

**SECTION 23 33 19**  
**ACOUSTICS**

**PART 1 – GENERAL**

**1.01 WORK INCLUDED**

- A. The work of this Section shall include, but is not limited to, the following:
  - 1. Sound attenuators
  - 2. Sound lining
  - 3. Vane axial fan diffuser/silencer

**1.02 RELATED DOCUMENTS**

- A. Section 23 05 01 – HVAC General Provisions
- B. Section 23 05 48 – Vibration and Seismic Controls for HVAC
- C. Section 23 05 93 – Testing, Adjusting and Balancing for HVAC
- D. Section 23 07 00 – Insulation for HVC
- E. Section 23 31 00 – HVAC Ducts and Casings
- F. Section 23 37 00 – Air Outlets and Inlets

**1.03 REFERENCE STANDARDS**

- A. Published specifications standards, tests or recommended methods of trade, industry or governmental organizations apply to work in this Section where cited below:
- B. ANSI/AMCA – American National Standards Institute /Air Movement Control Association  
ANSI/AMCA 300 Reverberant Room Method for Sound Testing of Fans
- C. ANSI/ASA – American National Standards Institute/Acoustical Society of America  
ANSI/ASA S1.13 Measurement of Sound Pressure Levels in Air
- D. ANSI/AHRI – American National Standards Institute /Air Conditioning and Refrigeration Institute
  - 1. ANSI/AHRI 440 Performance Rating of Room Fan-Coils
  - 2. ANSI/AHRI 575 Method of Measuring Machinery Within an Equipment Space
- E. AHRI – Air Conditioning and Refrigeration Institute
  - 1. Standard 440– Standard for Room Fan Coil and Unit Ventilator
  - 2. AHRI 885 Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminal and Air Outlets
  - 3. AHRI 880 Performance Rating of Air Terminals
- F. ASTM – American Society for Testing and Materials

1. ASTM C209 Standard Test Methods for Cellulosic Fiber Insulating Board
2. ASTM C411 Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
3. ASTM C423 Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
4. ASTM C518 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
5. ASTM C 534, Grade 1 Type II, Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form
6. ASTM C1071 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
7. ASTM C1338 Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings
8. ASTM C 1534, Standard Specification for Flexible Polymeric Foam Sheet Insulation Used as a Thermal and Sound Adsorbing Liner for Duct Systems”
9. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
10. ASTM E90-09 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
11. ASTM E413 Classification for Rating Sound Insulation
12. ASTM E477 Standard Test Method of Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers
13. ASTM G21 Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

G. ISO – International Organization for Standardization

1. ISO 5135 Acoustics – Determination of Sound Power Levels of Noise from Air-Terminal Devices, Air-Terminal Units, Dampers and Valves by Measurement in a Reverberation Room
2. ISO 3741 Acoustics – Determination of Sound Power Levels and Sound Energy Levels of Noise Sources Using Sound Pressure – Precision Methods for Reverberation Test Rooms

H. NFPA - National Fire Protection Association

1. NFPA 90A: Installation of Air-Conditioning and Ventilating Systems
2. NFPA 90B: Standard for the Installation of Warm Air Heating and Air-Conditioning Systems

I. NLVAP – National Voluntary Laboratory Accreditation Program

J. UL – Underwriters Laboratories Inc. UL 181 Standard for Factory-Made Air Ducts and Air Connectors

K. Refer to Section 23 37 00: Air Inlets and Outlet for additional reference standards.

1.04 QUALITY ASSURANCE

- A. Materials shall be delivered in nonbroken, factory furnished packaging and stored in a clean, dry indoor space that provides protection against weather and water.
- B. Insulation shall be applied by qualified personnel skilled in this trade. Insulation shall not

be applied until all surfaces are clean; dry, and free of dirt, dust, grease, frost, moisture, and other extraneous elements. Work shall be performed at the temperatures recommended by the product manufacturer.

