Appendix 17.1

Introduction to Noise

Contents

Tables

Figures

1 Introduction to Noise

1.1 Human Perception

1.1.1 Noise is commonly defined as unwanted sound, and is therefore subjective. The human perception of noise is influenced by physical, physiological and psychological factors. Physical factors include the sound pressure level at the position of the listener, physiological factors include the acuity of hearing, and psychological factors include acclimatisation to steady noise and the activity that an individual is undertaking while the noise is present.

1.1.2 Sound consists of vibrations transmitted to the ear as rapid variations in air pressure which can be measured accurately. The more rapid the variations in air pressure the higher the frequency of the sound. Frequency is defined as the number of pressure fluctuations per second and is expressed in Hertz (Hz).

1.1.3 The ear can detect both loudness and frequency of sound. However, the sensitivity of the human ear varies with frequency, and therefore noise is commonly measured using the A-weighted filter network which mimics the frequency response characteristics of the human ear. The 'A' notation is used to indicate when noise levels have been filtered using the A-weighting network.

1.1.4 Noise levels range from the threshold of hearing at 0 dB(A) to levels of over 130 dB(A) at which point the noise becomes painful. Noise levels over 80 dB(A) are considered potentially damaging to hearing. The table below presents guide to the A-weighted sound pressure levels in common areas and activities.

Table 1: Common Noise Levels

Source	Sound Pressure Level, dB(A)
Threshold of hearing – silent	0
Quiet bedroom	25-35
Quiet rural area	45-50
Suburban areas away from main traffic routes	50-60
Conversational speech at 1m distance	60-70
Busy urban street corner	70-80
Passenger car at 60 kmh and 7m distance	72
Health & Safety 'lower exposure action value' to prevent damage to hearing	80
Heavy diesel lorry at 40 kmh and 7m distance	85
Pneumatic drill (un-silenced) at 7m distance	95
Threshold of pain	130

1.2 Acoustic Descriptors

1.2.1 Outdoor noise levels fluctuate rapidly over time, and therefore to describe the acoustic environment it is necessary to collect statistical data on the distribution of noise levels during the period of interest.

1.2.2 The nomenclature used to represent acoustic quantities can appear complicated, however once understood it becomes a logical and efficient way of qualifying noise levels. As an example, the level recommended by BS 8233:2014 for noise levels in gardens is $L_{Aeq,T}$ 55dB:

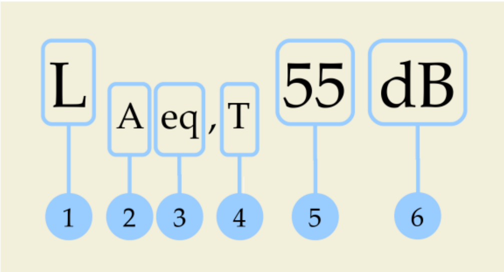

Figure 1: Noise Descriptor Nomenclature

1.2.3 The above descriptor is comprised as follows:

- The first grouping ('L') indicates that the quantity is a *sound pressure level*. Other common quantities are *sound intensity level* (L_I) and *sound power level* (L_W)
- The second grouping ('A') denotes that the sound pressure level is evaluated using the A-weighted filter network
- The third grouping of characters identify the statistical index. In this example, the letters indicate that the quantity is in terms of the ***eq**uivalent continuous noise level* (eq), which has some similarities with the concept of an average noise level. Numerical values are also shown, and these indicate the level exceeded for *n* per cent of the measurement (e.g. a value of $L_{A90,T}$ 45 dB indicates that the A-weighted sound pressure level exceeds 45 dB for 90% of the period analysed)
- The quantity ('T') shown after the statistical descriptor is the duration over which the quantity is evaluated. This is typically represented in minutes or hours, e.g. 15min, 16h
- The fifth term of the statistical descriptor identifies its numeric value. This value is usually given as a whole number or to one decimal place
- The sixth and final group of characters indicate that the units of the sound pressure level are decibels

1.2.4 A variety of statistical indices are used to quantify noise in different situations. The most common are described below.

1.3 Road Traffic Noise

1.3.1 The index adopted by the UK Government to quantify road traffic noise is the $L_{A10,18h,}$ which is the arithmetic mean of the noise levels exceeded for 10% of the time in each of the 18 one-hour periods between 6am and midnight. The $L_{A10,18h}$ index has been shown to have the best relationship with annoyance caused by road traffic noise, which has a strong low frequency content and is often more steady over the course of a day than other sources of environmental noise.

