A Guide for Specifying and Selecting Vent and Blowdown Silencers

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If you are tasked as an engineer to develop a specification for the purchase of a vent or blowdown silencer, it can appear somewhat overwhelming due to the high mass flows, pressures and temperatures involved. It doesn't have to be. This article will define a vent silencer specification data sheet and discuss each of the important fields that must be completed on the form, including background considerations. The information imparted encompasses the applied knowledge of acoustical theoreticians and vent silencer industry practitioners from over the last 50 years. The outcome should be a better understanding of the factors involved and information needed to specify and select the appropriate vent silencer for a given application, without over- or under-designing it.

This article defines a vent silencer specification data sheet and covers each of the important fields that must be completed on the form. These fields include those that must be identified by the purchaser and those that must be supplied by the silencer vendor. Understanding all of the factors involved will make to easier for you to select the right vent silencer for the application at hand.

But first, we will introduce vent and blowdown silencers and review the basic factors involved in predicting the noise generated by high-pressure vents. Listed here are the vent and blowdown applications that require silencers:

- Steam venting in power generation applications
- Natural gas compressor station and pipeline blowdowns
- Process control and relief valves in industrial applications
- Blowdown tanks and autoclaves
- Bypass valves on blowers and compressors
- Steam ejectors and hogging vents
- Discharge of high-pressure gas to substantially lower pressure environment (atmosphere).

The high-pressure gas can be steam or natural gas, which accounts for more than 90% of the applications, as well as air, nitrogen, oxygen, hydrogen, carbon dioxide, combinations thereof, and other gases.

Note that the terms "vent silencer" and "blowdown silencer" refer to the application for which each is used. They are equivalent silencer designs and are referred to as vent silencers when being used to vent at a constant flow rate for a period of time. They are referred to as blowdown silencers when they are blowing down a finite volume of gas starting at a high pressure and ending at a low pressure over a given time. Vent silencers are sized for *constant* flow and blowdown silencers are sized for *maximum* flow.

Noise Generated by High-Pressure Vents

Over the years, there has been a good deal of work done in the field of predicting the noise generated by the high-pressure venting of gases. This has resulted in the development of several empirical models supported by field evidence and tabular data on the subject. There are a number of open sources in the public domain providing access to these models and databases.

We will not review these models but will touch on the key factors involved in predicting the noise generated by high pressure vents.

Factors Influencing Noise Generated by High-Pressure Vents.

- Mass flow – the higher the mass flow, the noisier it becomes.
- The type of gas and its molecular weight/specific gravity – lighter gases are noisier.
- Temperature – higher temperatures result in lighter gas flows, and therefore, higher noise levels.
- Upstream versus downstream pressure – the higher the upstream pressure is relative to downstream pressure, the louder it will be.
- Choke flow (critical flow or sonic flow) – occurs when upstream pressure is roughly two times or greater than downstream pressure, making things much noisier.
- Orifice/opening size of valves, vents, orifice plates, diffusers, etc. – larger diameters result in low frequency noise, while smaller diameters produce higher frequency noise. For instance, diffusers create a shift in the noise spectrum from low frequency (one large vent opening) to high frequency (many smaller openings), which is much easier to attenuate.

Elements Creating Noise in High-Pressure Venting Systems. The noise at the end of a high-pressure vent pipe is a combination of the noise generated by the high-pressure-drop elements in the system. Essentially, any element that has a high-pressure drop across it or large change in area will create noise and should be included in the noise model to accurately predict overall noise level. The major elements that create noise in high-pressure venting systems are:

- Pressure relief and control values – present in virtually all venting systems.
- Vent pipes/nozzles – last element in venting systems, except for those using high-pressure silencer diffusers.
- High-pressure silencer diffusers – when included, usually designed to provide a specific backpressure at the rated flow (sometimes used as fail-safe device).
- Orifice plates – included in many systems as a flow regulator or fail-safe device.
- Enlargers (reducers), headers and abrupt transitions – included in pipe systems for various reasons.

Shock Noise Versus Turbulent Mixing. There are two phenomena that produce noise in a high-pressure venting system:

- Shock noise – occurs when a choked flow condition exists
- Turbulent mixing – caused by the ripping of the air as the vent gas decelerates to lower velocity, such as the atmosphere.