C. Acoustical criteria:

1. Noise levels, generated by equipment and ductwork, shall be attenuated to permit attainment of sound pressure levels in all 8 octave bands in occupied spaces that conform to the following Noise Criteria (NC) curves:
  - a. Lobbies, corridors, toilets, spaces within 10 feet of duct penetrations through shaft and equipment room walls and floors of equipment rooms: NC-40.
  - b. Assembly space: NC-30
  - c. Bedrooms: NC-30
  - d. Kitchen: NC-50
  - e. Public dining area: NC-45
  - f. Public Circulation Areas: NC-35 to NC-40
  - g. Locker rooms/dressing rooms/fitness center: NC-35
  - h. Yoga Room: NC-30
  - i. Parking garages and storage spaces: NC-50
  - j. All other spaces: NC 35
2. In addition to complying with the standard full octave band sound pressure levels based on maximum NC design requirements, acoustical performance of mechanical equipment when operating under design conditions shall not create any objectionable pure tones. A pure tone is defined as a peak sound pressure level which, when measured in  $\frac{1}{3}$ -octave band frequencies, is higher by more than 5 decibels than adjacent  $\frac{1}{3}$ -octave band frequencies.
3. Comply with specified NC levels for radiated noise from terminal and pressure regulating devices and/or duct breakout noise by having full octave band sound pressure levels of at least two contiguous frequencies tangent to the NC spectrum. A single frequency controlled NC environment is considered obtrusive and unacceptable.
4. During testing of sound attenuators there shall be air flowing through the tested sound attenuators at velocities specified in paragraph 2.02, plus or minus 5 percent.

D. Air distribution system equipment; terminal device noise:

1. Maximum permissible sound-power levels in octave bands of airborne transmissions through the combination of grilles, registers, diffusers, and terminal units, or related pressure reducing devices, when operated in installed condition with 3-feet of unlined duct shall be as follows:

Octave band frequency (Hertz) for maximum PWL in decibels referred to  $10^{-12}$  watts for space being served

Octave band frequency (hertz)	Octave band number	Maximum PWL in decibels referred to $10^{-12}$ watts for space being served				
		NC-30	NC-35	NC-40	NC-45	NC-50
63	1	60	65	70	68	70

Octave band frequency (hertz)	Octave band number	Maximum PWL in decibels referred to $10^{-12}$ watts for space being served				
		NC-30	NC-35	NC-40	NC-45	NC-50
125	2	58	60	65	63	66
250	3	55	60	65	58	62
500	4	53	60	60	56	61
1,000	5	50	60	60	53	58
2,000	6	50	60	60	52	57
4,000	7	40	50	60	51	56
8,000	8	37	42	47	52	57

2. Pressure-reducing terminal devices above ceiling; radiated noise:

Maximum permissible radiated sound-power levels in octave bands when operated in installed condition over occupied spaces, is as follows:

Octave Band Frequency (Hertz)	Octave Band Number	Maximum PWL in decibels referred to $10^{-12}$ watts			
		NC-35	NC-40	NC-45	NC-50
63	1	72	76	79	82
125	2	70	74	77	80
250	3	61	65	68	71
500	4	60	64	68	72
1,000	5	57	62	68	72
2,000	6	56	60	65	70
4,000	7	66	70	75	80
8,000	8	65	70	75	80

3. Provide sound lining in accordance with UL 181.
4. Provide all materials in accordance with NFPA, UL and state and local codes.

## 1.05 SUBMITTALS

### A. Shop drawings:

1. Sound attenuators.
2. Sound lining.
3. Certification that sound lining meets erosion test method described in the latest edition of UL 181, Factory-Made Air Ducts and Connectors.
4. Non-hardening caulking.
5. Submit certified test data from approved laboratory for pressure drop and insertion loss ratings. ASTM – American Society for Testing and Materials E477 and C423.
  - a. For square or rectangular attenuators: test results for a 24-inch by 24-inch cross-section attenuator.
  - b. Certification data for pressure drop and net insertion loss: based on tests of same attenuator.
  - c. Attenuators and tests: subject to inspection upon request.
  - d. Record acoustic ratings, including dynamic insertion loss and self-noise

- e. power levels with an airflow of 2,000 feet per minute face velocity.  
Leak Test: test units for airtightness at 200 percent of associated fan static pressure or 6-inch water gauge static pressure, whichever is greater.
- B. Noise generated by mechanical equipment shall be a guaranteed maximum when operating at the specified conditions.

