SILENCER SELECTION

INSTRUCTIONS

For general information in HVAC Acoustics, consult the following publications:

> 2017 ASHRAE Fundamentals Handbook, Chapter 8 Sound and Vibration

> 2015 ASHRAE Applications Handbook, Chapter 48 Noise and Vibration Control

> Algorithms for HVAC Acoustics, 1991

> A Practical Guide to Noise and Vibration Control for HVAC Systems, 1991

Before following the procedures below, it may be beneficial to first familiarize yourself with the 18 Common Silencing Problems summarized and illustrated through Silencer Application Solutions (SAS sheets) found in the Application section of the this Guide.

To select a silencer, it is necessary to determine:

1. How much insertion loss (IL) is necessary to achieve the specified room sound criterion
2. How much additional pressure drop (PD) is allowable at the system duct velocity
3. Where the silencer should be located
4. How much silencer airflow generated noise (GN) can be tolerated
5. Silencer type to meet system/application requirements
6. Silencer model to meet IL, PD and GN requirements
7. Silencer construction

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1 Insertion Loss Required

EACH DUCT SYSTEM needs to be analyzed separately. All possible sound sources and paths should be considered. Common paths often forgotten include duct break-out noise and equipment noise radiated to the environment through intake or exhaust louvers.

It is critical that the duct system analysis begin at the initial sound source and continue in order, duct element by element, to the occupied space. This will ensure that the noise level can be calculated at any point along the system to help determine if break-out noise and/or airflow generated noise need to be controlled (see below).

The octave band sound power levels of the noise generating elements are summed logarithmically (e.g. main fan or AHU, terminal boxes and airflow generated noise of ductwork, fittings, terminal devices, etc.). The natural attenuation elements, such as ductwork, plenums and fittings, etc. are subtracted. (**See ASHRAE's "System Design Procedures"[1] for more details**.)

The silencer should not be included in the initial calculation. Its required insertion loss is the positive difference between the estimated resultant sound pressure level in the space and the room criterion[2] for the space. If a duct system transmits noise to more than one space, the greatest insertion loss for each octave band is the insertion loss required.

Vibro-Acoustics' V-A Select computer program automates the duct system analysis procedure. **See the V-A Select manual** for more information.

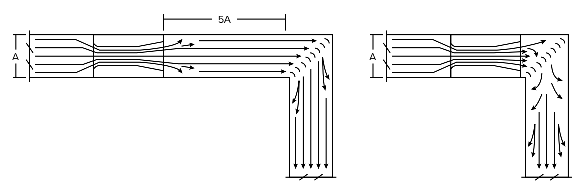
[1] ASHRAE Applications Handbook, 2015, P. 48.18.
[2] ASHRAE Applications Handbook, 2015, P. 48.3

2 Maximum Allowable Pressure Drop

DETERMINE how much silencer pressure drop (including system effects) has been allowed for in the system design. Ordinarily, the silencer pressure drop (including system effects) should not exceed 0.35" (85 Pa).[1]

The user should always consider the added losses due to aerodynamic system effects. That is, if the silencer is located where less than ideal conditions at the inlet and/or at the discharge of the silencer exist, then the silencer's effective pressure drop will be increased. (Total silencer PD = silencer PD per catalog ASTM E-477-13 rating + system effect losses). In some situations the added system effect losses can exceed the pressure drop of the silencer.

Figure: Effect of Silencer Location on Pressure Drop Performance



For example, an elbow fitting located immediately following a silencer will prevent regain of static pressure from the silencer's exit velocity pressure. Furthermore, local velocities within the elbow fitting will be greater than the average duct velocity and more turbulent. These factors will produce higher overall static pressure losses.

[1] ASHRAE Applications Handbook, 2015, P. 48.24

SILENCER SYSTEM EFFECTS

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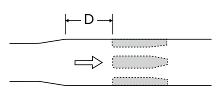
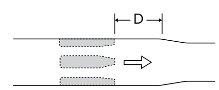
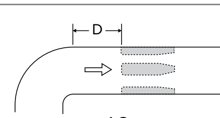
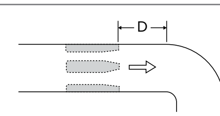
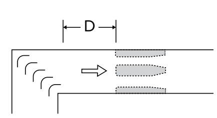
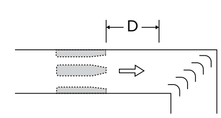
THE FOLLOWING are guidelines to estimate increased pressure losses due to varying silencer inlet and discharge conditions. These should be considered only as very approximate guidelines. Substantial variations can occur depending upon the type of silencer, its internal geometry, size of silencer, size of duct, airflow turbulence, etc.

Note: the factors shown do NOT include pressure drops of the duct element. These must be added separately.

