WEBINAR GUIDANCE

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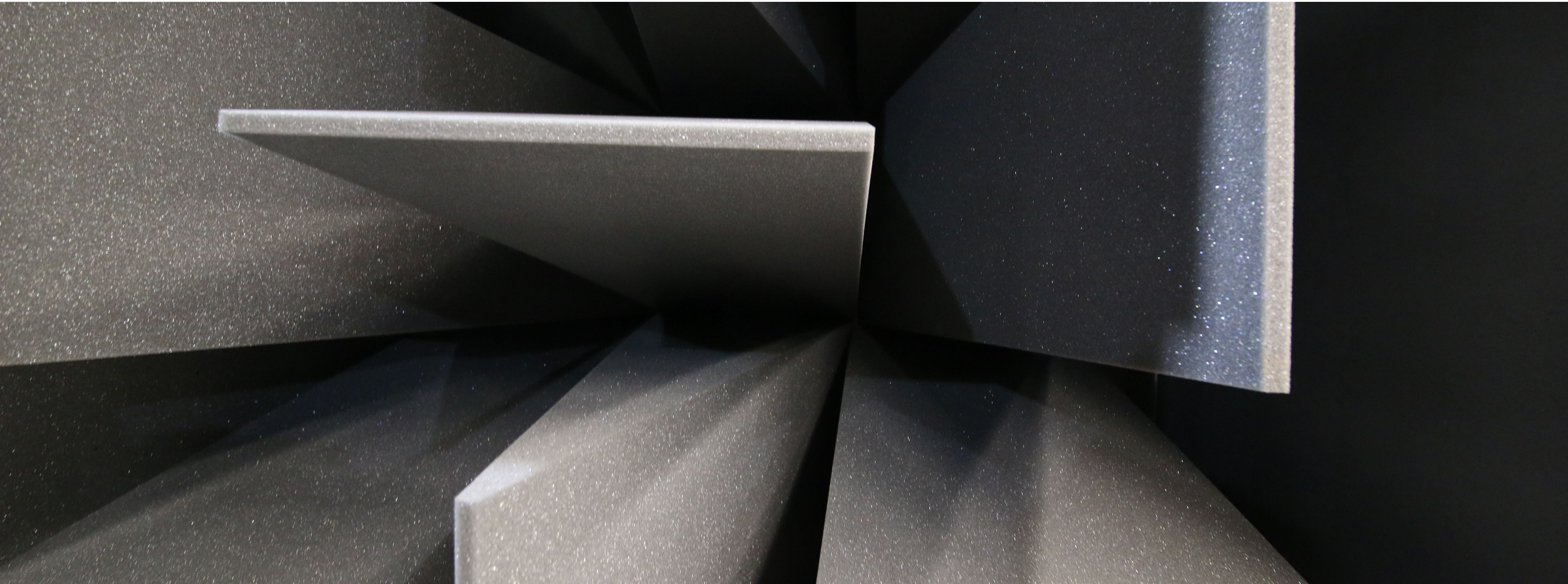
A copy of the material will be made available after presentation.

INTRODUCTION TO ACOUSTICS

Tom Gardner CEng, MSc. MBA, MIOA



The objective of the presentation is to give a basic introduction to Acoustics

- Sound propagation
- Hearing
- Units
- Addition of dB values
- Distance from sound source
- Acoustic environments
- A weighting & noise quality assessment
- Noise control

Why is the study of acoustics important?

If it is excessive, noise will lead to:

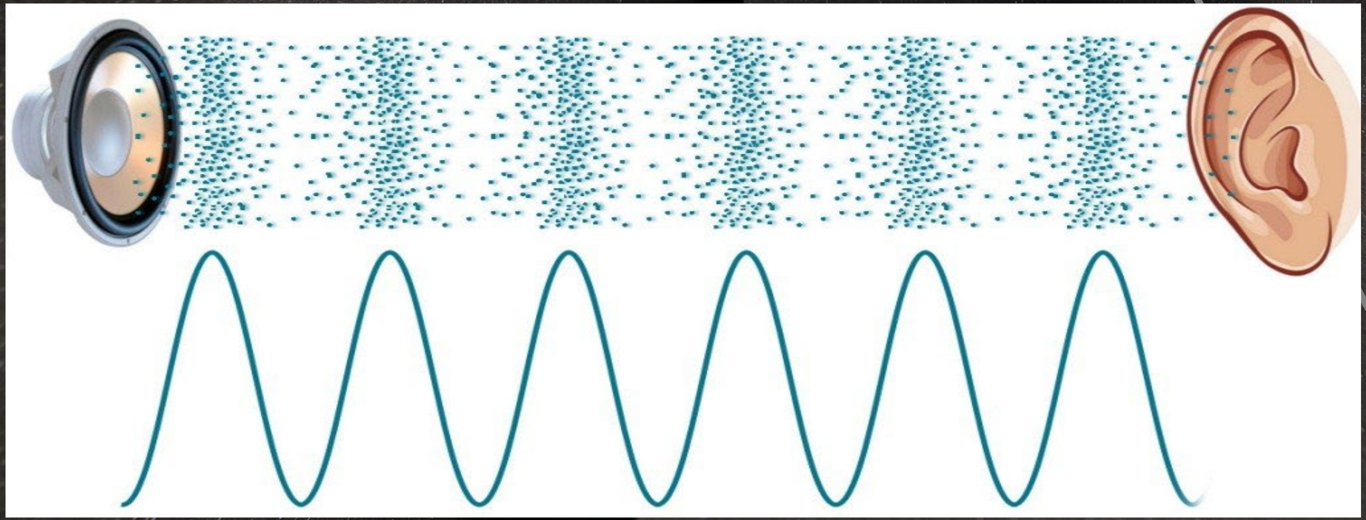
- Loss of Concentration
- Breakdown of Communication
- Impaired Hearing

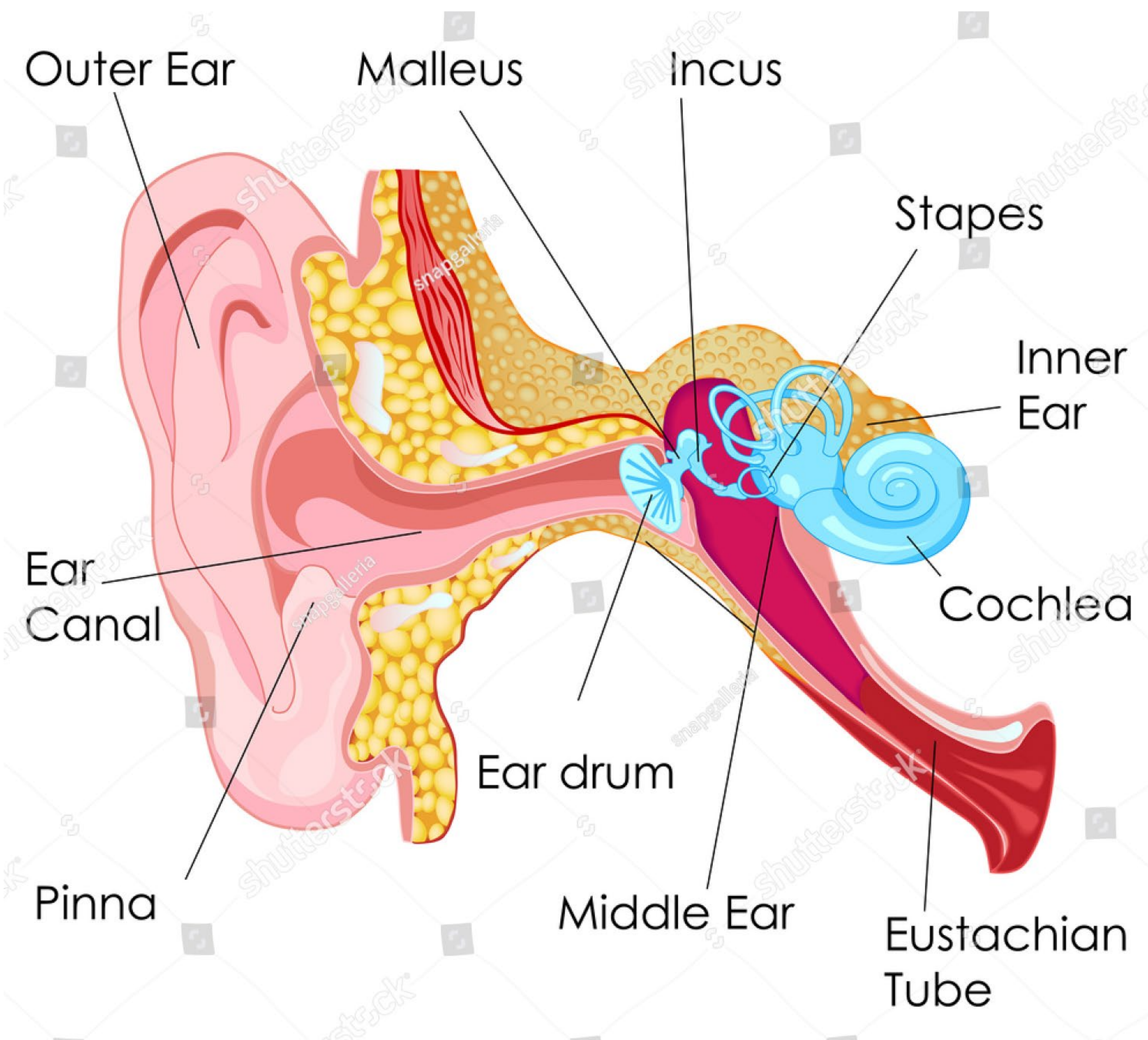
What is Hearing and what is Noise?

