BRITISH ACOUSTICAL SOCIETY

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"IMPULSIVE NOISE: UNIVERSITY OF NEWCASTLE-UPON-TYNE".

A METHOD FOR THE ASSESSMENT OF IMPACT NOISE WITH RESPECT TO INJURY TO HEARING

A.M. Martin

Institute of Sound & Vibration Research - University of Southampton

1. ABSTRACT. A three-part system of measurement is described which is intended to meet the need for the assessment of impact noises encountered in a wide range of occupations. The system is based upon the conclusion that an energy concept is valid for long-term exposures to impact noise. It sets out simple methods for the measurement of "equivalent-continuous noise level" of various types of noise. Impact noise is divided into three categories according to repetition rate. Measurement technique varies according to category; but the system as a whole is intended to fit in with the Hygiene Standard for Wide-Band Noise recently published by the British Occupational Hygiene Society (1971).

2. INTRODUCTION. At the present time there is no widely accepted means whereby risk to hearing can be predicted for exposures to the types of impact noise normally encountered in industry. The term impact noise is used here to include all noises with pressure-amplitude-time waveforms consisting of a high pressure peak followed by an approximately exponential decay in the pulse envelope. Atherley and Martin(1971) have shown that the "immission" concept proposed by Robinson(1968) in connection with continuous noise may be extended to include industrial impact noise. They put forward equations which relate certain parameters of impact noise to equivalent-continuous noise level (ECNL). This is the level in dB(A) of continuous noise that would deliver in the course of 8 hours the same amount of sound energy as is actually received over a typical working day (Hygiene Standard 1971). ECNL is derived from a combination of two factors: the measured A-weighted sound level(L_A), or alternatively the equivalent A-weighted sound level (L_{AEq}), and the length of time of exposure (t) during a typical working day. The determination of these parameters, and hence the ECNL of a particular noise, allows an assessment of that noise to be made in terms of the hygiene standard. In the system of measurement to be described, the sound level of the noise is derived from measurements of the pressure waveform (in some cases the sound level can be measured directly). The system is designed to deal with broken patterns of exposure, fluctuation levels, and combinations of different types of noise.

3. THE MEASUREMENT OF ECNL FOR IMPACT NOISE. Impact noise may be classified into three categories according to repetition rate (Martin, 1970). The techniques involved in measuring the ECNL of a noise are governed by the category to which the noise belongs. Measurements may be made directly or from tape recordings. Where the A-weighted sound level can be measured directly, a precision sound level meter (SLM) is used. In all other cases a microphone and amplifier (or equivalent) should be used in conjunction with a calibrated oscilloscope.

3.1 CATEGORY 1: impact noises with repetition rates greater than 10 impacts/second. The A-weighted sound levels of noises in this category are measured directly using a precision sound level meter

with the meter time constant set to "slow". The measurements are dealt with as though the noise were continuous in character. If the duration of the noise is 8 hours per day, the sound level registered by the SLM will give ECNL directly. If the total exposure time, t, is less than 8 hours per day, ECNL may be derived from chart A.

