



Standard Test Method for Measuring Insertion Loss of Pneumatic Exhaust Silencers¹

This standard is issued under the fixed designation E 1265; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

^{ε1} NOTE—Keywords were added editorially in November 1995.

1. Scope

1.1 This test method covers the laboratory measurement of both the acoustical and mechanical performance of pneumatic exhaust silencers designed for quieting compressed gas (usually air) exhausts from orifices connected to pipe sizes up to $\frac{3}{4}$ in. NPT. This test method is not applicable for exhausts performing useful work, such as part conveying, ejection, or cleaning. This test method evaluates acoustical performance using A-weighted sound level measurements.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Specific precautionary statements are given in Section 8.*

2. Referenced Documents

2.1 ASTM Standards:

C 634 Terminology Relating to Environmental Acoustics²

2.2 ANSI Standards:

S1.4 Specification for Sound Level Meters³

S1.13 Method for the Measurement of Sound Pressure Levels³

S1.31 Precision Method for the Determination of Sound Power Levels of Broad-Band Noise Sources in Reverberation Rooms³

S1.33 Engineering Methods for the Determination of Sound Power Levels of Noise Sources in a Special Reverberation Room³

B2.1 Taper Pipe Thread (NPT)—Standard Designation for Tapered Pipe Threads³

2.3 Federal Standard:

Rules and Regulations—Hand and Portable Power Tools and Equipment⁴

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, see Terminology C 634. Particular terms of interest are: *sound level* and *average sound pressure level*.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *flow ratio*—the ratio of gas flow with the pneumatic exhaust silencer installed relative to flow of the unrestricted pipe.

3.2.2 *flow resistance*—the reduction of fluid flow caused by various restrictions, surface roughness, devious paths, obstacles, etc. This term is sometimes referred to as “back pressure.”

3.2.3 *Discussion*—For this test method back pressure is a qualitative term, therefore, there is no need to measure.

3.2.4 *insertion loss of a pneumatic exhaust silencer (at a specific supply pressure)*—the difference in average A-weighted sound levels measured with and without the pneumatic exhaust silencer installed on an unrestricted or “open” pipe.

3.2.5 *Discussion*—Insertion loss, as defined in this test method, differs from the definition in Terminology C 634. As stated in 1.1, this test method uses A-weighting rather than discrete frequency bands. It compares a set of sound pressure data measured in a reverberation room rather than determining absolute sound power levels. This test method is intended to assess the difference in sound regenerated at the pipe orifice and does not evaluate sound propagating along the pipe interior.

3.2.6 *pneumatic exhaust silencer*—a device attached to a pipe fitting or orifice. The silencer reduces the sound produced when the released pressurized exhaust gases (usually air), merge with ambient (static) air in the region surrounding the orifice. Such silencers are not usually intended to perform useful work such as part conveying, ejection, or cleaning. The

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² *Annual Book of ASTM Standards*, Vol 04.06.

³ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

⁴ This United States Occupational Safety and Health Administration Regulation, Federal Register, Vol 36, Number 105, Part II, p. 10653, May 1971, is available from Superintendent of Documents, Government Printing Office, Washington, DC 20402-9371.

port sizes of the pneumatic exhaust silencers addressed by this test method are: $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$ in. NPT (based on the American National Standard Taper Pipe Thread designation, (B.2.1), specified in fractions of an inch).

4. Summary of Test Method

4.1 A special air reservoir system terminates in a reverberation room where acoustical measurements are made to assess the sound produced by both an open pipe and the pipe terminated with a silencer. Both flow volume and A-weighted sound level measurements are made as the air supply valve is opened between the reservoir and the piping system. The test procedure is repeated for three air reservoir pressures both with and without silencer. The flow ratios are calculated from the flow volumes with an unrestricted pipe and with the silencer. The insertion loss is determined by the difference in A-weighted sound levels. This is done for each of the three air reservoir pressures. The overall pneumatic exhaust silencer performance is then reported as insertion loss versus flow ratio.

5. Significance and Use

5.1 This test method permits the evaluation of both the acoustical and mechanical performance of pneumatic exhaust silencers designed for quieting compressed gas exhausts (usually air). The data can be used by manufacturers to assess or improve their products, or by users to select or specify a silencer. The data acquired using this measurement method allow for performance comparisons of competitive products and aid in the selection of an appropriate device.