Sound is fluctuations in air pressure in the area close the ear.

Sound is a sequence of waves of pressure which propagate through a compressible medium, such as air or water.

During propagation, waves can be reflected, refracted, or attenuated by the medium.





Sound waves enter the ear canal and make the ear drum vibrate. This action moves the tiny chain of bones, malleus (hammer), Incus (anvil) and stapes (Stirrup) in the middle ear. The last bone in this chain 'knocks' on the membrane window of the cochlea and makes the fluid in the cochlea move.

The cochlea is lined with tiny cells covered in airs that are so small you would need a microscope to see them. They may be small, but they're awfully important. When sound reaches the cochlea, the vibrations (sound) cause the hairs on the cells to move, creating nerve signals that the brain understands as sound.

How Noise damages the hearing mechanism?

Sensorineural hearing loss (Most common)

The delicate hairs located in the cochlea become progressively damaged by exposure to excessive noise. Critical levels vary depending on the frequency, the duration and the physiology of the subject. First action level is usually 80 dBA, but damage can occur below this.

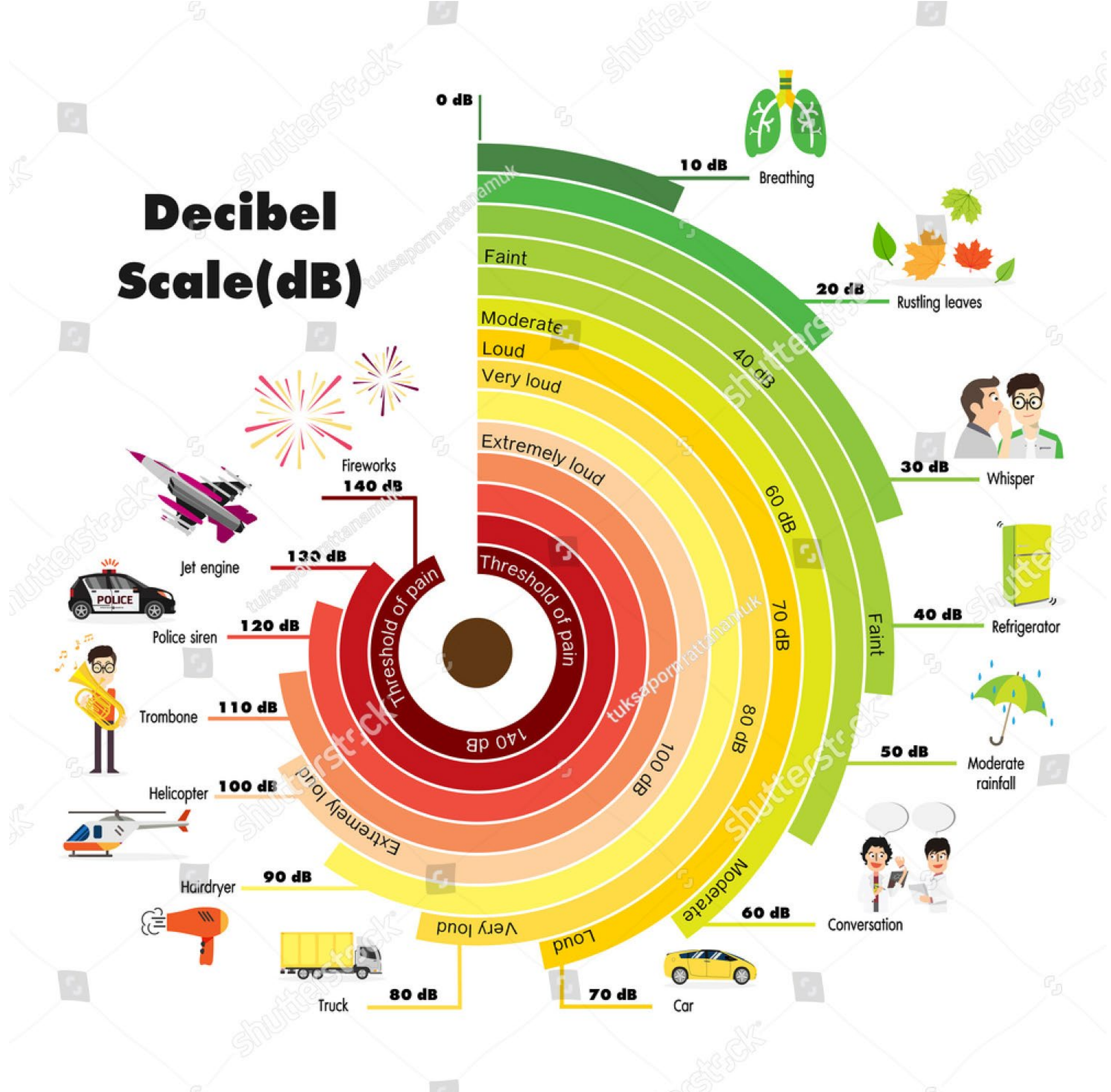
Acoustic trauma (Extremely rare)

