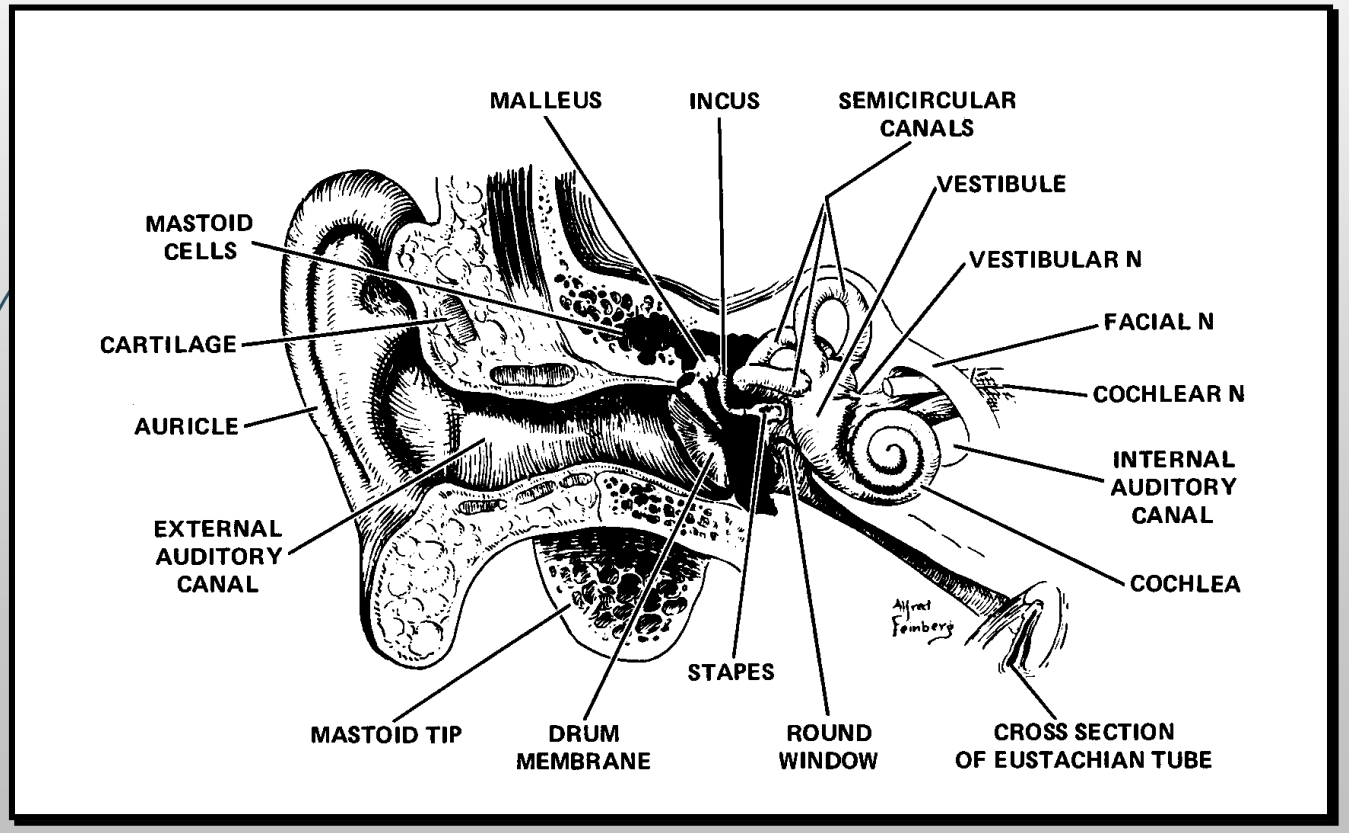
Basic Environmental Noise and Noise Perception

Topics Covered

- What is Noise?
- Acoustic Terminology
- Physics of Sound
- Sound Level Measurement
- Physiological and Psychological Effects
- How we perceive sound / noise

What Is Noise?

Definition of Noise: Any disagreeable, undesired or unwanted sound.



Acoustical Terminology

Acoustical Environment: All of the factors, interior or exterior, which effects the acoustical conditions of the location, space or structure under consideration.

