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PERTH TO INVERNESS

Appendix 17.1

Glossary of Acoustic Terminology

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1. Glossary of Acoustic Terminology

1.1. Introduction to Acoustics, Sound and Noise

1.1.1. The word ‘acoustic’ is derived from the Greek words ‘akoustikós’ (meaning "of or for hearing, ready to hear") and ‘akoustos’ (meaning "heard, audible").

1.1.2. Acoustics is the branch of physics concerned with the properties of sound, including ultrasound, infrasound and vibration. A scientist or engineer who works in the field of acoustics is an acoustician or acoustic engineer.

1.1.3. Sound can be measured by a sound level meter or other measuring system. Noise is related to a human response, and is routinely described as unwanted sound, or sound that is considered undesirable or disruptivei. Care has been taken in this document to use the most relevant of these terms (whereby ‘sound’ is used predominantly); however, in most reference documents, and, indeed, generally, ‘sound’ and ‘noise’ are used interchangeably. Consequently, just because the term ‘noise’ is used doesn’t necessary mean a negative effect exits or will occur, and the context of the accompanying text should be taken into account.

1.1.4. Human hearing is able to respond to sound in the frequency range 20 Hz (deep bass) to 20,000 Hz (high treble), and over the audible range of 0 dB (the threshold of perception) to 140 dB (the threshold of pain).

1.1.5. The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify sound in a manner that approximates the response of the human ear, a weighting mechanism is used, which reduces the importance of lower and higher frequencies in a similar manner to human hearing.

1.1.6. The weighting mechanism that best corresponds to the response of the human ear (though not necessarily perfectly) is the ‘A’-weighting scale. This is widely used for environmental sound measurement, and the levels are denoted as dBA, dB(A) or LAeq, LA90 etc. according to the metric being measured or determined (see the Definitions over leaf).

1.1.7. The decibel scale is logarithmic rather than linear, and hence a 3 dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10 dB increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3 dB is generally regarded as the minimum difference needed to perceive a change under normal listening conditions. Where other changes occur (associated with the change in sound level), such as additional vehicle movements on a road, which can be seen, then these may result in changes in sound level being more noticeable than they might otherwise be.

1.1.8. Further to such visual clues, and any other non-acoustical factors that affect people’s response (such personal characteristics, and social, residential or environmental factors), the subjective response to a sound is dependent not only upon the sound pressure level and component frequencies, but also its intermittency. Consequently, various metrics have been developed to try and correlate people’s attitudes to different sounds with the sound level and its fluctuations. The metrics used in this document, as per the relevant guidance, are defined overleaf.

1.2. Definitions

- Acoustic environment: Sound from all sound sources as modified by the environment. Can be actual or simulated, outdoor or indoor, as experienced or in memory. Modifications by the environment includes: effects on sound propagation, resulting, for example, from meteorological conditions; absorption; diffraction; reverberation; and reflection.
- Airborne sound: Sound that reaches the point of interest by propagation through air.
- Ambient sound: Totally encompassing sound in a given situation at a given time, usually composed of sound from many sources near and far.
- Ambient sound level, La = $L_{Aeq,T}$: Equivalent continuous A-weighted sound pressure level of the totally encompassing sound in a given situation at a given time, usually from many sources near and far, at the assessment location over a given time interval, T. It is a measure of the “residual sound” and the “specific sound” when present.
- Annual Average Weekday Traffic (AAWT): The average volume of vehicle traffic of a highway or road for a year, excluding weekends and bank holidays, and adjusted for seasonal variations.
- A-weighting, dB(A): The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
- Background sound: Underlying level of sound over a period, T, which might in part be an indication of relative quietness at a given location.
- Baseline year: For an assessment of noise and vibration, the baseline year is taken as the first full year of operation of the road project.
- Basic noise level (BNL): The measure of road traffic sound at a reference distance of 10 m from the nearside carriageway edge. It is determined from obtaining the estimated sound level from the 18 hour flow and then applying corrections for vehicle speed, percentage of heavy vehicles, gradient and road surface as described in the Calculation of Road Traffic Noise (1988).
- Broadband sound/noise: Sound whose energy is distributed over a wide section of the audible range.
- Calibration: The measurement system/chain should be periodically calibrated, within a laboratory, against traceable calibration instrumentation, to either National Standards or as UKAS-Accredited, as required. The calibration of the system should also be checked in the field using a portable calibrator before and after each short term measurements, and periodically for longer term monitoring.
- Class 1: The Class of a sound level meter describes its accuracy as defined by the relevant international standards – Class 1 is more accurate than Class 2. The older standard IEC 60651 referred to the grade as "Type", whereas the new standard IEC 61672 refers to it as the "Class". The most accurate meters used in the field (as opposed to a laboratory) are Class 1. Class 2 meters can be used in some instances; however WSP use Class 1 (or Type 1) meters by default, as required by BS 4142:2014, for example.
- Context: The circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood. When considering context, pertinent factors include: the absolute level of sound; the character and level of the residual sound compared to the character and level of the specific sound; evidence on human response to the sound; and the sensitivity of the receptor and whether

