

SECTION 230548 NOISE AND VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Inertia bases.
2. Vibration isolators.
3. Duct silencers.
4. Cross-talk silencers.
5. Acoustic housings.
6. Ductwork lagging.
7. Acoustical louvers.

B. Related Sections:

1. Division 03 - Cast-In-Place Concrete: Execution requirements for placement of isolators in floating floor slabs specified by this section and product requirements for concrete for placement by this section.
2. Division 07 - Joint Protection: Product requirements for joint sealers specified for placement by this section.
3. Division 08 - Louvers: Product requirements for acoustic wall louvers.
4. Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping: Product requirements for anchors and piping expansion compensation.
5. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment: Product requirements for pipe hangers and supports.
6. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC: Requirements for sound and vibration measurements performed independent of this section.
7. Section 23 33 00 - Air Duct Accessories: Product requirements for both solid and flexible duct connectors for duct silencers specified for placement by this section.

1.02 REFERENCES

A. Air Movement and Control Association International, Inc.:

1. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.

- B. American National Standards Institute:
 - 1. ANSI S1.4 - Sound Level Meters.
 - 2. ANSI S1.8 - Reference Quantities for Acoustical Levels.
 - 3. ANSI S1.13 - Methods for the Measurement of Sound Pressure Levels in Air.
 - 4. ANSI S12.36 - Survey Methods for the Determination of Sound Power Levels of Noise Sources.
- C. Air-Conditioning and Refrigeration Institute:
 - 1. ARI 575 - Method of Measuring Machinery Sound within Equipment Space.
- D. American Society of Heating, Refrigerating and:
 - 1. ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.
 - 2. ASHRAE Handbook - HVAC Applications.
- E. ASTM International:
 - 1. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
 - 2. ASTM E477 - Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
 - 3. ASTM E596 - Standard Test Method for Laboratory Measurement of the Noise Reduction of Sound-Isolating Enclosures.
- F. Sheet Metal and Air Conditioning Contractors':
 - 1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

1.03 PERFORMANCE REQUIREMENTS

- A. Provide vibration isolation on motor driven equipment over 0.5 hp (0.35 kW), which is connected piping and ductwork.
- B. Provide minimum static deflection of isolators for equipment as follows, unless noted otherwise in documents:
 - 1. Basement, Under 20 hp (15 kW)
 - a. Under 400 rpm: 2 inches.
 - b. 400 - 600 rpm: 1 inch (25 mm)
 - c. 600 - 800 rpm: 0.5 inch (12 mm)
 - d. 800 - 900 rpm: 0.2 inch (5 mm)

- e. 1100 - 1500 rpm: 0.14 inch (4 mm)
 - f. Over 1500 rpm: 0.1 inch (3 mm)
- 2. Basement, Over 20 hp (15 kW)
 - a. Under 400 rpm: 3 inches
 - b. 400 - 600 rpm: 2 inch (50 mm)
 - c. 600 - 800 rpm: 1 inch (25 mm)
 - d. 800 - 900 rpm: 0.5 inch (12 mm)
 - e. 1100 - 1500 rpm: 0.2 inch (5 mm)
 - f. Over 1500 rpm: 0.15 inch (4 mm)
- 3. Upper Floors, Critical
 - a. Under 400 rpm: 4 inches
 - b. 400 - 600 rpm: 4 inches
 - c. 600 - 800 rpm: 3.5 inch (90 mm)
 - d. 800 - 900 rpm: 2 inch (50 mm)
 - e. 1100 - 1500 rpm: 1 inch (25 mm)
 - f. Over 1500 rpm: 0.5 inch (12 mm)
- C. Consider upper floor locations critical unless otherwise indicated.
- D. Use concrete inertia bases for fans having static pressure in excess of 3.5 inches water column (0.85 kPa) or motors in excess of 40 hp (30 kW), and on base mounted pumps over 10 hp (7.5 kW).
- E. Maintain sound level of spaces at levels not to exceed those listed below by utilizing acoustical devices.
- F. Maintain rooms at following maximum sound levels, in Noise Criteria (NC) as defined by ASHRAE Handbook., HVAC Applications:
 - 1. Conference Rooms: 35
 - 2. Private Offices: 35
 - 3. Public Circulation: 45-50
 - 4. Laboratories: 45-50
 - 5. Corridors: 45-50
 - 6. Public Areas: 45-50
 - 7. Lecture and Classrooms: 35