Airborne Sound: Sound transmitted through air or gas as a medium rather than through a liquid or solid.

Ambient Noise: The all-encompassing noise associated with a given environment.

Attenuation: A reduction in the magnitude of a sound signal.

Acoustical Terminology

A-Weighting: A Frequency response characteristic incorporated in all sound level meters and similar instrumentation meeting specific standardized response requirements.The A-weighting is characterized by a de-emphasis of lower frequencies.

Background Noise: The composite noise produced by all sources of interference in a system used for the production, detection, measurement, or recording of a signal independent of the presence of a signal.

Decibel: A unit of level when the base logarithm is the tenth root of ten and the quantaties concerned are proportional to power.

Acoustical Terminology

Frequency: The number of cycles occurring per second of a periodic sound or vibration. The unit is Hertz (Hz), formerly cycle per second (cps).

Hearing: The subjective response to sound, including the entire mechanism of the outer, middle and internal ear, and the nervous and cerebral processes which translate the sound into meaningful signals.

Acoustical Terminology

Impulsive Noise: Noise characterized by brief excursions of sound pressure which significantly exceed the background noise. The duration of a single impulse is usually interpreted as being less than one second.

Masking: The process by which the threshold of audibility of one sound is raised by the presence of another sound. Also the amount, in decibels, by which that threshold is raised.

Acoustical Terminology

Noise: Any unwanted sound. Any sound which can produce, at least potentially, undesirable effects or reactions in the human organism.

Noise Reduction: The attenuation of unwanted sound.

Sound: For our purpose a fluctuation in atmospheric pressure which is capable of evoking an auditory sensation.

Acoustical Terminology

Sound Level Weighting: Frequency - Weighting of the measured sound pressure levels according to the standardized A, B or C weighting used in sound level meters.

Sound Level Meter: An instrument used to measure sound pressure levels and meets the specifications of ANSI S1.4 or an equivalent standard.

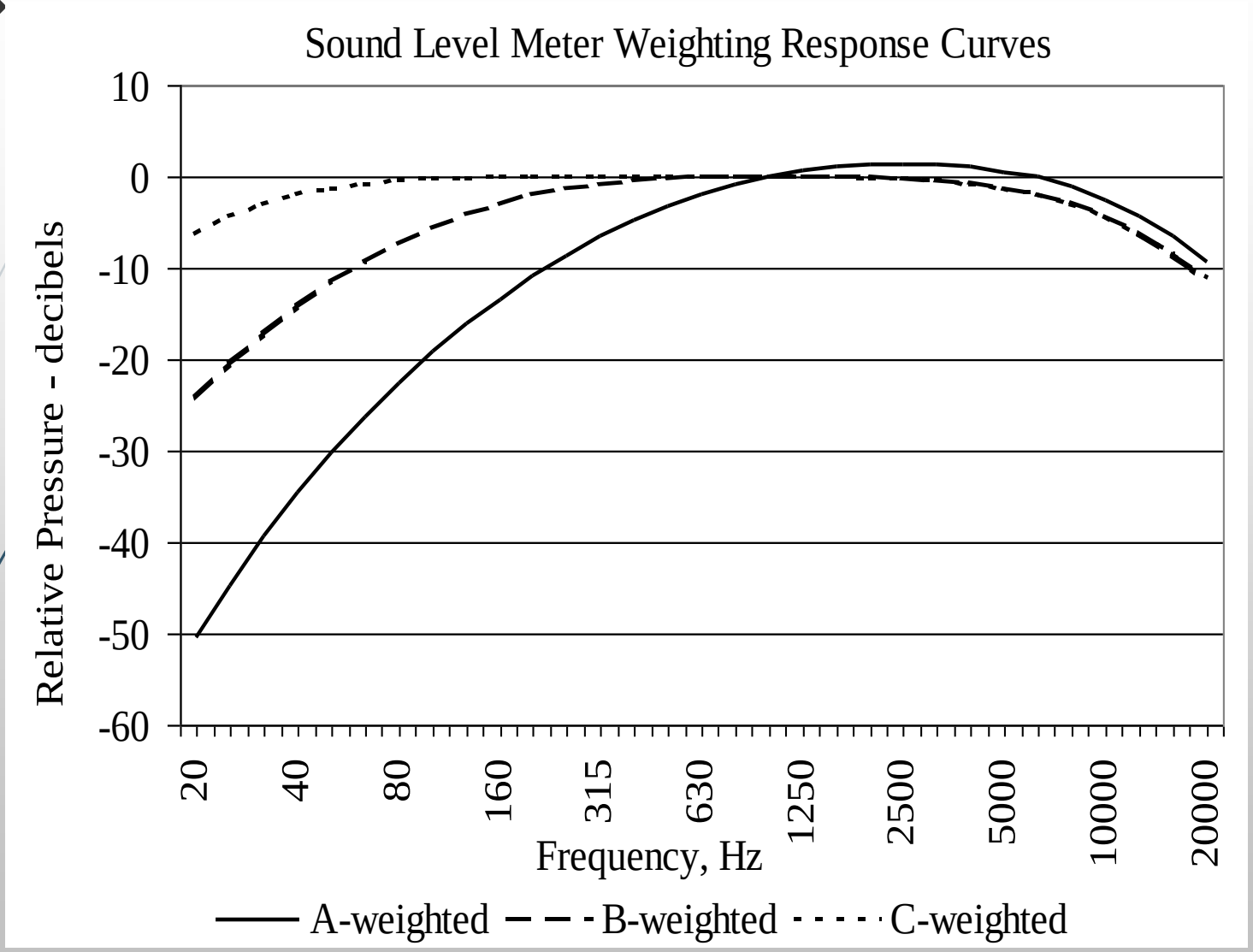
Sound Pressure Level: Ten times logarithm to the base ten of ratio of the mean square sound pressure to the square of the reference sound pressure; thus also twenty times the logarithm to the base ten of the ratio of the RMS sound pressure to the reference.

