## INTRODUCTION

### GENERAL

Since 1991, Fantech under the Q-Tech Acoustic Products brand has continuously invested in research and development programs. The investment in this program results in Fantech continuously testing new designs and materials in its own ISO7235:2003 and BS4718:1971 acoustic attenuator test rig. The results of this program include the first published test data for a range of attenuators based on Australian sourced materials and the advent of the unique Q-Seal range of specialised attenuators. Our continued investments in the research and development of acoustic products results in the most accurate and dependable data for acoustic products, unrivalled by any other supplier in the industry.

Fantech maintains strong relationships with universities, testing houses and the industry to ensure that the experience gained from the use of our products in the real world feeds back into the design of our new products. We will continue to be involved in the latest acoustic technology and innovation and we will continue to provide our customers with products they can rely upon.

The following pages, incorporates a glossary of acoustic terms to assist the user of the Fans By Fantech catalogue in understanding the depth of technical information supplied for our fans and attenuators.

### SOUND POWER LEVEL

The sound power is defined as the rate at which a sound source emits energy. Since sound energy in everyday situations ranges from $10^{-12}$ Watts to 1000 Watts, a logarithmic scale is used for practicality; this provides us with a sound power range from 0 to 150 dB, which is a lot more manageable.

The sound power level is denoted as $L_W$ and is defined as:-

$$L_W = 10 \log_{10} \frac{(\textit{sound power of source}, \text{W})}{(\textit{reference power}, 1\text{pW})}$$

and is expressed in decibels, dB

Where:
W = Watts and
pW = $10^{-12}$ Watts

### SOUND PRESSURE LEVEL

The sound pressure is what you actually hear and is the effect of the sound power in the hearing environment. It will be a function of the volume of the space, its acoustic absorption qualities and the distance of the listener from the sound source.

Sound pressure level is also expressed in dB and is relative to the quietest sound which a healthy young person can hear at 1kHz; 2 x $10^{-5}$ N/m$^2$ (or Pa).

The sound pressure level, like sound power is expressed on a logarithmic scale and denoted as $L_p$. It is defined as:

$$L_p = 20 \log_{10} \frac{(\textit{sound pressure}, \text{Pa})}{(\textit{reference pressure}, 2 \times 10^{-5}\ \text{Pa})}$$

### INFORMATION ON FAN NOISE TEST STANDARDS

Where noted in the product data pages within this catalogue fan noise levels are tested to BS848 Part 2: 1985 “Fans for general purposes. Methods of noise testing”.

This test standard describes methods that may be applied to calculate the sound power level of fans. That is, the In-Duct method, the Reverberant Room method and the Free Field method. The sound pressure level of a product is measured using one of these test methods. A calculation is then used to convert the measured sound pressure levels to sound power levels.

## ATTENUATOR INFORMATION

### STATIC INSERTION LOSSES

BS 4718 : 1971 “Methods of Test for Attenuators for Air Distribution Systems” requires manufacturers to test and publish static insertion loss figures.

An insertion loss is defined as “the reduction in noise level at a given location due to the placement of an attenuator in the sound path between the sound source and that location”. A static insertion loss is the insertion loss with no air flow passing through the attenuator.

Therefore placing an attenuator in between a fan and the measuring position, will reduce the noise level at the measuring position by the insertion loss.

### DYNAMIC INSERTION LOSSES

Fantech test attenuators to BS4718: 1971 “Methods of Test for Attenuators for Air Distribution Systems”. This test standard sets out a procedure for the testing of static insertion losses; i.e. the measuring of insertion losses without air flow.

Some overseas companies publish dynamic insertion losses; that is the testing of insertion losses with air flow involved. At higher passage velocities the static insertion loss can vary from the dynamic insertion loss by a small margin, depending on the direction of the air flow compared to the noise propagation direction.

For typical velocities associated with a HVAC system, the static insertion losses and dynamic insertion losses are virtually identical and can be assumed to be the same.

### AIRWAY VELOCITY

For a given attenuator size a higher air flow results in a higher airway passage velocity. Higher passage velocities will increase the regenerated noise level of the attenuator. This is particularly critical when the attenuator is serving a low noise level zone; i.e. film studio. A number of suggested maximum passage velocities with the appropriate room NR level are tabulated. Critical noise applications should be checked by an Acoustics Engineer.



| | | **Approx.** | |
|---|---|---|---|
| **NR25** | Do not exceed | 8 m/s | In attenuator airway |
| **NR30** | Do not exceed | 10 m/s | In attenuator airway |
| **NR35** | Do not exceed | 13 m/s | In attenuator airway |
| **NR40** | Do not exceed | 15 m/s | In attenuator airway |
| **NR45** | Do not exceed | 18 m/s | In attenuator airway |