1.04 SUBMITTALS

- A. Division 01 - Submittal Procedures: Submittal procedures.
- B. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each. Indicate assembly, materials, thickness, dimensional data, pressure losses, acoustical performance, layout, and connection details for sound attenuation products fabricated for this project.
- C. Product Data: Submit schedule of vibration isolator type with location and load on each. Submit catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance for standard sound attenuation products.
- D. Design Data: Submit calculations indicating maximum room sound levels are not exceeded.
- E. Test Reports: Indicate dynamic insertion loss and noise generation values of silencers. Acoustic housings meet or exceed specified sound transmission loss values.
- F. Manufacturer's Installation Instructions: Submit special procedures and setting dimensions. Indicate installation requirements maintaining integrity of sound isolation.
- G. Manufacturer's Certificate: Certify isolators meet or exceed specified requirements.
- H. Manufacturer's Field Reports: Indicate sound isolation installation is complete and in accordance with instructions.
- I. Submit shop drawings for the items listed below. The shop drawings must be complete when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection.
 - 1. A complete description of products to be supplied, including product data, dimensions, specifications and installation instructions.
 - 2. Detailed selection data for each vibration isolator supporting equipment, including:
 - a. The equipment identification mark
 - b. The isolator type
 - c. The actual load
 - d. The static deflection expected under the actual load
 - e. The specified minimum static deflection
 - f. Calculations confirming wind restraints per Paragraph 1.06 L.
 - 3. Steel rails, steel base frames and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method and location of equipment attachment bolts.
 - 4. Details required to convey complete understanding of work.

1.05 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Closeout procedures.
- B. Project Record Documents: Record actual locations of acoustic housings and ductwork lagging. Record actual locations of hangers including attachment points.

1.06 QUALITY ASSURANCE

- A. Perform Work in accordance with AMCA 300, ANSI S1.13, ARI 575, ANSI S12.36 standards and recommendations of ASHRAE 68.
- B. All vibration isolation systems including mountings, and hangers, shall be furnished by the same manufacturer.
- C. The vibration isolation systems shall be designed to achieve an 80% to 95% isolation at the lowest rotational speed of the equipment regardless of the condition of the mounting floor.
- D. The flexible isolators shall be properly adjusted and installed in accordance with the weight distribution of the equipment to provide a stable mounting decoupled system. Each flexible isolator shall be designed and installed so that the equipment support base remains level during deflection. The natural frequency for each support point, based upon the load per isolator and its stiffness, shall not differ by more than plus or minus 10%.
- E. The isolation system shall not cause the equipment to generate any mechanical problem, mechanical failure or misalignment of the couplings and bearings.
- F. Furnish information as may be required to verify that all vibration control equipment will meet static deflections and percentage of isolation reduction specified for various uses.
 - 1. Should operation of any system cause noise or vibration which is, in the opinion of the Engineer, "objectionable," Contractor shall, at his own expense, make such changes in piping, equipment, etc., as may be necessary to eliminate the objectionable noise or vibration.
 - 2. Should the installation of any equipment or piping transmit the noise to any portion of the structure which is, in the opinion of the Engineer, "objectionable," Contractor shall, at his own expense, install such isolation and make such changes or additions as may be necessary to prevent the transmission of the noise or vibration.
- G. Particular attention is directed to the problem of preventing noise and vibration transmission from Mechanical Equipment Rooms and Fan Rooms to adjacent areas. It is of paramount importance that no noise or vibration emanating from equipment in these rooms be perceptible in adjacent areas. Contractor shall incorporate in his installation all devices and accessories to accomplish this result. Such devices shall include vibration eliminator bases and sound absorber pads, muffler at air compressor air intakes, acoustical lining or sound traps at fresh air intake louvers, and other sound insulation, all as may be required.

- H. All electrical connections, drain connections, piping connections, etc., made to equipment which rests on vibration isolators shall be sufficiently flexible to permit the equipment to be properly installed.
- I. When concrete pads are called for to be under isolation, they shall be extended to span at least 2 of the supporting beams and they shall be reinforced with rods or mesh so that the concrete can act as a beam reinforcing the floor and providing a better support for the isolation. The vibration control equipment manufacturer shall submit templates and weight at each support point to the Concrete Section to achieve this.
- J. Where supplementary steel is required to support piping this steel shall be designed to provide a maximum deflection of 0.08 inches at the midspan under the supported load. Piping shall be rigidly supported from the supplementary steel and the supplementary steel isolated from the building structure by means of isolators.
- K. Acoustical Performance Specifications: It is the intent that noise levels due to air conditioning and/or ventilating equipment, ducts, grilles, registers, diffusers and air system pressure reducing devices will permit attaining sound pressure levels in occupied spaces conforming to the following NC curves as explained in the latest issue of the ASHRAE Guide and Data Book.
- L. Design isolators for equipment and all supports, curbs, etc. installed outdoors to provide adequate restraint to withstand the force of a 120 mph wind applied to any exposed surface of the isolated equipment. Isolators for outdoor equipment shall have bolt holes for attachment to equipment and to supports. The vibration isolation Vendor shall submit verifying shear and over turning calculations, for all equipment, supports, curbs, etc. and equipment installation arrangement, stamped by a licensed Professional in the State of New Jersey. The design and supply of miscellaneous support steel above and below isolators will be the responsibility of the vibration isolation manufacturer.
- M. Static deflection of isolators shall be as provided as noted below. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.
- N. Vibration Criteria:
 - 1. Mechanical and electrical equipment operated by motors over one horsepower and unless otherwise noted, and associated piping and ductwork, shall be isolated from the structure by means of resilient vibration and noise isolators supplied by a single manufacturer to the HVAC Contractor. The isolator manufacturer shall include the complete design for the supplementary basis; a tabulation of the design data on the isolators including outside diameter; free, operating and solid heights of the springs; free and operating heights of the neoprene or fiberglass isolators; and isolation efficiency based on the lowest operating speed of the equipment supported.
 - 2. All rotating equipment shall be balanced both statically and dynamically. The equipment supporting structure shall not have any natural frequencies within $\pm 20\%$ of the operating speeds. The equipment, while operating, shall not exceed a self-excited vibration velocity of 0.10 inches per second when measured with a vibration meter on the bearing caps of the machine in the

