


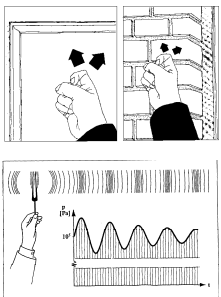
Audio Demos

Chuck Ebbing

- Retired (1999) from Carrier
- 47 years Experience in Acoustical Engineering
- BSEE Purdue MSEE SUNY
- Taught Acoustics and Noise Control at RPI, SU, Carrier
- Camp on Grindstone (1960)
- House in LaFargeville (2005)
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Vibrating Surfaces Radiate Sound



- Sound Waves travel at about 1100 ft/sec in air
- These wave fronts vary the atmospheric pressure by tiny amounts.

Radiated Sound

Vibrates Ear Drums and Other Surfaces

- The *outer, inner and middle ear* acts like a *microphone feeding a frequency analyzer*
- The output of the ear is **digitized by the firing of nerve cells which transfer their electrical pulses to the auditory center in the brain**
- We extract information in the brain.
- Sound Meters *only measure the energy in the sound waves, not the information.*
- **The sound if loud enough can induce feelable vibration into the body at low frequencies.**

What are the potential wind farm noise hazards to humans?

Annoyance


- Can the noise produced by the wind farm significantly increase the background noise?
- Are their transient noises that are annoying?
- Are their pure tones present?
- Will there be low frequency audible noise present?
- Can it vibrate my house?
-Yes.....

So What Causes Sound?

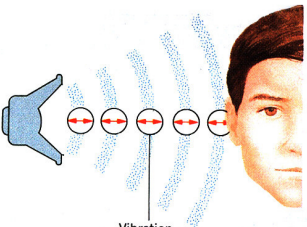
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What Causes Sound?

- The air molecules are set into vibration by the vibration of the lips.
- In the case of wind turbines it is due to the blades passing the support post
- Or from the mechanical vibration of the blades or turbine structure



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Vibration of an individual air molecule

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We Make Meanings Of Sights And Sounds By Recognizing Patterns

- Our sense of hearing is always trying to make sense of the changing ambient noises by recognizing the sound patterns we are hearing.
- When we detect new or unexpected sound patterns our attention is initially focused on that sound. If the sound is your favorite song you tune in and focus your attention.
- However there are unwanted or acoustically ugly sounds that we can only ignore by tuning them out.
- The problem is, that in tuning them out, we use up more and more of our thinking resources, causing stress.
- And that makes it harder to do effectively what we do.



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How many people do you see?

How many people do you see at the same time?

Are we pattern recognizers?

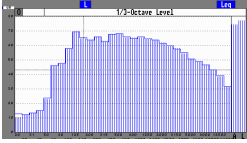
Does a sound level meter measure what we hear?

- Sound level meters are very useful in measuring some aspects of the sound
- But they do not always measure everything that we hear or how we hear it.
- Single number measurements such as 35 dBA does not measure **Annoyance** only the **Sound Level Loudness**.



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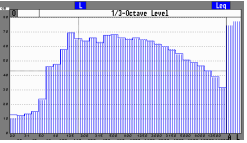
Does a good analyzer tell you all you need to know to analyze Sound Quality?



- Two uniquely different sounds generate the same A-weighted sound pressure level and the same spectra.
- Sound analysis analyzers do not take annoyance or sound quality into account
- I'll play two sounds which produce the same readings on my sound level meter.

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Does a good analyzer tell you all you need to know to analyze Sound Quality?



- Do the two sounds measure the same dBA?
- Yes
- Do the two sounds have the same **Annoyance?**
- Sound level meters measure loudness not annoyance.
- Sound Quality is judged in the brain of the beholder.

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Bajdek

- Noise from wind farms is significantly more annoying than aircraft or traffic noise.
- Increased annoyance is undoubtedly related to the character of wind turbine sound, i.e., amplitude modulated sound pulses at about 1-2 second period. This annoyance is not reflected in the dBA rating of the noise.
- Common practice in the HVAC industry is to add penalties for very impulsive (+5dB) or tonal (+5dB) noise sources.

