THE USE OF L_{Aeq} IN MINERAL EXTRACTION NOISE ASSESSMENT

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1. INTRODUCTION

The United Kingdom is currently undergoing a "Green" revolution. Developments of every kind are now subject to a close scrutiny of their environmental implications. This is particularly so in the case of mineral extraction sites where noise is often put forward by the Local Planning Authority (LPA) as one of many reasons for refusal of planning permission. Such a decision invariably results in a Public Inquiry at which evidence regarding predicted noise levels and their impact on the surrounding community can be presented. Recent experience by Wimpey Environmental at such Inquiries, however, is that differing assessment procedures and noise indices are submitted, resulting in a certain incompatibility between the evidence of opposing parties.

This paper discusses the use of L_{Aeq} in the assessment of noise from mineral extraction sites. The method of predicting noise in terms of dBL_{Aeq} from a number of operations on a site will be illustrated with reference to practical situations. Case histories will also be presented .

Reference will be made to published research work and forthcoming planning guidance notes together with the use of planning conditions framed in terms of L_{Aeq}.

2. HISTORICAL BACKGROUND

L_{Aeq} is more accurately expressed as the A-weighted, energy-equivalent, continuous sound pressure level i.e a continuous level of noise containing the same sound energy as the actual time-varying sound. Exact mathematical definitions are readily available(1) although in acoustical terms, L_{Aeq} is not a very old concept.

It may, therefore, be useful to consider some references to mineral extraction noise assessment and L_{Aeq}.

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The Wilson Report, 1963(2):

The recommendations of this Committee have been the cornerstone of much environmental noise legislation – indeed some local authorities still quote it in planning conditions. Specific reference is made to noise from mineral workings and these activities are likened in the report to construction or civil engineering projects. This analogy is both valid and frequent throughout subsequent studies. For mobile plant it is suggested that;

> "at present, noise levels in daytime outside the nearest building at the window of the occupied room closest to the site boundary, should not exceed :–
> 70 dBA in rural, suburban and urban areas away from main road traffic and industrial noise;
> 75 dBA in urban areas near main roads and in heavy industrial areas".

No further elaboration on the noise descriptor is given. Reference is, however, made to internal noise levels in dwellings which "should command wide acceptance". These are given as 40 dBL_{A10} during the day and 30 dBL_{A10} at night.

No mention is made of L_{Aeq} in the Wilson Report.

The Noise Advisory Council – Noise Units (3) :

In 1975 the Research Sub–Committee of the Noise Advisory Council (NAC) were considering prospects for a "unified measure" of noise. A Working Party was appointed with the following brief:

> "To prepare a critical review of present methods of quantifying noise in urban areas in relation to the response it arouses; to determine whether a unified index is available by which noise from different sources acting singly or together may be measured in relation to subjective reaction; to preview any work which might be necessary to develop such a unified index; and to report to the Sub–Committee".

The Working Party considered a number of characteristics required of a unified noise scale;
a) it should concur in numerical terms with peoples' response to noise
b) it should permit the influence of background noise to be determined

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c) it should be applicable to various kinds and mixtures of noises
d) it should be amenable to prediction of scale values for use in planning purposes
e) it should be capable of rating noise from a single event and from an arbitrary succession of events
f) it should be internationally acceptable

Various national and international noise descriptors were considered but these were reduced to a choice of two. L_{Aeq} was one of them and the other was Noise Pollution Level (L_{NP}) (4). This descriptor incorporates L_{eq} but accounts for the variability of intruding noise events.

The Working Party concluded that noise level measurements should be made using the A-weighting scale. It was also concluded that L_{NP} was better at determining human reaction than L_{Aeq} since it directly accounts for the variability of the noise. The advantage in accuracy, however, was outweighed by the disadvantageous increase in complexity of calculation.

A tentative suggestion was, therefore, made to adopt L_{Aeq} as the unified noise scale, pending the outcome of further research work on the subject whereby a direct comparison with L_{NP} could be made.

British Standard 5228:1975 - Code of Practice for Noise control on construction and demolition sites(5):

Section three of this standard describes noise and neighbourhood nuisance. It recommends the use of L_{Aeq} for the assessment of community response to noise. Guidance on measurement and prediction, together with typical plant noise levels and noise control procedures, is given although no reference to acceptable limits is made. Valuable data on measurement and prediction of L_{Aeq} for site operations was contained in a report produced by the Construction Industry Research and Information Association (6).

BS5228 was revised in 1984 (7) although levels of plant noise which are quoted, are typically excessive due to new technology and subsequent EEC legislation. Many of the noise prediction techniques which are described are, however, very useful in assessing the noise impact from mineral extraction sites.

The Noise Advisory Council – Guide to Measurement and Prediction of L_{eq} – (8):

Following the publication of Noise Units(3), subsequent legislation began to incorporate L_{Aeq}. This reflected a gradual legislative transition to L_{Aeq} and in order to facilitate this the NAC published a "Guide to Measurement and Prediction of the Equivalent Continuous Sound Level L_{eq}."

Section 4.4 refers to noise from industrial premises, fixed installations and construction sites. The Working Party recognised, however, that the inclusion of construction sites into this category may not be appropriate due to the mobile nature of the noise sources.

The Guide then goes on to provide advice on an approach to noise prediction.

3. PREDICTION TO OBTAIN L_{Aeq}

Source Noise Data. The measurement of sound power levels from earth–moving machinery and construction plant has been harmonized under EEC Directives(9). Different types of plant must now conform to agreed levels of sound power which are related to the mechanical output power of the machine. This information should be readily available to consultants since all plant should clearly display a sticker indicating its sound power output. There are, however, a number of problems associated with this information: a) The figure quoted is usually an upper classification limit to which the machine conforms i.e actual noise emissions may be several dB lower b) The figure quoted is an average based on measurements taken at several positions around the machine c) No frequency dependent levels are provided. Bearing these limitations in mind, however, this information can readily be used to evaluate L_{Aeq} at a given distance from the machine.