vertical, horizontal and axial directions, or at the equipment mounting feet if the bearings are concealed.

3. Vibration testing shall be in accordance with procedure established by "Testing Vibration Isolation Systems", Page 52.38 of ASHRAE HVAC Systems and Applications – 1987.
4. When it is determined by the Owner that any equipment vibration exceeds the specified level, the contractor in consultation with the Professional shall, at no cost to the Owner, determine the source of the vibration and make the necessary corrections or replacement to reduce it to the acceptable level.

O. Sound Pressure Levels:

1. The sound pressure levels around mechanical and electrical equipment (boilers, fans, pumps, pressure reducing valves, motors, turbines, elevators, transformers, etc.) in equipment spaces shall not exceed 85 dbA at any point, 3 feet from equipment, with all equipment in the room operating. The sound criteria apply to the complete operating range of each piece of equipment.
2. The maximum interior background sound pressure levels for the various usage areas within the building shall be indicated on Table 2, "Recommended Indoor Design Goals for HVAC System Sound Control" – ASHRAE HVAC Systems and Applications – 1987, Page 52.4, or as otherwise specified. Each area, so designated, shall be tested and reported for noise level with all equipment operating and space unoccupied.
3. Equipment installed outside the building, at grade, in areaways, attached to walls, and on the roof, such as cooling tower fans, air conditioning units, refrigerant condensers, fans, exhaust silencers, air intakes, etc. shall comply with all local, city, state and federal sound level regulations.
4. When equipment or space sound pressure levels exceed the specified criteria, the contractor in consultation with the Professional shall, at no cost to the Department, determine the source of the noise and make the necessary corrections to reduce it to the acceptable levels.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer.
- C. Design application of duct silencers, acoustic housings, seismic snubbers under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of NJ.

1.08 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.09 WARRANTY

- A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.

PART 2 - PRODUCTS

2.01 INERTIA BASES

- A. Manufacturers: Subject to requirements of the specification, provide the following manufacturer's products by one of the following or approved equal:
 - 1. Mason Industries - M.I.I
 - 2. Vibration Eliminator Corp. - V.E.C
 - 3. VMC Group - V.M.C.I
 - 4. Substitutions: Division 01 - Product Requirements.
- B. Furnish materials in accordance with IBC-NJ.
- C. Structural Bases:
 - 1. Design: Sufficiently rigid to prevent misalignment or undue stress on machine, and to transmit design loads to isolators and snubbers.
 - 2. Construction: Welded structural steel with gusset brackets, supporting equipment and motor with motor slide rails.
- D. Concrete Inertia Bases:
 - 1. Mass: Minimum of 1.5 times weight of isolated equipment.
 - 2. Construction: Structured steel channel perimeter frame, with gusset brackets and anchor bolts, adequately reinforced, concrete filled.
 - 3. Connecting Point: Reinforced to connect isolators and snubbers to base.
 - 4. Concrete: Reinforced 3,000 psi (20 MPa) concrete.

2.02 FLOOR MOUNTING OF AXIAL FANS AND CENTRIFUGAL FANS SMALLER THAN 27" WHEEL DIAMETER - MOUNTING TYPE I

- A. Each such fan and driving motor shall be mounted on an integral one piece structural base, reinforced to prevent flexure of the base at startup during operation of fan. The unitized structural base for the fan and motor shall include motor slide rails. The structural steel frame shall be drilled and tapped to receive the fan and motor so that the frame shall act as a template.
- B. The structural steel integral base shall be supported on steel spring mountings. These mountings shall be positioned in accordance with the weight distribution to

insure adequate deflection and vibration isolation. Isolator types shall be one of the following:

Type SLR	-	M.I.I.
Type OSC	-	V.E.C.
Type ASCM	-	V.M.C.I.

Minimum static deflection shall be 2".