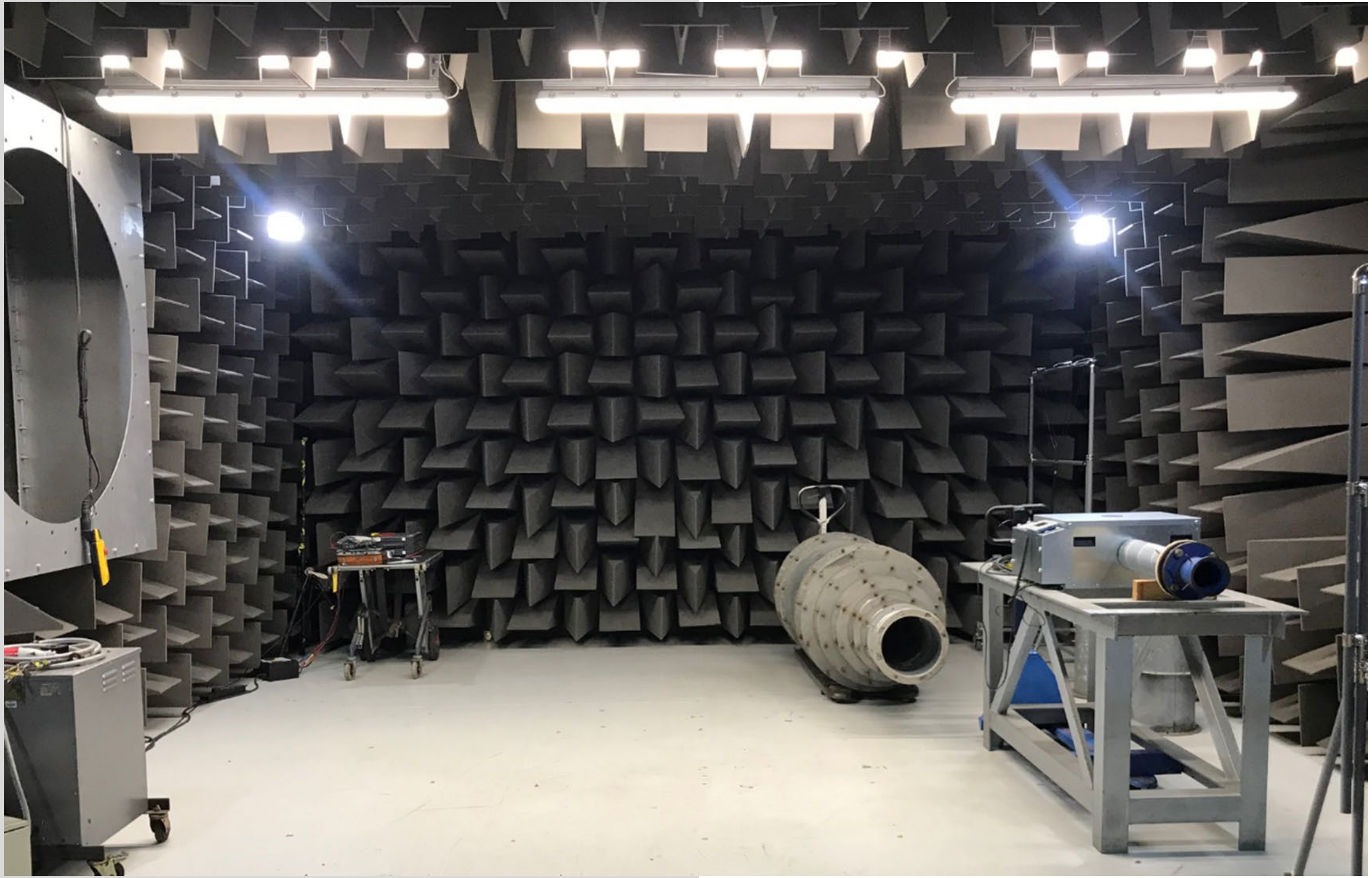
Damaged eardrum caused by massive pressure wave, e.g. explosion >160 dB

Sometimes self inflicted !!

"A Temporary Threshold shift" is a temporary shift in the auditory threshold. It may occur suddenly after exposure to a high level of noise, a situation in which most people experience reduced hearing. A temporary threshold shift results in temporary hearing loss. However, there may be residual long-term damage to your hearing.

- Human hearing system covers an incredible range.
- Frequency range 20Hz to 16,000Hz
- Our ears can recognise sound pressures, expressed in terms of pascals from as low as 20 μPa (hearing threshold), up to 200,000,000 μPa or 200Pa (pain threshold).
- Above 80dBA it is generally recognised as being the level at which - if worked for through an 8Hr shift, protection needs to be used.
- Very low noise levels can be uncomfortable for some people as its possible to sense the blood pumping through your body. (Our anechoic chamber).





It is important to understand the main Acoustic terms

Sound Pressure Level – Lp – SPL – dB or sometimes dBA (A weighted)

– The Sound Pressure Level is what we hear and react to

– The Sound Pressure Level depends upon the strength of the source Lw and the environment in which it is located and how far away from the source the person is

– The Sound Pressure Levels are the result of acoustic calculations

Sound Power Level – Lw – SWL - dBW

– Sound Power Level reflects the energy of a sound creating source, a Fan is one

– Sound Power is an absolute property that does not change, unless there is a change in its working condition

– Sound Power Level is the basis of acoustic calculations

Sound Power of Some Typical Woods Products

Fan Type	Typical Sound Power Level
315 mm JM @ 900 rpm	56 dB
500 mm JM @ 1400 rpm	85 dB
900 mm JM @ 1440 rpm	98 dB
630 mm JM @ 2910 rpm	105 dB
1250 mm JMTS @ 1450 rpm	113 dB
Large Axials up to 2.8 m	130 dB

Addition of sound levels

In general sound levels are added like this:

e.g.

100 dB + 100 dB = 103 dB

100 dB + 90 dB = 100 dB

$SL_{Total} = 10 \times \log_{10} (10^{(SL1/10)} + 10^{(SL2/10)})$

e.g.

100 dB + 100 dB = $10 \times \log_{10} (10^{(100/10)} + 10^{(100/10)})$ = 103 dB

100 dB + 90 dB = $10 \times \log_{10} (10^{(100/10)} + 10^{(90/10)})$ = 100 dB

Addition of sound levels

Difference Between Levels (dB)	Addition to Higher level (dB)
0,1	+3
2,3	+2
4,5,6,7,8 & 9	+1
10 or more	0

We can find the overall sound level from the octave bands:

Fan 80JM/25/6/6/24, duty 4.72 m3/s @ 75 Pa. Overall Sound Power level Lw 85 dB

Using the FST the inlet Sound Power levels are

Frequency Hz	**63**	**125**	**250**	**500**	**1K**	**2K**	**4K**	**8K**
Sound Power Level Lw	**79**	**77**	**77**	**76**	**73**	**69**	**67**	**62**

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+2 **81**

+3 **80**

+1 **74**

+1 **68**

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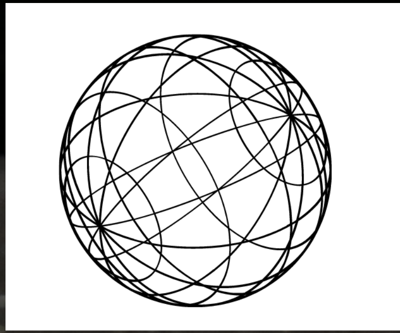
Adjustments for sound pressure levels from the sound power level of a source at various distances

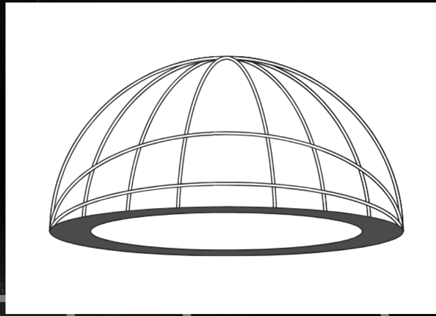


Spherical radiation treats the noise as a point source in the middle of a sphere

Free to radiate in all directions

Surface Area = $4\pi r^2$

Distance to listener (m)	Subtract from Lw for spherical propagation	Subtract from Lw for hemi-spherical propagation
0.5	-5.0	-2.0
1	-11.0	-8.0
2	-17.0	-14.0
3	-20.5	-17.5
4	-23.0	-20.0
5	-25.0	-22.0
10	-31.0	-28.0
20	-37.0	-34.0
30	-40.5	-37.5