Critical noise level application should be checked by an acoustics engineer

### TYPICAL APPLICATIONS AND BENEFITS OF ATTENUATOR TYPES

| Model | Application | Benefits |
|---|---|---|
| **Small Circular Type Attenuators** | | |
| CC | Bathroom and Toilet exhaust fans | Lightweight |
| | Tenancy fit outs | Low cost |
| | Apartment fans | Semi-Flexible |
| **Circular & Rectangular Attenuators** | | |
| C./C.P & RT/RS NTA/NSA* | Car park exhaust fans | Circular: Easy fitting |
| | Return Air fans | Circular Open: Low pressure drop |
| | Swimming Pools | Circular Pod: High performance |
| | Kitchen Exhausts | |
| | Smoke Spill fans | Rectangular: High performance |
| **Cross-talk Attenuators** | | |
| CS/T/U/Z | Room to room air transfer ducts | Different designs to suit a wide range of wall/roof configurations |
| | Police stations | |
| | Office areas | |
| **Sound Bar Acoustic Louvres** | | |
| SBL1/2 ASB | Plant rooms | Short lengths |
| | | Weatherproof |

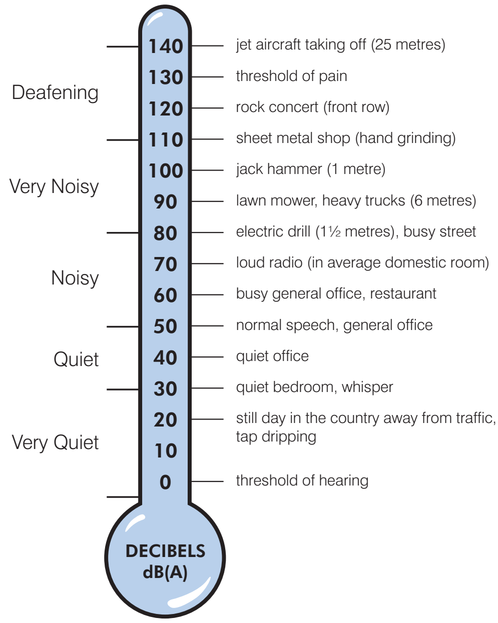
*NTA/NSA AirLay series are suitable for temperatures up to 80°C and dry applications only.

## dB(A) LEVELS

The ear responds not only to the absolute sound pressure level of a sound, but also to its frequency content. It actually gives a weighting to the level of sound according to its frequency content, and ascribes a certain loudness. This means that if we want to know how a person will judge the sound, we must somehow translate our objective measured units of sound pressure level and frequency content into subjective units of loudness.

A sound level meter accepts all of the frequency components of a sound, and adds all their absolute levels together to give an overall sound pressure level, dB (Linear).

The illustration below shows typical overall sound pressure levels produced by some everyday sources.




However the ear is not as sensitive to lower frequency sound pressure levels as it is to higher frequency sound pressure levels. In the 1930's, experiments were carried out on 11 people by Harvey Fletcher at the Bell Telephone Laboratories in New York to determine how loud tones of different frequencies sounded subjectively. Therefore the "A" weighting (or the "A" in dB(A)) was devised so that the sound meter would filter each frequency of sound by a certain amount before adding them together to give a loudness that more closely follows the sensitivity of the human ear.

| Octave Band Centre Frequency, Hz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| 'A' frequency weighting corrections | -26 | -16 | -9 | -3 | 0 | +1 | +1 | -1 |

The 'A' frequency weighting corrections are shown below.

The 'A' frequency weighting suggests that if a tone of 40 dB is played at 1000 Hz, a 40 dB tone played at 63 Hz would sound 26 dB quieter, or be 14 dB(A). Due to its simplicity and convenience, the 'A' frequency weighting has become popular and is now used for many different noise sources at different levels. In fact, most legislation regarding noise is written using dB(A)s, in addition nearly all manufacturers of fans and other noise generating machines quote their noise levels in dB(A)s at 1, 1.5, or 3 metres assuming spherical distribution. It is therefore important that we understand the 'A' frequency weighting and how dB(A)s are calculated.

## CALCULATING dB(A) LEVELS

Published dB(A), or 'A' frequency weighted, sound pressure levels are theoretical values. These are, in fact, calculated from the sound power level data and are quoted at a specified distance i.e. 1, 1.5, or 3 metres. For example, using the Fantech model AP0804AP10/23 (duty 7000 L/s @ 80 Pa, inlet side), by applying an 'A' frequency weighting correction to the fan sound power levels for each frequency and then logarithmically adding the values from left to right the resultant overall sound power level for this unit will be 98 dB(A). A further calculation is required to convert this value from the 'A' weighted sound power level to an 'A' weighted sound pressure level at a prescribed distance from the noise source i.e. 77 dB(A) @ 3m.

See next page for a detailed example of this calculation.