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VISUAL SCREENS



- Visual Screens for Wind Turbines can't be used to eliminate the sight of the flicker or turbine.
- Hearing the turbine noise, seeing the Turbine and
- Possibly the flicker...
- Is much worse than just hearing it.

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Just what is the residual ambient and why is important.

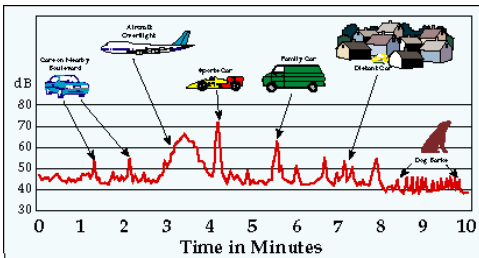


Figure 2. Typical Outdoor Sound Measured on a Quiet Suburban Street

So what would be the result if you "turned off the cars, plane and dog?"

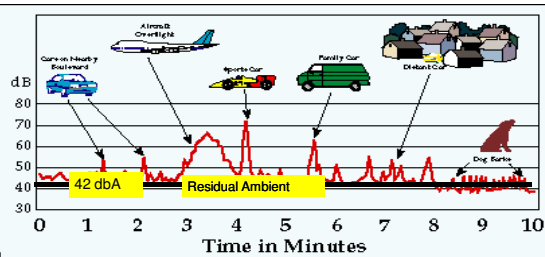


Figure 2. Typical Outdoor Sound Measured on a Quiet Suburban Street

Rural Areas have little traffic and are Very Quiet

- A good practical indicator that can be used to judge your Acoustic Ambient was given to me by Rick James, E-Coustic Solutions, Okemos, MI 48805, Email: rickjames@e-coustic.com
- "If, on a clear windless morning or evening, you can hear distinct traffic or other sounds from distances of a mile or more from your location the long-term background sound level is most likely 25 dBA, or lower."

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Sound Is Noise If :

- too loud

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Sound Is Noise If :

- too loud
- unexpected

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Sound Is Noise If :

- too loud
- unexpected
- uncontrolled

22

Sound Is Noise If :

- too loud
- unexpected
- uncontrolled
- occurs at the wrong time

23

Sound Is Noise If :

- too loud
- unexpected
- uncontrolled
- occurs at the wrong time
- has pure tone components

24

Sound Is Noise If :

- too loud
- unexpected
- uncontrolled
- occurs at the wrong time
- has pure tone components
- conveys unwanted information

25

Sound Is Noise If :

- too loud
- unexpected
- uncontrolled
- occurs at the wrong time
- has pure tone components
- conveys unwanted information
- unpleasant

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HVAC Noises

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HVAC Noise

→ **Tonality**

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HVAC Noise

→ **Tonality**
→ **Rumble**

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HVAC Noise

→ **Tonality**
→ **Rumble**
→ **Hiss**

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HVAC Noise

- Tonality
- Rumble
- Hiss
- Roar

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HVAC Noise

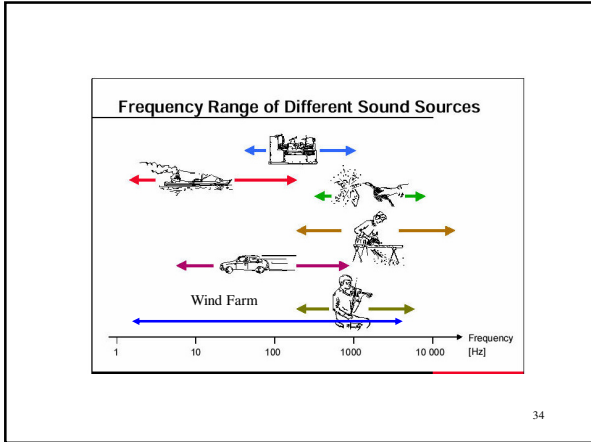
- Tonality
- Rumble
- Hiss
- Roar
- Beating