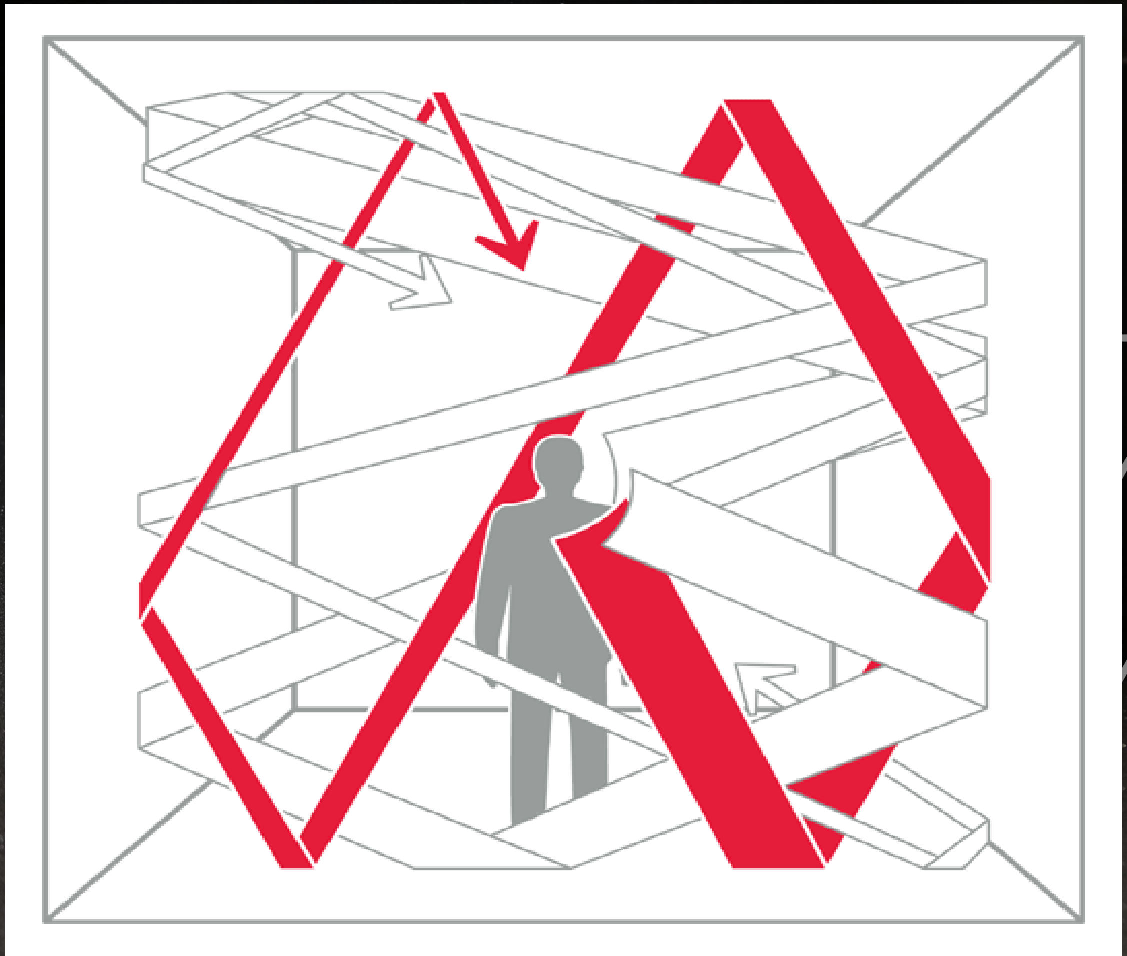
Hemispherical radiation treats the noise as a point source in the middle of a hemisphere

Free to radiate in all directions above the base plane

Surface Area = $2\pi r^2$

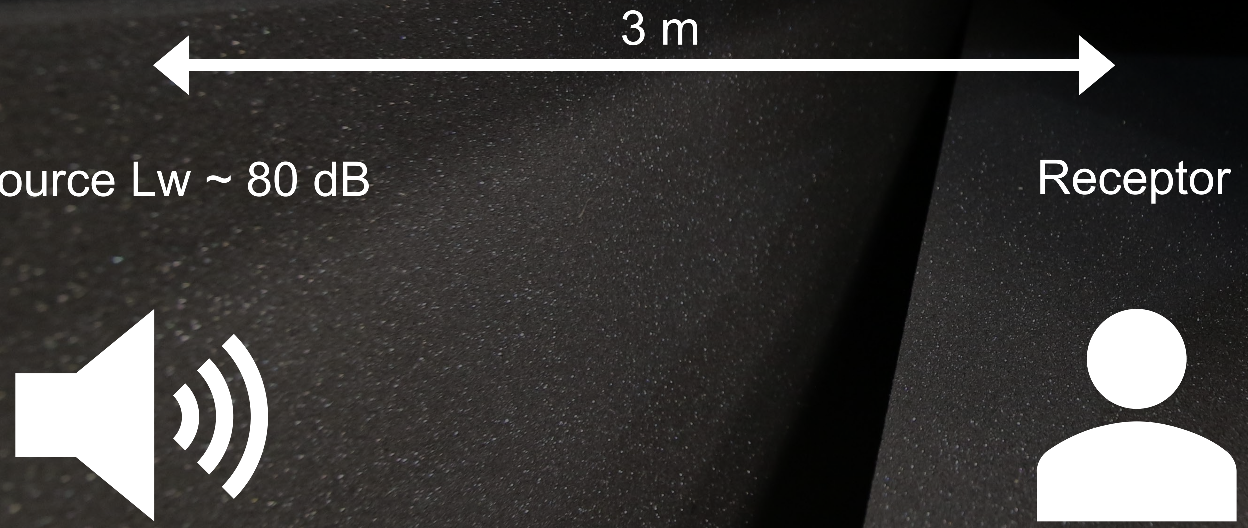
Note- These relationships **ONLY** apply to **spherical and hemi-spherical propagation** in a **free field** environment

- When we are in an enclosed space the sound is reflected by the walls. The amount of reflection depends on how much energy is absorbed by the walls.
- Reverberation is the word that describes how “Live” a room is. A fully reflective test chamber is called a reverberation chamber.
- If the room completely absorbs the sound and there is no reflected noise then it is considered “Dead” like FWG Anechoic Chamber.



Sound Pressure Level in different acoustic environments

What is the Sound Pressure Level at the receptor?