## dB(A) CALCULATION EXAMPLE

**1. 'A' weighting corrections**

| | In-duct Sound Power Levels, $L_w$dB re 1pW | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency (Hz)** | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| **AP0804AP10/23 Inlet** | 94 | 88 | 95 | 94 | 94 | 91 | 88 | 80 |
| **'A' frequency weighting correction** | -26 | -16 | -9 | -3 | 0 | +1 | +1 | -1 |
| **dB(A) Sound Power level** | 68 | 72 | 86 | 91 | 94 | 92 | 89 | 79 |

**2. Calculating an overall sound level**

For each sound power level:
a. Calculate the difference between the sound power level and the sub total.
b. Refer to the Decibels dB(A) diagram on the previous page to determine the value to add.
c. Add the value to add to the highest of the sub total and the sound power level.

| Sub Total | Octave Freq. Hz | Sound Power Level | Difference | Add | Sum |
|---|---|---|---|---|---|
| - | **63** | 68 | - | - | 68 |
| 68 | **125** | 72 | 4 | 1.5 | 73.5 |
| 73.5 | **250** | 86 | 12.5 | 0.2 | 86.2 |
| 86.2 | **500** | 91 | 4.8 | 1.2 | 92.2 |
| 92.2 | **1k** | 94 | 1.8 | 2.2 | 96.2 |
| 96.2 | **2k** | 92 | 4.2 | 1.4 | 97.6 |
| 97.6 | **4k** | 89 | 8.6 | 0.6 | 98.2 |
| 98.2 | **8k** | 79 | 19.2 | 0 | 98.2 |

98.2 dB(A) is rounded to 98 dB(A).

**3. Converting Sound Power to Sound Pressure**

To convert this 'A' weighted sound "power" level to an 'A' weighted sound "pressure" level (which is calculated for a specified distance from the source) the following equation is used:

$$L_P = L_W - 20\log_{10}(d) - 11$$

Where:

$L_W$ = Sound Power Level re $10^{-12}$W (dB)
$L_P$ = Sound Pressure Level re 20μPa (dB)
d = Distance from fan in metres (m)

Therefore, to determine the dB(A) sound pressure level at a distance of 3m:

$$L_P = 98 - 20\log_{10}(3) - 11$$
$$L_P = 98 - 10.5 - 11$$
$$L_P = 98 - 21$$
$$L_P = 77 \text{ dB(A) @ 3m}$$

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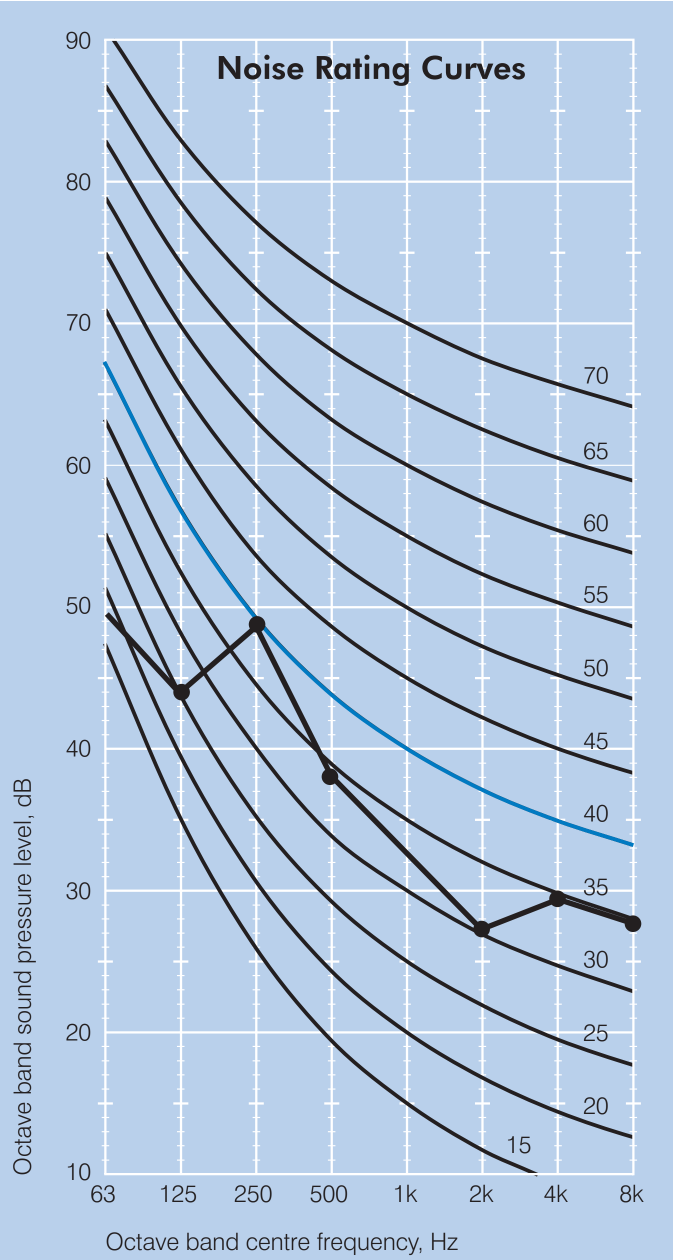
## NR & PNC Ratings