Shock noise is the louder of the two. By adjusting the elements in a piping system it is possible to reduce the shock noise by reducing the magnitude or quantity of choked flow conditions present. Turbulent mixing, on the other hand, is always present, though less of an issue.

Vent Silencer Data Sheet

Many engineering concerns, consultants, manufacturers and end-user companies have developed forms for the specification and evaluation of vent silencers over the years. The vent silencer data sheet shown in Figure 1 is a compilation of those forms.

The data sheet is color coded to identify purchaser-supplied information (general, important and necessary) and vendor-supplied information (important and necessary). Following the specification and evaluation process presented in the data sheet will provide a silencer selection that best meets the needs of the application.

Note that we not address the "general" purchaser information noted on the data sheet. It goes without saying that the purchaser should provide these data for record keeping and document-control purposes.

Equipment Description

Here the vent silencer operating conditions are identified along with details regarding the vendor and the equipment that they are proposing. Vent silencer operating conditions include:

- Service – as a rough guide, "continuous" if operating more than eight hours per week and "intermittent" if operating less than eight hours per week.
- Location – if outdoor breakout noise is less of a concern and

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paint finish is more important. If indoor, the reverse is true.

- Ambient conditions – important to know for structural design consideration along with the selection of a paint systems suitable for weather conditions.
- Orientation – vertical is the most common, since it is more economical and easier to attenuate in this configuration.

Vendor and equipment details:

- Vendor name and silencer model – for reference and documentation.
- Silencer weight, length and diameter – for design of silencer support structure and for evaluating bids.

Operating Conditions

The operation conditions section of the data sheet is where the purchaser defines their process and the vendor identifies the operating parameters of the silencer they are offering.

Gas Being Vented and Its Operating Conditions.

The gas and its characteristics. First, the type of gas must be identified, along with its ratio of specific heats (k or Cp/Cv) and molecular weight (MW) or specific gravity (SG). These data are all necessary for calculating vent system operating parameters and noise data.

Mass flow. The mass flow rate of venting systems is most often dictated by system operating capacity at a given pressure or by regulated flow through a control or relief valve or through a flow-regulating orifice plate or venturi. This is generally the domain of the purchaser and the system involved. In blowdown applications, however, it is normally the responsibility of the silencer vendor to determine the maximum blowdown mass flow rate. This is addressed subsequently.

Volume flow. The maximum volume flow rate of the gas being discharged at the end of the silencer should be calculated and recorded on the data sheet by the silencer vendor. The calculation should be carried out based on atmospheric pressure and exit temperature so that it corresponds to the flow conditions in the silencer acoustic passages. This makes it possible to calculate the silencer passage velocity, which plays an important role in the life of a vent silencer.

The higher the passage velocity in a vent silencer, the lower its life span. Much of the industry subscribes to the following rules regarding the selection of vent silencers:

- Continuous operation – 10,000 fpm to 15,000 fpm silencer passage velocity
- Intermittent operation – 15,000 fpm to 20,000 fpm silencer passage velocity

Pressure and temperature upstream of valve. The operating pressure and temperature upstream of the valve (or other flow restriction) and mass flow rate are the key variables in determining the noise of the venting process. The purchaser should set these values. When a temperature range exists, the range should be listed so that the vendor can check the noise at both conditions.

Pressure and temperature at silencer inlet. The vendor should be able to determine the operating pressure and temperature at the silencer inlet flange connection based on the upstream conditions, venting system components, and vent silencer they are offering. The operating pressure identified will dictate whether or not ASME construction of the inlet assembly/diffuser *must* be carried out. The temperature will play a role in choosing the type of material for its construction.

Silencer backpressure. Silencer backpressure (or pressure drop) is the pressure differential between the silencer inlet flange and silencer outlet (almost always atmospheric pressure), excluding inlet nozzle/diffuser exit loss. Inlet nozzle/diffuser exit loss is excluded, because it is often at a choked flow condition with a high pressure, which has nothing to do with the silencer's resistance to flow. In other words, it is part of the venting system, not the silencer.

The purchaser should set the allowable silencer backpressure at a value of less than 15 psi to avoid ASME construction concerns or at a lower pressure so as not to impact on the gas flow rate through the system (less than 50% of inlet nozzle pressure). Five psi is often used as a safe number.