To determine the allowable silencer catalog pressure drop for selection and specification purposes:

$$\text{Allowable Catalog Silencer PD} = \frac{\text{Total Allowable Silencer Pressure Drop including System Effects}}{(\text{Inlet System Effect Factor} \times \text{Outlet System Effect Factor})}$$

Vibro-Acoustics' **V-A Select** program allows the user to evaluate system effects when selecting silencers. See the **V-A Select Manual** for more information.

Duct Element	Silencer system effect factor duct element on...	
	Silencer Inlet	**Silencer Discharge**
Transitions		
7-1/2 degrees per side Distance of transition from silencer		
D[1] = 1	1.0	1.0
D = 2	1.1	1.1
D = 3	1.2	1.1
25 degrees per side Distance of transition from silencer		
D = 1	1.3	1.1
D = 2	1.6	1.1
D = 3	1.8	1.1
45 degrees per side Distance of transition from silencer		
D = 1	1.7	1.1
D = 2	1.9	1.1
D = 3	2.0	1.1
Elbow – radius type Distance of radius elbow from silencer		
D = 0	1.2	1.4
D = 1	1.1	1.2
Elbow – mitered type with short turning vanes Distance of mitered elbow from silencer		
D = 0	1.2	1.1
D = 1	1.2	1.1
D = 2	1.2	1.2

[1] D is the diameter of round duct or equivalent diameter of rectangular duct.

SILENCER SYSTEM EFFECTS

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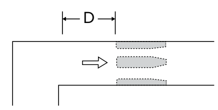
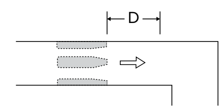
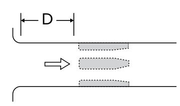
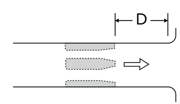
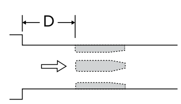
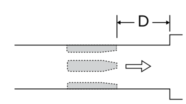
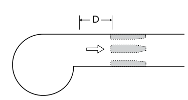
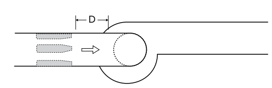
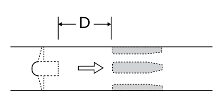
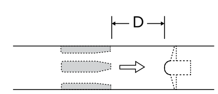
Duct Element	Silencer system effect factor duct element on...	
	Silencer Inlet	**Silencer Discharge**
Elbow – mitered type with no turning vanes		
Distance of mitered elbow from silencer		
D[1] = 0	1.2	2.9
D = 1	1.0	1.8
D = 2	1.1	1.4
Abrupt entry or exit		
Smooth Inlet or Discharge Distance of entry or exit from silencer		
D = 0	1.1	1.8
D = 1	1.0	1.4
D = 2	1.0	1.1
D = 3	1.0	1.0
Abrupt entry or exit		
Sharp Inlet or Discharge Distance of entry or exit from silencer		
D = 0	1.2	2.0
D = 1	1.1	1.5
D = 2	1.0	1.2
D = 3	1.0	1.0
Centrifugal fan		
Distance of centrifugal fan from silencer		
D = 0	1.5	2.0
D = 1	1.2	1.7
D = 2	1.1	1.5
D = 3	1.0	1.2
Axial fan (Also see below – effect of silencer on fan)		
Distance of axial fan from silencer		
D = 0	1.5	2.0
D = 1	1.2	1.7
D = 2	1.1	1.5
D = 3	1.0	1.2

[1] D is the diameter of round duct or equivalent diameter of rectangular duct.

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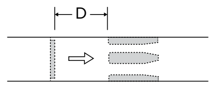
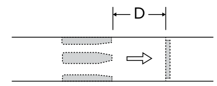
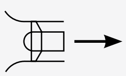
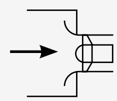
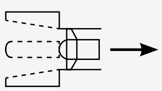
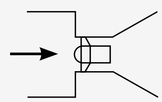
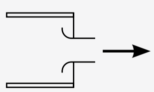
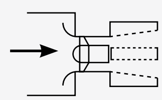
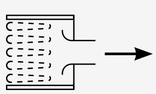
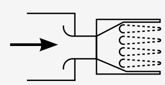
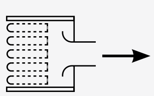
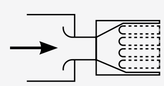
Duct Element	Silencer system effect factor duct element on...	
	Silencer Inlet	Silencer Discharge
Coils or filters Distance of coils or filters from silencer		
D[1] = 0	1.6	1.6
D = 1	1.0	1.3
D = 2	1.0	1.1

[1] D is the diameter of round duct or equivalent diameter of rectangular duct.

