Noise Resources - Types of Noise

All noise is not created equal - nor is it perceived in the same way. There are many different types of noise, and depending on the circumstances and upon the person, some noises are far more annoying than others.

This is important, because the typical method of measuring noise (i.e., assessing the dBA) may not reflect all of the problematic components of the noise. In fact, it is widely acknowledged that noise measurements based on the A-weighted frequencies (dBA or LAeq) do not adequately characterize most noise environments and do not adequately assess the health impacts of noise on human well-being. (Berglund et al., 1999)

Certain noise characteristics can greatly increase the annoyance factor and the health impacts associated with noise. These factors include:

- the presence of tones (tonal noise)
- the presence of low frequency noise
- fluctuating, intermittent or periodic sounds; and
- impulsive sounds.

Below you will find some information on the different types of noise, with bibliographic references at the bottom of the page. For more information on types of noise, download OGAP's Noise Stakeholder Submission

Tonal Noise

> ***Noise with distinct tones, for example, noise from fans, compressors, or saws, is generally far more annoying than other types of noise. This annoyance factor is not taken into account in a broadband measurement. A spectral analysis may be needed to assess annoyance.*** ~ Environmental Noise Handbook, Breul and Kjaer

> ***Most energy industry facilities typically exhibit either a tonal or impulse/impact component. Examples of tonal components are transformer hum, sirens, and piping noise.*** ~ Noise Control Directive User Guide, Alberta Energy and Utilities Board

Tones are noises with a narrow sound frequency composition (e.g., the whine of an electrical motor). Annoying tones can be created in numerous ways: machinery with rotating parts such as motors, gearboxes, fans and pumps often create tones. An imbalance, or repeated impacts may cause vibration that, when transmitted through surfaces into the air, can be heard as tones. Pulsating flows of liquids or gases can also create tones, which may be caused by combustion processes or flow restrictions.

Tones can be identified subjectively by listening. Regulations, however, often require an objective measurement of tonal content as well. In such cases, frequency analysis, where a noise signal is electronically separated into various frequency bands (e.g., octave bands or third-octave bands) may be employed. The tonal audibility or annoyance factor is then calculated by comparing the tone level to the level of the surrounding spectral components.

Measuring tonal noise using 1/3-octave band frequency analysis

Germany - DIN 45680 method (Leventhall, 2003)
In Germany, there is an assumption that the great majority of low frequency noise problems from industrial sources are tonal. (See low frequency noise, below). For tonal frequencies, the allowable noise limit is less than for non-tonal noises.

If the level in a particular third-octave band is 5 dB or more above the level in the two neighboring bands, the noise is described as tonal. This is similar to a standard for tonality set by the ISO (1987).

Alberta Energy and Utilities Board (EUB)
In Alberta, if no tonal noise is present, oil and gas operators are allowed to emit noise at 5 dBA above the basic allowable noise level.

The test for the presence of tonal components consists of two parts.

> 1) The sound pressure level of any one of the slow-response, A-weighted, 1/3-octave bands between 20 and 16 000 Hz is 10 dBA or more than the sound pressure level of at least one of the adjacent bands within two 1/3-octave bandwidths. In addition, there must be a minimum of a 5 dBA drop from the band containing the tone within two bandwidths on the opposite side.
> 2) The tonal component must be a pronounced peak clearly obvious within the spectrum.

Oregon Noise Control Regulations
Oregon requires the use of octave bands to determine audible discrete tones from industrial noise "when the Director has reasonable cause to believe that the requirements of [the Oregon Noise Control Regulations] do not adequately protect the health, safety or welfare of the public." The Oregon Noise Control Regulations outline a procedure for determining whether or not the noise contains tonal components.

Penalties for tonal noise

In some jurisdictions, when noise has an obvious tonal content, a penalty or correction may be used to account for the additional annoyance. (ISO, 1987) The penalty for tones varies between 0 dB (no penalty) and 6 dB. (Bruel and Kjaar, 2000) This penalty is added to the measured dB level before the measured dB level is compared to the legal allowable noise limit.

For example, if the noise from a compressor is measured as 40 dBA, but it is determined that the noise has tonal components, a penalty of 6 dBA would result in a level of 46 dBA. If the noise standard is 45 dBA, the noise from the compressor would be out of compliance.