The vendor should enter the actual backpressure of the silencer in the table based on the conditions specified.

Valve and Inlet Connection.

Valve diameter and type. The inlet and outlet diameter of the upstream valve and the valve type should be specified by the purchaser. This information will allow the vendor to assess its noise-generating characteristics. If the valve has special noise trim, the silencer vendor should be advised, and any noise related data from the valve manufacturer should be included as part of the specification.

Silencer inlet connection. The silencer inlet connection size is necessary for the vendor to properly select the silencer. Its rating and type should also be specified by the purchaser. However, if it isn't, the vendor is still obligated to provide a flange (and inlet nozzle assembly/diffuser) in accordance with ASME code, if applicable.

The location of the inlet connection can be specified by the purchaser or left to the vendor's discretion. The most economical choice is to use an end inlet connection.

Flow Control. Every venting system has some type of flow control mechanism. It can be as simple as opening a valve and letting the flow come as fast as possible. In this case, the flow becomes choked at the vent outlet, limiting the rate of flow. This is a condition that you generally want to avoid because it results in the highest possible mass flows and noise levels, requiring larger and more expensive silencers to do the job.

The flow control options on venting systems are:

- Valves – the most commonly used flow control method
- Orifice plates – these can be used for flow control and also used as a failsafe backup to flow-regulating valves
- Silencer diffuser – can be designed to regulate but must be designed and manufactured per ASME code, making them somewhat expensive
- Choke flow at vent opening with no other flow regulator – not recommended

Blowdown Applications. A blowdown application is defined as one where the objective is to evacuate high-pressure gas from a given volume. Normally, there is a time constraint and a final blowdown pressure specified that is close to atmospheric pressure (often 50 psig). The most common use of blowdown silencers is on natural gas compressor stations and pipelines.

The following data are required from the purchaser on a blowdown application:

- Pressurized volume – Bigger volumes require larger silencers.
- Maximum blowdown time – Longer times permit the use of smaller silencers; for emergency blowdown situations, maximum allowable blowdown might be 180 seconds or even 60 seconds.
- Final blowdown pressure – If you specify a final pressure below 50 psig, it will make it more difficult to meet the time requirement with an economic silencer selection.

It is the vendor's responsibility to calculate the maximum blowdown mass flow rate and to record it on the data silencer for the purchaser to review.

Maximum versus average flow rate. It is critical that the "maximum" and *not* "average" flow rate be used in selecting the silencer to be used. If average flow rate is used to select the silencer, for the first 35% of the blowdown cycle, the silencer will be running at as much as 2.5 times the allowable maximum velocity for a blowdown silencer. This means, that for a period of time, the silencer could be running at a silencer passage velocity as high as 2.5   20,000 fpm = 50,000 fpm. This would substantially reduce the life of the silencer and could result in a catastrophic failure of the silencer.

Acoustic Data

The acoustic data section of the data sheet is where the purchaser sets the acoustic specification for the application and where the vendor shows their calculations demonstrating compliance with the specification.

Maximum Allowable Sound Pressure Level. The most critical piece of information required from the purchaser is maximum allowable sound level (dBA) at the criterion point distance from the silencer. If the noise concern is "environmental," then the criterion point distance might be the closest residence, property line, or a

SILENCER DATA SHEET	CUSTOMER	SPECIFICATION NO.	DATE (YY-MM-DD)	
	TYPICAL MIDSTREAM NG LLC	44-H-5-DS-01	15-05-21	
dB Noise Reduction	PROJECT	INQUIRY NO.	REV. DATE	Rev.
	STATION 417	804431		A
	LOCATION	PREPARED BY		B
	426 MAPLEGLOVE ROAD	JOHN PRASKEY		C
	SMITHVILLE OK 78298	PAGE 1 OF 1		D