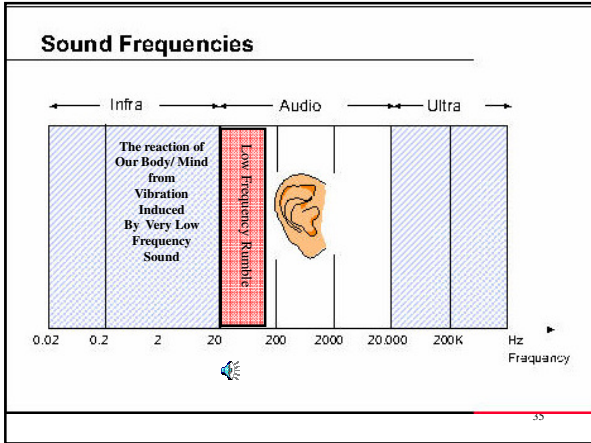
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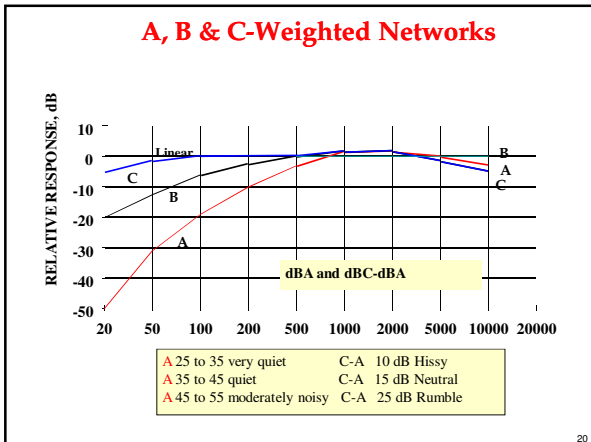
HVAC Noise

- Tonality
- Rumble
- Hiss
- Roar
- Beating
- Spectrum Balance (Neutral Sound)

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So How Much Low Frequency Noise is too Much?

- In 1978 I published an ASHRAE Technical Paper Showing that Rooms Rumble when there is an unbalance of the very low frequencies in relation to the high frequencies.
- *Control of Low Frequency Duct-Generated Noise in Building Air Distribution Systems** (ASHRAE Transactions, Vol. 84, Part 2, 1978, PG. 191)
- Later the Development of Room Noise Criteria permitted practitioners to determine what noise reduction was necessary to prevent rumble.
- For Occupied Indoor Spaces ASHRAE has developed Room Noise Criteria Curves.

1978 ASHRAE PAPER

Shown under what acoustical conditions air conditioning systems in buildings produced low frequency rumble in buildings.

Paper showed from actual jobs, that if you keep the loudness of the low frequency noises less than the higher frequency sounds people are not bothered by Rumble.

It has been established that excess low frequency noise can cause stress.

CONTROL OF LOW FREQUENCY DUCT-GENERATED NOISE IN BUILDING AIR DISTRIBUTION SYSTEMS

CHARLES S. FARNS DANIEL FRAGNETT STEPHEN HOLDS
*REPRINTED

One of the primary sources of noise originates in building air-conditioning systems. Rumble, that is, noise in the frequency range of 10 to 100 Hz, is a common complaint in buildings. This noise is caused by the ductwork and its components. The noise is caused by the ductwork and its components. The noise is caused by the ductwork and its components.

These conditions, caused primarily by the ductwork, are a common complaint in buildings. This noise is caused by the ductwork and its components. The noise is caused by the ductwork and its components.

The reduction of noise is a primary objective in the design of air conditioning systems. This noise is caused by the ductwork and its components. The noise is caused by the ductwork and its components.

This paper discusses the factors and suggests design techniques that will reduce the level of ductwork noise in building air distribution systems.

SCOPE OF PAPER—This paper discusses the factors and suggests design techniques that will reduce the level of ductwork noise in building air distribution systems.

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Good News Bad News

- The Air Conditioning Industry has the know how to predict (estimate) if Rumble is present on an actual job or in the planning stage.
- The Bad News is *either the Wind Industry doesn't know, or if it does, it has not seen fit to be transparent with the public on this issue.*
- They do not acknowledge that low frequency noise can cause problems.