5.2 Flow rate is an important parameter to consider when the application involves machinery or equipment that requires compressed air or other gases to be exhausted rapidly. For example, in an automatic pneumatic press, compressed air must be exhausted rapidly to avoid a premature second cycle. For this reason, flow ratio is reported in addition to acoustical performance.

6. Assumptions

6.1 Studies have shown that the sound level (in decibels) produced by quieted pneumatic exhausts generally is linear with supply pressure for the range of pressures covered in this test method. It is assumed that the air supply pressures called for in this test method include those typical of most applications. Sound levels may be extrapolated for silencers operating at pressures slightly beyond the test range. A linear relationship can be assumed between discrete test supply pressures.

6.2 Generally, the sound power produced by pneumatic exhausts is dominant in the frequency range from 500 to 10 000 Hz. This frequency range allows testing in a relatively small reverberation room. ANSI Standard S 1.33 (Appendix A), provides guidelines for the design of an appropriate test room.

NOTE 1—Reverberation rooms as small as 17 m³ are sufficient for making A-weighted measurements of noise generated by pneumatic exhaust silencers. The minimum volume of 70 m³ recommended in ANSI S1.33 can be ignored.

6.3 The performance of pneumatic exhaust silencers tends to deteriorate over time, due to clogging and other factors. The primary purpose of this test method is to evaluate the optimum

performance of pneumatic exhaust silencers, therefore only new or unused silencers should be tested. This test method may also be used to measure the performance of a silencer during its actual or simulated service life.

7. Apparatus

7.1 Reverberation Room:

7.1.1 The reverberation room shall conform to the requirements in ANSI S1.33, except for the minimum volume. (See Note 1.)

7.1.2 The reverberation room shall be equipped with a duct-type muffler or silencer to control static air pressure while simultaneously reducing extraneous sound entering the test room from adjacent areas.

7.1.2.1 This duct-type muffler shall have an adequate “free” cross-sectional area to allow the air introduced by the test process to be vented rapidly, relieving the pressure within the test room. The static pressure in the reverberation room shall be measured initially while testing the largest open pipe to determine if the free cross-sectional area is adequate to allow air to escape. If the gage pressure⁵ rises to more than 4 kPa, then the cross-sectional area of the duct or the room volume must be increased.

7.1.2.2 The construction of the duct-type muffler and the reverberation room shall be adequate to ensure that the background sound level within the test room is at least 10dB below the lowest sound level measured during the evaluation. The muffler shall also be so selected as to avoid “self-generated” sound.

7.2 Piping System:

7.2.1 The test apparatus shall consist of a system similar to that shown in Fig. 1. The critical elements are the compressor-tank capacity, size of supply pipes and method of assembly, lengths of certain pipe sections, and design of devices in the air stream (that is, valves, regulators, flow meters, temperature, and pressure sensors).

7.2.1.1 *Reservoir Capacity*—The minimum air reservoir size is determined by the maximum unrestricted pipe diameter planned for the test. Use a reservoir whose size is adequate to permit obtaining three contiguous 1 s average sound levels within 2 dB of each other (see 9.3.3.2).

NOTE 2—Based on experience, the minimum storage tank capacity for testing $\frac{1}{8}$ in. NPT devices is approximately 2.8 ft³(0.08 m³). The minimum air reservoir size should be increased proportionally for larger test specimens.

7.2.1.2 If a dedicated compressor and air reservoir are located near the test site and the piping meets the specifications, the separate air reservoir of 7.2.1.1 may be eliminated. Once the required supply pressure has been reached, the compressor motor must be shut down to ensure that the compressor does not restrict as the air pressure is released for the test.

⁵ The Magnehelic gage, available from F.W. Dwyer Co., P. O. Box 3029, 1123 Meams Rd., Ivyland, PA 18974, or equivalent, has been found satisfactory for this measurement.

