The North Wales Wind Farms Connection Project

Environmental Statement Chapter 13 - Emissions Technical Appendix 13.1

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Appendix 13.1 Description of Noise and Vibration Units

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DESCRIPTION OF NOISE AND VIBRATION UNITS

1 NOISE

1.1.1 •The sounds that we hear are a result of successive air pressure changes. These air pressure changes are generated by vibrating sources, such as motor vehicle engines, and they travel to a receiver, i.e. the human ear, as air pressure waves.

1.1.2 The human ear is capable of detecting a vast range of air pressures, from the lowest sound intensity that the normal ear can detect (about 10-12 watts/m2) to the highest that can be withstood without physical pain (about 10 watts/m2). If we were to use a linear scale to represent this range of human sensitivity it would encompass a billion units. Clearly this would be an unmanageable scale yielding unwieldy numbers.

1.1.3 The scale can be compressed by converting it to a logarithmic or Bel scale, the number of Bels being the logarithm to the base 10 of one value to another (as applied by Alexander Graham Bell to measure the intensity of electric currents). The Bel scale gives a compressed range of 0 to 12 units which in practice is a little too compressed. A change of 1 Bel represents a doubling or halving of loudness to the average listener. A more practical operating range of 0 to 120 is obtained by multiplying by 10, i.e. 10 x Bel, which produces the scale units known as decibels or dB.

1.1.4 Examples of typical sound intensity levels within the decibel range of 0 to 120 dB are listed below:

- Four engine jet aircraft at 100m 120 dB;
- Riveting of steel plate at 10m 105 dB;
- Pneumatic drill at 10m 90 dB;
- Circular wood saw at 10m 80 dB;
- Heavy road traffic at 10m 75 dB;
- Telephone bell at 10m 65 dB;
- Male speech, average at 10m 50 dB;
- Whisper at 10m 25 dB
- Threshold of hearing, 1000 Hz 0 dB

1.1.5 Due to this logarithmic scale noise levels have to be combined logarithmically rather than arithmetically. For example, two equal sound sources of 70 dB each, when operated simultaneously, do not produce a combined level of 140 dB but instead result in a level of 73 dB, i.e. a rise of 3 dB for each doubling of sound intensity. Subjectively, a 3 dB change does not represent a doubling or halving of loudness; to make a sound appear twice as loud requires an increase in sound pressure level of about 10 dB.

1.1.6 The sensitivity of the human ear to different acoustic frequencies of sound can be taken into account when measuring or calculating noise by applying a filter or weighting which equates to the frequency response of the human ear. This is referred to as an A-weighting and when applied results in noise levels expressed as dB(A). dB(A) noise levels reflect the human perception of loudness.

1.1.7 Due to the often broadband and variable nature of environmental noises such as traffic, people exposed to different levels of noise do not make consistently different judgements about the noise climate until the difference in average noise level is about 3 dB(A). This is equivalent to a doubling of sound energy or, for example, a doubling of traffic flow. However, individuals are able to detect much lesser changes in noise exposure in any given situation and under ideal conditions can detect differences of as little as 1dB.

1.1.8 Noise levels that fluctuate over time can be measured using a variety of noise indices. One index that correlates fairly well with community annoyance due to road traffic noise is the $L_{A10\ (18\text{-hour})}$ noise index. The L_{A10} is the A-weighted sound level exceeded for 10% of the time, and the $L_{A10\ (18\text{-hour})}$ is the arithmetic mean of the 18 hourly L_{A10} values during the period 6am to midnight (0600 to 2400 hours).

1.1.9 An alternative index used in the UK to characterise intermittent sources of noise such as railways or construction sites is the equivalent continuous noise level, L_{Aeq}. It is a measure of the total sound energy generated by a fluctuating sound signal within a given time period and can be derived by 'spreading' the total sound energy evenly over the same time period as the fluctuating signal, hence the term 'equivalent continuous noise level'.

1.1.10 Other useful noise units include the L_{Amax}, which is the maximum A-weighted sound level often used to characterise single events, and the L_{A90} which is the level of noise exceeded for 90% of the time and is an indicator of the background noise levels in the absence of specific sources such as traffic.

2 VIBRATION

2.1.1 Vibrating sources, such as motor vehicle engines or the movement of vehicles over road surface irregularities, can produce not only displacement of the air molecules which we perceive as noise, but also displacement within the material components of the source or materials in contact with the source. These energy waves can travel through the ground in a similar manner to air pressure waves through the atmosphere and, dependent on the amount of energy being transmitted, be perceived as vibration.

2.1.2 Vibration can produce three effects:

- at levels above the threshold of perception it may cause human annoyance;
- at extreme levels (above those commonly associated with road traffic) it may cause building damage; and
- it may be re-radiated as audible noise.

2.1.3 Vibration can be defined as an oscillating motion about a fixed reference position. The number of times that a complete oscillation takes place during one second is called the 'frequency' measured in hertz (Hz) or cycles/second. The movement of an oscillating body can be described in terms of its displacement, velocity or acceleration.

2.1.4 For a simple oscillating signal, the peak-to-peak value measures the maximum excursion of the vibration about the stable reference position, it is particularly useful for measuring the vibratory displacement of machine parts. The peak value is the highest positive excursion from the stable reference position and is used to measure the energy level of short duration shocks; these are commonly measured as peak particle velocity (ppv) in mm/s.

2.1.5 For a complex vibration signal, the peak measures described above will not take account of the fluctuations that occur with time; this is called the signal's 'time history'. The RMS or 'root mean square' value is the most appropriate unit for measuring either the destructive abilities of a vibration or its potential for causing human annoyance because it takes account of the full time history of the signal and provides an amplitude value which is directly related to the energy content. Values are commonly measured as rms accelerations in m/s^2.

2.1.6 For a symmetrical signal the positive and negative excursions are equal, therefore, if the signal were to be averaged a ‘zero’ value would be obtained. This effect can be countered by first squaring the signal values before taking a mean. (The square of a negative value produces a positive value.) This squaring action will of course overestimate the vibrational energy and needs to be countered in turn by finally taking a square root of the mean, hence the term ‘root mean square’.

2.1.7 The probability of adverse comment due to a given vibration time history can be determined by using the rms frequency weighted acceleration and the duration of exposure to calculate a Vibration Dose Value (VDV). The VDV has ‘fourth power’ time dependency, therefore, unlike the rms value (which uses the square root of a squared value) the VDV is derived from the fourth root of the integral of the fourth power of the acceleration, in units of $m/s^{1.75}$. It provides a time dependent and frequency weighted unit of vibration that correlates with human response.