUATING UNITS

Refer to specification Section 23 31 00, HVAC DUCTS AND CASINGS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Vibration Isolation:

1. No metal-to-metal contact will be permitted between fixed and floating parts.
2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports.
3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and belt tension. Bases shall be level throughout length and width. Provide shims to facilitate pipe connections, leveling, and bolting.
4. Provide heat shields where elastomers are subject to temperatures over 38 degrees C (100 degrees F).
5. Extend bases for pipe elbow supports at discharge and suction connections at pumps. Pipe elbow supports shall not short circuit pump vibration to structure.
6. Non-rotating equipment such as heat exchangers and convertors shall be mounted on isolation units having the same static deflection as the isolation hangers or support of the pipe connected to the equipment.

- B. Inspection and Adjustments: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust,

repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2 ADJUSTING

- A. Adjust vibration isolators after piping systems are filled and equipment 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. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4inch (6-mm) movement during start and stop.
- D. Adjust active height of spring isolators.

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SELECTION GUIDE FOR VIBRATION ISOLATORS

| EQUIPMENT | ON GRADE | | | 20FT FLOOR SPAN | | | 30FT FLOOR SPAN | | | 40FT FLOOR SPAN | | | 50FT FLOOR SPAN | | |
|-------------------------------------|----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|
| | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL |
| REFRIGERATION MACHINES | | | | | | | | | | | | | | | |
| ABSORPTION | --- | D | --- | --- | SP | 1.0 | --- | SP | 1.0 | --- | SP | 1.7 | --- | SP | 1.7 |
| PACKAGED HERMETIC | --- | D | --- | --- | SP | 1.0 | --- | SP | 1.7 | --- | SP | 1.7 | R | SP | 2.5 |
| OPEN CENTRIFUGAL | B | D | --- | B | SP | 1.0 | --- | SP | 1.7 | B | SP | 1.7 | B | SP | 3.5 |
| RECIPROCATING: | | | | | | | | | | | | | | | |
| 500 - 750 RPM | --- | D | --- | --- | SP | 1.7 | R | SP | 1.7 | R | SP | 2.5 | R | SP | 3.5 |
| 751 RPM & OVER | --- | D | --- | --- | SP | 1.0 | --- | --- | 1.7 | R | SP | 2.5 | R | SP | 2.5 |
| COMPRESSORS AND VACUUM PUMPS | | | | | | | | | | | | | | | |
| UP THROUGH 1-1/2 HP | --- | D, L, W | --- | --- | D, L, W | --- | --- | D, L, W | --- | --- | D, L, W | --- | --- | D, L, W | --- |
| 2 HP AND OVER: | | | | | | | | | | | | | | | |
| 500 - 750 RPM | --- | D | --- | --- | S | 1.7 | --- | S | 2.5 | --- | S | 2.5 | --- | S | 2.5 |
| 750 RPM & OVER | --- | D | --- | --- | S | 1.0 | --- | S | 1.7 | --- | S | 2.5 | --- | S | 2.5 |
| PUMPS | | | | | | | | | | | | | | | |
| CLOSE COUPLED | UP TO 1-1/2 HP | --- | --- | --- | --- | D, L, W |

| EQUIPMENT | | ON GRADE | | | 20FT FLOOR SPAN | | | 30FT FLOOR SPAN | | | 40FT FLOOR SPAN | | | 50FT FLOOR SPAN | | |
|--------------|------------------|-----------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|
| | | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL |
| | 2 HP & OVER | --- | --- | --- | I | S | 1.0 | I | S | 1.0 | I | S | 1.7 | I | S | 1.7 |
| BASE MOUNTED | UP TO 10 HP | --- | --- | --- | --- | D, L, W | --- |
| | 15 HP THRU 40 HP | I | S | 1.0 | I | S | 1.0 | I | S | 1.7 | I | S | 1.7 | I | S | 1.7 |
| | 50 HP & OVER | I | S | 1.0 | I | S | 1.0 | I | S | 1.7 | I | S | 2.5 | I | S | 2.5 |

ROOF VENTILATORS

ABOVE OCCUPIED AREAS:

| | | | | | | | | | | | | | | | |
|-------------|-----|-----|-----|----|---|-----|----|---|-----|----|---|-----|----|---|-----|
| 5 HP & OVER | --- | --- | --- | CB | S | 1.0 |
|-------------|-----|-----|-----|----|---|-----|----|---|-----|----|---|-----|----|---|-----|

CENTRIFUGAL BLOWERS

UP TO 50 HP:

| | | | | | | | | | | | | | | | |
|----------------|---|---|-----|---|---|-----|---|---|-----|---|---|-----|---|---|-----|
| UP TO 200 RPM | B | N | 0.3 | B | S | 2.5 | B | S | 2.5 | B | S | 3.5 | B | S | 3.5 |
| 201 - 300 RPM | B | N | 0.3 | B | S | 1.7 | B | S | 2.5 | B | S | 2.5 | B | S | 3.5 |
| 301 - 500 RPM | B | N | 0.3 | B | S | 1.7 | B | S | 1.7 | B | S | 2.5 | B | S | 3.5 |
| 501 RPM & OVER | B | N | 0.3 | B | S | 1.0 | B | S | 1.0 | B | S | 1.7 | B | S | 2.5 |