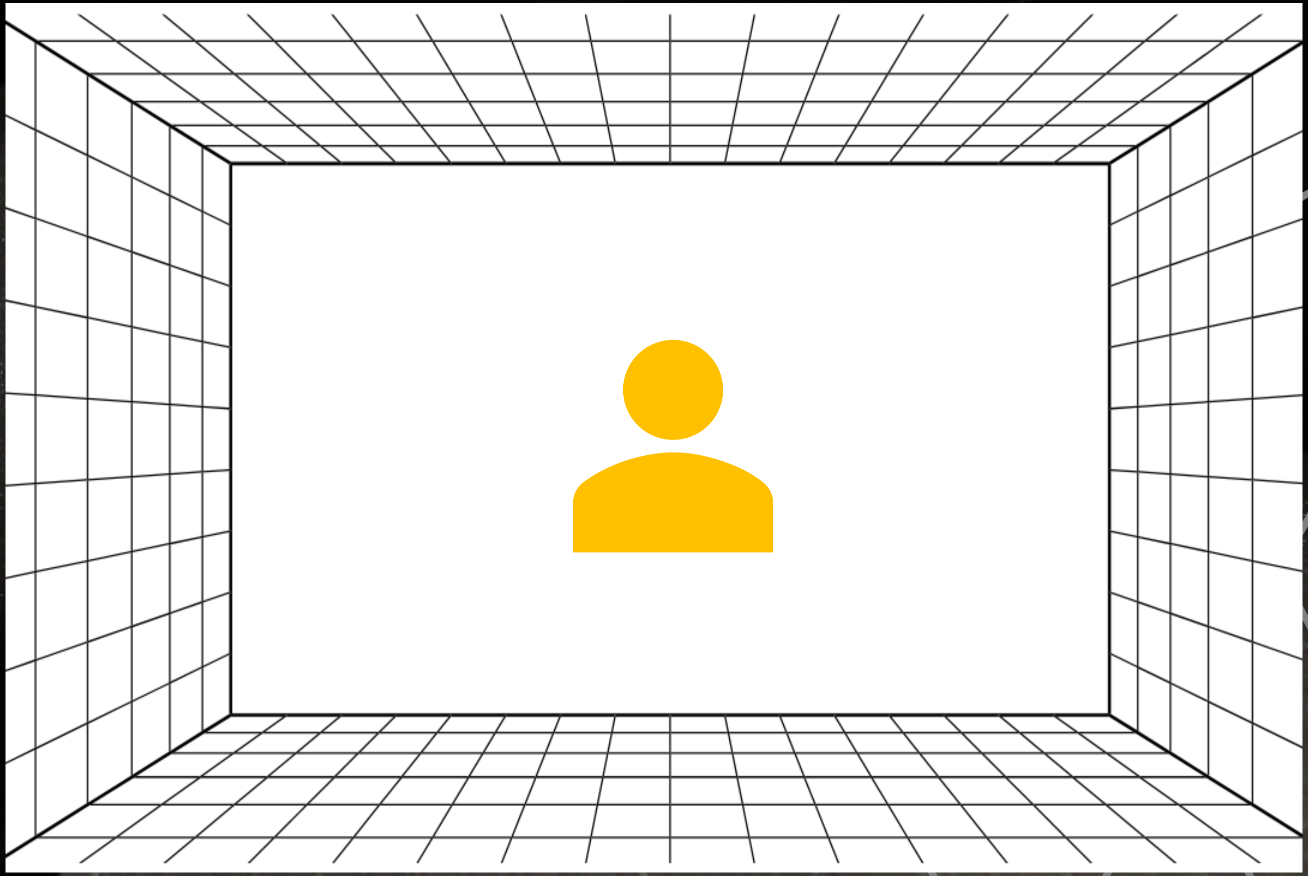
Free Field: 80 – 21 = 59 dB

Assuming omni-directional source

Free Field: 80 – 21 = 59 dB

Reverberant: 80 – 8 = 72 dB

Total 72 dB

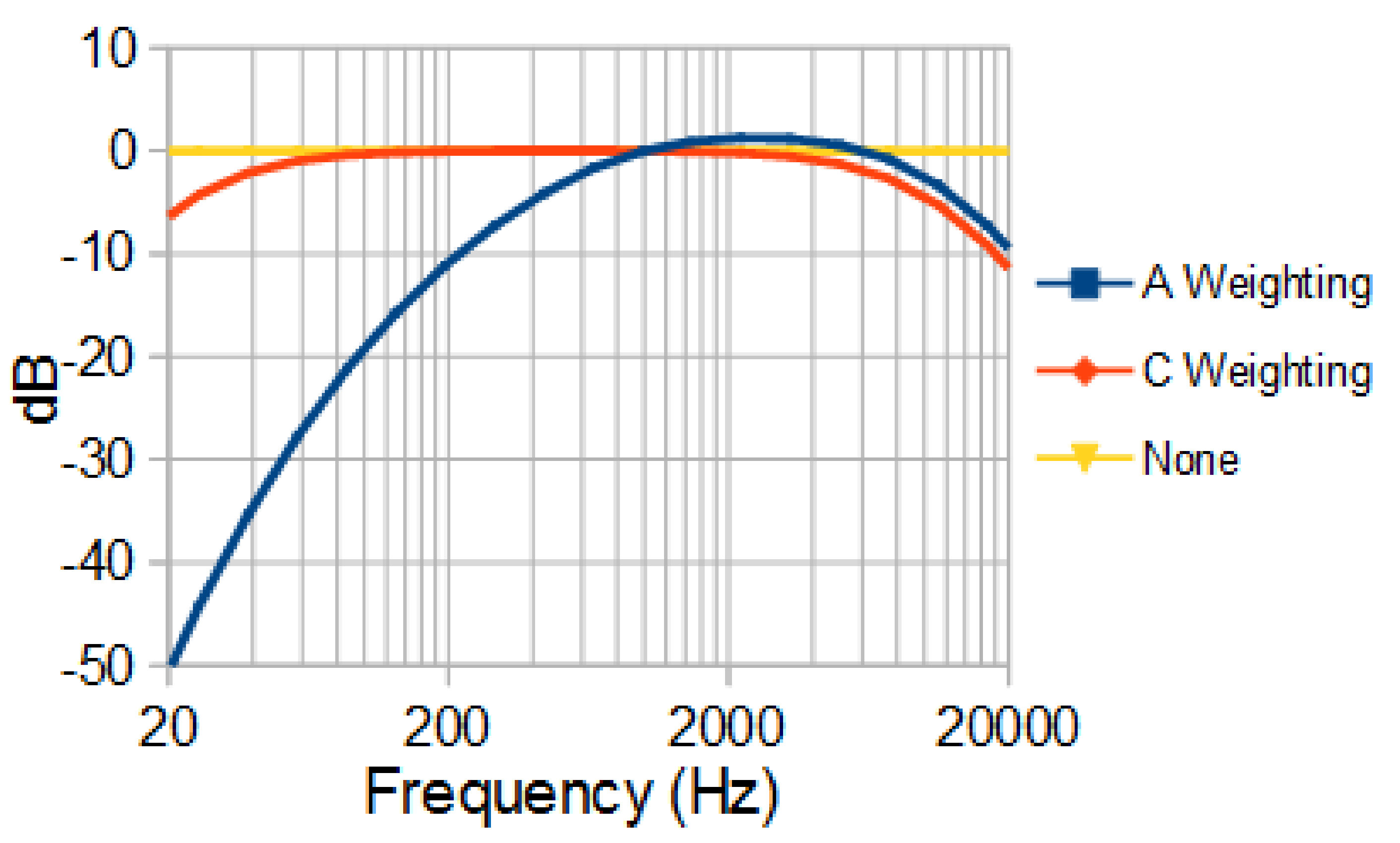


Assuming omni-directional source

- The problem with sound determined directly from instruments is that it does not reflect how we hear sound and our sensitivity to sound
- The ear is most sensitive between 500Hz to 4000 Hz
- Applying a weighting to a sound spectrum is a way of making an allowance of how sound is perceived by the human ear

"A" – Used in almost all cases

"None" – Sound Level Meter



Woods
AIR MOVEMENT

Manipulation of Sound Levels for weighting networks

Relative Response (dB)								
	Frequency (Hz)							
Scale	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
dB(A)	-26.2	-16.1	-8.6	-3.2	0	1.2	1	-1.1