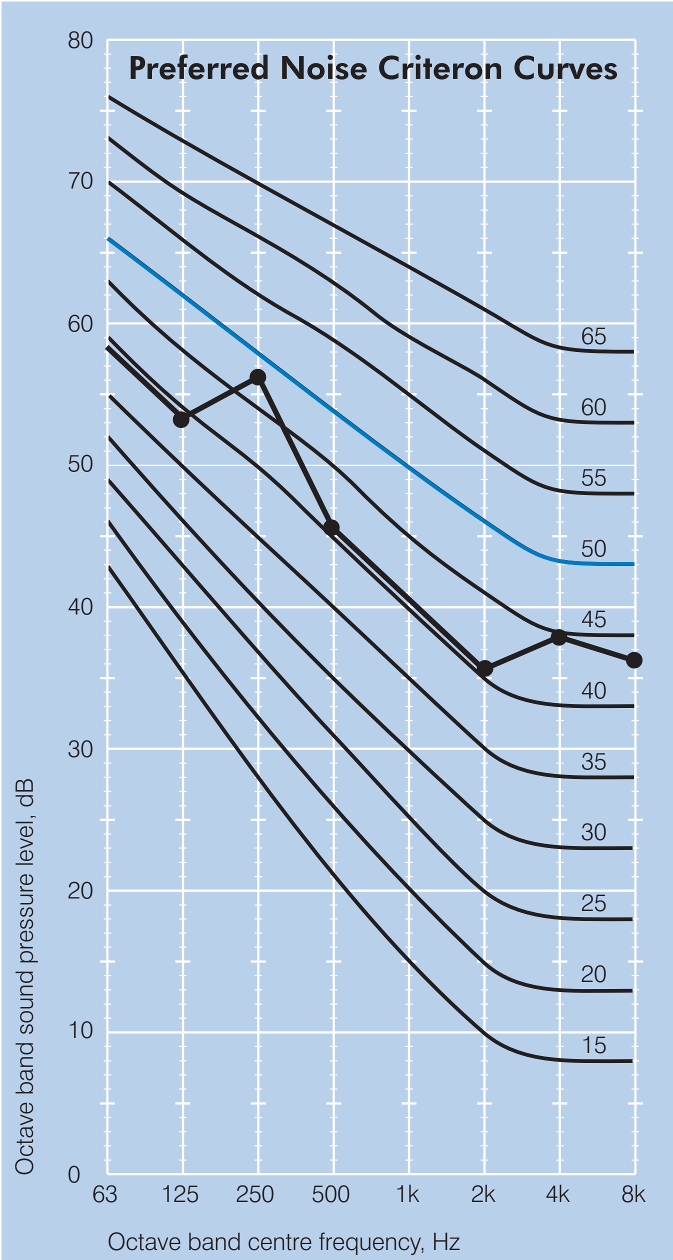
The Noise Rating (or NR Contour) curves were proposed by Kosten and Van Os (1962) to rate internal noise levels. Some acoustic consultants preter to use the Preferred Noise Criterion (PNC) curves. These were designed by Beranek (1971) to achieve more acceptable noise quality and lower allowable levels of low and high frequency noises. They are designed to be used with broadband constant noise sourced (eg. motors, engines), and do not allow for the increased annoyance associated with tonal, or pulsating noises.

NR or PNC levels are only applicable to a space/room and not to a piece of equipment. When a consultant specifies a target NR or PNC level in a space, an acoustic analysis is required that considers the complete system including the selected fan, attenuator, duct, and fittings, in order to determine if the designed system will meet this target. As a rule of thumb to determine the approximate equivalent maximum dB(A) level within the space/room add 5 to the NR or PNC value.

It is therefore important to understand that a fans sound power level spectrum cannot be used to determine a NR or PNC value on the curves below, nor can a fans dB(A) @ 3m value be converted to a NR or PNC value.

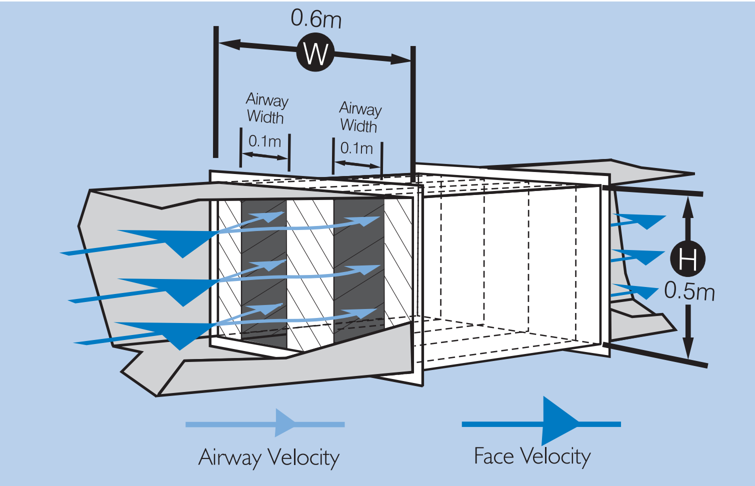
To use the curves, plot the noise spectrum within the space from the resulting acoustic analysis onto the NR or PNC curves grid. The curve which covers all points of the plotted spectrum is the NR or PNC value. IN the examples below, the NR rating is 40, and the PNC rating is 50.