60 HP & OVER:

| | | | | | | | | | | | | | | | |
|---------------|---|---|-----|---|---|-----|---|---|-----|---|---|-----|---|---|-----|
| UP TO 300 RPM | B | S | 1.7 | I | S | 2.5 | I | S | 3.5 | I | S | 3.5 | I | S | 3.5 |
|---------------|---|---|-----|---|---|-----|---|---|-----|---|---|-----|---|---|-----|

| EQUIPMENT | ON GRADE | | | 20FT FLOOR SPAN | | | 30FT FLOOR SPAN | | | 40FT FLOOR SPAN | | | 50FT FLOOR SPAN | | |
|------------------------------------|-----------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|
| | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL |
| 301 - 500 RPM | B | S | 1.7 | I | S | 1.7 | I | S | 2.5 | I | S | 3.5 | I | S | 3.5 |
| 501 RPM & OVER | B | S | 1.0 | I | S | 1.7 | I | S | 1.7 | I | S | 2.5 | I | S | 2.5 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| COOLING TOWERS | | | | | | | | | | | | | | | |
| UP TO 500 RPM | --- | --- | --- | --- | SP | 1.0 | --- | SP | 1.7 | --- | SP | 2.5 | --- | SP | 3.5 |
| 501 RPM & OVER | --- | --- | --- | --- | SP | 1.0 | --- | SP | 1.0 | --- | SP | 1.7 | --- | SP | 2.5 |
| INTERNAL COMBUSTION ENGINES | | | | | | | | | | | | | | | |
| UP TO 25 HP | I | N | 0.3 | I | N | 0.3 | I | S | 1.7 | I | S | 2.5 | I | S | 2.5 |
| 30 THRU 100 HP | I | N | 0.3 | I | N | 1.7 | I | S | 2.5 | I | S | 3.5 | I | S | 3.5 |
| 125 HP & OVER | I | N | 0.3 | I | N | 2.5 | I | S | 3.5 | I | S | 4.5 | I | S | 4.5 |
| AIR HANDLING UNIT PACKAGES | | | | | | | | | | | | | | | |
| SUSPENDED: | | | | | | | | | | | | | | | |
| UP THRU 5 HP | --- | --- | --- | --- | H | 1.0 |
| 7-1/2 HP & OVER: | | | | | | | | | | | | | | | |
| UP TO 500 RPM | --- | --- | --- | --- | H, THR | 1.7 |
| 501 RPM & OVER | --- | --- | --- | --- | H, THR | 1.0 | --- | H, THR | 1.0 | --- | H, THR | 1.7 | --- | H, THR | 1.7 |
| FLOOR MOUNTED: | | | | | | | | | | | | | | | |
| UP THRU 5 HP | --- | D | --- | --- | S | 1.0 |

| EQUIPMENT | ON GRADE | | | 20FT FLOOR SPAN | | | 30FT FLOOR SPAN | | | 40FT FLOOR SPAN | | | 50FT FLOOR SPAN | | |
|--|-----------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|-----------------|-----------|----------|
| | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL | BASE TYPE | ISOL TYPE | MIN DEFL |
| 7-1/2 HP & OVER: | | | | | | | | | | | | | | | |
| UP TO 500 RPM | --- | D | --- | R | S, THR | 1.7 |
| 501 RPM & OVER | --- | D | --- | --- | S, THR | 1.0 | --- | S, THR | 1.0 | R | S, THR | 1.7 | R | S, THR | 1.7 |
| IN-LINE CENTRIFUGAL AND VANE AXIAL FANS, FLOOR MOUNTED: (APR 9) | | | | | | | | | | | | | | | |
| UP THRU 50 HP: | | | | | | | | | | | | | | | |
| UP TO 300 RPM | --- | D | --- | R | S | 2.5 | R | S | 2.5 | R | S | 2.5 | R | S | 3.5 |
| 301 - 500 RPM | --- | D | --- | R | S | 1.7 | R | S | 1.7 | R | S | 2.5 | R | S | 2.5 |
| 501 - & OVER | --- | D | --- | --- | S | 1.0 | --- | S | 1.0 | R | S | 1.7 | R | S | 2.5 |
| 60 HP AND OVER: | | | | | | | | | | | | | | | |
| 301 - 500 RPM | R | S | 1.0 | R | S | 1.7 | R | S | 1.7 | R | S | 2.5 | R | S | 3.5 |
| 501 RPM & OVER | R | S | 1.0 | R | S | 1.7 | R | S | 1.7 | R | S | 1.7 | R | S | 2.5 |