PURCHASER
- GENERAL DATA
- SHOULD PROVIDE
- MUST PROVIDE

VENDOR
- SHOULD PROVIDE
- MUST PROVIDE

No.			Rev.
1	**EQUIPMENT DESCRIPTION**		
2	SERVICE/DESCRIPTION: COMPRESSOR INTAKE	ITEM SIL-001 ; ITEM 1 OF 1 ; QUANTITY 2	
3	PIPING SILENCER	MANUFACTURER* dB NOISE REDUCTION	
4	SERVICE: INTERMITTENT	MODEL NO* 413-062420 ; WT* 36330 (lb)	
5	LOCATION: ☑ OUTDOOR ☐ INDOOR	SILENCER LENGTH* 481 (in) ; OD* 124 (in)	
6	AMBIENT CONDITIONS: REFER TO 00-STD-DB-0007	ORIENTATION ☑ VERTICAL ☐ HORIZONTAL	
7	**OPERATING CONDITIONS**		
8	FLUID / GAS: NATURAL GAS	VALVE DIA: 10 IN X 10 OUT (in) TYPE: BALL	
9	k = Cp/Cv = 1.32 ; MW or SG 0.582	INLET CONNECTION (BOTTOM / SIDE)	
10	MASS FLOW RATE (lb/hr)	SIZE ; RATING ; TYPE ; LOCATION	
11	MAX VOLUME FLOW AT DISCHARGE * 720101 (acfm)	16 ; 600 LB ; ANSI RFWN ; SIDE	
12	PRESSURE UPSTREAM OF VALVE 800 (psig)	FLOW CONTROL ☐ VALVE ☑ ORIFICE PLATE	
13	TEMPERATURE UPSTREAM OF VALVE 78 to 145 (°F)	☐ SILENCER DIFFUSER ☐ CHOKED FLOW AT VENT	
14	PRESSURE AT SILENCER INLET * 199 (psig)	BLOWDOWN APPLICATIONS	
15	TEMPERATURE AT SILENCER INLET * 66 (°F)	PRESSURIZED VOLUME 19747 (cu.ft)	
16	SILENCER BACKPRESSURE[a] - ALLOWED 5 (psi)	MAXIMUM BLOWDOWN TIME 180 (sec)	
17	SILENCER BACKPRESSURE[a] - ACTUAL * 3.95 (psi)	FINAL BLOWDOWN PRESSURE 50 (psig)	
18	[a] Silencer backpressure excludes nozzle / diffuser exit loss	MAX BLOWDOWN MASS FLOW RATE * 2182787 (lb/hr)	
19	**ACOUSTIC DATA**		
20	MAX ALLOWABLE SPL 85 dBA OVERALL AT 50 (ft) FROM SIDE OF SILENCER		
21	☑ AT INLET ☐ AT OUTLET ☑ AT GRADE, WITH SILENCER INLET AT 3 (ft) ABOVE GRADE		

No.	OCTAVE BAND (Hz)	63	125	250	500	1000	2000	4000	8000	dBA	NR
23	PWL AT VENT OUTLET WITHOUT SILENCER *	155	164	167	164	160	157	155	153	166	
24	SPL AT CRITERION POINT WITHOUT SILENCER *	121	129	129	124	117	112	107	103	125	
25	SILENCER DYNAMIC INSERTION LOSSES *	25	38	52	57	46	39	31	26		
26	SPL AT CRITERION POINT WITH SILENCER *	96	91	77	67	71	73	76	77	83	42