2.03 FLOOR MOUNTING OF CENTRIFUGAL FANS WITH WHEEL DIAMETER 27" AND LARGER - MOUNTING TYPE II

A. Each such fan and motor shall be mounted on a reinforced spring supported concrete foundation. The foundations shall be poured within structural perimeter frame set on roofing paper. The structural perimeter frame shall be supplied by the vibration isolation vendor and shall incorporate equipment anchor bolts, templates and mounting brackets for each base spring support. Spring supports shall be located under the brackets and shall incorporate a neoprene acoustical pad and leveling adjustment to raise the entire isolation base one inch above the foundation pad. Each structural frame shall include top and bottom reinforcing steel for concrete.

B. Concrete inertia base thickness shall be in accordance with the following schedule:

<u>Motor Size</u>	<u>Minimum Inertia Block Thickness Required</u>
Up to 50 HP	8"
60 to 75 HP	10"
100 HP & Greater	12"

C. Mounting assemblies shall be one of the following:

Type SLR	-	M.I.I.
Type OSC	-	V.E.C.
Type ASCM	-	V.M.C.I.

Minimum static deflection shall be 2".

2.04 FLOOR MOUNTING OF FACTORY ASSEMBLED TUBULAR FANS AND BELTED UTILITY VENT SETS - MOUNTING TYPE III

A. Each such equipment shall be mounted on neoprene-in-shear isolators. Mounting shall be one of the following:

Type ND	-	M.I.I.
Type RD	-	V.M.C.I.
Type 368SD	-	V.E.C.

2.05 FLOOR MOUNTING OF FACTORY ASSEMBLED AIR HANDLING UNITS - MOUNTING TYPE IV

A. This equipment shall be mounted directly on stable bare steel (non-skid) spring isolators; except that where the units to be mounted are furnished with internal structural frames and external lugs (both of suitable strength and rigidity), or without any severe overhangs, no additional structural frame need be furnished and

installed beneath the unit. The motor shall be integrally mounted to the unit and shall be mounted on side rails. Isolator types shall be one of the following:

Type SLR	-	M.I.I.
Type OSC	-	V.E.C.
Type ASCM	-	V.M.C.I.

- B. Diagonal hanger rod isolators shall be provided as required to limit horizontal motion to 1/4" maximum.

2.06 MOUNTING OF CEILING SUPPORTED FACTORY ASSEMBLED FANS, TUBULAR FANS, AXIAL FANS AND BELTED UTILITY VENT SETS - MOUNTING TYPE V

- A. Hung by isolation with retainers containing steel springs and neoprene isolator element. Structural sub-base or unit integral supports if adequate as approved by Engineer. Isolators shall be as follows:

Type DNHS	-	M.I.I.
Type RSH	-	V.M.C.I.
Type SNRC	-	V.E.C.

- B. Diagonal hanger rod isolators shall be provided as required to limit horizontal motion to 1/4" maximum under fan operating conditions.

2.07 MOUNTING OF CENTRIFUGAL PUMPS - GREATER THAN 3 HP - MOUNTING TYPE VI

- A. Each pump with its driving motor shall be bolted and grouted to a spring supported concrete inertia base reinforced as required.
- B. Each concrete base (rectangular or "T" shape) for horizontally split pumps shall include supports and base elbows for the suction and discharge connections. Base elbows shall be bolted and grouted to the concrete foundation.
- C. Concrete inertia base thickness shall be 6" minimum.
- D. The spring supported concrete inertia foundation shall be poured within structural perimeter frame (reinforced as shown) of the required thickness indicated on the above schedule. The structural perimeter frame shall be equipped with height saving brackets and stable bare spring isolators having spring diameters no less than 0.8 of the compressed height of the spring at rated load. The mountings shall provide minimum static deflections of 1 inch. The structural perimeter frame, mounting templates, height saving brackets and spring system shall be provided as an assembly by the vibration control vendor. Each structural frame shall include top and bottom reinforcing steel in concrete.
- E. Install under inertia bases at suction and discharge base elbow locations and at motor end, a 6" x 6" x 7/8" high resilient pad, to limit movement of base during pump startup.

F. Mounting assemblies shall be one of the following:

Type KSL	-	M.I.I.
Type MDF	-	V.M.C.I.
Type SN	-	V.E.C.

Minimum spring deflection shall be 2".

2.08 MOUNTING OF CENTRIFUGAL PUMPS (3 HP OR LESS) - MOUNTING TYPE VII

A. Pumps 3 HP or less shall be bolted and grouted to rubber-in-shear supported reinforced concrete inertia blocks that are a minimum of 6 inches thick. Rubber-in-shear isolators shall provide a minimum static deflection of 3/8 inch and shall be protected against corrosion. Isolator types shall be one of the following:

Type SLR	-	M.I.I.
Type OSC	-	V.E.C.
Type ASCM	-	V.M.C.I.

2.09 ROOF-MOUNTED EXHAUST FANS AND CONDENSING UNITS – TYPE X

A. Rooftop air exhaust fan and condensing unit shall be supported by prefabricated welded galvanized metal curb, minimum 18 gauge, 18" high insulated roof curbs.