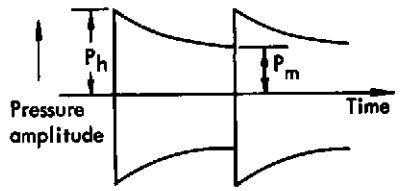


FIG 1

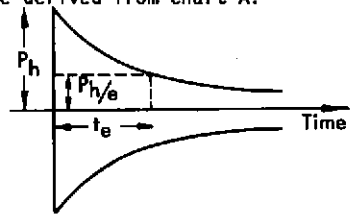


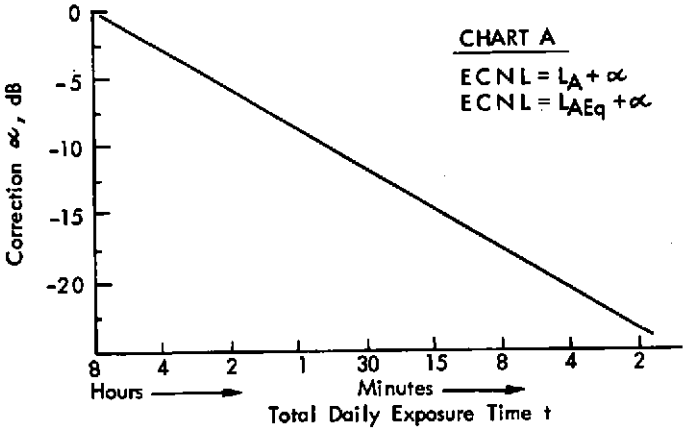
FIG 2

This gives a correction, Y, in dB which is to be added to the measured sound level for various values of the total exposure time.

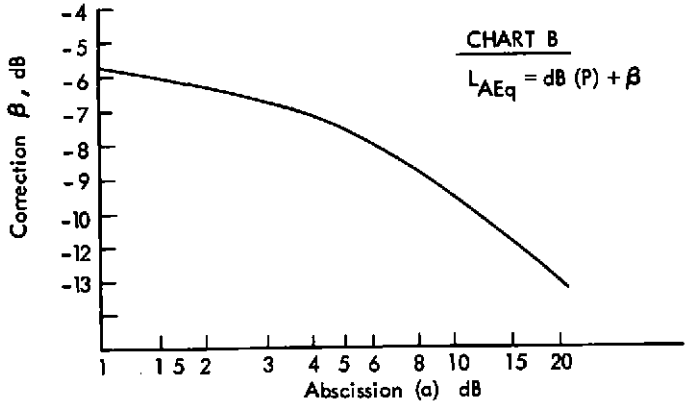
Short-term fluctuations in level of less than 10 dB(A) may be dealt with by "eye-averaging" the meter reading. If these variations are between 5 and 10 dB(A), 1 dB should be added to the average. For fluctuations in excess of 10 dB(A), or where the sound level varies more slowly with time, ECNL should be calculated for each individual level and its total "on" time using chart A. The individual values of ECNL are then summed using one of the standard Techniques for the addition of decibels. (See for example the Hygiene Standard, 1971).

3.2 CATEGORY 2: noises with repetition rates in the range 1 to 10 impacts/second. The pressure-time trace of noises in this category are displayed on a calibrated oscilloscope and their equivalent A-weighted sound levels are calculated from the waveform parameters. However, owing to the fact that it is sometimes difficult to obtain an accurate value for the decay-time parameter under certain conditions, the measure taken from the oscilloscope trace depends upon the characteristics of the noise which may be sub-divided into two types. (i) If the rate of decay of the impact is relatively slow, ie. they do not decay to a low level (less than 10 dB below the peak) or there are large irregularities in the decay envelope, the abscission, a, of the waveform is determined. Abscission is defined as the difference in decibels between the peak sound pressure, P_h, of an impact and the minimum sound pressures, P_m, reached by the decay of that impact. A drawing of the envelope of a typical pressure waveform of this type is shown in figure 1, together with the relevant parameters. The oscilloscope graticule should be calibrated in terms of sound pressure in Newtons/metre^2. Average values of the parameters P_h and P_m, both in Newtons/metre^2, are measured from the oscilloscope trace of the noise and the abscission is calculated from the expression:- $a = 20 \log_{10}(P_h/P_m)$. The peak sound pressure P_h is then converted to dB(P) using the expression:- $dB(P) = 20 \log_{10}(P_h) + 94$. The equivalent A-weighted sound level of the noise may then be derived by adding a correction β, in dB, to the peak value in dB(P), thus:- $L_{AEq} = dB(P) + \beta$. Where β is dependent upon the abscission. Chart B gives values of β for abscissions between 1 and 20 dB. (The technique is only useful for values of abscission within this range). If the exposure time of the noise is 8 hours per day, then ECNL is equal to L_{AEq}. Again, if the total exposure time is less than 8 hours, L_{AEq} is converted to ECNL by means of the on-time adjustments shown in chart A.