## ATTENUATOR AIRWAY VELOCITY

For industrial applications and to determine attenuator re-generated noise, the airway velocity must be found as described below:




$$\text{Open Area Ratio} = \frac{\text{2 Passages X Airway Width}}{\text{Width}}$$

$$= \frac{2(0.1\text{m})}{0.6\text{m}} = \frac{0.1\text{m}^2}{0.3\text{m}^2} = 0.33 \text{ (i.e. 33\%)}$$

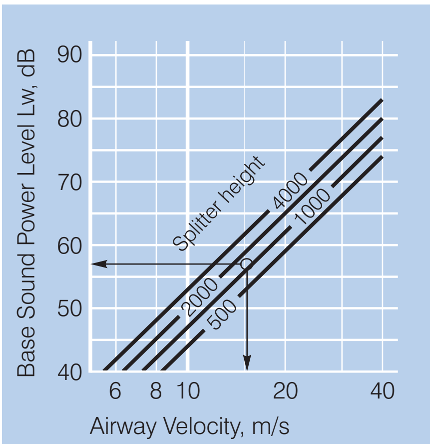
$$\text{Face Area} = 0.6\text{m X } 0.5\text{m} = 0.3\text{m}^2$$

$$\text{Face Velocity} = \frac{\text{Airflow}}{\text{Face Area}} = \frac{1.5\text{m}^3/\text{s}}{0.3\text{m}^2} = 5\text{m/s}$$

$$\text{Airway Velocity} = \frac{\text{Face Velocity}}{\text{Open Area Ratio}} = \frac{5\text{m/s}}{0.33} = 15\text{m/s}$$

## ATTENUATOR RE-GENERATED/ AIR FLOW GENERATED NOISE :

As air passes through an attenuator it will frequently pass at speeds as much as 2 to 4 times the air flow speed in the duct. Moving air creates noise, so in noise sensitive rooms and installations where attenuators are placed close to air grilles and terminals, particular care must be taken to ensure that this does not become the dominating noise source. The relationship between airway velocity and generated noise is shown below for rectangular attenuators.




## SPECTRUM CORRECTIONS FOR AIRWAY VELOCITY :

| Airway Velocity m/sec | Octave Band Centre Frequency, Hz | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| **<8** | -2 | -6 | -7 | -10 | -12 | -16 | -19 | -22 |
| **≥8 & ≤32** | -3 | -5 | -8 | -7 | -8 | -10 | -13 | -15 |
| **>32** | -3 | -6 | -10 | -7 | -7 | -8 | -10 | -12 |