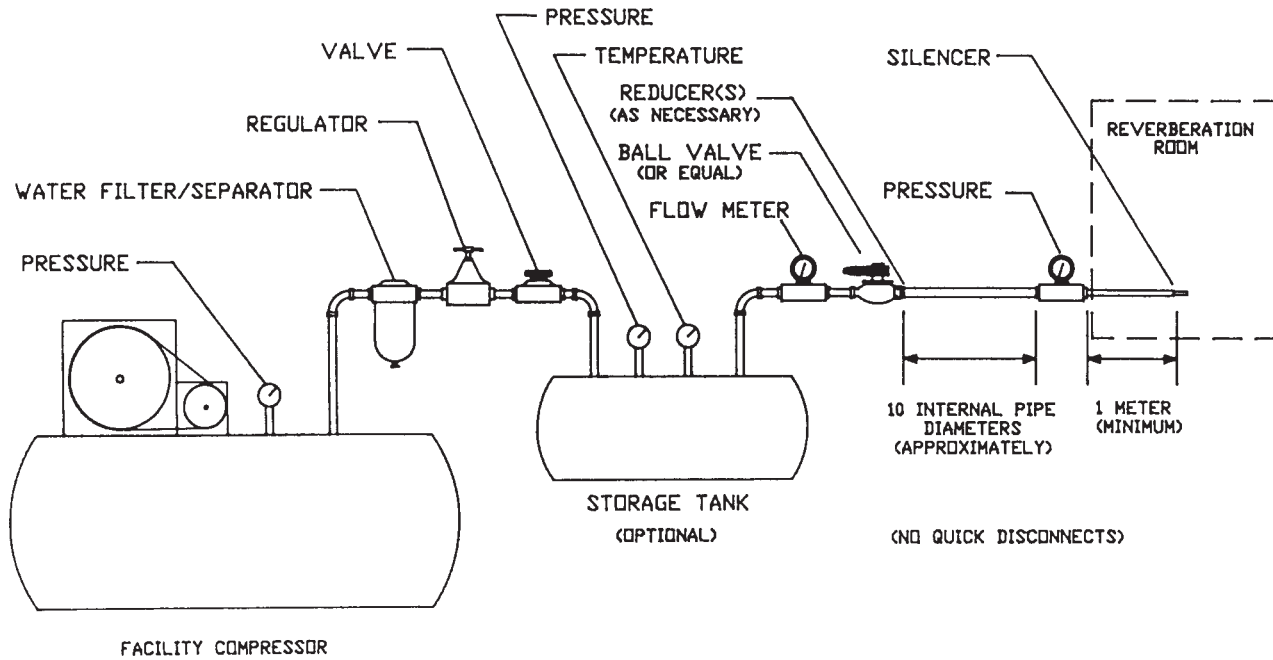


FIG. 1 Apparatus for Pneumatic Exhaust Silencers

7.2.1.3 *Water Trap*—The system shall be equipped with a water trap (preferably at the tank outlet) to collect condensed water and provide a means for draining moisture from the system.

7.2.1.4 *Supply Pipes*—All pipes in the system shall be Schedule 40 cast iron, steel, copper, or poly(vinyl chloride) (PCV). The final downstream segment of pipe shall be a minimum of 1 m-long steel or cast iron, appropriately sized for the pneumatic exhaust silencer under test.

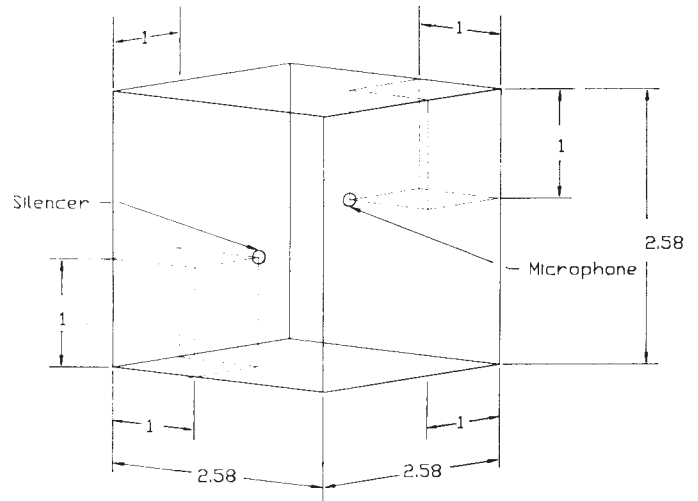
NOTE 3—Steel or cast iron is necessary to reduce transmission of sound through the pipe wall into the reverberation room.

7.2.1.5 *Method of Assembly*—When assembling pipe components, avoid irregularities and obstructions that restrict flow or create unwanted turbulence. Burrs shall be removed and pipe threads properly mated to avoid exposed threads in the gas stream. Changes in size and direction shall be accomplished with the minimum number of fittings. This is particularly important in the final pipe section and at the orifice where the pneumatic exhaust silencer is to be installed.