Noise Metrics

Almost all noise Laws, Codes and Ordinances set noise in terms of dBA and some use dBC.

A-weighted Noise Sound, dBA – is the process of measuring sound with the same sensitivity to frequency as human ear.

C-weighted Noise Sound, dBC – is a good measure of low frequency annoyance.


Sound Level Meter Weighting Response Curves
Relative Pressure - decibels
10
0
-10
-20
-30
-40
-50
-60
20
40
80
160
315
630
1250
2500
5000
10000
20000
Frequency, Hz
A-weighted
B-weighted
C-weighted

Character of Sound / Noise

By examining this curve we can get a pretty good idea about how noise is perceived.

The A-weighted curve has no correction at 1000 Hz which his the middle of human hearing range.

Therefore, we hear best at the frequencies that have the least correction.

Range of Typical Sounds

Sound Source	dBA	Sound Pressure	
		Pascals	PSI
Threshold of Hearing	0	0.00002	0.0000000029
Quiet Sound Studio	20	0.0002	0.00000003
Quiet Rural Setting at Night	30	0.0006	0.00000009
Soft Whisper at 6-feet	35	0.0011	0.00000016
Rustle of Leaves at Night	40	0.0020	0.00000029
Medium Quiet Office Area	50	0.0063	0.00000092
Normal Conversation at 3-feet	60	0.0200	0.00000291
Vacuum Cleaner at 10-feet	70	0.0632	0.00000919
Night Club	90	0.6325	0.00009195
Reference Level	94	1.0024	0.00014573
Loud Gym+A50 Basketball Game	100	2.0000	0.00029075
	110	6.3246	0.00091945
F-18 at 200 feet	120	20.0000	0.00290755
	1 Pascal = 1 Newton / meter 2		

Physics of Sound

1. How noise decreases with distance ?
2. How barriers reduce noise levels ?
3. What happens with multiple sources ?
4. Effects of Wind
5. Vegetation
6. Other Factors which attenuate sound

Geometric Divergence

How sound decreases with increasing distance.

Doubling the distance from a source decreases the noise levels by 6 dB; halving the distance increases it by 6 dB

Twice as far	– 6 dB
Four times as far	–12 dB
Eight times as far	–18 dB

Geometric Divergence

Large front end loader
= 80 dBA at 25 feet

At 50 feet
= 74 dB

At 100 feet
= 68 dB

At 200 feet
= 62 dB

$$SPL = 20 * LOG10\left(\frac{Distance\ Two}{Distance\ One}\right)$$

Noise Barriers

- A very common and effective method to reduce noise levels.
- May be a fence, berm, building, hill or anything that blocks the line of sight from the noise source to the noise receiver.
- Generally the higher the barrier the greater the attenuation.

