

Appendix A9.1

Noise and Vibration Perception and Terminology

Noise

A9.1.1. Between the quietest audible sound and the loudest tolerable sound there is a million to one ratio in sound pressure (measured in Pascals, Pa). Because of this wide range, a noise level scale based on logarithms is used in noise measurement called the decibel (dB) scale. Audibility of sound covers a range of approximately 0 to 140dB. The human ear system does not respond uniformly to sound across the detectable frequency range and consequently instrumentation used to measure noise is weighted to represent the performance of the ear. This is known as the 'A weighting' and annotated as dB(A). Table A9.1.1 lists the sound pressure level in dB(A) for common situations.

Table A9.1.1: Sound Pressure Levels for a Range of Situations

Typical Noise Levels dB(A)	Example
0	Threshold of hearing
30	Rural area at night, still air
40	Public library, Refrigerator humming at 2m
50	Quiet office, Boiling kettle at 0.5m
60	Normal conversation
70	Telephone ringing at 2m, Vacuum cleaner at 3m
80	General factory noise level
100	Pneumatic drill at 5m
120	Discotheque - 1m in front of loudspeaker

A9.1.2. The noise level at a measurement point is rarely steady, even in rural areas, and varies over a range dependent upon the effects of local noise sources. Close to a busy motorway, the noise level may vary over a range of 5dB(A), whereas in a suburban area this variation may be up to 40dB(A) and more due to the multitude of noise sources in such areas (cars, dogs, aircraft etc.) and their variable operation. Furthermore, the range of night-time noise levels will often be smaller and the levels significantly reduced compared to daytime levels. When considering environmental noise, it is necessary to consider how to quantify the existing noise (the ambient noise) to account for these second to second variations.

Background Noise Levels

A9.1.3. A parameter that is widely accepted as reflecting human perception of the ambient noise is the background noise level, L_{90} , this is usually A weighted and can be displayed as L_{90} dB(A) or L_{A90} (dB). This is the noise level exceeded for 90 per cent of the measurement period and generally reflects the noise level in

the lulls between individual noise events. Over a one hour period, the L_{A90} will be the noise level exceeded for 54 minutes.

Road Traffic Noise Levels

- A9.1.4. The index adopted by the Government to assess traffic noise is $L_{A10,18h}$, which is the arithmetic mean of the noise levels exceeded for 10 per cent of the time in each of the eighteen 1-hour periods between 06:00 and 24:00. A reasonably good correlation has been shown to exist between this index and residents' perception of traffic noise over a wide range of exposures. When 18-hour traffic flows are very low it is not possible to predict $L_{A10,18h}$ levels using the standard UK prediction methodology in CRTN and an alternative method using the $L_{Aeq,16h}$ parameter and the Noise Advisory Council method can be used.

Ambient or Activity Noise Levels

- A9.1.5. The equivalent continuous A-weighted sound pressure level, L_{Aeq} (or L_{eq} dB(A)) is the single number that represents the total sound energy measured over that period. L_{Aeq} is the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measurement period. It is commonly used to express the energy level from individual sources that vary in level over their operational cycle.

Noise Changes

- A9.1.6. Human subjects are generally only capable of noticing changes in noise levels of no less than 3dB(A). It is generally accepted that a change of 10dB(A) in an overall, steady noise level is perceived to the human ear as a doubling (or halving) of the noise level. These findings do not necessarily apply to transient or non-steady noise sources.

Free-field and Façade Noise Levels

- A9.1.7. Most environmental noise measurements and assessments are undertaken as 'free-field', away from any existing reflecting surfaces (other than the ground). However, it is sometimes necessary to consider noise levels immediately external to a façade when considering the impact on residents inside properties and this requires the addition of 3dB(A) to the predicted (or measured) free-field level due to noise reflection from the façade.

Sound Power

- A9.1.8. Sound power is the rate per unit time at which airborne sound energy is radiated by a source. It is expressed in watts (W). Sound power level is a logarithmic measure of the sound power in comparison to the reference level of 1pW (picowatt). The sound power level is given the letter " L_w " or SWL. It is not the same thing as sound pressure (L_p). Any L_p value is dependent of the

distance from the noise source and the environment in which it was measured. L_w values are preferred for noise prediction purposes as their value is independent of distance or environment. There are recognised formulas for converting L_w to L_p .

- A9.1.9. A-weighted sound power levels are usually denoted L_{wA} (dB) or sometimes L_w (dBA) or SWL (dBA).

L_{Amax}

- A9.1.10. Even though sounds appear fairly steady to the human ear they are seldom if ever steady in level. To accommodate this factor, sound level meters (SLMs) are generally provided with at least two meter responses or exponential averaging circuits (fast and slow). Fast meter response has a time constant of 1/8th of a second (125ms) and approximates the integration time of human hearing. The maximum level, L_{AFmax} is the highest A-weighted sound pressure level measured during a noise event, on a 'fast' sound level meter response setting. Slow meter response has a time constant of 1 second and is intended to obtain an approximate average value of rapidly fluctuating levels from simple meter readings. L_{ASmax} is the highest A-weighted sound pressure level measured during a noise event, on a 'slow' sound level meter response setting.

Vibration

Peak Particle Velocity (ppv)

- A9.1.11. Vibration-induced damage can arise in different ways, making it difficult to arrive at universal criteria that will adequately and simply indicate damage risk. Damage can occur directly due to high dynamic stresses, due to accelerated ageing or indirectly, when high quasi-static stresses are induced by, for example, soil compaction.
- A9.1.12. Guidance on acceptable vibration levels in structures is provided in *BS5228-2:2009+ A1:2014 Code of practice for noise and vibration control on construction and open sites. Part 2: Vibration*. This Standard recommends that a conservative threshold for minor or cosmetic damage should be taken as a peak particle velocity of 15mms^{-1} at 4Hz increasing to 20mms^{-1} at 15Hz for intermittent vibration to determine whether there is any risk of building damage, particularly from construction works involving piling.

Vibration Dose Value (VDV)

- A9.1.13. The adoption of the VDV parameter is based on social studies undertaken in the 1980s and early 1990s into human response to vibration. *BS6472* requires that the VDV be determined separate for the 16 hour daytime (07.00-23.00) and 8 hour night-time (23.00-07.00) periods.

A9.1.14. The VDV is given by the fourth root of the integral of the fourth power of the acceleration after it has been frequency-weighted:

$$\text{VDV} = (\int_0^T a^4(t) dt)^{0.25}$$

where VDV is the vibration dose value (in $\text{ms}^{-1.75}$)

$a(t)$ is the frequency-weighted acceleration (ms^{-2})

T is the total period of the day (in seconds) during which vibration may occur

VDV_b is the VDV with the appropriate frequency weighting for use with vertical vibration.

A9.1.15. The basic procedure is to estimate, or measure, the frequency weighted root mean square (r.m.s.) acceleration levels, and to integrate the several components with respect to time over the day or night-time period so as to compute the VDV. The VDV is measured in each of the three whole-body orthogonal axes and the maximum from the three axes used. Where the vibration conditions are constant or regularly repeated throughout the day and assessment is based on measured data, only one representative period need be measured, and the 16 hour daytime (or 8 hour night-time) overall VDV level may be calculated from the shortened measurement. The predicted or measured VDV may then be compared to data in section 6 of *BS6472* to identify the likelihood of complaint.