B. Provide wind bracing as required.

C. All mounting hard wires and wind bracing shall be hot dipped galvanized.

2.10 SUPPORT OF PIPING

A. General: The following water piping shall be resiliently supported.

1. All piping in Mechanical Equipment Rooms.
2. All piping located on the roof.
3. Where shown on drawings.

B. Resilient diagonal mountings or other approved devices shall be provided as required to limit piping motion due to equipment startup or shutdown, to a maximum of 1/8 inch.

Where isolated piping 8" and over is supported directly below exposed steel beams, attachment to the beam shall be made by means of channel beam attachments welded to the underside of the bottom flange and located directly under the web of the beam.

C. The steel spring element of the hangers or floor mounting assembly shall provide 1 inch static deflection.

- D. All piping hanger rod isolators shall be one of the following:
- | | | |
|------------|---|----------|
| Type PC30N | - | M.I.I. |
| Type RSH | - | V.M.C.I. |
| Type SNRC | - | V.E.C. |
- E. Floor supported water piping shall be mounted on one of the following, or as approved:
- | | | |
|-----------|---|----------|
| Type SLR | - | M.I.I. |
| Type ASCM | - | V.M.C.I. |
| Type OSC | - | V.E.C. |
- F. Mounting of Piping Risers:
1. Pipe riser guides, anchors and supports including piping anchors in Mechanical Equipment Rooms or occupied spaces shall be isolated from the building structure such that there shall be no direct metal-to-metal contact of the piping with the building structure.
 2. Piping Guides:
 - a. Steel guide bars shall be welded to the pipe at a maximum spacing of 60 deg. The outside diameter of the opposing guide bars shall be smaller than the inside diameter of the pipe riser clamp in accordance with standard field construction practice. Each end of the pipe riser clamp shall be rigidly attached to an all-directional pipe anchor isolation mounting which, in turn, shall be rigidly fastened to the steel framing within the shaft, as described on the drawings.
 - b. The all-directional piping anchor isolation mountings shall consist of a telescoping arrangement of two sizes of steel tubing separated by a minimum of 1/2 inch thick heavy duty neoprene and canvas duct isolation pad. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. The allowable load on the isolation material shall not exceed 500 psi.
 - c. Mountings shall be Type ADA - Mason Industries or as approved.
 - d. Piping shall be constructed with a 360 deg. 10 gauge metal sleeve around the piping. The thermal insulation requirements for the piping shall be provided between the piping and the sleeve. Heavy duty neoprene and canvas duct isolation pad of thickness equal to thermal insulation requirements shall space the metal sleeve away from the piping with urethane or other suitable thermal insulation provided in the voids between the pipe sleeve and isolation pad material. The metal sleeve outside diameter shall be smaller than the pipe riser clamp inside diameter in accordance with standard field construction practice. The pipe riser clamp shall be rigidly attached to the steel framing within the shaft.
 3. Anchors:
 - a. The pipe riser clamp at anchor points shall be welded to the pipe and to pairs of vertical acoustical pipe anchor mountings which, in turn, shall be rigidly fastened to the steel framing in the pipe shaft.

- b. The acoustical pipe anchor mountings shall be capable of safely accepting loads developed by the installed piping and shall consist of a bolted assembly of steel plates with laminations and 1/2 inch thick heavy duty neoprene and canvas duct isolation material. A heat shield of 1/4 inch transite shall be provided. The isolation material loading shall not exceed 500 psi.
- c. Acoustical pipe anchor mountings shall be Type VPA Mason Industries or as approved.

4. Supports:

- a. Piping supports within shafts shall be provided with suitable bearing plates and two (2) layers of 1/4 inch thick ribbed or waffled neoprene pad loaded for 50 psi maximum. The isolation pads shall be separated with 1/4 inch steel plate.
- b. Piping isolation supports of the base of risers shall be two layers of 1/2 inch thick heavy duty neoprene and canvas duct isolation pad separated by 1/4 inch thick steel plate. Suitable bearing plates sized to provide a pad loading of 500 psi maximum shall be provided. The stanchion between the pipe and isolation support shall be welded to the pipe and welded or bolted to the isolation support. The isolation support shall be bolted to the floor slab with resilient sleeves and washers.
- c. All pipe support resilient materials shall be HP Mason Industries, or as approved.
- d. Piping penetrations of shafts, floor slab and/or partitions: There shall be no direct contact of piping with shaft walls, floor slabs and/or partition. All uninsulated piping shall be sleeved with one inch fiberglass the full depth of the penetration.

2.11 MOUNTING OF CONTROL AIR COMPRESSORS

- A. Air Compressors shall be mounted as described for pumps greater than 3 HP on spring isolators with minimum 3 inch static deflection.

