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Low frequency noise criteria: foundation, applicability and consequences

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Abstract

In recent years in The Netherlands there is an increasing attention to nuisance attributed to low frequency (LF) noise. In order to decide whether there is in practice a LF noise problem and moreover to decide whether noise-reducing measures are necessary, there should be an objective criterion. Key question is whether it is possible to formulate a criterion that deals in an appropriate way with both the interests of the annoyed persons as well as the interests of the possible cause of the LF noise.

There are some criteria that try to deal with the LF noise problems but each criterion has its own characteristics and imperfections. Using some real cases as illustration the available criteria will be evaluated. Doing so, the requirements of an adequate assessment criterion will be discussed.

One of the basic assumptions of the available criteria is the LF hearing threshold. Due to the fact that not many experimental data on hearing thresholds in the LF region are available, most of the mentioned thresholds are based on experimental data in the normal audible frequency band. The perception of LF noise however differs from the perception of 'normal sound' and therefore the 'rules' of normal sound will not automatically apply for LF noise. It is for instance difficult to distinguish between the perception of airborne LF noise and vibrations. Another difficulty of LF noise is that the perception is very individual. This hinders the make of a general criterion.

1. Introduction

In order to evaluate the existing LF noise levels there should be an objective criterion. This is especially the case when there is a discussion between an annoyed person and the possible cause of the LF noise. Noise-reducing measures can not be founded on the subjective perception of one or more annoyed persons.

There are, however, no unambiguous general assessment criteria available. Three in the Dutch situation used LF criteria will be evaluated. Doing so some basic requirements of an adequate assessment criterion will be discussed.

2. The available criteria

In The Netherlands three possible criteria are used for the assessment of LF noise, namely: criteria derived from a VROM-study [1], DIN 45680 [2] and the NSG-guideline LF noise [3].

All three criteria deal with the SPL inside dwellings measured in the 1/3-octave bands.

Figure 1 gives an overview of the three available criteria. The values are given for the frequency regions as mentioned in the criterion, i.e. VROM-study 4 to 160 Hz, DIN 45680 8 to 100 Hz and NSG guideline 20 to 100 Hz.

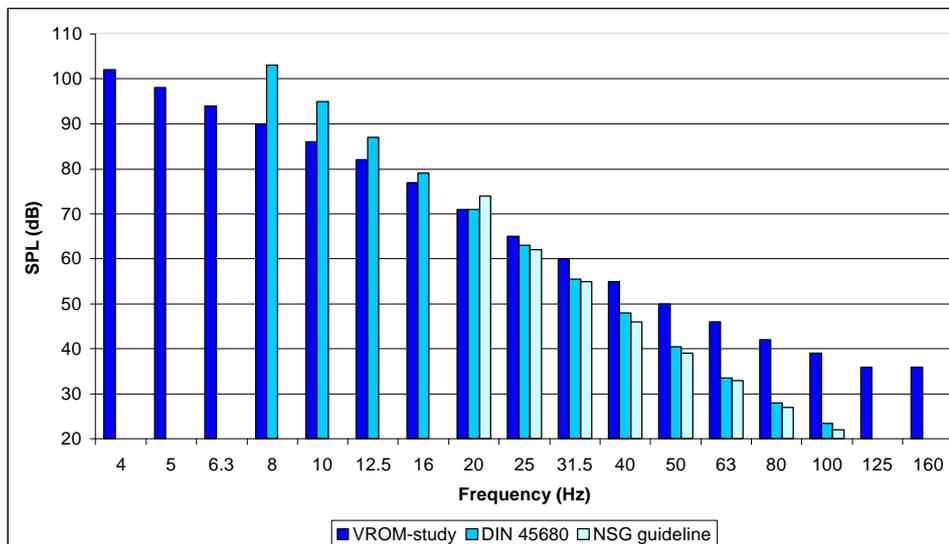


Figure 1: Comparison of three LF noise criteria (proposed limiting value VROM-study based on an allowed value of 25 dB(A); LF hearing threshold according to DIN 45680; reference curve of the NSG guideline LF noise)

The difference between the VROM-study and DIN 45680 / NSG guideline is remarkable. Beneath 20 Hz (infra sound) the VROM curve is noticeable lower than the LF hearing threshold of DIN 45680. The reference curve of the NSG guideline does not deal with the frequencies below 20 Hz. The values mentioned in the NSG guideline for this frequency band are however noticeable higher than the VROM curve. Above 20 Hz (the LF audio region) it is apparent that the VROM curve is higher than both the hearing threshold of DIN 45680 and the NSG reference curve.

Furthermore it can be mentioned that:

- both the VROM-study and DIN 45680 deal with the quality of sound (tonality and/or fluctuation). The NSG guideline does not take this aspect into account;
- the VROM-study and DIN 45680 to a certain extent deal with the link between LF noise and 'normal sound'. The NSG guideline does not take the total SPL in dB(A) into account.

3. Practical use of the available criteria

Given the differences between the available LF noise criteria it is necessary to make a choice between one of these criteria when a LF noise problem arises in practice. Which criterion is acceptable or appropriate? This is not only a matter of 'how to satisfy the annoyed person' (benefit) but also a financial or economical problem (costs). How to deal with LF noise problems when one or more noise criteria are exceeded with substantial noise reducing measures as a consequence?