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## REFERENCE INFORMATION: ACOUSTIC LOSSES OF LINED DUCT & BENDS

### Table 1: 25mm lined duct

| Width (mm) | Height (mm) | Insertion Loss, dB/metre, Octave Band Centre Frequency (Hz): 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
|---|---|---|---|---|---|---|---|---|---|
| 100 | 100 | 6.7 | 6.8 | 7.1 | 11.6 | 33.1 | 34.0 | 15.4 | 9.0 |
| 100 | 150 | 5.0 | 5.4 | 6.2 | 10.6 | 29.2 | 29.4 | 14.2 | 8.6 |
| 100 | 200 | 4.2 | 4.7 | 5.7 | 10.1 | 27.1 | 27.0 | 13.5 | 8.4 |
| 100 | 250 | 3.8 | 4.4 | 5.4 | 9.7 | 25.9 | 25.5 | 13.1 | 8.3 |
| 150 | 150 | 3.6 | 4.1 | 5.2 | 9.5 | 25.0 | 24.6 | 12.8 | 8.2 |
| 150 | 250 | 2.7 | 3.2 | 4.4 | 8.5 | 21.4 | 20.6 | 11.6 | 7.8 |
| 150 | 300 | 2.5 | 3.0 | 4.2 | 8.3 | 20.5 | 19.5 | 11.3 | 7.7 |
| 150 | 400 | 2.3 | 2.7 | 3.9 | 7.9 | 19.3 | 18.2 | 10.9 | 7.6 |
| 200 | 200 | 2.5 | 3.0 | 4.2 | 8.3 | 20.5 | 19.5 | 11.3 | 7.7 |
| 200 | 300 | 2.1 | 2.4 | 3.7 | 7.6 | 18.1 | 16.9 | 10.4 | 7.4 |
| 200 | 400 | 2.0 | 2.2 | 3.4 | 7.2 | 16.8 | 15.5 | 9.9 | 7.3 |
| 200 | 600 | 1.8 | 2.0 | 3.1 | 6.8 | 15.5 | 14.1 | 9.4 | 7.1 |
| 250 | 250 | 2.1 | 2.4 | 3.6 | 7.4 | 17.6 | 16.3 | 10.2 | 7.4 |
| 250 | 400 | 1.8 | 1.9 | 3.1 | 6.7 | 15.2 | 13.8 | 9.3 | 7.0 |
| 250 | 500 | 1.7 | 1.8 | 2.9 | 6.5 | 14.4 | 13.0 | 9.0 | 6.9 |
| 250 | 600 | 1.7 | 1.7 | 2.8 | 6.3 | 13.9 | 12.4 | 8.7 | 6.8 |
| 300 | 300 | 1.8 | 2.0 | 3.1 | 6.8 | 15.5 | 14.1 | 9.4 | 7.1 |
| 300 | 400 | 1.7 | 1.8 | 2.9 | 6.4 | 14.1 | 12.7 | 8.9 | 6.9 |
| 300 | 600 | 1.6 | 1.6 | 2.6 | 5.9 | 12.7 | 11.2 | 8.3 | 6.6 |
| 300 | 800 | 1.4 | 1.5 | 2.5 | 5.8 | 12.1 | 10.5 | 8.0 | 6.6 |
| 400 | 400 | 1.6 | 1.6 | 2.6 | 5.9 | 12.7 | 11.2 | 8.3 | 6.6 |
| 400 | 600 | 1.2 | 1.3 | 2.3 | 5.5 | 11.3 | 9.8 | 7.7 | 6.4 |
| 400 | 800 | 1.1 | 1.2 | 2.1 | 5.2 | 10.5 | 9.0 | 7.3 | 6.3 |
| 400 | 1000 | 1.0 | 1.1 | 2.0 | 5.0 | 10.0 | 8.5 | 7.1 | 6.2 |
| 500 | 500 | 1.2 | 1.3 | 2.2 | 5.4 | 11.0 | 9.5 | 7.5 | 6.4 |
| 500 | 600 | 1.1 | 1.2 | 2.1 | 5.2 | 10.3 | 8.8 | 7.2 | 6.2 |
| 500 | 800 | 1.0 | 1.0 | 1.9 | 4.8 | 9.5 | 8.0 | 6.9 | 6.1 |
| 500 | 1000 | 0.9 | 0.9 | 1.8 | 4.7 | 9.0 | 7.5 | 6.6 | 6.0 |
| 600 | 600 | 1.0 | 1.1 | 1.9 | 4.9 | 9.7 | 8.2 | 6.9 | 6.1 |
| 600 | 800 | 0.9 | 0.9 | 1.7 | 4.6 | 8.8 | 7.3 | 6.5 | 5.9 |
| 600 | 1200 | 0.8 | 0.8 | 1.5 | 4.2 | 7.9 | 6.5 | 6.1 | 5.7 |
| 600 | 1600 | 0.7 | 0.7 | 1.4 | 4.1 | 7.5 | 6.1 | 5.8 | 5.6 |
| 800 | 800 | 0.8 | 0.8 | 1.5 | 4.2 | 7.9 | 6.5 | 6.1 | 5.7 |
| 800 | 1000 | 0.7 | 0.7 | 1.4 | 4.0 | 7.4 | 6.0 | 5.8 | 5.6 |
| 800 | 1200 | 0.6 | 0.6 | 1.3 | 3.9 | 7.0 | 5.6 | 5.6 | 5.5 |
| 800 | 1600 | 0.6 | 0.6 | 1.2 | 3.7 | 6.5 | 5.2 | 5.3 | 5.4 |
| 1000 | 1000 | 0.6 | 0.6 | 1.3 | 3.8 | 6.8 | 5.4 | 5.5 | 5.5 |
| 1000 | 1200 | 0.6 | 0.6 | 1.2 | 3.6 | 6.4 | 5.1 | 5.3 | 5.3 |
| 1000 | 1600 | 0.5 | 0.5 | 1.1 | 3.4 | 5.9 | 4.6 | 5.0 | 5.2 |
| 1000 | 2000 | 0.5 | 0.5 | 1.0 | 3.3 | 5.5 | 4.3 | 4.8 | 5.1 |
| 1200 | 1200 | 0.5 | 0.5 | 1.1 | 3.4 | 6.0 | 4.7 | 5.1 | 5.2 |
| 1200 | 1600 | 0.5 | 0.5 | 1.0 | 3.2 | 5.4 | 4.2 | 4.8 | 5.1 |
| 1200 | 2000 | 0.4 | 0.4 | 0.9 | 3.1 | 5.1 | 3.9 | 4.6 | 5.0 |
| 1200 | 2400 | 0.4 | 0.4 | 0.9 | 3.0 | 4.9 | 3.7 | 4.4 | 4.9 |