Noise Barriers

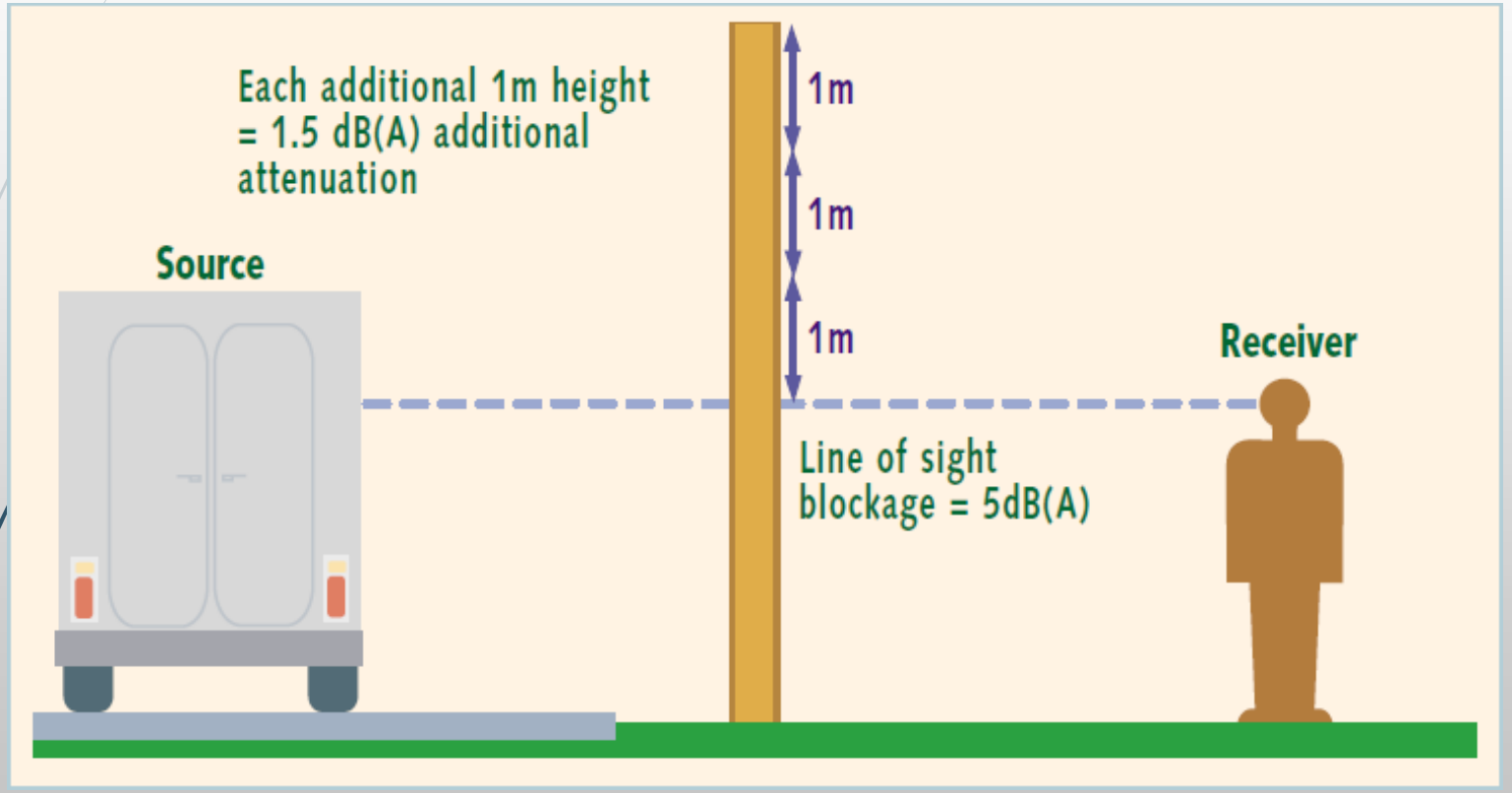
The level of attenuation provided by a barrier depends on:

Distance – closer the barrier is to either the source or receiver, the more attenuation provided.