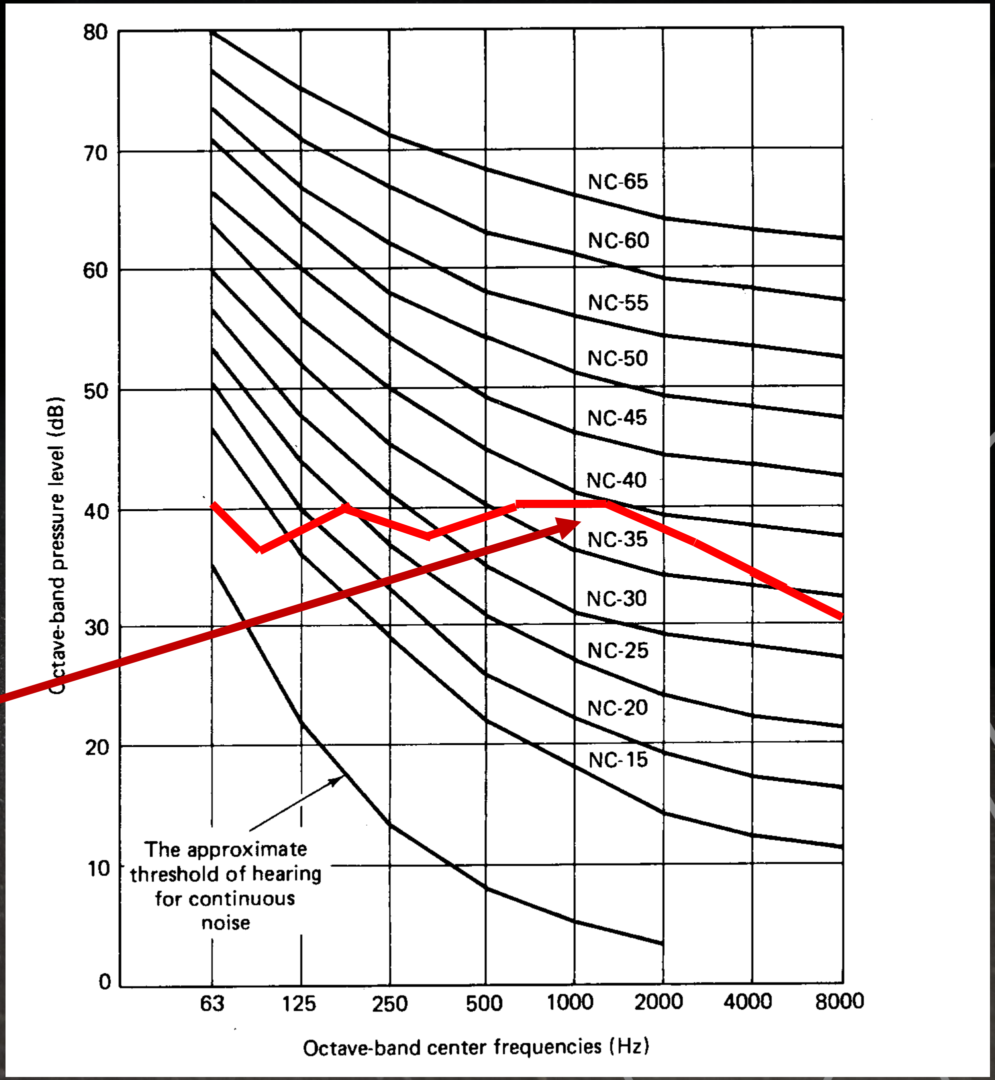
Rating curves are used as a way of judging how acceptable noise will be within an environment

There are many types and we will look at the most common

Noise Criteria NC are the original rating method used for evaluating the suitability of Indoor environments

The NC rating is the lowest curve that is above all Octave band values of the source

In this case the NC40 curve is the lowest curve that is higher than the spectrum so that is the rating.

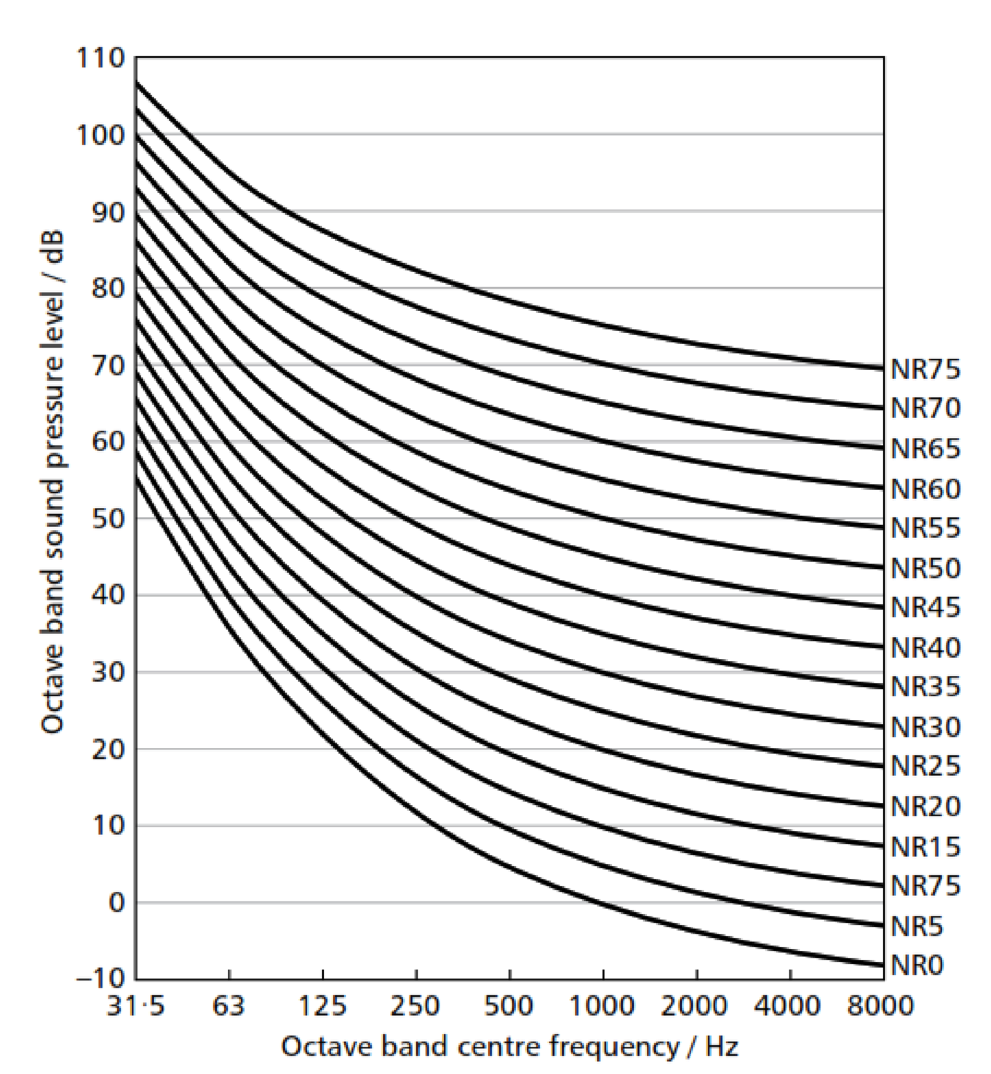


NR Noise Rating Curves

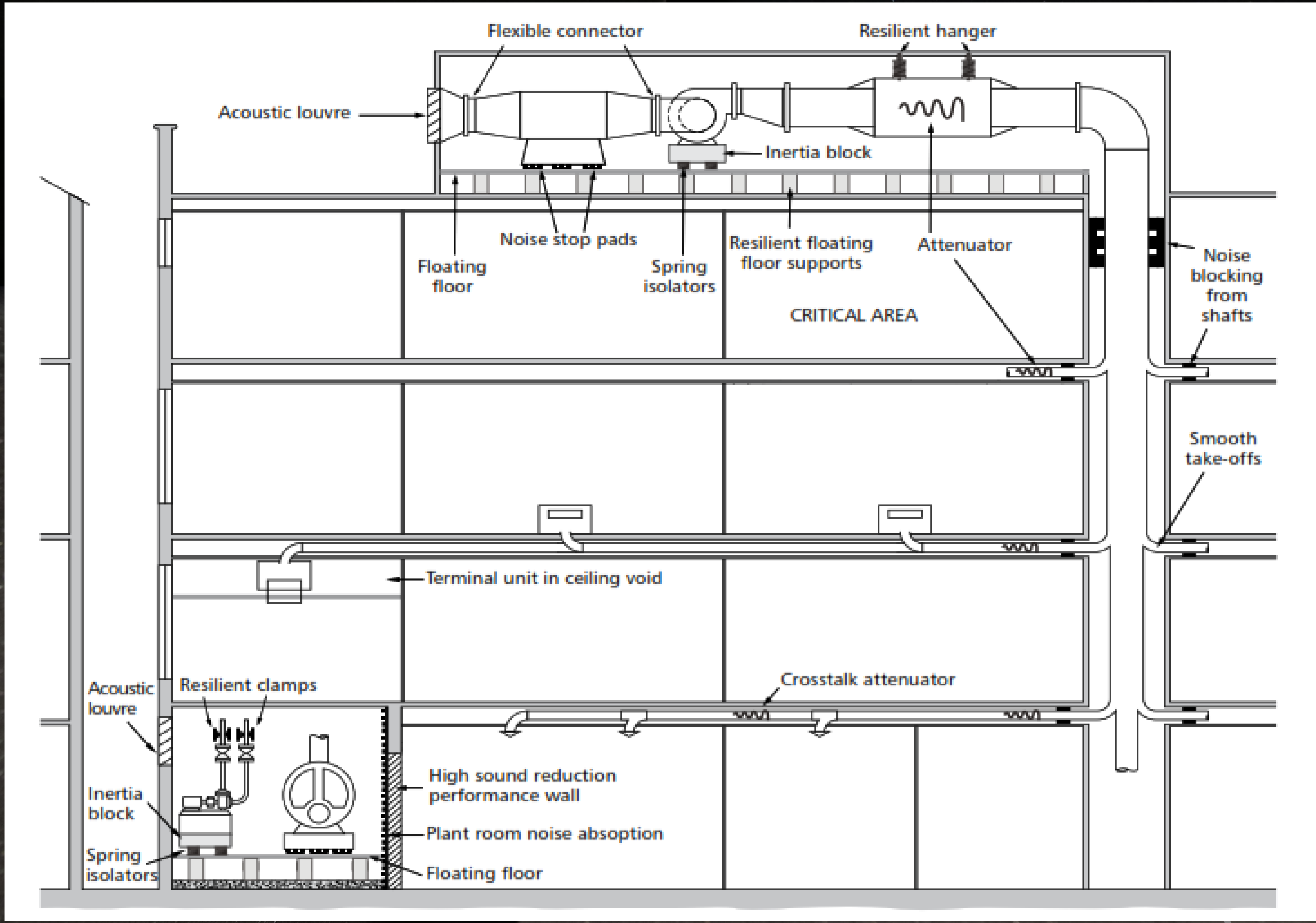
NR Curves are most commonly used for external noise level impact