### Table 2: 50mm lined duct

| Width (mm) | Height (mm) | Insertion Loss, dB/metre, Octave Band Centre Frequency (Hz): 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
|---|---|---|---|---|---|---|---|---|---|
| 100 | 100 | 11.8 | 12.6 | 14.8 | 24.4 | 33.1 | 34.0 | 15.4 | 9.0 |
| 100 | 150 | 8.5 | 9.9 | 12.8 | 22.3 | 29.2 | 29.4 | 14.2 | 8.6 |
| 100 | 200 | 7.1 | 8.6 | 11.7 | 21.2 | 27.1 | 27.0 | 13.5 | 8.4 |
| 100 | 250 | 6.4 | 7.9 | 11.1 | 20.5 | 25.9 | 25.5 | 13.1 | 8.3 |
| 150 | 150 | 5.9 | 7.4 | 10.7 | 20.0 | 25.0 | 24.6 | 12.8 | 8.2 |
| 150 | 250 | 4.2 | 5.6 | 9.0 | 17.9 | 21.4 | 20.6 | 11.6 | 7.8 |
| 150 | 300 | 3.9 | 5.1 | 8.5 | 17.3 | 20.5 | 19.5 | 11.3 | 7.7 |
| 150 | 400 | 3.4 | 4.6 | 8.0 | 16.6 | 19.3 | 18.2 | 10.9 | 7.6 |
| 200 | 200 | 3.9 | 5.1 | 8.5 | 17.3 | 20.5 | 19.5 | 11.3 | 7.7 |
| 200 | 300 | 3.1 | 4.1 | 7.4 | 15.9 | 18.1 | 16.9 | 10.4 | 7.4 |
| 200 | 400 | 2.7 | 3.7 | 6.8 | 15.1 | 16.8 | 15.5 | 9.9 | 7.3 |
| 200 | 600 | 2.4 | 3.2 | 6.2 | 14.2 | 15.5 | 14.1 | 9.4 | 7.1 |
| 250 | 250 | 2.9 | 3.9 | 7.2 | 15.5 | 17.6 | 16.3 | 10.2 | 7.4 |
| 250 | 400 | 2.4 | 3.1 | 6.1 | 14.0 | 15.2 | 13.8 | 9.3 | 7.0 |
| 250 | 500 | 2.2 | 2.9 | 5.7 | 13.5 | 14.4 | 13.0 | 9.0 | 6.9 |
| 250 | 600 | 2.1 | 2.7 | 5.5 | 13.1 | 13.9 | 12.4 | 8.7 | 6.8 |
| 300 | 300 | 2.4 | 3.2 | 6.2 | 14.2 | 15.5 | 14.1 | 9.4 | 7.1 |
| 300 | 400 | 2.2 | 2.8 | 5.6 | 13.3 | 14.1 | 12.7 | 8.9 | 6.9 |
| 300 | 600 | 2.0 | 2.4 | 5.0 | 12.3 | 12.7 | 11.2 | 8.3 | 6.6 |
| 300 | 800 | 1.6 | 2.2 | 4.8 | 11.9 | 12.1 | 10.5 | 8.0 | 6.6 |
| 400 | 400 | 2.0 | 2.4 | 5.0 | 12.3 | 12.7 | 11.2 | 8.3 | 6.6 |
| 400 | 600 | 1.5 | 2.0 | 4.4 | 11.4 | 11.3 | 9.8 | 7.7 | 6.4 |
| 400 | 800 | 1.3 | 1.7 | 4.0 | 10.8 | 10.5 | 9.0 | 7.3 | 6.3 |
| 400 | 1000 | 1.2 | 1.6 | 3.8 | 10.4 | 10.0 | 8.5 | 7.1 | 6.2 |
| 500 | 500 | 1.4 | 1.9 | 4.3 | 11.1 | 11.0 | 9.5 | 7.5 | 6.4 |
| 500 | 600 | 1.3 | 1.7 | 4.0 | 10.7 | 10.3 | 8.8 | 7.2 | 6.2 |
| 500 | 800 | 1.1 | 1.5 | 3.6 | 10.0 | 9.5 | 8.0 | 6.9 | 6.1 |
| 500 | 1000 | 1.0 | 1.3 | 3.4 | 9.6 | 9.0 | 7.5 | 6.6 | 6.0 |
| 600 | 600 | 1.1 | 1.5 | 3.7 | 10.2 | 9.7 | 8.2 | 6.9 | 6.1 |
| 600 | 800 | 1.0 | 1.3 | 3.3 | 9.5 | 8.8 | 7.3 | 6.5 | 5.9 |
| 600 | 1200 | 0.8 | 1.1 | 2.9 | 8.8 | 7.9 | 6.5 | 6.1 | 5.7 |
| 600 | 1600 | 0.8 | 1.0 | 2.7 | 8.4 | 7.5 | 6.1 | 5.8 | 5.6 |
| 800 | 800 | 0.8 | 1.1 | 2.9 | 8.8 | 7.9 | 6.5 | 6.1 | 5.7 |
| 800 | 1000 | 0.8 | 1.0 | 2.7 | 8.3 | 7.4 | 6.0 | 5.8 | 5.6 |
| 800 | 1200 | 0.7 | 0.9 | 2.5 | 8.0 | 7.0 | 5.6 | 5.6 | 5.5 |
| 800 | 1600 | 0.6 | 0.8 | 2.3 | 7.6 | 6.5 | 5.2 | 5.3 | 5.4 |
| 1000 | 1000 | 0.7 | 0.8 | 2.4 | 7.8 | 6.8 | 5.4 | 5.5 | 5.5 |
| 1000 | 1200 | 0.6 | 0.8 | 2.3 | 7.5 | 6.4 | 5.1 | 5.3 | 5.3 |
| 1000 | 1600 | 0.6 | 0.7 | 2.0 | 7.1 | 5.9 | 4.6 | 5.0 | 5.2 |
| 1000 | 2000 | 0.5 | 0.6 | 1.9 | 6.8 | 5.5 | 4.3 | 4.8 | 5.1 |
| 1200 | 1200 | 0.6 | 0.7 | 2.1 | 7.2 | 6.0 | 4.7 | 5.1 | 5.2 |
| 1200 | 1600 | 0.5 | 0.6 | 1.9 | 6.7 | 5.4 | 4.2 | 4.8 | 5.1 |
| 1200 | 2000 | 0.5 | 0.5 | 1.7 | 6.4 | 5.1 | 3.9 | 4.6 | 5.0 |
| 1200 | 2400 | 0.4 | 0.5 | 1.7 | 6.2 | 4.9 | 3.7 | 4.4 | 4.9 |