Height – The noise barrier must be several feet higher than the source to have ANY effect.

Length – for roadway noise the length of the barrier is very important.

Noise Barriers



Multiple Noise Sources

- What Happens when there is more than one noise source?
- Noise from different sources is added logarithmically: NOT arithmetically.
- Source 1 is 75 dB and Source 2 is 75 dB(A) total noise is 78 dB(A) not 150 dB(A)

Multiple Noise Sources

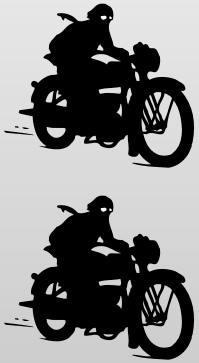
Comparison Many Sources

1 Source

80 dB(A)

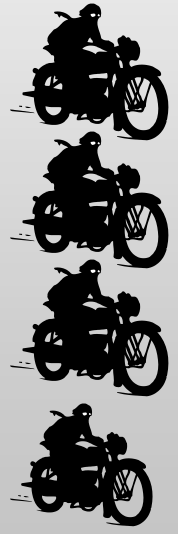
2 Sources

83 dB(A)



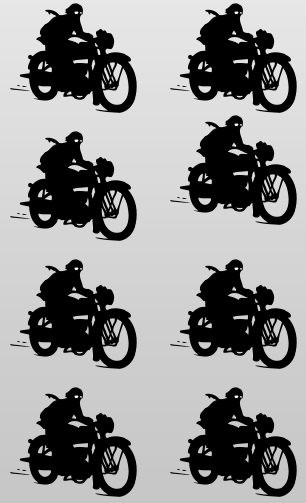
4 Sources

86 dB(A)



8 Sources

89 dB(A)



REMEMBER: 3 dB(A) For Each Doubling of Identical Sources

Wind Effects

- 5 to 10 mph wind blowing from noise source to receiver – increase of 5 to 15 dB
- 5 to 10 mph wind blowing to noise source from receiver – decrease of 5 to 15 dB

Vegetation

- Vegetation does very little to attenuate noise.
- Thick stand of trees at least 50 feet deep will provide 1 to 3 dB noise attenuation.
- Bushes and shrubs provide no noise attenuation.

Other Factors

- Ground Absorption – sound is reflected more by snow and hard surfaces than by grassy or low vegetation (typical high altitude sage brush landscape). Minor factor.
- Atmospheric Absorption – greater for high frequencies, minimal for low frequencies. Which is why we can hear a train at great distances.

Perception of Noise

How noise is perceived also depends on social and environmental factors.

People who like motorcycles or remote controlled airplanes, do not find noise from them objectionable.

Someone, who doesn’t like motorcycles will find the noise objectionable; hence why noise laws are based on measureable dB levels.

Perception of Noise

- Out in the environment
  - A 10 dB increase is perceived as being twice as loud
  - A 10 dB decrease is perceived as being half as loud.
  - A 3 dB increase or decrease is perceived as being different, with no quantification of scale.

Psychological Effects of Noise

Very Important

Noise levels associated with city, county and state noise laws are not high enough to cause hearing loss or any other physiological damage.

OSHA and MSHA limits of noise for an 8-hour workday is 85 dBA.

Psychological Effects of Noise

The annoyance will cause lack of sleep, anger, frustration, etc.

The emotional effects will lead to people thinking that the offending noise is adversely affecting them.

Almost always community noise CAN NOT cause hearing loss.

Psychological Effects of Noise

The perception of noise is highly dependent on the quality or character of the noise.

High frequency noises are more objectionable than low frequency noises.