## **PART 2 – PRODUCTS**

### **2.01 ACCEPTABLE MANUFACTURERS**

- A. Sound attenuators: IMI, Vibro-Acoustics, Kinetics Noise Control, or approved equal.
- B. Sound attenuators, vane axial fan diffuser/silencers: Price, IMI or approved equal.
- C. Sound linings, fiberglass: Certainteed ToughGuard, Johns Manville, Owens-Corning Fiberglas, or approved equal.
- D. Circular duct lining: Casco Circliner, Johns Manville Spiracoustic, or approved equal.
- E. Factory pre-fabricated double wall lined duct: United McGill, Sheet Metal Products, or approved equal.
- F. Fire retardant adhesive and sealer: Foster 85-20 or approved equal.
- G. Non-hardening caulking shall be guaranteed to be permanently elastic. Manville Clipper Duxseal, Tremco TREMstop Smoke & Sound Sealant or approved equal.

### **2.02 MATERIALS**

- A. Factory-prefabricated sound attenuators:
  - 1. Fire performance: adhesives, sealants, packing materials and necessary accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E84.
  - 2. Rectangular attenuators: fabricate casings with a minimum of 22-gauge solid galvanized sheet metal for outer casing and 26-gauge, ASTM A653/A653M, perforated galvanized sheet metal for inner casing.
  - 3. Round attenuator outer casing:
    - a. ASTM A653/A653M G60 galvanized sheet steel.
    - b. Up to 24 inches in diameter: 22 gauge.
    - c. 26 through 60 inches in diameter: 18 gauge.
    - d. Casings fabricated of spiral lockseam duct may be one gauge lighter than that indicated.
  - 4. Round attenuator interior casing, partitions and baffles:
    - a. ASTM A653/A653M G60 galvanized sheet steel.
    - b. Minimum 26-gauge and designed to minimize aerodynamic losses.
    - c. Sheet Metal Perforations: 1/8-inch diameter for inner casing and baffle sheet metal.

5. Attenuation filler materials
  - a. Fiberglass based acoustical insulation bonded to 26 gauge (0.016-inch-thick) acoustical barrier.
  - b. All exposed fiberglass face shall be bonded with a fiberglass scrim cloth per Oxel 919 treatment to a minimum strength per square inch of 80 pounds. warp and 70 pounds filler, packed under a minimum of 5 percent compression.
  - c. Fiberglass based insulation shall be vermin and moisture proof with a flame-spread maximum of 25.
  - d. Outer casings: fully-welded cold-rolled and powder-coated after fabrication.
6. Rectangular casing seams shall be located in the corners of the attenuator shell to provide strength and rigidity. Interior partitions shall be fabricated from single piece, perforated sheets with die-formed entrance and exit shapes. Attachment of the interior partitions to the casing shall be by means of an interlocking track assembly. Tracks shall be solid galvanized steel and shall be welded to the outer casing. The track assembly shall stiffen the exterior casing, provide a reinforced attachment detail for the interior partitions, and shall maintain a uniform airspace width along the length of the attenuator.
7. No sound-absorptive material of any kind shall be used in the silencers. The silencers shall attenuate air/gas transmitted noise solely by controlled impedance membranes and broadly tuned resonators.
8. Attenuators subjected to corrosive environments shall be constructed of type 316 stainless steel.
9. Attenuators shall form rigid units that do not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
  - a. Do not use nuts, bolts or sheet metal screws for unit assemblies.
  - b. Continuously weld joints.
  - c. Suspended attenuators: factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
10. Performance data shown based on the IMI Acoustics silencer type FGR silencers: minimum performance as determined by duct-to-reverberant room test method shall be as follows:

