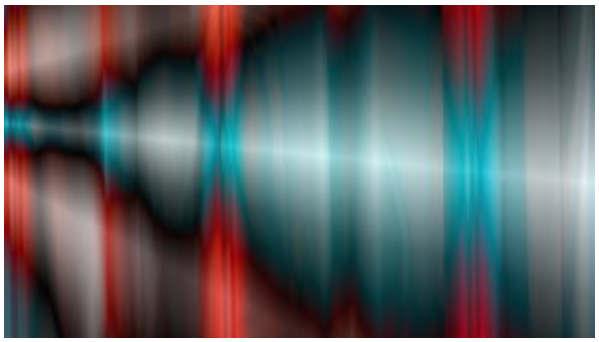
Canadian Audiologist
The Official Publication of the Canadian Academy of Audiology

Annoyance and Low-Frequency Noise

Published July 6th, 2020

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Most noises found in everyday life are broadband in nature, with their energy quasi-uniformly spread across the spectrum. Their measurement and assessment are relatively easy and there are commonly accepted standards on how to do it. There are, however, situations, where most of the energy is concentrated in the lower end of the audible spectra, (the so-called low-frequency noises) where the assessment presents problems that are not yet solved. That is the primary reason for the existence of different methods adopted by different countries and jurisdictions.

Hazardous Noise

In the field of Industrial Hygiene, noise is considered hazardous when it affects the organ of hearing, causing hearing loss. As a stress agent, it may also generate other effects such as annoyance, sleep interference, educational disruption, and speech interference. There can also be effects on the nervous system, the cardiovascular system, and other body systems. However, noises that may lead to effects on systems beyond that of the ear are generally not taken into consideration in noise standards.

As a result of laboratory and epidemiological studies, there is an almost universal consensus that noise exposures above 85 dBA (8hs/day, 5 days/week) may cause hearing loss. This is well documented in the ISO Standard 1999[1] which is a large well-respected international model of noise exposure.

A noise assessment is performed in two steps. The first consists of the measurement of noise exposure. It is performed using preferably an integrating sound level meter or a dosimeter. The second step requires comparing the measured result to the above-mentioned limit of 85 dBA. If the limit is exceeded, then the noise is considered hazardous.

What is not often mentioned is that this criterion applies to broadband noises, such as noises where the energy is spread across the audible spectrum. This is the case with the majority of industrial

and construction noises.

Non-hazardous Noise

There are no uniform criteria for defining a non-hazardous noise. There are guidelines, bylaws, and local regulations that vary among countries and local jurisdictions. One of the reasons for this situation is the complexity of the problem. When dealing with non-hazardous noises, many variables must be considered beyond the sound level.

Some of these variables pertain to the **noise itself**, such as:

- Frequency content
- Duration
- Impulse characteristics
- Special characteristics of the noise that make it irritating

Some of these variables pertain to the **context** within which the noise occurs:

- Time of the day the noise occurs
- History of previous exposure to the noise in question

Other variables may be considered **psychological reactions** to the intruding noise (It is worth remembering the old saying: music is what I do and noise what my neighbor generates…) such as finding it

- unnecessary or unnecessarily loud,
- a threat to personal health and safety,
- a threat to economic investment, and
- beyond the affected person's control.

Whoever has had dealings with annoying noise has many anecdotes to tell about situations where a loud noise was dismissed as such on the basis that the person causing it was a "nice" person. In other situations, the noise was considered intruding just because the person responsible for the noise and the person affected by the noise were not on the best of terms concerning their personal relationship.

Depending on the circumstances, there are some recommended limits, such as 30 dBA inside a bedroom for steady-state continuous noise and 55 dBA
level from steady continuous noisein outdoor living areas. During the night, outdoor levels should not exceed 45 dBA so that people may sleep with their bedroom windows open. In schools, levels should not exceed 35 dBA during teaching sessions. In hospitals during nighttime, the recommended value is 30 dBA.

Establishing limits for non-hazardous noise is very complex. Annoyance is always a problem, no matter how well other effects are controlled.

Problems with Assessment of Low-Frequency Noise (LFN):

There is no definition of what constitutes a low-frequency noise. The term applies to noise with most of the energy contained below 200 Hz but the American National Standards Institute (ANSI) does define Infrasound as “sound at frequencies less than 20 Hz."[2]

LFN does not affect hearing (It may if there was enough energy in or around 150 Hz, that could affect hearing in that region which would affect voice pitch, leading to problems with voice identity/emotion/etc..) in general, but it can be quite annoying. Because of its physical characteristics, it does not decay and travels distances without attenuation. Furthermore, sound barriers, natural or artificial, are mostly ineffective because of the diffracted energy that goes “over” or “around” the obstacle. The transmission loss of materials decays with frequency. Therefore, low-frequency noise penetrates easily through walls into enclosures and living places. To make matters even worse, because of the long-wavelength comparable to the size of rooms and offices, low-frequency noise can generate standing waves with clearly audible “hot spots” that are highly annoying and exceedingly difficult to control.

The use of the A-weighted filter under-values the impact of low frequencies. Therefore, a noise with mainly low frequencies content (such as the one from a large truck engine) will show a low reading on a sound level meter, even though an observer can perceive it as an impressive roar. This author remembers measuring 35 dBA in a workplace that was perceptibly shaking because of the presence of several looms. The noise was felt in the chest of the observers, but remarkably, there was no consequential measurement that could be obtained using the sound level meter.

To summarize, when measuring low-frequency sound sources using the dBA weighting, readings tend to be low, even when the noise is highly annoying. Because of this problem, several attempts have been made to improve the assessment of LFN. The objective has been to obtain a relatively easy way to measure the noise with a result that correlates with the subjective feeling experienced by those exposed to the noise.

A proposal has been made in the past to use the difference between the results of measuring in dBC and dBA and if the difference is substantial to apply a penalty by increasing the dBA reading. Although it has received some acceptance, there is still the need for research to establish:

a. the difference dBC – dBA that will classify a given noise as “low frequency,” and
b. the size of the penalty to be applied to the measured noise. This penalty should be proportional to the dBC-dBA difference.

Conclusion

Here, I have focused on annoyance from non-hazardous, low-frequency noise, and the difficulties in its assessment. The use of dBA is not acceptable unless different limits are set. The dBC – dBA method has also been proposed without defining and justifying the critical parameters mentioned above to provide support for penalties applied to the measured noise levels.

We see a need for psycho-acoustic research to be conducted to define and justify these parameters and in particular:

a. Laboratory studies assessing annoyance from noise with different low-frequency content, both artificial or real-life (occupational, windmills, transit), and
b. Surveys in real-life situations including measurements and questionnaires.

References

1. International Organization for Standardization ISO 1999 (2013): Acoustics - Estimation of noise-induced hearing loss.

2. American National Standard Institute, ANSI/ASA S1.1-2013: Acoustical Terminology.