No.			Rev.
27	SPL - SOUND PRESSURE LEVEL IN dB, REF 2 X 10^{-5} Pa	PWL - SOUND POWER LEVEL IN dB, REF 10^{-12} W	
28	**MECHANICAL CHARACTERISTICS**		
29	SILENCER SHELL	SILENCER DISCHARGE ☑ OPEN	
30	DESIGN PRESSURE 5 (psig)	☐ WHISTLE CUT COWL ☐ 45° COWL ☐ 90° COWL	
31	DESIGN TEMPERATURE -20 to 200 (°F)	☐ PLATE FLANGE ID: ?? OD: ?? (in)	
32	MINIMUM CASING THICKNESS 1/4 (in)	SILENCER SUPPORTS	
33	CORROSION ALLOWANCE 1/8 (in)	☐ BRACKETS ☐ LEGS ☐ SADDLES	
34	SHELL MANUFACTURED PER ☑ AWS / CWB	☑ SKIRT & BASE RING ☐ INLET NOZZLE	
35	INLET ASSEMBLY / DIFFUSER	OTHER ACCESSORIES	
36	DESIGN PRESSURE 600 (psig)	☐ BIRD SCREEN ☐ GROUNDING LUG	
37	DESIGN TEMPERATURE 145 (°F)	☑ ORIFICE PLATE NPS: 16 (in)	
38	INLET / DIFFUSER MANUFACTURED PER (1.5 X DESIGN)	☐ REDUCER ?? X ?? (in)	
39	☑ ASME SEC VIII, DIV I ☑ RT ☐ HYDROSTATIC TEST	EXTERIOR PAINT SYSTEM	
40	REGISTERED: ☐ YES ☑ NO	SURFACE PREP - SSPC: ; 1ST ; 2ND ; 3RD	
41	☐ ASME B31.1 PIPE CODE ☐ RT	☐ SP3 ☑ SP6 ☐ SP10 ; COAT ; COAT ; COAT	
42	☐ AWS / CWB	INORGANIC ZINC ☐ ☐ ☐	
43	EXTERIOR MAT'LS: ☑ C.S. ☐ 304L ss ☐ 316L ss	TWO PART EPOXY ☑ ☐ ☐	
44	INTERNAL MAT'LS: ☑ C.S. ☐ 304L ss ☐ 316L ss	POLYURETHANE ☐ ☑ ☐	
45	LIFTING LUGS WELD NDT ☑ PT ☐ MT	HIGH HEAT ALUMINUM ☐ ☐ ☐	
46	DRAIN & PLUG 2" NPT, 3000 LB, C.S.	☐ MANUFACTURER'S STANDARD ☐ UNPAINTED	
47	STRUCTURAL DESIGN REFER TO 00-STD-DB-0013	☐ PER SPECIFICATION NOTED BELOW	
48	**NOTES**		
49	1. VENDOR TO SPECIFY WHERE NOTED WITH AN *		
50	2. NOISE LEVELS TO INCLUDE NOISE RADIATED FROM SHELL OF SILENCER.		
51			
52			
53			
54			

Figure 1. Vent silencer data sheet.

distance specified by regulations. If the noise primarily is an OSHA, health and safety issue, then the distance specified should be the closest distance from the vent silencer that an employee might be during gas venting.

Do not specify a near-field distance measured from the silencer outlet unless this is, in fact, where someone could be standing while the silencer is discharging. This scenario is very unlikely, and dangerous. Specifying a 3-foot (1.0 m) distance from the silencer outlet will result in a silencer that is much larger and more expensive than specifying a distance relative to the silencer inlet.

Including a 3-5 dBA safety factor to the maximum allowable sound level is recommended.

Use Measured Noise Data If Available. It may be that there is measured unsilenced octave-band sound pressure level data available for the discharge vent. If this is the case, the data should be used and entered (after adjustment, if necessary) on line 24 of the acoustic data table (SPL at criterion point without silencer). Measured data are far more accurate than even the best calculated data and should be used when available. Unfortunately, it is rare that measured data exist, making the use of calculated data a necessity.

PWL at Vent Outlet Without Silencer. When measured unsilenced data are not available, it is the vendor's responsibility to determine and enter the calculated octave-band sound power level (PWL) data at the vent outlet without silencer on line 23 of the acoustic data table. It is important that all potential vendors enter their data, since they are the starting point for the selection of the appropriate vent silencer for the application. It is also important that they account for all of the noise generated by the elements in the system and that it is based on the operating conditions identified on the silencer data sheet. This includes noise radiated from the silencer casing.

SPL at Criterion Point Without Silencer. Line 24 of the acoustic data table lists the unsilenced octave-band sound pressure level data at the criterion point. These data may be based on measured values if available (see "measured noise data" above). If not available, the data should be calculated by the silencer vendor and entered in the table. Typically, the SPL at the criterion point is calculated as follows:

$$Unsilenced\ SPL_{cp} = Unsilenced\ PWL_{vent} - \frac{Hemispherical}{divergence} - \frac{Directivity}{correction} - \frac{Atmospheric}{absorption} \quad (1)$$

The above equation is based on free-field conditions. The equation for hemispherical divergence with Q = 2, and tables for directivity and atmospheric absorption are readily available from published sources.

