Health Canada Santé Canada | Canada

Environmental and Workplace Health

A Primer on Noise

The following information provides the reader with background information and a description of basic concepts related to acoustics that are referred to in the summary of results from Health Canada's Wind Turbine Noise & Health Study.

What is sound and how is it different from noise?

Even though the terms are sometimes used interchangeably, scientists sometimes make a distinction between ***sound*** and ***noise***. The simplest way to distinguish between the two is we hear "sound", and when this becomes unwanted, it is referred to as noise. The reasons for considering the noise unwanted, depend on its physical characteristics (e.g., intensity, frequency and duration) and its interactions with people. The unwanted effects can range from annoyance, interference with conversation and disturbance of sleep to hearing damage. The first three types of effects depend not just on characteristics of the noise, or its occurrence over time (e.g. a continuous noise from highway traffic, intermittent noise from aircraft flyovers, an impulsive gun shot, the tonal warning sound of a back-up alarm), but also on what activities are engaged in when it is heard and the time of day that it is heard. For instance, some sounds may be desirable during the day, but interpreted as unwanted noise if they disturb sleep. Similarly, sounds with noticeable tones can be more unpleasant or intrusive.

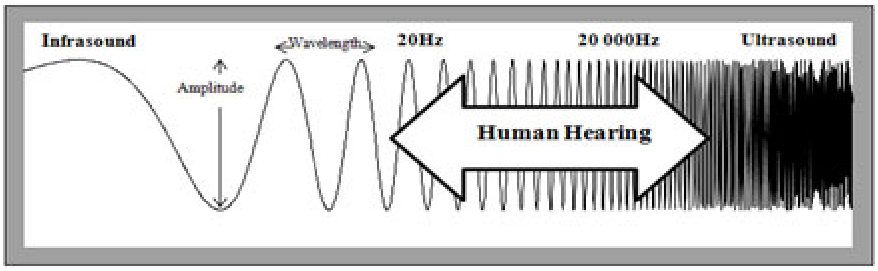
How is sound created?

When an object vibrates back and forth it causes small increases and decreases in air pressure that travel, or ***propagate***, through the air as ***sound waves***. When scientists refer to the ***frequency*** of a sound, they are referring to how many complete sound waves the source produces in a single second, i.e. cycles per second, or Hertz (Hz). The frequency of a sound is very important when trying to understand how people may respond to it because the human ear is not as sensitive to extremely low or high frequencies. Although it is not fixed, in general, a young person with normal hearing can typically hear sounds at normal everyday levels with frequencies between 20Hz and 20,000Hz, but human ear is most sensitive to sounds between 2000Hz and 5000Hz.

Frequencies below 20Hz are categorized as ***infrasound*** and, as noted above, generally fall outside the range of human hearing at normally occurring sound levels. Infrasound is common in the environment and can originate from naturally occurring events such as thunderstorms, volcanoes and earthquakes or can originate from man-made sources such as rocket launches, explosions and some mining activities. Infrasound can also be produced by large wind turbines and large boilers. ***Low frequency noise*** has been used to describe frequencies between 20Hz and about 200Hz. The perception of infrasound and very low frequency noise (less than about 30 Hz) is often described as a "feeling" or "pressure" rather than something that is heard. Because this type of noise can easily pass from outside a building to inside a building, it can, depending on the level, cause light weight structures in a home to vibrate or rattle and this can cause annoyance.

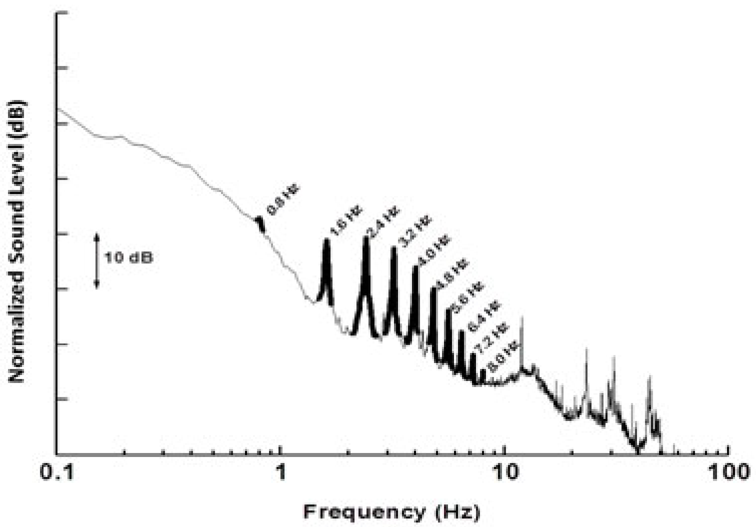
Figure 1 provides the frequency spectrum identifying infrasound, LFN and speech frequencies.