Low Frequency Noise

> ***A large proportion of low-frequency components in noise may increase considerably the adverse effects on health.***

. . .low frequency noise. . . can disturb rest and sleep even at low sound levels.

The evidence on low frequency noise is sufficiently strong to warrant immediate concern.

~ Guidelines for Community Noise, World Health Organization

Low frequency noise does not have a consistent definition, but it is commonly defined as noise that has a frequency between 20 and 100 - 150 Hz. Noise at levels below 20 Hz is referred to as infrasound.

Depending on the actual conditions, many types of noise can be regarded as low frequency noise:

- Low frequency noise and infrasound are produced by machinery, both rotational and reciprocating, and all forms of transport and turbulence. Typical sources include pumps, compressors, diesel engines, aircraft and fans.
- Combustion turbines are capable of producing high levels of low frequency noise. This noise is generated by the exhaust gas.
- The firing rate of many diesel engines is usually below 100 Hz, so road traffic noise can be regarded as low frequency. Similar considerations can be made for engines or compressors in industries or co-production plants.
- Burners can emit broadband low frequency flame roar.
- Structure borne noise, originating in vibration, is also of low frequency, as is neighbor noise heard through a wall, since the wall blocks higher frequencies more than lower ones.
- Low frequency noise can be noise or vibration from traffic or from industries, totally or partly transmitted through the ground as vibration and reradiated from the floor or the walls in the dwelling.

Low frequency noise creates a large potential for community annoyance. It is most often experienced inside of homes and buildings where resonance amplifies the sound. It is a general observation that indoor noise is perceived as more "low-frequency-like" than the same noise heard out of doors. (Torben Poulsen,and Frank Rysgaard, 2002)

Also, low frequency noise can be a factor at much greater distances than audible noise sources. A case study in Northern Carolina near a wind turbine documented low frequency noise problems at residences located more than 1/2 mile from the turbine. (SERI, 1995)

Health Effects of Low Frequency Noise

It is well established that the annoyance due to a given noise source is perceived very differently from person to person. For many humans, their ears are not very sensitive to low levels of low frequency sound. At low frequencies, however, noise may not be perceived as sound but rather is "felt" as a vibration or pressure sensation.

For those who are sensitive to low frequency sound the effects can be dramatic. Complainants often describe the noise as:

- Humming
- Rumbling
- Constant and unpleasant
- Pressure in ears
- Affects whole body
- Sounds like large, idling engine
- Coming from far away

Vasudevan and Gordon 1977) conducted field measurements and laboratory studies of people who complained of low frequency noise in their homes, and concluded the following:

- The problems arose in quiet rural or suburban environments
- The noise was often close to inaudibility and heard by a minority of people
- The noise was typically audible indoors and not outdoors
- The noise was more audible at night than day
- The noise had a throbbing and rumbly characteristic
- The complainants had normal hearing

In an epidemiological survey of sufferers from low frequency noise, the following health effects were documented. Comparisons were made between a test group of people who lived with low frequency noise in their homes, and a control group of individuals not regularly exposed to LFN. (Mirowska and Mroz. 2000)

Symptoms	**Test Group** (%)	**Control Group** (%)
chronic fatigue	59	38
heart ailments	81	54
chronic insomnia	41	9
repeated headaches	89	59
ear, neck and back aches	70	40
ear, eye and other pressure	55	5
shortness of breath	58	10
irritation, nerves, anxiety	93	59
frustration, depression and indecision	85	19

The New Mexico Game and Fish has stated that even for human beings in a recreational setting, low frequency noise has been shown to cause stress reactions including raised blood pressure and increased muscle tension.

Measuring and Regulating Low Frequency Noise

When prominent low-frequency noise components are present, noise measurements based on A-weighting are inappropriate. A-weighting has the effect of reducing measured levels of low and very high frequencies, but has less filtering effect on most mid-range sound frequencies where speech and communication are important.

Berglund et al (1999) have suggested that, "Since A-weighting under-estimates he sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighting." The Danish government, however, does not recommend using the C-weighted noise level to assess low frequency noise, however, because "there is a poor relationship between the C-weighting function and the shape of the equal-loudness contours at low frequencies and low levels."