Manufacturers' data is usually based on EEC certification information or typically is presented in "dBA" at given distances from the machine.

The accuracy of computer predictions for planning purposes can be severely limited by the accuracy of the input noise data. The preferred approach is, therefore, to measure noise from comparable machines at existing sites. This allows operational sound power levels to be determined, together with octave/third–octave band information. Having measured this information the value of L_{Aeq} at a particular receiver position can be calculated in each octave band, accounting for attenuation during propagation and with reference to the operating time of the source. The resulting spectra at the receiver position are then A-weighted and logarithmically added to give a resulting figure of $L_{Aeq,(T)}$ over the time period T.

Having obtained sound power information for the particular source by one of the above methods the sound pressure level can be calculated at a distance "r" by assuming a point source radiating above a hard, flat surface.

$$L_p = L_w + DI - 20 \log r - 11 \text{ dB}.$$

Directional information is usually unavailable, so hemispherical radiation is normally assumed. This results in DI = 3dB. The sound power level relates to continuous operation of the machine at full power. In the real situation with plant operating on a mineral extraction site a 50% operational time at full power is typical; for example a bulldozer will push forwards at full power and then reverse at low power.

Sound Propagation. Using the above as a starting point, other effects which provide excess attenuation must be considered. One of the most significant of these is barriers. Even though Maekawa's paper on the subject was published more than twenty years ago (10) it is still found in regular use. Much work has taken place on the subject since then, however, and it is questionable whether Maekawa's "equivalent thin screen" approach should be applied to wide barriers such as buildings, hills and cliff faces since it may well underestimate the true attenuation of these wide structures. Limiting values of attenuation may, in reality, be of the order of 20–25 dB.

Another contentious area is that of excess ground attenuation. This is an important consideration in the case of mineral extraction for two reasons. The first of these is the large distances involved and the second is the frequency range which is dominant in the noise sources. For engineering purposes, the approaches described in Calculation of Road Traffic Noise (1988) (11) and in the CONCAWE report(12) have been found to be useful. CRTN should be used for distances up to 300m after which the CONCAWE technique should be adopted. Atmospheric absorption, wind and temperature gradients and the effect of vegetation/tree cover over the intervening ground may also be considered although generally their effect will be marginal and open to much debate.

Wimpey Environmental uses a computerized prediction technique which allocates plant on a grid and calculates received noise levels at position on a matrix around the site. Allowances are made for ground absorption, barriers etc.

4. ESTABLISHING NOISE LIMITS

The general trend in the assessment of environmental noise at this time is a move towards the use of L_{Aeq} as the sole noise descriptor. This is reflected, for example, in British Standard 4142:1990(13) for rating industrial noise, draft mineral planning guidance note (MPG) 11,(14) and draft planning policy guidance (PPG) note "Planning and noise" (15). Indeed the draft PPG states that "the equivalent noise level over a time period T ($L_{Aeq,T}$) has emerged as the best general purpose index for environmental noise". The draft PPG refers to mineral extraction under the heading of construction and waste disposal sites. It states, however, that noise from mineral extraction sites should be referred to MPG note 11, 1992. For construction noise, however, the PPG note suggests a night-time limit of 45 $dBL_{Aeq\ (1\ hour)}$ at 2m from the facade of the nearest noise sensitive property (night-time to be defined by local circumstances).

The most recent and significant piece of work in this area has been carried out by W S Atkins Engineering Sciences for the Department of the Environment (16).

As a result of noise measurement surveys, noise predictions and social surveys around various quarries, the following limits are proposed;

Mobile plant 55 – 60 $dBL_{Aeq,\ (1\text{-}hour)}$ (0700–1900)
Fixed plant 50 – 55 $dBL_{Aeq\ (1\text{-}hour)}$ (0700–1900)

40 – 45 $dBL_{Aeq,\ (1\text{-}hour)}$ (2200–0600)
45 – 50 $dBL_{Aeq,\ (1\text{-}hour)}$ (Other times)

MPG note 11 presents mineral planning authorities (MPA's) with a range of conditions in which planning conditions may be framed. These may be set with consideration to the background noise level or may be set in absolute terms. The MPG note does state, however, that a MPA "must bear in mind that it is the total noise received at a property which is important". The note then goes on to state that "noise limits should be set in terms of $L_{Aeq\ (T)}$ over a 1–hour measuring period." There are a number of difficulties with MPG 11 as it stands at present. These have been highlighted in detail by a working party of the Institute of Acoustics.(17)

Since it is likely to be the case that for planning applications, measurements and predictions are likely to be free–field, conversion to facade levels will have to be made. This will require the addition of between 1 and 4 dB to the measured/ predicted levels.

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5. CASE HISTORIES

Recent case histories involving measurement and prediction of L_{Aeq} for mineral extraction sites will be discussed. Reference to landfill sites will also be made where the same noise sources are involved as for mineral extraction sites.

6. CONCLUSIONS

The general trend in the measurement, prediction and evaluation of environmental noise is towards the adoption of L_{Aeq} as a unified noise descriptor. In the case of mineral extraction sites it is appropriate to measure, predict and phrase noise limits in terms of L_{Aeq}. It is sometimes criticised that L_{Aeq} does not adequately take account of high levels of noise which are of short duration. With the exception of blasting, other noise on mineral extraction sites is appropriate for evaluation in terms of L_{Aeq}. On some occasions, it has been argued that a 5dB tonal penalty should be applied to mineral extraction noise, but there is no evidence that this is a reasonable approach for normal site operations.

7. REFERENCES

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