7.2.1.6 *Minimum Pipe Section*—The pipe section located between the pressure sensor and the pneumatic exhaust silencer, shall be a straight section at least 1 m long to avoid turbulence prior to the silencer (see Fig. 1). Lengths of pipe between the storage tank and pressure sensor shall be kept to a minimum to avoid flow-generated pressure losses.

7.2.1.7 The final segment of pipe shall be positioned in the reverberation room so the pneumatic exhaust silencer under test is at least 1 m from any room surface. (See Fig. 2.)

7.2.1.8 Valves, regulators, flow meters, temperature, and pressure sensors located in the test air stream shall be designed to minimize flow restriction and turbulence. A “ball” valve (straight-flow ball type, or equivalent) is recommended for flow control. This valve shall have an inside diameter equal to the inside diameter of the upstream and downstream pipe



NOTE 1—Minimum dimensions in metres.

FIG. 2 Microphone Location for Pneumatic Exhaust Silencers

segments connected to the valve. The temperature sensor shall be located on the air reservoir rather than in the supply piping. The flow meter should preferably be a hot-wire anemometer or an electronic thermal mass flow sensor due to their minimal effect on the airstream.

NOTE 4—Vortex-shedding flow meters that require a “blunt object” in the airstream shall not be used. Similarly, differential-pressure transmitter flow meters, that require a flow restricting orifice plate, shall not be used. It may be possible to use a differential-pressure transmitter flow meter in conjunction with a venturi, flow nozzle, or pitot tube to minimize flow restriction.

7.2.1.9 *Precision Regulator*, shall be provided prior to the air reservoir specified in 7.2.1.1. This regulator shall not allow pressure in the air reservoir to vary more than 2 % regardless of supply pressure variation.

7.2.1.10 “In-line” silencers (for treatment of sound within the airstream) are not recommended. These silencers may create undesirable flow restriction or turbulence. Sound propagating downstream from the compressor or other sources is not expected to influence the test results.

7.2.1.11 In instances where both a compressor and air reservoir are used, vibration isolation must be provided for the piping system to reduce potential structure-borne noise. This can be accomplished by installing a section of reinforced flexible hose between the compressor and the air reservoir.

7.3 Acoustical Instrumentation:

7.3.1 The sound level meter, microphone, and any associated instrumentation shall meet the requirements for a “Type 1 Precision” sound level meter as specified in ANSI S1.4. Sound level measurements shall be made with A-weighted frequency characteristics. The instrumentation shall be capable of measuring sequential 1 s average sound pressure levels (as specified in Terminology C 634).

8. Hazards

8.1 Caution should be exercised when working with compressed gas (air) to avoid the risk of injury. The Occupational Safety and Health Administration (OSHA) has established a 30 psig blocked static air pressure limit for hand-held air guns and nozzles (see 2.3). Since this test method uses air pressure in excess of 30 psig, personnel conducting tests in accordance with this test method should avoid directing the flow of air at the skin or clothing.

9. Procedure

9.1 Calibration:

9.1.1 Acoustical:

9.1.1.1 Calibrate the instrumentation, including the acoustical calibrator, and certify at intervals not exceeding one year, by a qualified facility (refer to ANSI S1.4, Section 8). It is recommended that calibration be traceable to a primary reference standard such as those maintained by the National Institute of Standards and Technology (NIST).

9.1.1.2 Prior to the initial daily measurements, calibrate the measurement instruments in accordance with ANSI S1.13, “Calibration and Maintenance of Instrumentation,” (Section 5.6). This calibration shall include measurements to confirm appropriate level and frequency response using an acoustical calibrator in accordance with ANSI S1.33, “Calibration,” Section 5.6.

9.1.2 Flow:

9.1.2.1 Calibrate temperature, flow, and pressure meters and sensors and certify them periodically by a qualified facility (intervals not exceeding one year are recommended). This calibration shall be traceable to a primary reference standard such as those maintained by the National Institute of Standards and Technology (NIST).

9.1.2.2 Prior to each test session, calibrate the flow measurement equipment.

9.1.2.3 Establish accuracy and linearity of the flow measurement system by determining flow of the unrestricted pipe with known conditions. Volume of the storage tank must be determined as well as pressure and temperature of the compressed air. Measure flow over some specific brief period of

time and determine the subsequent pressure and temperature. Initially, use this test method over the pressure range of interest (using at least three supply pressures) to establish linearity of the flow measurement system.