Many jurisdictions measure both dBA and dBC, and take the following steps (or something similar) to determine whether or not there is a low frequency noise problem:

- **Step 1: Is (dBC - dBA) > x ?**
  The difference between dBC and dBA provides crude information about the presence of low frequency components in noise. Research suggests that when the difference (x) is great enough, that further investigation or action related to low frequency noise is warranted.
  \- In Germany, x > 20 dB is used as an initial indication of the presence of low frequency noise, and the need to conduct further investigations. (Leventhall, 2003)
  \- If x > 10 dB it is recommended by the World Health Organization (1999) that a frequency analysis of the noise be performed.
  \- Kjellberg and co-workers (1997) have suggested that when x > 15 dB, an addition of 6 dB to the measured A-weighted level is a simple procedure for addressing the annoyance.

  Step 2: Conduct frequency analysis of low frequency noise and compare to criteria.
  There are numerous methods for determining the significance of low frequency noise. Over the past 25 years, many European countries (Sweden, the Netherlands, Germany, Denmark) have developed national criteria for environmental low frequency noise. According to Leventhall (2003), the move to develop criteria was driven by specific problems, "particularly gas turbine installations, which radiate high levels of low frequency noise from their discharge."

In Sweden and Germany, low frequency noise may be considered a nuisance if its level exceeds a criterion in any third-octave band. The United States, a standard for low frequency noise from wind turbines has been developed for the U.S. Department of Energy. (Kelley, 1987) Also, some counties in northern Michigan have developed ordinances that reference low frequency noise as a separate than other noise issues. Denmark has taken an entirely different approach. (Please see OGAP/SJCA Submission to the Colorado Noise Stakeholder Committee for more details on the various approaches to regulating low frequency noise).

Fluctuating, Intermittent and Periodic Noise

> ***Fluctuating noises may be far more annoying than predicted by average sound levels.*** (Leventhall, 2003)

Oil and gas pumpjacks can create fluctuating or intermittent noises. Pumpjacks may operate and automatically shut off for specific periods of time. When improperly maintained, pump jacks can develop rubbing noises or squeaking noises.

When there is a cyclical rubbing or squeaking, when machinery operates in cycles, when single vehicles pass by, the noise level increases and decreases rapidly. These sorts of regular or periodic variations of sound pressure levels with time have been found to increase the annoying aspects of the noise. Research suggests that variations at about 4 per second are most disturbing (Berglund et al., 1999). Noises with very rapid onsets could also be more disturbing than indicated by average sound pressure levels (e.g., dBA).

It has been suggested that a penalty of 3 dB may adequately deal with the annoyance caused by fluctuating noise. (Broner and Levanthall, 1983) In Colorado, there is a 5 dB penalty for periodic noises.

Impulsive Noise

> ***Impulsive noise. . . is brief and abrupt, and its startling effect causes greater annoyance than would be expected from a simple measurement of sound pressure level.***
> ~ Environmental Noise Handbook, Breul and Kjaer

Impulsive sounds, such as gun shots, hammer blows, explosions of fireworks or other blasts, are sounds that significantly exceed the background sound pressure level for a very short duration. Examples of impulsive noise in the oil and gas industry could include venting and flaring, pipe-on-pipe impacts due to unloading pipe at a well site, and pile driving.

Typically each impulse lasts less than one second. Measurements with a sound meter set to 'Fast' response do not accurately represent impulsive sounds. To cope with this, a third time constant called I (for impulse) has been developed. The time constant of I is 35 milliseconds, which is sufficiently short to permit detection and display of transient (rapidly changing) noise in a way resembling the human perception of sound.

In Alberta, Canada, measurements of the A-weighted impulse response setting sound level measurement and the A-weighted slow-response setting sound level are taken. If the difference is 10 dBA or less, the impulsive sound is not deemed significant. (AEUB, 1999)

The maximum penalty for impulsiveness varies from country to country, and both subjective (based on the type of source, using a list enumerating noise sources such as hammering, explosives, etc.).and objective methods are used to determine the penalty.

In Colorado and Denmark, a 5 dB penalty is added for impulsive noise, while in France a penalty of 3, 5 or 10 dB is assessed, depending on the duration of the impulsive noise. (Bruel and Kjaer, 2000)

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