Figure 1 : Sound Frequency Spectrum



The frequency of rotation of a source can be used to help identify the source that is producing the sound. For example, a wind turbine with 3 blades, spinning at 16 revolutions (full rotations) per minute (RPM) will have a ***fundamental frequency*** that corresponds to 0.8 Hz (i.e. (3 blades X 16 RPM) divided by 60 seconds). Therefore, in this example, one can isolate the wind turbine sound from background noise if in the measured sound at a given distance, the sound level due to the wind turbine is high enough to show frequency peaks at the fundamental frequency and at multiples of the fundamental frequency. These multiples are called ***harmonics*** and for a source with a 0.8Hz fundamental frequency, they would be 1.6 Hz, 2.4 Hz, 3.2 Hz, 4.0 Hz, 4.8 Hz, and so on.

Figure 2: Wind Turbine infrasound Measurements



How is sound measured?

Frequency is only one component of sound that scientists are interested in measuring. The amount of pressure fluctuation in air created by a noise source is measured in ***Pascals*** (Pa). The human ear is capable of detecting changes in ***sound pressure*** that are as low as 0.00002 Pa, the threshold detectable by a healthy young adult. The sound pressure is perceived as ***loudness***. Humans are sensitive to such a wide range of sound pressure fluctuations that it can be confusing to work in *Pa*. To reduce the numbers to a more manageable set of values, rather than Pa, scientists report in decibels, (dB), using the detection threshold as the reference level, that is, 0 dB. When sound pressure in *Pa* is converted to dB it is referred to as the ***sound pressure level*** (SPL). Table 1 provides typical sound pressure levels associated with different types of sources or situations.

Table 1: Typical Sound Pressure Levels for Common Sources

Sound source	Distance between listener and source	Sound Pressure Level
Jet aircraft	50m	140
Chainsaw	1m	110
Shoulder of busy road	5m	80
Conversational speech	1m	60
Quiet bedroom at night		30
Threshold of pain		130
Average hearing threshold		0

Understanding A-Weighting and C-Weighting

The human ear is not equally sensitive to all frequencies. Scientists that study the community response to noise typically measure different sounds levels with a unit called the A-weighted decibel (dBA). The A-weighting reflects how people respond to the loudness of common sounds; that is, it places less importance on the frequencies that the ear is less sensitive to. For most community noise sources, this is an acceptable practice, but when a source contains a significant amount of low frequencies, an A-weighted filter may not fully reflect the intrusiveness or the effect that the sound may have (e.g annoyance). In these cases, the use a C-weighted filter (dBC) may be more appropriate because it is similar to the A-weighting except that it includes more of the contribution from the lower frequencies than the A-weighted filter.

What is the difference between sound pressure level and sound power?

Although they are related, it is easy to confuse sound pressure with ***sound power***. Sound power refers to the amount of energy that a source transfers into the air per second. This energy is measured in ***Watts*** (W). A very quiet sound, like a whisper may produce only 0.0000001W of energy per second, while an aircraft engine can produce as much as 100,000W. For the same reason as described above for sound pressure, scientists often convert sound power measured in W to a dB scale. A sound power range between 0dB and 170dB is much more practical and can be used to describe the sound power of most noise sources. In order to understand how sound power is related to sound pressure, one must be aware that the sound power of a noise source is constant under specific conditions. That is, the total amount of energy produced by the noise source per second, in the form of sound, (i.e. its sound power) will be the same, no matter where the source is located provided that it is operating under the same conditions. This allows scientists to predict the sound pressure level (SPL) at a location of interest based on the known sound power of a noise source. In Health Canada's Wind Turbine Noise Health Study, the wind turbine SPLs outside the homes in the study were predicted using the sound powers of the wind turbines in the residences' vicinity. Predicting SPL from the sound power requires the consideration of multiple factors known to influence the SPL that is measured at a distance from the wind turbine. These factors go beyond simply how far away the noise source is from the location of interest and include, but are not limited to, the sound power of a given model of wind turbine, the number of turbines, as well as any barriers or hills that might intervene between the wind turbines and the measurement location, and local weather conditions (e.g. humidity, temperature, wind speed and wind direction).

Outdoor to indoor sound pressure level difference

Although a home acts like an obstacle to the sound waves, thereby reducing its level, individuals are often most concerned about noise from outside that is heard inside a home. People are especially concerned about noise when it interferes with sleep. Recall the discussion above regarding the frequency of a sound. A source that produces high frequencies (i.e. many complete cycles per second) has relatively short sound waves compared to a source that produces lower frequencies. These short sound waves are more readily blocked by structures (e.g. the walls and roof of homes) in comparison to low frequency sounds with long sound waves which can, generally, more readily pass through structures and travel over longer distances.

For additional information:

- Wind Turbine Noise and Health Study: Summary of Results

Date Modified: 2014-10-28