Alternatives to the use of weighting curves are dBA levels and various time weighted

But all curves and predictions are only as good as the quality of the base data



Introduction to Acoustics – Duct Borne, Structure Borne and Breakout-Out Noise



Attenuation provided by the air path between Source & Receiver

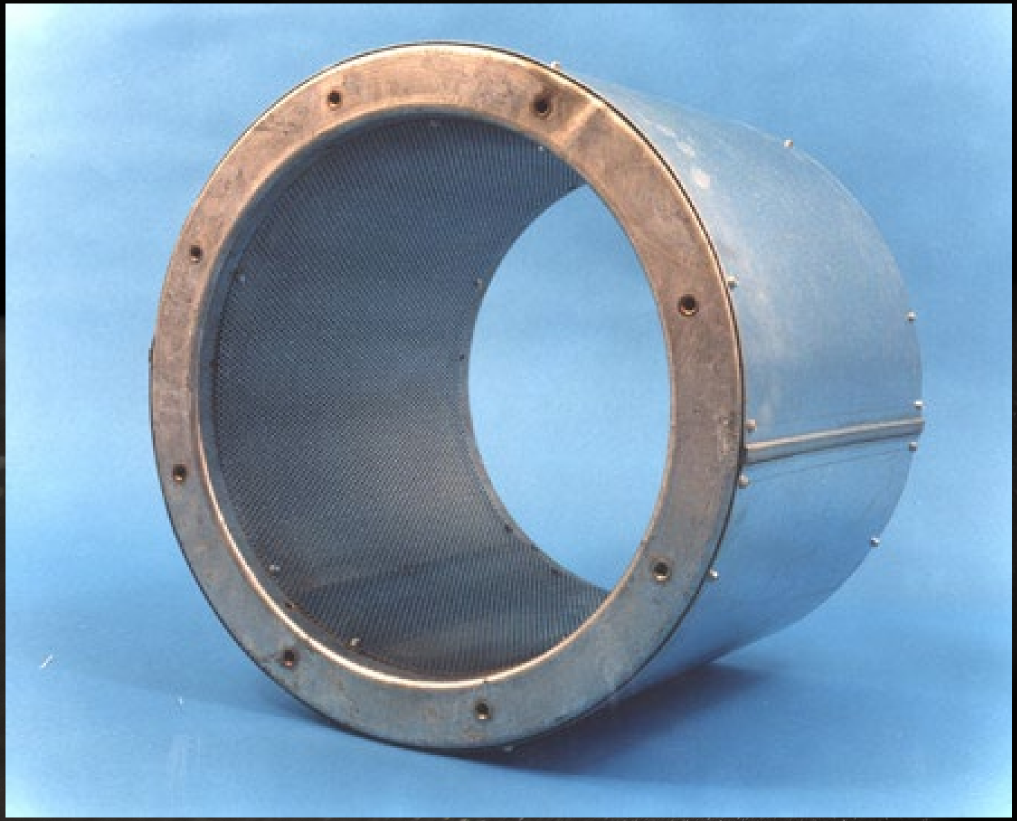
Silencers mounted in the air path can be selected to achieve the required noise level for the specific ventilated environment

Noise will find a path through the weakest links, position noise control as close to the source as possible

Isolate vibration that may well excite structures

Air velocity through devices

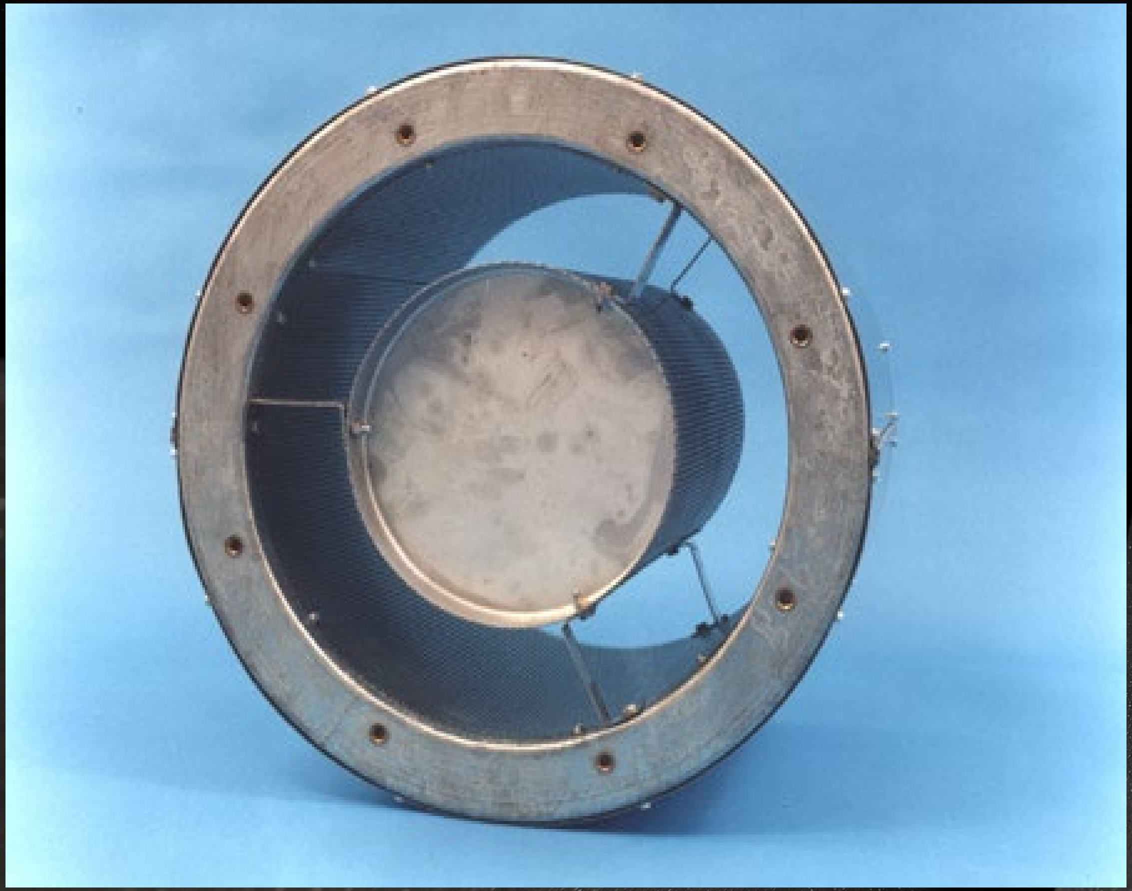
Acoustic surface in the receiving room



B Type silencers have no additional pressure drop

1D Long typically 7 - 10dBA reduction
2D Long typically 10 - 13dBA reduction

"Noise control for free"