9.2 *General Measurements*—Make the following measurements in the reverberation room: barometric pressure, relative humidity, and temperature of the air supply (a sample data sheet is shown in Fig. 3).

9.3 Sound Level Measurements:

9.3.1 To avoid flow-generated noise, equip the microphone with a suitable wind screen in accordance with ANSI S1.13, Section 5.7.1.1.

9.3.2 Position the microphone in the reverberation room so that it represents the spatial average sound level. The minimum distance to any room surface shall be at least 1 m as shown in Fig. 2. In addition, the microphone in the reverberation room shall be at least 1 m from the pneumatic exhaust silencer under test. Measure the background A-weighted sound level in the reverberation room prior to and following each pneumatic exhaust silencer evaluation.

9.3.3 Perform the following tests at three supply pressures: 60, 80, and 100 psig (414, 552, and 690 kPa).

9.3.3.1 Measure the A-weighted sound level using an unrestricted pipe with the same port size as the pneumatic exhaust silencer under test. Measure the sound level as the ball valve is rapidly opened, supplying compressed air to the piping system.

NOTE 5—Typically these valves can be fully opened in less than ½ s.

9.3.3.2 Acquire three A-weighted sound levels over successive 1 s intervals to the nearest ½ dB (or better). If the range of the data is within 2 dB, calculate the arithmetic average of the three values. (See Terminology C 634).

NOTE 6—If the sound level drops so rapidly that the range of data values exceeds 2 dB, the measurement cannot be made in accordance with this test method. In this case, it is likely that a greater capacity storage tank will be required to evaluate the pneumatic exhaust silencer under test. Figs. 4 and 5 are examples of this problem. Fig. 4 shows acceptable conditions, Fig. 5 shows unacceptable conditions.

9.3.3.3 Obtain the sound level measurements immediately after the valve is opened. If operation of the valve generates an acoustical transient, then the first three successive 1 s sound levels within 2 dB after the transient should be used. Do not begin the first sound level measurement beyond 2 s after opening the valve.

9.3.3.4 Install the pneumatic exhaust silencer on the pipe orifice and the measurements of 9.3.3.2 shall be repeated.

9.4 Flow Measurements:

9.4.1 Measure air flow volume, in standard cubic feet per minute (SCFM) or litres per second (L/s), when the control valve is opened, supplying compressed air to the piping system. Conduct flow measurements at each of the three standard supply pressures simultaneous with the sound measurements. Conduct flow measurements with both the unrestricted pipe and with the pneumatic exhaust silencer mounted.

9.4.2 Flow should be relatively constant during the acoustical measurements. Measure the average flow over the 3 s measurement interval. If flow variations greater than $\pm 2\%$ occur during the acoustical measurement interval, the measurements cannot be made in conformance with this test method. In

MANUFACTURER: _____ Date: _____
 MODEL: _____ SIZE (NPT): _____

	BEFORE	AFTER
BAROMETRIC PRESSURE, mm Hg	_____	_____
RELATIVE HUMIDITY, %	_____	_____
AIR SUPPLY TEMPERATURE (tank), C	_____	_____
TEST ROOM AMBIENT NOISE LEVEL, dBA	_____	_____

	Air Supply Pressure, psig (kPa)		
	60 (414)	80 (552)	100 (690)
OPEN PIPE:			
1) Flow (SCFM)	_____	_____	_____
Avg Sound Level @ 1 s	_____	_____	_____
Avg Sound Level @ 2 s	_____	_____	_____
Avg Sound Level @ 3 s	_____	_____	_____
2) Ensemble Average	_____	_____	_____
SILENCING DEVICE INSERTED:			
3) Flow (SCFM)	_____	_____	_____
Avg Sound Level @ 1 s	_____	_____	_____
Avg Sound Level @ 2 s	_____	_____	_____
Avg Sound Level @ 3 s	_____	_____	_____
4) Ensemble Average	_____	_____	_____
FLOW RATIO: (line 3/line 1)	_____	_____	_____
INSERTION LOSS: (line 2 – line 4) dB	_____	_____	_____
NOTES:			