Axial/Fan Silencer System Effects

The effects of various Free Air Silencer Inlets/Discharges upon horsepower consumed by an Axial Fan in a Constant System with Constant Air Flow. Percentages are indicative only, and would differ in different systems.

FREE INLET			H.P. CONSUMED				FREE DISCHARGE
Standard Bellmouth Inlet		Constant System	100%	100%	Constant System		Abrupt fan discharge to room 4
1 Inlet cone silencer well matched to fan hub		Constant System	99%	97%	Constant System		Fan manufacturer's evase
Acoustic plenum		Constant System	105%	97%	Constant System		Discharge cone Silencer well matched to fan motor hub 5
2 Plenum with aerodynamic low turbulence splitters		Constant System	106%	99%	Constant System		Non-aerodynamic evase (typical) & aerodynamic splitters
3 Plenum with blunt turbulent splitters		Constant System	110%	104%	Constant System		Non-aerodynamic evase (typical) & blunt non-aerodynamic splitters 6

SEE DIAGRAM

1 Inlet Cone Silencer must be aerodynamically matched to fan hub, otherwise H.P. consumed increases considerably to 105% - 110% or more!

2 Splitters designed so turbulent wake is gone before reaching plane of the fan blades, for lowest fan noise.

3 Blunt, untapered splitters with either radius or sharp edged tails, create excess turbulence & fan noise from turbulence.

4 Although unlikely in practice, this was chosen as the reference configuration.

5 Discharge Cone Silencers must be matched to fan motor hub, or fan H.P. can be well in excess of 100%!

6 Blunt, untapered splitters do not allow pressure/velocity recovery before dumping air to the room causing excessive, abrupt expansion pressure losses.

General Notes: A. If a fan consumes less horsepower, it generates less noise and therefore needs less silencing.
B. Turbulence allowed to impinge upon the plane of the axial fan blades can create 10-15 dB or more excess fan sound power.

3 Silencer Location

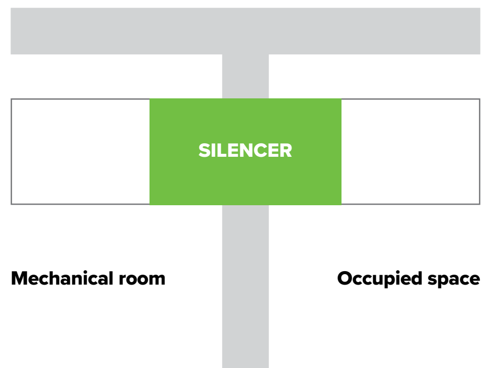
SILENCERS SHOULD generally be located as close to the fan or noise source as possible. This will help contain the noise at the source and limit potential points along the system where the unsilenced noise may break out. However, turbulent airflow usually exists close to noise sources such as fans, valves, dampers, etc. Therefore the user should evaluate aerodynamic system effects (see above).

If silencers are carefully designed they can actually improve flow conditions close to fans. Special fan inlet and discharge silencers, including cone silencers and inlet box silencers, minimize aerodynamic system effects, and contain noise at the source. Their effective added pressure drop could even be slightly negative if the silencer improves the flow into or out of the fan, thus increasing the fan's performance.

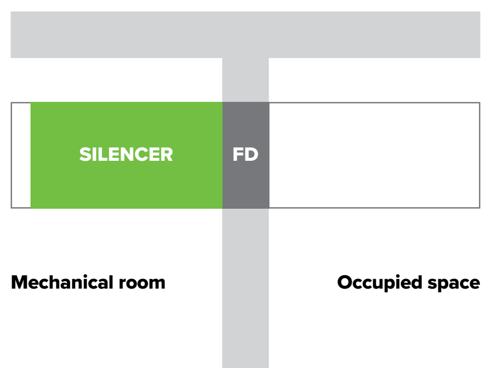
Despite the foregoing, the best acoustic location for a duct silencer may be straddling the mechanical room wall to minimize ductborne and breakout/break-in noise (**see figure**). However, fire dampers are often located at this point. As a compromise, many times silencers are located inside the mechanical room close to the mechanical room wall. However, if space does not permit this position, the silencer may need to be located outside the mechanical room. In such cases, high transmission loss (HTL) silencer walls may be required to prevent noise from breaking in or out of the silencer before it is fully attenuated. Connecting duct between the silencer and wall may also have to be HTL wall construction.