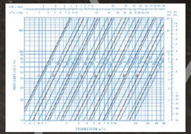


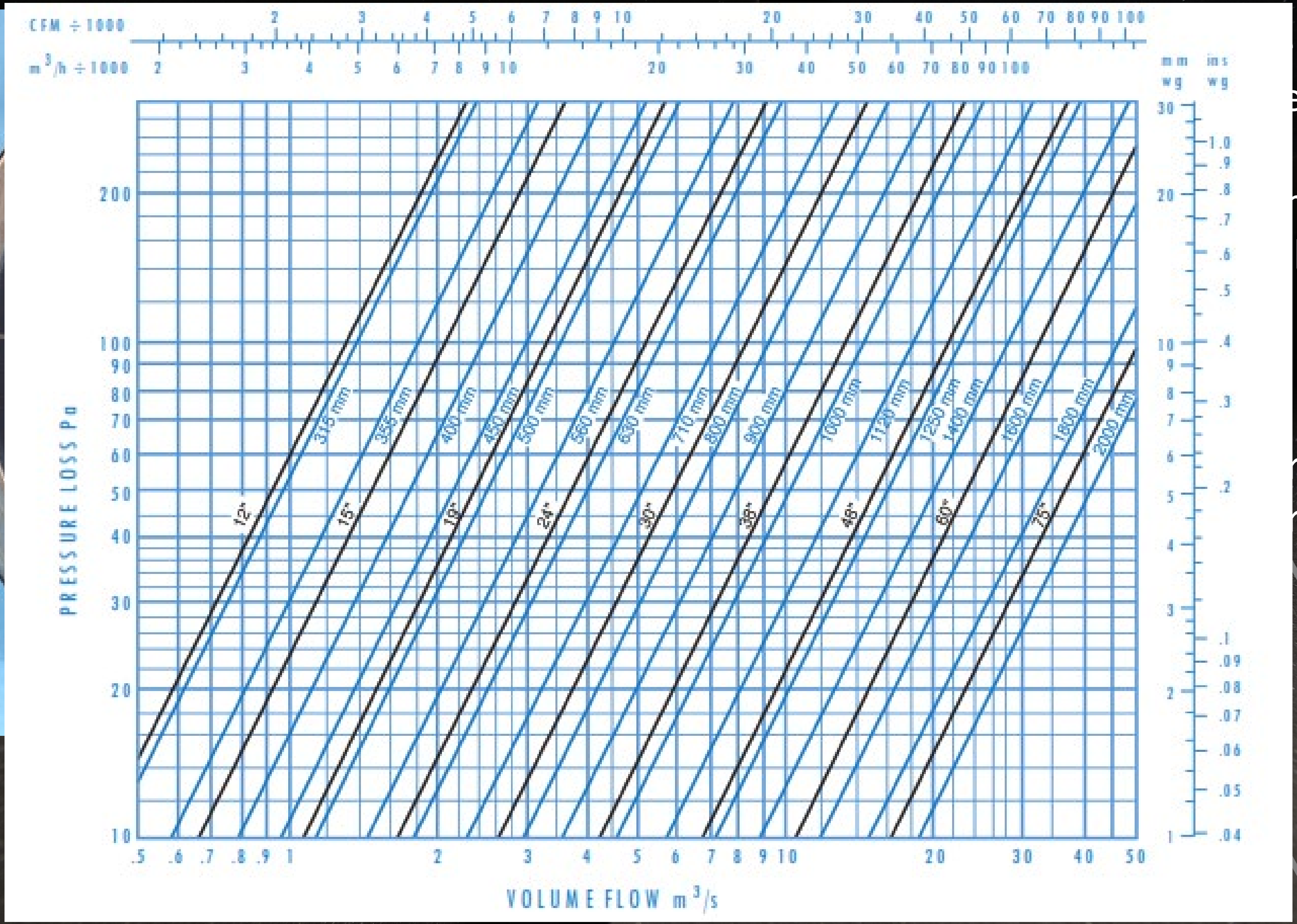
C Type podded silencers have an additional pressure drop caused by the pod in the airway.

C type silencers must not be mounted within 2D of the inlet to a fan or 1D from the outlet otherwise fan performance can be reduced and sound levels will be increased!

1D Long typically 12 - 15dBA reduction
2D Long typically 15 - 18dBA reduction

Allow for additional pressure drop
K = 0.5





an additional pressure
e airway.

mounted within 2D of
he outlet otherwise fan
and sound levels will

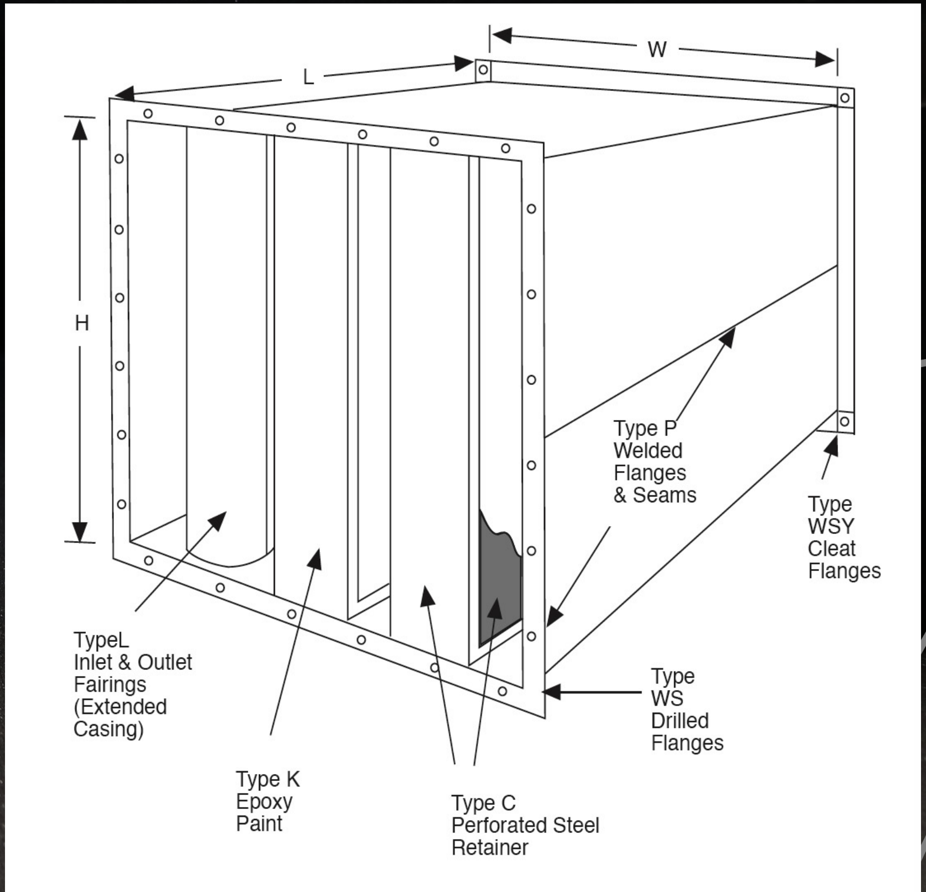
reduction
reduction

drop

Remember that if we force air through a narrow airway then the resistance will be high, resistance is the cost of delivering the required volume flow.

Narrower airways = higher pressure drop and higher attenuation

Very high airway velocity may cause noise generation as the air passes through the system



We have considered:

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