2.12 AIR COMPRESSOR FLEXIBLE CONNECTORS

- A. Flexible stainless steel metal pipe connectors shall be installed in two (2) planes 90 deg. to each other in the discharge piping from the compressor. Flexible connectors shall have a minimum burst pressure of four times the operating pressure. Pipe sizes through 2" I.D. shall be furnished with hex male nipple fittings and pipe sizes 2-1/2" I.D. and larger shall be furnished with fixed steel flanges, both sides. Connectors shall be one of the following:

Type BSS	-	M.I.I.
Type MFP	-	V.M.C.I.

2.13 GRILLES, REGISTERS AND DIFFUSERS

- A. The maximum permissible sound power levels in octave bands of grilles, registers and diffusers when operated in an installed condition per plans and specification, shall be as follows:

Maximum Sound Power Level for Terminal Devices Servicing Occupied Spaces

See Acoustical Performance Criteria
Maximum PWL (db) re 10-12 Watts

<u>Octave Bands</u>	<u>NC-35</u>	<u>NC-40</u>
1	62	66
2	56	60
3	50	54
4	46	51
5	43	48
6	42	47
7	41	46
8	42	47

2.14 VARIABLE AIR VOLUME BOXES

- A. Discharge Noise:

1. The maximum permissible sound power levels of these units when operated in an installed condition per plans and specifications shall be such that the resulting sound pressure levels in occupied spaces shall conform to noise criteria levels as stated in "Acoustical Performance Criteria" hereinbefore described. Low pressure duct downstream of units shall be acoustically lined but length of lining shall be not less than required to achieve criteria.

- B. Radiated Noise:

1. Where located exposed or over occupied spaces, the maximum permissible radiated sound power levels in octave bands when operated in an installed condition per plans and specifications, shall be as follows:

<u>Octave Bands</u> <u>Mid/Freq. (cps)</u>	<u>Maximum PWL (db) re:10-12 Watts</u>	
	<u>NC-35</u>	<u>NC-40</u>
125	70	74
250	61	65
500	60	64
1000	57	62
2000	56	60
4000	56	70

2. The manufacturer shall submit to the Architect guaranteed discharge and radiated sound power levels in octave bands, and shall substantiate that the

equipment operating in an installed condition as per plans and specifications shall conform with those discussed above.

3. Should the architect desire that units be checked for conformance of discharge and radiated noise to the above acoustical performance, the cost of such tests will be paid up by the Owner provided that the test proves conformance. Otherwise, the cost of such tests and cost of corrective measures shall be borne by the manufacturer.

2.15 ACOUSTICAL PERFORMANCE WITHIN EQUIPMENT SPACES

- A. Equipment room noise levels and noise transmission to adjacent buildings shall comply with all State and City Noise Ordinances.

2.16 MOTOR ACOUSTICAL PERFORMANCE

- A. Motor drives for pumps when installed per plans and specifications shall operate with noise levels not exceeding 90 dba.
- B. Noise levels shall be determined in accordance with IEEE Standard u/85 Test "Procedure for Air-Borne Noise Measurements on Rotating Electric Equipment."

2.17 RECTANGULAR FACTORY BUILT SOUND TRAPS

- A. Prefabricated duct silencers for non-laboratory exhaust systems shall be constructed of all incombustible materials and shall be standard product of a responsible manufacturer. The shell of the silencer shall be at least 22 gauge galvanized steel sheet and shall be leakproof when subjected to a differential pressure of 8 inches w.g.
- B. Silencers for Laboratory exhaust system shall be Packless silencers, constructed of 304 stainless steel and shall be constructed to a differential pressure of 8" w.g. No sound absorption material of any kind is to be used in the silencers. Silencers shall attenuate air/gas transmitted noise solely by virtue of controlled impedance membranes and broadly tuned resonators.
- C. Materials of construction for non-laboratory exhaust systems shall be, in addition to the sheet-metal, mineral fiber, acoustic fiber, acoustic fill, completely covered by a moisture resistant barrier of Mylar. Mylar sheet shall be held away from the sheetmetal by a stand-off for D.I.L. improvement.
- D. Pressure drop shall not be greater than shown on the Sound Traps Schedule. Total system pressure before and after the sound traps shall be measured after the traps are installed. Should the pressure drop be greater than specified or scheduled, the Contractor shall replace the traps and/or modify the entrance or discharge aerodynamic flow to achieve the specified results. The cost of corrective measures shall be borne by the Contractor.
- E. The sound traps shall provide the following net insertion ratings under design air flow velocities as scheduled on the drawings. The ratings shall be determined by the duct to reverberant room test method. Units shall be tested with Mylar sheet.

<u>BANDS</u>	<u>BAND WIDTH CENTER FREQ. (CPS)</u>	<u>DYNAMIC NET INSERTION LOSS (DB)</u>				
		<u>SOUND TRAP TYPES</u>				
		<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
2	123	10	14	18	20	13
3	250	18	24	24	35	18
4	500	30	36	40	45	28
5	1000	42	48	45	50	40
6	2000	34	44	46	48	47

The maximum db of sound self-generated by the above sound trap types shall not exceed the following sound power levels at face velocities at 1600 fpm.