dwellings or other premises used for residential purposes will already incorporate design measures that secure good internal and/or outdoor acoustic conditions.

- Decibel (dB): A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds (s1 and s2) is given by 20 log10 (s1/s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20 Pa.
- Dwelling: A building used for living purposes. A mobile home used for permanent living should be included in an assessment.
- Façade/façade level: At a distance of 1 m in front of a large sound reflecting object such as a building façade. According to BS 8233:2014, "Façade level measurements of LpA are typically 1 dB to 2 dB higher than corresponding free-field measurements because of the reflection from the façade." The Calculation of Road Traffic Noise (1988) uses 2.5 dB, whilst BS 5228-1:2009+A1:2014 recommends 3 dB. Owing to the latter examples, together with other historical documents, it is more usual to apply 3 dB.
- Fast time-weighting (F): Averaging time used in sound level meters. Defined in BS EN 61672-2:2013 Electroacoustics. Sound level meters. Pattern evaluation tests.
- Free-field/free-field Level: Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5 m away.
- Heavy duty vehicle (HDV): See Heavy vehicles.
- Heavy goods vehicle (HGV): See Heavy vehicles.
- Heavy vehicles: According to the Calculation of Road Traffic Noise (1988), 'heavy vehicles' are vehicles with unladen weight greater than 1.525 tonnes. The classification assumes that vehicles within each group are acoustically similar. However, since this classification system was first introduced in 1975, the proportion of vehicles within the range 1.525 tonnes to 3.5 tonnes has grown significantly and the maximum permissible weight of heavy vehicles has increased from 38 to 44 tonnes. Therefore, the range in vehicle noise emissions within the heavy vehicle category has increased. To address this problem, it is recommended in the Design Manual for Roads and Bridges (2011) that the heavy vehicle category is redefined as vehicles with unladen weight greater than 3.5 tonnes. Those vehicles with an unladen weight between 1.525 and 3.5 tonnes should be treated as light vehicles. Note: heavy duty vehicle (HDV) and heavy goods vehicle (HGV) are typically used interchangeably, as if describing all heavy vehicles matching the adopted weight threshold. Strictly, as the name suggests, HGV wouldn't include buses, but which would need to be checked.
- Hertz (Hz): The unit of Frequency or Pitch of a sound. One hertz equals one cycle per second. 1 kHz = 1000 Hz, 2 kHz = 2000 Hz, etc.
- $L_{AF10,18h}$: The $L_{AF10,18h}$ level is the arithmetic mean of all the levels of L_{AF10} during the period from 06:00 to 24:00. From research, it has been found that subjective response to road traffic noise is closely linked to higher sound levels experienced and is correlated well with the $L_{AF10,18h}$ index. Unless stated otherwise, it should be measured/presented using the fast time-weighting (F).
- $L_{AF10,T}$: The A-weighted sound pressure level exceeded for 10% of the time over the period, T, measured using fast time-weighting (F), see below. It can be considered to be the "average maximum" sound level, and is generally used to describe road traffic sound.
- $L_{AF90,T}$: The A-weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T, measured using time

fast time-weighting (F). Generally used to describe the 'background' sound conditions.