Model	Pressure Drop (inches wg)	Face Velocity (feet/minute)	Insertion Loss (db) Octave Band Center Frequency (Hz)								Generated Noise Lw (dB re 10 <sup>-12</sup> Watts) Octave Band Center Frequency (Hz)							
			1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
			63	125	250	500	1k	2k	4k	8k	63	125	250	500	1k	2k	4k	8k
1212	0.63	-2000	17	20	19	28	29	29	31	36	53	42	41	39	40	40	25	27
	0.16	-1000	17	20	18	27	29	29	31	36	52	41	31	22	18	19	22	25
	0	0	17	20	18	27	29	29	31	36	—	—	—	—	—	—	—	—
	0.16	+1000	17	19	18	27	28	29	31	37	52	41	31	22	18	19	22	25
	0.63	+2000	17	19	18	27	27	29	31	37	52	41	31	22	18	19	22	25
1818	0.24	-2000	13	15	18	24	34	32	47	49	53	42	41	39	40	40	25	27
	0.06	-1000	13	15	17	23	33	31	47	49	52	41	31	22	18	19	22	25
	0	0	13	15	17	23	33	31	47	49	—	—	—	—	—	—	—	—
	0.06	+1000	13	15	17	23	33	31	47	49	52	41	31	22	18	19	22	25
	0.24	+2000	13	15	17	23	33	31	47	49	52	41	31	22	18	19	22	25

Model	Aerodynamic Performance Data Face Velocity (fpm) & Pressure Drop (inches wg.)									
	500	750	1000†	1250	1500	1750	2000†	2500	2750	3000†
1212	.04	.09	.16	.25	.35	.48	.63	.98	1.18	1.40
1818	.02	.04	.06	.10	.14	.19	.24	.37	.45	.54

## B. Vaneaxial fan diffuser/silencer:

1. Construct diffuser/silencers of inorganic, noncombustible materials meeting applicable standards and code requirements
2. Maximum flame spread rating of 25. Maximum smoke developed of 50.
3. The diffuser/silencer shall be specifically designed for mounting at the inlet and outlet of manufacturer's vaneaxial fan. Diffuser/silencer performance shall be specifically rated with the fan manufacturer and fan size selected. Provide flow direction indicator labels on the exterior casing.
4. Diffuser/silencers shall include an internal core of consistent diameter along the entire length in direction of airflow. The core diameter shall be selected based on the adjacent hub diameter or, in the case of C-frame mounted motors, the motor frame size for the respective fan system on which the diffuser silencer is installed. The core shall be constructed from lock forming quality type G-90 galvanized perforated steel in the same gauge as the internal diffuser core. The core shall be supported by a minimum of 3 welded radial attachment brackets installed at a 120 degree angle to each other to provide uniform support.
5. Silencer shall contain acoustic grade glass fiber under minimum 15 percent compression, with glass fiber cloth liner to protect acoustical media from erosion.
6. Provide 2-inch long, 12-gauge, sleeved end connections as standard. When noted, rolled angle flanges shall be welded to the sleeve by the manufacturer. Where the minimum diffuser core diameter is 36 inches or greater, an additional support rod shall be welded between the radial bracket and the sleeve to prevent a twist from being exerted on the internal core by the airflow of the fan.
7. Diffuser/silencers shall function as pressure regain devices to minimize system pressure losses at the fan. Fan selections are based on the regain performance of the diffuser/silencer configurations specified.
8. The diffuser/silencer shall meet the following requirements for dynamic insertion loss. The performance is based on forward flow, 2000 feet per minute inlet/outlet velocity, and centerbody element diameter approximately equal to one third of the inlet diameter:

Fan diameter/ silencer length (inches)	Dynamic insertion loss in decibels for Octave band center frequency in hertz							
	63	125	250	500	1,000	2,000	4000	8000
21/21	1	3	8	14	13	11	8	7
21/42	1	8	11	20	22	17	14	13
25/25	1	4	7	12	13	11	9	7
25/50	1	8	10	21	20	15	13	11
29/29	1	8	16	19	19	14	10	9
29/58	1	9	15	24	25	17	16	13
32/32	1	5	10	14	13	11	9	8
32/64	1	9	17	25	24	17	15	14
36/36	1	5	10	14	13	11	10	7
36/72	2	8	17	25	23	17	15	12
42/42	3	7	19	25	25	18	17	13
42/84	3	7	19	25	25	18	17	13
48/48	4	12	18	20	16	12	11	10
48/96	3	6	15	22	20	15	13	11



Fan diameter/ silencer length (inches)	Dynamic insertion loss in decibels for Octave band center frequency in hertz							
	63	125	250	500	1,000	2,000	4000	8000
54/54	2	4	8	12	13	9	9	7
54/108	3	6	14	21	20	14	13	11
60/60	1	4	7	12	13	11	9	7
60/120	3	8	17	21	20	15	13	11
66/66	2	4	9	15	17	14	11	9
66/99	4	9	21	23	25	18	17	13
72/72	2	4	14	15	17	14	11	10
72/108	4	9	20	22	25	20	14	12
78/78	3	5	10	14	15	14	10	9
78/117	5	10	15	22	23	18	17	11
84/84	3	5	9	15	14	13	10	8
84/126	5	10	13	21	22	17	17	10

## C. Fiberglass duct lining:

1. Low-pressure fiberglass duct liner downstream of terminal units shall be finished with an acrylic polymer facing stenciled NFPA 90.
2. Medium pressure duct liner shall be finished with perforated 24-gauge galvanized sheet metal, 28 percent minimum open area or foil facing.
3. Thickness:
  - a. In ductwork: minimum 1 inch matte faced unless otherwise noted on the Drawings or specification.
  - b. In plenums and in supply, return or exhaust duct downstream of local floor equipment rooms: Minimum 2 inches, 3 pound per cubic foot density, semi-rigid.
  - c. For sound lining where used in lieu of external thermal insulation, minimum thickness shall conform to requirements as specified in Section 23 07 00: Insulation.
  - d. Linear diffuser supply plenums: minimum 0.5 inch, 1.5 pound per cubic foot density.
4. Minimum density ducts: 1.5 pounds per cubic foot.
5. Minimum density, plenums: 3 pounds per cubic foot.
6. Flame-spread shall be maximum 25; fuel contributed and smoke developed shall be maximum 50.
7. Suitable for duct velocity of 4,000 feet per minute. Meet erosion test method described in UL 181.
8. Dynamic loss coefficient: maximum 1.2.
9. K Factor: maximum 0.23 BTU per inch-hour – degree F – square foot; R Value minimum: 4.2 at 1-inch thickness.
10. Minimum sound-absorption coefficients (ASTM C423 Type A Mounting) for sound-absorbing duct lining material when tested while mounted per ASTM E795.

Lining thickness	Noise reduction coefficient (NRC) minimum
0.5 inch	0.45

Lining thickness	Noise reduction coefficient (NRC) minimum
1.0 inch	0.70
1.5 inch	0.85
2.0 inch	0.95