<u>Bands</u>	<u>Band Width Center Freq. (cps)</u>	<u>Sound Power Level db re: 10-12 Watts Sound Trap Types</u>		
		<u>A,B,C</u>	<u>D</u>	<u>E</u>
2	125	54	29	51
3	250	52	35	51
4	500	50	30	49
5	1000	47	31	47
6	2000	48	35	50

- F. Certification: Certified test data of pressure drop and insertion loss rating shall be submitted by the Contractor for a 24 x 24 cross section rectangular trap or 24 inch diameter conical trap. The certification data for both pressure drop and insertion loss shall be based upon tests of the same trap for both measurements. The certifying laboratory shall be open to inspection and/or test of sound traps upon request of architect.
- G. Provide sound trap at each supply air fan discharge and as shown. Unless otherwise indicated, pressure drop across sound trap, under nominal flow conditions, shall not exceed 0.20" W.G.

2.18 ACOUSTICAL LINING

- A. Duct lining for supply, return and exhaust air systems:
- Duct lining shall be 1-1/2 lb. per cu. ft. density Owens Corning AEROFLEX, Johns Manville or Knauf. Unless greater thicknesses are specified, the minimum thickness installed shall be 1".

Duct lining shall meet requirements of NFPA-90A and all materials used shall have a flamespread rating of 25 or less and smoke developed rating of no higher than 50.
 - The leading edge (facing into the air flow) of each non-abutting section such as the first section facing into the fan, or the first section after a sound trap shall have a metal nosing.
 - Application: All portions of duct designated to receive duct liner shall be completely covered with Duct Liner. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. The black coated surface of the Duct Liner shall face the air stream. The Duct Liner shall be adhered to the sheet metal with 100% coverage of adhesive and all exposed leading edges

and all transverse joints coated with adhesive. Adhesive shall be Duct Line, ASC-A-7001C-1972. The Duct Liner shall be additionally secured with mechanical fasteners (mechanical fasteners shall conform to Mechanical Fastener Standard FM-1-1971, available from Sheet Metal and Air Conditioning Contractors National Association), which shall compress the Duct Liner sufficiently to hold it firmly in place. Duct Liner shall be cut to assure overlapped and compressed longitudinal corner joints. Fasteners shall start within 3" of the upstream transverse edges of the liner and 3" from the longitudinal joints and shall be spaced at a maximum of 6" o.c. around the perimeter of the duct, except that they may be a maximum of 6" from a corner break. Elsewhere they shall be a maximum of 16" o.c., except that they shall be placed not more than 6" from a longitudinal joint of the liner nor 12" from a corner break.

4. The following ducts shall be acoustically lined:
 - a. Provide acoustical lining for all ductwork downstream of VAV terminal units serving classrooms, conference spaces and lecture spaces. Provide acoustical lining for ductwork downstream of other VAV terminal units a minimum distance of 15 feet, in all directions, or as shown on drawings for all other spaces with return air (offices, corridors, etc.). Laboratory VAV terminal units shall not have acoustical lining.
 - b. All ductwork downstream of non-laboratory supply and return air ductwork in mechanical equipment rooms, but not less than 30 ft. from supply fan discharge and 25 ft. from return fan inlets, in all branches and mains.
 - c. Ductwork upstream of (non-laboratory) exhaust fans a minimum distance of 20 feet, in all branches or mains, unless sound traps are provided.
 - d. All transfer ducts and jumper ducts.
 - e. In addition to above, wherever shown on drawings.
- B. Dimensions of lined ducts shown on drawings are the inside dimensions of the duct after the lining has been installed.
- C. Duct liner shall meet the requirements of NFPA 90A, 90B and ASTM-C 1071 and installed in accordance with SMACNA.
- D. All adhesives shall conform to the current South Coast Air Quality Management District (SCAQMD) Rule #1168. The Volatile Organic Compound (VOC) content shall not exceed 80 grams per liter.

2.19 DUCTWALL EXTERNAL SOUNDPROOFING (DES)

- A. Materials:
 1. Fiberglass insulation shall be 4 lb. per cubic foot density.

2. Thickness of the fiberglass shall be 1/2 in. greater than height of ductwork angles, one in. minimum.
3. The jacket shall be aluminum (.016) laminated to lead (.015) with a visco-elastic film similar to Muffle-Jac as manufactured by Childers Products Company.
4. Sound transmission loss greater than STC26 for the aluminum/lead laminate.
5. Banding shall be .02 in.x 3/4 in. stainless steel.
6. Sealant: Chil-Seal CP-70 by Childers or equal.