- L_{AFmax}: The maximum A-weighted sound pressure level during a given time period. L_{max} is sometimes used for the assessment of occasional loud sounds, which may have little effect on the overall L_{eq} noise level, but could still affect the sound environment. Unless described otherwise, it is measured using the fast time-weighting (F).
- $L_{eq,T}$: A sound level index called the equivalent continuous sound level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded. Where the value is A-weighted, is will be presented '$L_{Aeq,T}$' or 'dBA $L_{eq,T}$', otherwise is should be an un-weighted (or linear) value.
- Line source: A sound source composed of many point sources in a defined line, such as a train, flow of traffic on a motorway, or constant aircraft take-offs and landings. Sound levels measured from line sources decrease at a rate of 3 dB per doubling of distance.
- $L_{night,outside}$: In terms of assessments of night-time road traffic noise based on the Design Manual for Roads and Bridges, the $L_{night,outside}$ index is the equivalent continuous sound level $L_{Aeq,8h}$ for the period 23:00 to 07:00 hours assessed outside a dwelling and is free-field.
- L_{night}: In terms of assessments of road traffic noise based on the Design Manual for Roads and Bridges, the L_{night} is a façade level derived from the $L_{AF10,18h}$ using the TRL conversion method.
- L_{night}: In terms of Directive 2002/49, the L_{night} is the equivalent outdoor sound pressure level associated with a particular type of sound source during night-time (at least 8 hours), determined over all the night periods of a year.
- L_p: See Sound Pressure Level.
- L_W: See Sound Power Level.
- Noise-sensitive premises (NSP): A term from BS 5228-1:2009+A1:2014, representing any occupied premises outside a construction site used as a dwelling (including gardens), place of worship, educational establishment, hospital or similar institution, or any other property likely to be adversely affected by an increase in sound level.
- Octave/octave band: Band of frequencies in which the upper limit of the band is twice the frequency of the lower limit. For example, the 1000 Hz (1 kHz) octave band contains noise energy at all frequencies from 707 to 1414 Hz.
- Percentile level: The sound pressure level exceeded for N% of a specified time interval, see $L_{AF90,T}$ etc.
- Point source: A sound source whose dimensions are small compared to the propagation distances involved. Due to the Inverse Square Law, the sound level pressure level decreases by 6 dB every time the distance between the measurement point and the source is doubled.
- Residual sound: ambient sound remaining at the assessment location when the specific sound source is suppressed (or absent) to such a degree that it does not contribute to the ambient sound.
- Residual sound level, $L_r = L_{Aeq,T}$: Equivalent continuous A-weighted sound pressure level of the residual sound at the assessment location over a given time interval, T

- Sound level metrics, Indices or Parameters: Sound levels usually fluctuate over time, so it is often necessary to consider an average or statistical sound level. This can be done in several ways, so a number of different metrics have been defined, according to how the averaging or statistics are carried out.
- Sound power: The sound energy radiated per unit time by a sound source. Measured in Watts (W).
- Sound power level, L_W: Sound power measured on a decibel scale, relative to a reference value of 10^{-12} W.
- Sound pressure: Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
- Sound pressure level (sound level), L_p: The sound level is the sound pressure relative to a standard reference pressure of 20 Pa ($20x10^{-6}$ Pascals) on a decibel scale.
- Soundscape: Acoustic environment as perceived or experienced and/or understood by a person or people, in context.
- Third-octave band: Octave bands sub-divided into three parts, equal to 23% of the centre frequency. Used when octave analysis is not discrete enough. The cut-off frequencies have a ratio of 2 1/3, which is approximately 1.26. For example a 1 kHz third-octave band filter has a centre frequency of 1000 Hz with lower and upper frequencies of 891 Hz and 1112 Hz respectively.
- Type 1: See Class 1 above.
- UKAS: United Kingdom Accreditation Service, recognised by government to assess organisations that provide certification, testing, inspection and calibration services against internationally agreed standards.

[i] Taken from the Foreword to BS 4142:2014 *Methods for rating and assessing industrial and commercial sound*.