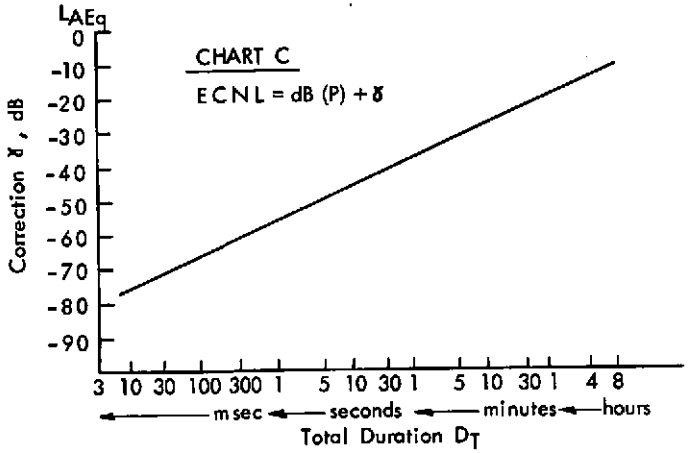
Short-term variations in the parameters P_h and P_m, in Newtons/metre^2 of less than 20% may be averaged arithmetically. In cases where larger fluctuations of these parameters occur with time, the individual values of ECNL should be derived separately in conjunction with chart A and summed using the standard techniques. (ii) If the abscission of the noise is greater than 20 dB ie. the impacts decay to a relatively low level or the decay is exponential and regular, the decay-time



Corrections to be added to L_A or L_{AEq} to derive ECNL



Corrections to be added to peak value, in dB (P), to derive L_{AEq}



Corrections to be added to peak value, in dB (P), to derive ECNL

parameter may be determined with reasonable accuracy. In this case the noise may be measured and treated as in category 3.

3.3 CATEGORY 3: impact noises with repetition rates less than 1 impact/second. The pressure waveforms are displayed on the screen of a calibrated oscilloscope. A typical waveform in this category, and the parameters employed to describe it, are shown in figure 2. The ECNL of such noises may be determined directly from a knowledge of these parameters.

Average values of the peak sound pressure, P_h, in Newtons/metre^2 and the decay time, t_e, in seconds are measured from the waveform. Decay time is defined as the time taken for the envelope of the pressure waveform to decay to $1/e$ (ie.0.37) of the original peak value. The total number of impacts generated in an 8 hour day, N_T, is determined and the total duration, D_T, is then calculated from the expression:- $D_T = N_T \times t_e$. Next the peak sound pressure, P_h, is converted to dB(P). ECNL may then be derived directly by adding a correction, γ, in dB to the peak value in dB(P), thus:- ECNL = dB(P) + γ. Where γ is given in chart C for different values of the total duration, D_T.

Short term variations in P_h may be treated as described for category 2 and similar variations in t_e may be averaged arithmetically. However, for large fluctuations with time in either of these parameters, it is preferable to deduce the individual ECNLs.

4. DISCUSSION. Accurate calibration of the measuring equipment, before and after making measurements is most important. It is recommended that a non-random standard acoustic source be used to calibrate the oscilloscope graticule in terms of Newtons/metre^2 and the SLM, when used, in terms of dB SPL.

The characteristics of an impact noise will in many cases vary during the work period and these variations may be random or periodic. To ensure that a reliable result is obtained, a number of measurements should be made over an extended period of time; the more variable the noise, the greater the number of measurements required. In cases where the exposure pattern is interrupted or complex, work-study type procedures should be followed to obtain a reliable measure of the total time of exposure or total number of impacts.

If the temporal pattern of exposure is broken and relatively high level background noise is also present, or a number of different sources are acting together each with a different exposure pattern, the ECNL of each noise should be determined separately and the total value calculated using the standard technique for summing decibels.

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