Figure 2 gives an example of LF noise spectra inside a dwelling. The measurements were performed on two different days but in the same bedroom. In this case the annoyed person was a young woman (less than 30 years) and the possible cause of the annoyance (noise source) was unknown. On the first measurement day the person described the noise during the measurements as annoying but ‘bearable’. On the second measurement day the perceived noise during the measurements was ‘unbearable’.

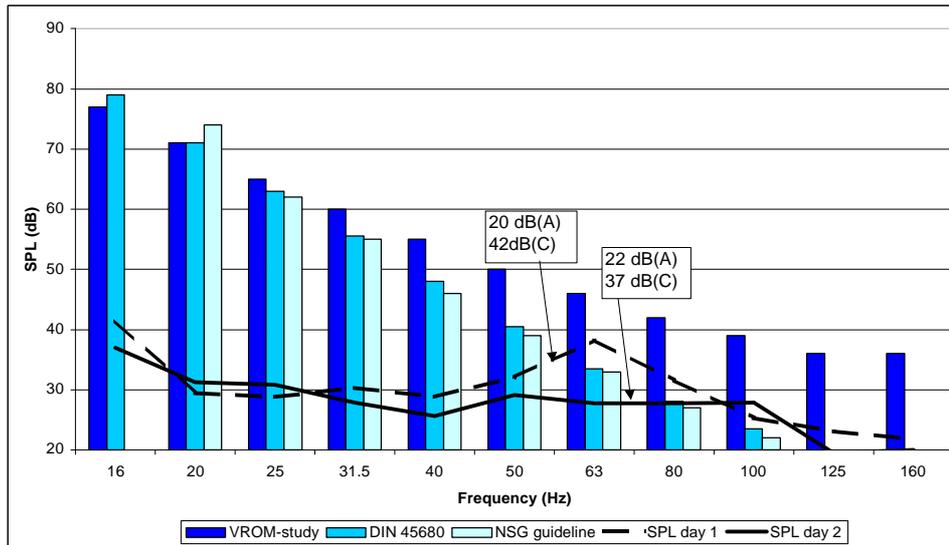


Figure 2: Measured LF noise inside a dwelling (bedroom) compared to the three LF noise criteria (VROM-study; DIN 45680; NSG guideline LF noise)

Given the three assessment criteria the perception of the annoyed person is remarkable. The first day two of three criteria are (amply) exceeded and the second day only one criterion (NSG guideline LF noise) is slightly exceeded. The perception of the person is contrary: the nuisance on the second day was at a higher level than the nuisance on the first day. It should be clear that, based on these measurement data, noise-reducing measures could not be forced. This example is not an unique one; experimental data on more cases confirm this phenomenon. It illustrates that the available assessment criteria do not fully satisfy. Therefore a satisfying, general and unambiguous assessment criterion should be developed. The requirements for a LF criterion are however difficult to derive.

4. Requirements for criteria on low-frequency noise

4.1 Airborne low-frequency noise versus vibration

It is very difficult to distinguish between airborne LF noise and vibration. Under laboratory circumstances a clear distinction between noise and vibration should be possible. In practical situations however this is very difficult.

Moreover, the annoyed persons very often confuse LF noise and vibration. They find it very difficult to describe the feeling or the perception, which gives rise to the complaint.

An adequate LF noise criterion should take these aspects into account. A possibility to do so is for instance an assessment of vibration levels in dwellings.

4.2 Low-frequency noise versus 'normal sound'

Annoyed persons find it very difficult to describe the feeling or the perception of the sound. A good distinction between LF noise and 'normal sound' is difficult. There are however, generally spoken, great differences between the perception of LF noise and the perception of 'normal sound'. For instance, for normal sound a certain level above the hearing threshold is acceptable or even desirable; LF noise exceeding the hearing threshold in most cases gives rise to annoyance resulting in complaints.

Another disadvantage of LF noise versus 'normal sound' is the fact that the SPL inside dwellings strongly depend on the dimensions of the room and the construction of the facade.

A LF noise criterion should deal with these aspects as well as the link between LF noise and 'normal sound'.

4.3 Individual perception versus a general criterion

The perception of LF noise is very individual. From literature [4] it is known that the perception of LF noise depends on:

- the sex: generally women 'suffer' more from LF noise than men;
- the age: elder people often 'suffer' more from LF noise than younger people. This can be explained by the fact that for instance older people usually have a deafness for higher frequencies;
- the state of mind: happy people 'suffer' less from LF noise than more or less unhappy people.

It should be clear that a general LF noise criterion has to deal with these individual aspects. One way to do so is a statistical approach, starting with the LF hearing thresholds. There are, however, not many experimental data available especially on LF hearing thresholds. Most of the literature derives LF hearing thresholds from 'normal hearing thresholds'.

Conclusions

The requirements for a general, unambiguous LF noise criterion are many, complex and differ widely. This hinders the creation of a general criterion.

There is a lack of experimental data on LF hearing thresholds. This makes further investigation on especially LF hearing thresholds necessary.

It is however questionable if the make of an unambiguous, general LF noise criterion is possible. One might even ask if it is necessary or desirable.

References

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