Considerations for Silencer Location

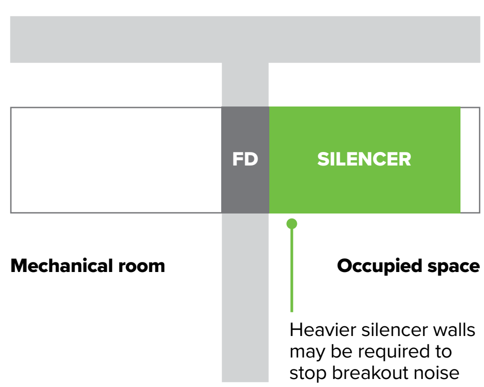
BEST SILENCER LOCATION IF NO FIRE DAMPER



BEST SILENCER LOCATION IF FIRE DAMPER IS REQUIRED



ALTERNATE SILENCER LOCATION



4 Maximum Allowable Airflow Generated Noise

IN THE MAJORITY OF INSTALLATIONS, a concern for silencer airflow generated noise is generally unwarranted because it does not materially contribute to the overall system noise level. This is particularly true if the silencer is properly located close to the source and pressure drops are not excessive.

ASHRAE[1] recommends that in general, airflow generated noise should be evaluated if silencer static pressure drops exceed 0.35” (including system effects), the noise criterion is below RC-35(N), or if the silencer is located very close to or in the occupied space.

To roughly calculate the maximum allowable silencer generated noise when the silencer is located very close to or in the occupied space: Subtract 5dB per octave from the room sound criterion spectrum.

Note: ASHRAE does not recommend selecting silencers with pressure drops in excess of 0.35” pressure drop (including system effect). If the noise criterion is below RC-35(N) consider retaining a qualified Acoustical Consulting Engineer having expertise in HVAC noise control.

5 Select Type of Silencer

ONCE THE ABOVE STEPS HAVE BEEN FOLLOWED, DETERMINE:

> **Silencer shape** (Rectangular or Circular dependent on the connection shape of the ductwork).

> **Silencer type**

> **Dissipative (RD and CD):** Uses acoustic grade glass fiber protected by perforated metal.

> **Film-Faced (RFL and CFL):** Dissipative type with film such as Tedlar or Mylar lining between the perforatedmetal and the acoustical glass fiber. An acoustical spacer is used between the perforated metal and the liner to reduce insertion loss degradations caused by the film liner.

> **No-Media (RNM, CNM and CENM):** Completely void of absorptive media or fill of any kind.

[3]ASHRAE Applications Handbook, 1995 p. 43.17

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6 Select Silencer

COMPARE THE ACTUAL INSERTION LOSS required spectrum with the insertion loss spectrum shapes for different silencer sizes and pressure drops available (see Performance Data Section or use the V-A Select or Quick Pick Computer Programs). Select the silencer that best fits the insertion loss required and does not exceed the maximum allowable silencer pressure drop and generated noise.

Ensure that the silencer length selected fits within the allowable space and does not affect the aerodynamic system effects calculated in step 2 above.

As a guideline, Vibro-Acoustics' silencer model numbers include a duct velocity range indicator (i.e., ULV, LV, MV, HV or UHV). This can be used to narrow the multiple silencer options:

Vibro-Acoustics' model numbers also include a frequency indicator (e.g. AC1, AC2, etc.). The lower the "AC" numeric the better the silencer performs in the low frequency range. The higher the number the better it performs at the mid and high frequency ranges.

Normally, the selection of a silencer is limited by the space available and allowable pressure drop. It should be recognized that for a given silencer, the pressure drop will increase as the square of the duct velocity. Thus, at lower system velocities, more insertion loss can be achieved at acceptable pressure drops. In higher velocity systems, longer silencer lengths with larger air passage ways may be required to maintain acceptable pressure drops and achieve the required insertion loss.

Vibro-Acoustics' V-A Select computer program can be used to efficiently select a silencer from the parameters determined in steps 1 through 4 above.

Normal Recommended Duct Velocity Ranges for Vibro-Acoustics' Silencers

	Ultra Low Velocity	Low Velocity	Medium Velocity	High Velocity	Ultra High Velocity
Silencer Type	**ULV**	**LV**	**MV**	**HV**	**UHV**
RD, RFL, RNM	0-500 fpm	500-750 fpm	750-1250 fpm	1250-2000 fpm	see SS8 and SS9
CD, CFL	see LV	0-1500 fpm	1500-3000 fpm	3000-5000 fpm	5000-7000 fpm
CNM	see LV	0-750 fpm	750-1250 fpm	1250-2000 fpm	2000-3500 fpm
CENM	see LV	0-1250 fpm	1250-1750 fpm	1750-2250 fpm	N/A

Note: Silencers can always be used in systems with lower velocities than the recommended operating range.
However, more silencer length may be required to achieve the required insertion loss.

7 Standard and Special Construction Options

For standard construction features see the applicable Silencer Sheet.

Vibro-Acoustics offers many special construction options which are needed for certain applications, **see Special Construction Options**.