### Table 3: Square lined bend with turning vanes

| d (mm) | Insertion Loss, dB/bend, Octave Band Centre Frequency (Hz): 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
|---|---|---|---|---|---|---|---|---|
| 100 | 0 | 0 | 0 | 1 | 4 | 7 | 7 | 7 |
| 150 | 0 | 0 | 0 | 1 | 4 | 7 | 7 | 7 |
| 200 | 0 | 0 | 1 | 4 | 7 | 7 | 7 | 7 |
| 250 | 0 | 0 | 1 | 4 | 7 | 7 | 7 | 7 |
| 300 | 0 | 0 | 1 | 4 | 7 | 7 | 7 | 7 |
| 400 | 0 | 1 | 4 | 7 | 7 | 7 | 7 | 7 |
| 500 | 0 | 1 | 4 | 7 | 7 | 7 | 7 | 7 |
| 600 | 0 | 1 | 4 | 7 | 7 | 7 | 7 | 7 |
| 800 | 1 | 4 | 7 | 7 | 7 | 7 | 7 | 7 |
| 1000 | 1 | 4 | 7 | 7 | 7 | 7 | 7 | 7 |
| 1200 | 1 | 4 | 7 | 7 | 7 | 7 | 7 | 7 |
| 1600 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 2000 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 2400 | 4 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |

### Table 4: Square lined bend without turning vanes

| d (mm) | Insertion Loss, dB/bend, Octave Band Centre Frequency (Hz): 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
|---|---|---|---|---|---|---|---|---|
| 100 | 0 | 0 | 0 | 1 | 6 | 11 | 10 | 10 |
| 150 | 0 | 0 | 0 | 1 | 6 | 11 | 10 | 10 |
| 200 | 0 | 0 | 1 | 6 | 11 | 10 | 10 | 10 |
| 250 | 0 | 0 | 1 | 6 | 11 | 10 | 10 | 10 |
| 300 | 0 | 0 | 1 | 6 | 11 | 10 | 10 | 10 |
| 400 | 0 | 1 | 6 | 11 | 10 | 10 | 10 | 10 |
| 500 | 0 | 1 | 6 | 11 | 10 | 10 | 10 | 10 |
| 600 | 0 | 1 | 6 | 11 | 10 | 10 | 10 | 10 |
| 800 | 1 | 6 | 11 | 10 | 10 | 10 | 10 | 10 |
| 1000 | 1 | 6 | 11 | 10 | 10 | 10 | 10 | 10 |
| 1200 | 1 | 6 | 11 | 10 | 10 | 10 | 10 | 10 |
| 1600 | 6 | 11 | 10 | 10 | 10 | 10 | 10 | 10 |
| 2000 | 6 | 11 | 10 | 10 | 10 | 10 | 10 | 10 |
| 2400 | 6 | 11 | 10 | 10 | 10 | 10 | 10 | 10 |