B. Installation:

1. Seal all duct joints airtight.
2. Adhere fiberglass with 100% coverage of adhesive and stick clips on 18 in., centers on the underside of large ducts where required. Fiberglass must cover angles and protrusions by 1/2 in. minimum. Wrap ductwork and insulation with lead/aluminum laminate with largest continuous sheets possible. Overlap all joints 2 in. minimum and seal joints with sealant specified. If fish-mouthing occurs, close gap with sheet metal screws as described below. On the underside of ducts only, stick clips may be used to support jacket. The exterior clip must be isolated from the jacket with an 1/8 in. thick oversized armaflex washer. All duct jacketing must be secured with banding on 12 in. maximum centers. The corners must be reinforced with 3 in. long, lin. x lin. x 1/8 in. thick aluminum extrusion where banding occurs. Use same extrusion under duct to keep jacket from sagging if required. If and only if the banding is not possible, then sheet metal screws (3/4 in. long maximum) may be used to secure the jacketing as described below:
 - a. Must not touch interior duct.
 - b. After screw has been installed, clean with nonflammable grease solvent.
 - c. Dab screw with epoxy adhesive to secure.

C. Provide DES as shown on drawings only.

2.20 DUCTWORK LAGGING

- A. Acoustic Insulation: 2 inch (50 mm) thick, 3 to 5 lb/cu ft (50 to 80 kg/cu m) density glass fiber or mineral wool insulation.
- B. Covering: Gypsum board with surface weight minimum 4 lb/sq ft (20 kg/sq m).

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Division 01 - Administrative Requirements: Coordination and project conditions.

- B. Verify equipment, ductwork and piping is installed before work in this section is started.

3.02 EXISTING WORK

- A. Provide access to existing piping and ductwork and other installations remaining active and requiring access.

- B. Extend existing piping and ductwork installations using materials and methods compatible with existing installations.

- C. INSTALLATION

- D. Support duct silencers rigidly to ductwork. Refer to Section 23 33 00.

- E. Lag ductwork, where indicated by wrapping with insulation and covering. Apply covering to be airtight. Do not attach covering rigidly to ductwork.

- F. Install isolation for motor driven equipment.

- G. Bases:

1. Set steel bases for 1 inch (25 mm) clearance between housekeeping pad and base.
2. Set concrete inertia bases for 2 inch (50 mm) clearance between housekeeping pad and base.

- H. Adjust equipment level.

- I. Install spring hangers without binding.

- J. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

- K. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

- L. Provide pairs of horizontal limit springs on fans with more than 6.0 inch (1.5 kPa) static pressure, and on hanger supported, horizontally mounted axial fans.

- M. Provide resiliently mounted equipment, piping, and ductwork with seismic snubbers. Provide each inertia base with minimum of four seismic snubbers located close to isolators. Snub equipment designated for post disaster use to 0.05 inch (1.5 mm) maximum clearance. Provide other snubbers with clearance between 0.15 inch (4 mm) and 0.25 inch (7 mm).

- N. All equipment, piping, etc., shall be mounted on or suspended from approved foundations and supports, all as specified herein, as shown on the drawings, or as required.
- O. All floor-mounted equipment shall be erected on 4" high concrete pads over the complete floor area of the equipment, unless specified to the contrary herein. Wherever hereinafter vibration eliminating devices and/or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted upon 4" high concrete pads unless specified to the contrary herein.
- P. The vibration isolation systems shall be guaranteed to have minimum one inch deflection or as indicated on the schedule or as specified.
- Q. Mounting sizes shall be determined by the mounting manufacturer, and the sizes shall be installed in accordance with the manufacturer's instruction.
- R. The installed vibration isolation system for each floor or ceiling supported equipment shall have a maximum lateral motion under equipment startup or shutdown conditions of 1/4". Motions in excess shall be restrained by approved spring type mountings.
- S. All mounting systems exposed to weather and other corrosive environments shall be protected with factory applied corrosion resistive materials.
- T. Where steel spring isolation systems are described in the 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 spring remain parallel during and after the spring has reached specified minimum deflection. Springs shall have a reserve deflection of 50% of rated deflection before reaching solid.
- U. Vibration isolation equipment submittal drawings shall include the following information:
 - 1. Isolation mounting deflections.
 - 2. Spring diameters, compressed spring heights at rated load; solid spring heights, where steel spring isolation mountings are used.
 - 3. Equipment operating speed.
- V. All neoprene isolators shall have a minimum static deflection of 3/8 inch unless otherwise shown.

3.03 FIELD QUALITY CONTROL

- A. Division 01 - Quality Requirements and 01 70 00 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Inspect isolated equipment after installation and submit report. Include static deflections.

- C. After start-up, final corrections and balancing of systems take octave band sound measurements over full audio frequency range in areas adjacent to mechanical equipment rooms, duct and pipe shafts, and other critical locations. Provide one-third octave band measurements of artificial sound sources in areas indicated as having critical requirements. Submit complete report of test results including sound curves.
- D. Furnish services of testing agency to take noise measurement. Use meters meeting requirements of ANSI S1.4.

END OF SECTION