1.4 Ambient Noise Level

1.4.1 General environmental noise from commercial, industrial or unidentified sources is often expressed in terms of the equivalent continuous sound pressure level over the time period of interest ($L_{Aeq,T}$). This is the notional continuous constant noise that contains the same sound energy over the period of interest as the actual fluctuating noise. This is not an 'average' sound level over a period, but the concept has some similarities and provides a single figure quantity that can be used to compare noise levels which fluctuate with time.

1.5 Background Noise Level

1.5.1 The $L_{A90,T}$ index identifies the noise level exceeded for 90% of the period of interest, and provides a good indication of the background noise level that remains in a location in the absence of any easily identifiable sources.

1.6 Maximum Sound Level

1.6.1 The maximum sound level (L_{Amax}) is the highest time-weighted sound level measured during a period. The time constant of the measure may either be **F**ast (125 ms), **S**low (1 s) or **I**mpulsive (35 ms), and it is usual to identify the time constant in the notation – e.g. L_{AFmax} indicates that the maximum sound level was measured with the fast time-weighting. The longer the time constant over which the measurement is integrated, the greater the smoothing effect of the time-weighting, which gives a lower numeric value of the measurement. If it is not clear which time weighting has been used for a measurement, then it is generally assumed to be the fast time weighting as this is most common.

1.7 Vibration

1.7.1 Groundborne vibration is typically measured in terms of velocity (millimeters per second) or acceleration (metres per second). Where sources of vibration are impulsive / intermittent it is the peak velocity or acceleration which is measured (and this will be the maximum value recorded during a specific event).

1.7.2 Acceptable levels for human exposure to vibration and for the evaluation of building vibration with respect to annoyance and comfort are provided in various standards and guidance documents. The table below presents a guide to the effects of vibration levels on buildings and humans.

Table 2: Guidance on the Effects of Vibration Levels

Vibration Level, PPV[1]	Effect
0.14mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction
0.3mm/s	Vibration might be just perceptible in residential environments
1.0mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents
5.0mm/s	Possible cosmetic damage to a building structure may occur from continuous works
10mm/s	Vibration is likely to be intolerable to humans for any more than a very brief exposure to this level. Minor damage to a building structure may occur from continuous works
20mm/s	Major damage to a building structure can occur from continuous works
[1] PPV is defined as the maximum instantaneous positive or negative peak of the vibration signal. It is specified in millimetres per second (mm/s). It should be noted that the PPV refers to the movement within the ground of molecular particles and not surface movement	

1.8 Glossary of Common Acoustic Terminology

A-Weighting

1.8.2 This is a measure of the overall level of sound across the audible spectrum with a frequency weighting (i.e. 'A' weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.

dB

1.8.3 Abbreviation of decibel.

dB(A)

1.8.4 Abbreviation of A-weighted decibel.

Decibel

1.8.5 The scale on which sound pressure level is expressed. In air it is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure ($2x10^{-5}$Pa).

Equivalent Continuous Sound Pressure Level (L_{eq})

1.8.6 The Equivalent Continuous Sound Pressure Level is the notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the A-weighted fluctuating sound measured over that period.

Façade and free-field levels

1.8.7 Due to the effects of reflection, sound pressure levels measured close to large vertical reflecting surfaces such as building façades are higher than those that are measured away from reflective surfaces. Sound pressure levels measured 1m from a large solid, reflecting surface are termed 'façade' levels, while those measured at least 3m away from any reflective surfaces (apart from the ground) are termed 'free-field'. Façade levels are typically 2.5 dB higher than free-field levels and therefore it is important to know the conditions under which a noise measurement or prediction has been undertaken.

L_{10} or L_{A10}

1.8.8 Acoustic nomenclature indicating that the value is exceeded for 10% of the period of interest. This index, evaluated over the period 06:00 to 24:00, is commonly used to describe road traffic noise.

L_{90} or L_{A90}

1.8.9 Acoustic nomenclature indicating that the value is exceeded for 90% of the period of interest. This index is taken to be a good indicator of the background noise level remaining at a location in the absence of any easily identifiable sources.

L_{eq} or L_{Aeq}

1.8.10 Acoustic nomenclature indicating that a value is expressed in terms of the Equivalent Continuous Sound Pressure Level.

Peak Particle Velocity (PPV)

1.8.11 PPV is defined as the maximum instantaneous positive or negative peak of the vibration signal. It is specified in millimetres per second (mm/sec). It should be noted that the PPV refers to the movement within the ground of molecular particles and not surface movement.

Sound Exposure Level (SEL)

1.8.12 SEL is the logarithmic measure of the A-weighted Sound Pressure Level squared and integrated over a stated period of time or event, relative to a reference sound pressure value. The SEL value contains the same amount of acoustic energy over a normalised one second period as the actual noise event under consideration.