11. Where acoustically lined circular or oval duct is required, lining shall be positively retained in place.

### **PART 3 – EXECUTION**

#### **3.01 INSTALLATION**

- A. To obtain satisfactory acoustical performance of the mechanical systems, complete the following:
1. Duct connections at inlet to the terminals
  2. Air-balancing
  3. Avoid excessive dampering right at the terminals
- B. Duct and duct supports shall not contact ceiling framing, ceiling supports, electrical, piping or pipe supports.
- C. Sound attenuators:
1. Install in accordance with manufacturer's recommendations to obtain published and specified performance.
  2. Provide 22-gauge galvanized steel wire mesh screen on all sound-attenuator inlets or outlets not connected to ductwork or fans.
  3. Provide water-tight aluminum jacket on all sound attenuators installed outside the building or exposed to the weather. Installation shall comply with SMACNA standards for outdoor installations.
- D. Fiberglass sound lining:
1. Adhere with 6-inch wide strips of adhesive at 12-inch centers at all joints in lining.
  2. In addition, secure with grip nail, standard stamp-on or weld pins, and 2-inch diameter integral or press-on head washers on maximum 16-inch centers and in compliance with SMACNA standards.
  3. Coat all edges with sealer
  4. Provide continuous sheet metal edge protection nosings at entering and leaving edges of lined duct sections and all joints.
  5. Dimensions of lined ductwork are clear inside dimensions after lining has been installed.
- E. AP Coilflex shall be applied using an automated coil line and water based adhesive. AP Spiralflex shall be applied to the inside of round duct according to the manufacturer's installation instructions specifically for the AP Spiralflex

## F. Extent of ductwork sound linings.

1. Supply: ductwork within mechanical equipment rooms and not less than 25 feet downstream of mechanical equipment room walls and floor slabs.
2. Exhaust, relief and return: ductwork in mechanical equipment rooms but not less than 25 feet from fan or 15 feet from room walls, floors or ceiling/slabs.
3. Outside air supply systems: minimum distance of 25 feet downstream of fan. Stop lining 10 feet from outside air intake.
4. Ductwork installed outside building: all exposed ductwork a minimum of 10 feet downstream of wall, roof or floor penetrations.
5. Ventilation systems: as indicated on the Drawings.
6. Exhaust systems: as indicated on the Drawings.
7. VAV terminal units: first 6 feet of ductwork at discharge side. There shall be no branch takeoffs within first five feet.
8. Ductwork downstream of fan coil units, heat pumps, AC units or fan powered terminal units: minimum 10 feet. Branch take-offs to diffusers are not allowed within 5 feet of unit discharge.
9. Ductwork upstream of ducted fan coils, heat pumps, AC units, fan powered boxes, VAV terminal units: 3 inlet diameters or 3 feet-zero inches, whichever is greater.
10. Minimum lengths specified or shown. Provide additional acoustical treatment as required to meet maximum permissible sound-power levels scheduled for equipment.
11. Sound-lined plenums: As specified and indicated on the Drawings.
12. All transfer and jumper ducts.
13. All linear diffuser supply plenums.

## G. Soundproofing of construction:

1. Required for packing between ductwork and the following construction:
  - a. Fan room and mechanical equipment room walls.
  - b. Floors, except in shafts.
  - c. Sound barrier ceilings.
  - d. Sound-rated walls: Any interior wall or partition with internal insulation. Refer to Architectural drawings.
2. Soundproofing:
  - a. Fill openings with fiberglass blanket or board for full depth of penetration.
  - b. Caulk each side of opening with non-hardening, non-aging caulking compound. Manville Clipper Duxseal or approved equal.
3. Soundproofing may be deleted when firestopping material is provided.

## H. Ductwall external soundproofing: vane axial fans including their inlet and discharge transitions and sound attenuators, and where indicated on the Drawings.

## I. Soundproofing Material: fiberglass board: 6 pounds per cubic foot density, ½ inch thicker than height of ductwork angles, with 2 inches minimum and an external jacket fabricated from 1/64-inch-thick lead sheet overlapped 2 inches and secured with tape. Weight: 1 pound per square foot.

- J. Sound attenuators tests:
  - 1. After installation, measure total system pressure before and after attenuators.
  - 2. If pressure loss exceeds maximum static pressure scheduled on the Drawings, replace attenuators and/or modify entrance and/or discharge aerodynamic flow to obtain specified performance.
- K. Do not install flexible duct through walls or ceilings.
- L. Acoustical testing: The contractor shall cooperate with the test and balance contractor to allow acoustical testing to be executed during the testing and balancing.

END OF SECTION 23 33 19