signature

FIG. 3 Sample Data Sheet for Testing Pneumatic Exhaust Silencers

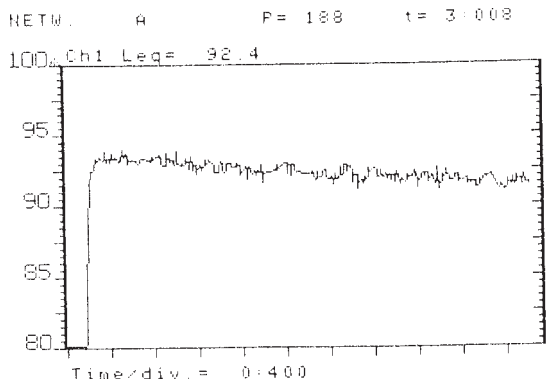


FIG. 4 Acceptable Conditions for Measuring A-Weighted Sound Levels

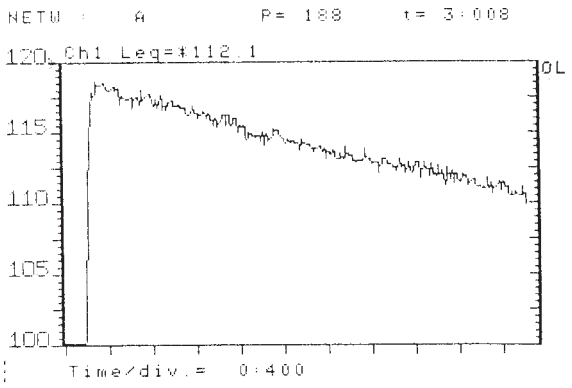


FIG. 5 Unacceptable Conditions for Measuring A-Weighted Sound Levels

this case, it is likely that an air reservoir of greater capacity will be required to evaluate the pneumatic exhaust silencer under test.

10. Calculation

10.1 The following computations shall be performed for each silencer tested at the three standard air supply pressures.

10.1.1 *Flow Ratio*—The gas flow with the pneumatic exhaust silencer installed divided by the flow of the open pipe, dimensionless.

10.1.2 *Average Insertion Loss*—The difference in A-weighted sound levels measured with and without the pneumatic exhaust silencer installed on an unrestricted pipe, for a specific air pressure, expressed in decibels.

11. Report

11.1 The pneumatic exhaust silencer performance shall be provided in tabular form for the three air supply pressures tested. For comparison purposes, this information can also be

plotted with insertion loss (decibels) on the ordinate axis and flow ratio (dimensionless) on the abscissa. A sample plot is shown in Fig. 6.

11.2 The sound levels measured using the unrestricted pipe shall be reported. These data will help ensure that the test facility is representative of other facilities.

12. Precision and Bias

12.1 There is a need for further research to establish the validity of this test method. Caution should be exercised in interpreting the numerical results. One objective of this test method is to encourage the measurement of existing silencers in order to refine the test procedure.

12.2 At the present time, no information is available to develop this section. A round-robin evaluation is planned. Upon completion of the round robin, a precision and bias statement will be submitted to support the test method.

13. Keywords

13.1 acoustical; insertion loss; pneumatic exhaust silencers

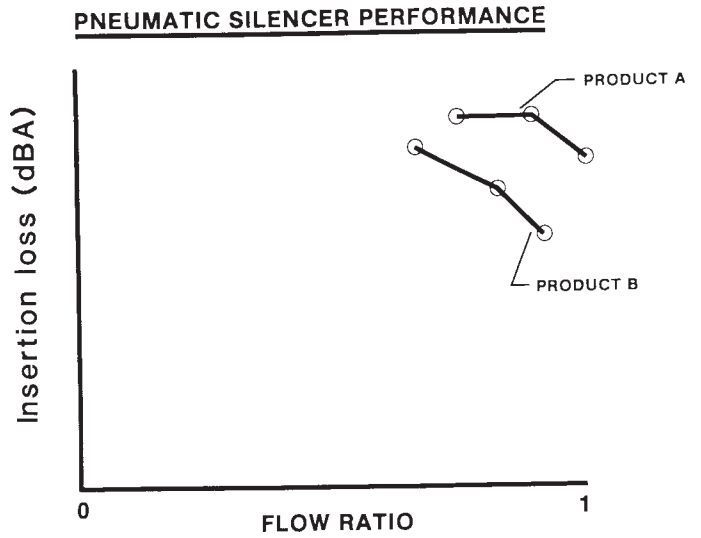


FIG. 6 Plot for Pneumatic Silencer Performance

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