Silencer Dynamic Insertion Losses. This is the vendor's published vent silencer performance data and is dependent on silencer diameter, length, type of inlet or diffuser, acoustic open area, and passage width. There are a variety of reactive/absorptive designs available from different manufacturers.

The vendor's silencer dynamic insertion loss (DIL) data should be entered on line 25 of the acoustic data table. The vendor should be prepared to guarantee their DIL values.

SPL At Criterion Point With Silencer. Line 26 of the acoustic data table is the silenced octave-band sound pressure level data at the criterion point with the silencer installed:

$$Silenced\ SPL_{cp} = Unsilenced\ SPL_{cp} - SilencerDILs \quad (2)$$

The overall sound level calculated at the end of the line must be less than or equal to the maximum allowable sound level from line 20.

Mechanical Characteristics

This section of the data sheet defines the mechanical design parameters of the vent silencer. An overview of these parameters follows.

Silencer Shell.

- Design pressure – normally equal to or greater than the allowable silencer backpressure.
- Design temperature – usually set to cover the maximum of the ambient temperature range and gas temperature range.
- Minimum casing thickness – can be set by the purchaser or left to the discretion of vendor.
- Corrosion allowance –usually refers to the casing corrosion allowance for carbon steel construction; often 1/16 inch but sometime 1/8 inch is used.

Inlet Assembly/Diffuser.

- Design pressure – equal to or greater than the operating pressure at the silencer inlet. Often set to 1.25-1.5 times the pressure or equal to the inlet connection flange rating.
- Design temperature – usually set to cover the maximum of the ambient temperature range and gas temperature range.
- Inlet/diffuser manufactured per – ASME code or AWS/CWB depending on pressure and regulatory requirements.
- Radiographic inspection (RT) – if ASME code is being used, then RT inspections of all welds should be carried out along with all other QC required by code.
- Hydrostatic testing – is not necessary but may be required by regulations for items manufactured per ASME code. If included, the test is usually carried out at 1.5 times design pressure.
- Registration – inlet assembles and diffusers manufactured per ASME code may require "registration" to satisfy jurisdictional regulations. When included, this requires another level of third party QC inspection.

Silencer Construction.

- Exterior and internal materials – the standard materials of construction for vent silencers are carbon steel, 304L stainless steel, and 316L stainless steel. The choice is simply a matter of initial capital cost versus silencer life span. In some applications, such as steam, a carbon steel exterior with stainless steel internals presents a good compromise.
- Lifting lugs weld non-destructive testing (NDT) – most vent silencer vendors carry out a liquid dye penetrant (PT) inspection on all lifting lug welds as standard. The option of magnetic particle (MT) inspection is also possible but usually at an additional expense.
- Drain and plug – standard from all vendors on vent silencers; usually ¾-inch NPT, 3000-lb, carbon steel, for smaller diameter silencers and 2-inch NPT, 3000-lb, carbon steel, for larger silencers.
- Structural design – vent silencers are generally treated as stacks, meaning they are subject to jurisdictional design and building codes (wind and seismic) requiring that they be certified by a professional engineer. There may also be the need to identify nozzle loads for use in designing the piping system leading up to the silencer.
- Cold steel requirements – in cases where ambient temperatures dip below 40° F, it will be necessary to set special low-temperature steel specifications and material testing requirements.

Accessories.

- Silencer discharge – most silencers are installed outdoors and discharge directly to the atmosphere; generally, they do not require weather protection, since they have internal drains and are designed for wet service.
- Weather protection – if weather protection is required, the typical options are whistle cut cowls, 45° cowls and 90° cowls.
- Silencer support options – mounting brackets, support legs, saddles, skirts with base rings and inlet nozzles (with appropriate reinforcement).
- Other accessories – outlet bird screens, grounding lugs, ship loose orifice plates, and pipe reducers for installation between the silencer inlet flange (smaller) and silencer inlet nozzle (larger).

Exterior Paint Systems. There are a number of one-, two-, and three-coat paint finish systems that can be applied to the exterior of vent silencers along with their appropriate surface preparations. The interior of vent silencers are rarely painted.

Acknowledgements

This article is a compilation of data from, and the experiences of acoustical theoreticians and vent silencer industry practitioners from over the last 50 years. I would like to express my appreciation for their openly sharing their knowledge. SV

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