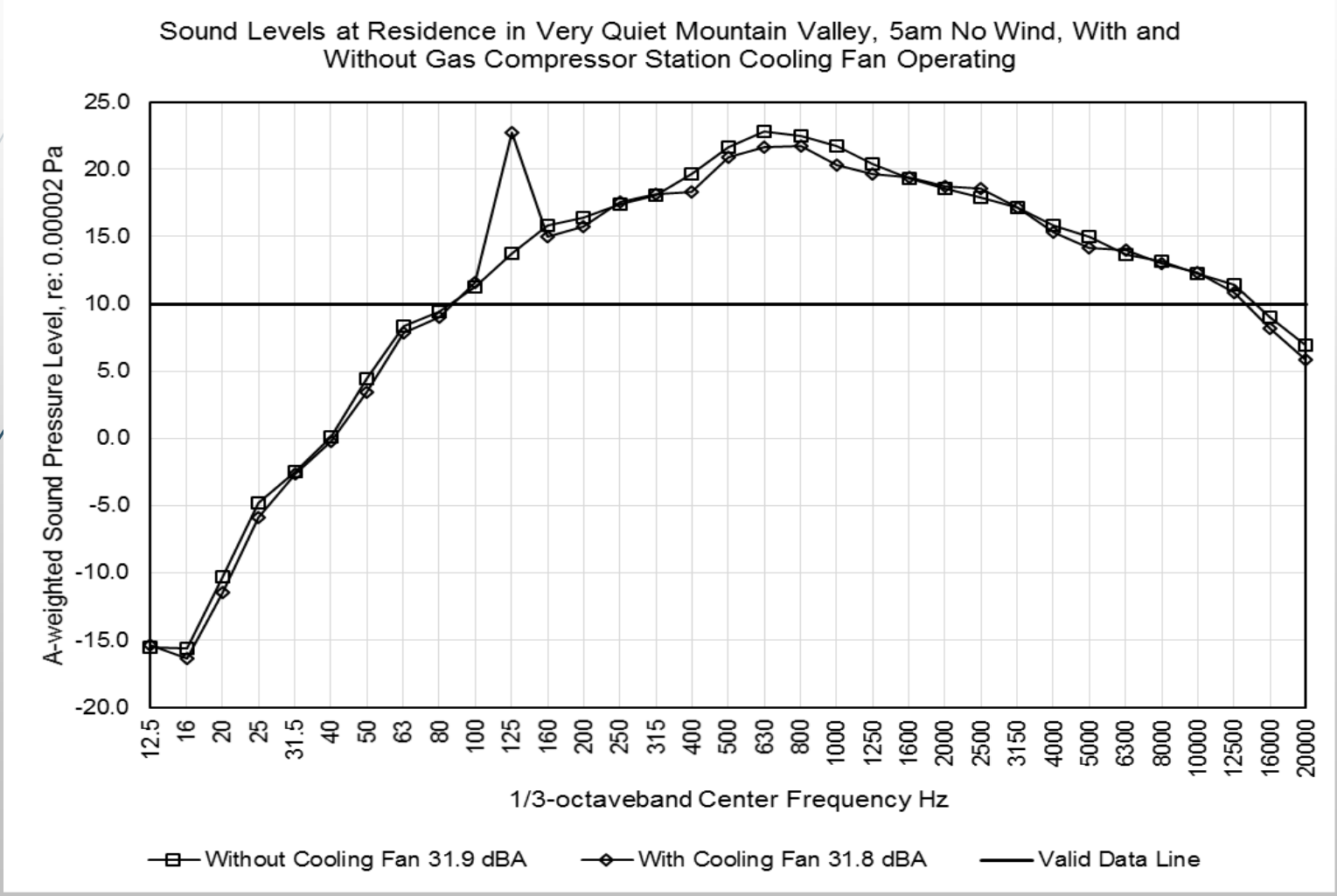
Periodic, Impulsive and pulsating noises are more annoying and noticeable than steady noises. A backfire from a car is more noticeable than typical traffic noise from a roadway.

Psychological Effects of Noise

Even though noise from a source may have the same dB level as the background, if the character (frequency and period) is different, then the noise will noticeable.

Example: Suppose the background noise in a rural area is 30 dB(A) and noise from a source is 30 dB(A). The noise source may still be audible, because the character of the noise is different.

Psychological Effects of Noise



Summary

Just because you can hear a sound from something does not mean the noise level exceeds noise limits.

All noise sources can be made quieter or silent, however, the cost may not typically not be trivial.