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The role of the Impulse Sound Level Meter - a quick practical estimate of hearing hazard

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In many industrial situations where exposure to high noise levels presents a risk to hearing, the estimation of the risk to hearing can be achieved from a knowledge of both the noise level and the period of exposure to the noise. The concept of equivalent continuous noise level (ECNL) as a measure for the prediction of injury to hearing has gained wide favour. Robinson (1) has shown that the risk to hearing from exposure to continuous noise can be estimated from a function of the ECNL calculated according to an equal energy concept. Atherley and Martin (2) have demonstrated that a similar technique can be used for the assessment of impact noise. Here the noise is measured in terms of the equivalent level of 'A' weighted continuous noise. In order to calculate this level it is necessary to have a knowledge of fundamental parameters of the impact noise, viz- the peak height and decay time of each impact and the repetition rate of the impacts (fig.1).

Existing methods for the determination of these parameters involve the use of elaborate equipment and techniques. For example, the waveform can be observed on a Cathode Ray Storage Oscilloscope fed from a wide band microphone and amplifier. However, the relative complexity of this method precludes its use for every day industrial applications. It is therefore desirable that a simple and easily applicable method be found. It is possible that eventually a relatively simple and cheap device may become available commercially. In the absence of such a device, it has become apparent that a number of organisations and individuals have acquired Impulse Sound Level Meters (ISLM) in the hope that these instruments would offer a simple method for the evaluation of impact noise. However, these instruments were originally intended to give a reading approximating to the subjective impression of loudness, produced by short bursts of tones or noise. Therefore the question remains whether these meters can be used to assess the risk to hearing from exposure to impact noise.

The purpose of this paper is to report on the implications of a series of laboratory and field measurements of recurrent impact noise made with a Brüel & Kjaer Impulse Precision Sound Level Meter type 2204 and then to comment on its value in the practical estimate of hearing hazard.

1) Laboratory Studies - Experiments were conducted to explore the use of the ISLM with respect to the assessment of the sound energy of recurrent impact noise over a range of parameters.
The impact signals were generated electrically and fed directly into the input stage of the ISLM. The pulse parameters were

determined by inspection of the waveform on a storage oscilloscope, whilst the sound level measurements were made using the ISLM in its 'hold' mode.

A wide range of pulse parameters was studied with both pure tones and wide band noise as carrier signals. Measurements of the sound levels were made with the meter set to both linear and 'A' weighted responses.

Three basic rules were apparent from these experiments:

1) The difference between the linear and 'A' weighted measurements were exactly as predicted from a consideration of the 'A' weighted response for a given carrier frequency.

2) The difference between the linear and 'A' weighted measurements was 2.5 dB when the carrier signal was a broad band noise.

3) An increase in the peak height of pulse from P_1 to P_2 produced a corresponding increase in the meter reading given by the expression $20 \, \mathrm{Log}_{10} \, (P_1/P_2)$ dB eg. a doubling of the peak height increased the meter reading by 6 dB.

Observations were also made of the effect on ISLM reading produced by variations in the pulse decay time and pulse repetition rate. The meter was set to linear response and the impacts consisted of pulses of constant height with a 4 kHz pure tone carrier signal.

Fig 2 shows the variations in the meter reading with decay time for single impacts occurring at the rate of one per second. Also represented is the time predicted by an energy law, where zero decibels is the level of a continuous pure tone with the same peak height as the impacts.

The salient feature of fig 2 is that for decay times up to 30 msecs a subtraction of 15 dB from the meter reading will produce results that follow the energy law to within ± 2 dB. For longer decay times the meter over-predicts the energy law by decreasing amounts falling to 6 dB at 250 msecs decay time.

In fig 3 is shown the variation with repetition rate of both meter reading and energy law for pulses of decay time 2 msecs and 28 msecs. Repetition rates between 1 and 100 impacts per second (ips) are illustrated. Zero decibels has the same interpretation as in fig.2.

For repetition rates above 30 ips, the meter reading and the energy law coincide to within ± 2 dB. For repetition rates less than 30 ips ~~msecs~~ a subtraction from the meter reading of $10 \, \mathrm{Log}_{10} \, (30/M)$ dB will predict the energy law to within ±2dB (where M is the repetition rate in impacts /second).

2) Field Studies - The major limitation of the ISLM appears to be that the evaluation of the meter reading in terms of ECNL requires a knowledge of the decay times of the pulses. The extent of the limitation in practice was investigated by studying a number of industrial processes which produced impact noise.

They were selected in order to give a wide range of types of noise typical of industry.

Two types of drop forge were studied: A) A forge which used 2-4 ton hammers and produced a relatively small number of blows with large peak pressures. B) A smaller forge which used 10-15 cwt hammers. Here a number of similar forges were operating simultaneously. Consequently, the number of impacts was greater than in A) but their peak heights were smaller.
Other processes investigated were C) a production line where metal cannisters were washed and filled with liquid. As the cannisters turned over and collided with one another, a series of impacts,

irregular in distribution of amplitude and in occurrence were created. D) A pile driver which operated in the open. In all these situations the purpose of the studies was to investigate alternative methods of measurement. Tape recordings, ISLM measurements and direct oscilloscopic measurements were compared for a number of experimental conditions.

In this way it was possible to indicate the limitations of ISLM readings and to make some suggestions as to how the readings could be interpretated more rigorously if some additional equipment such as a tape recorder were available.

If a particular example of recurrent impact noise consisted of individual pulses, which do not overlap, the correction for decay time would be made to the ISLM reading, first, then the adjustment for repetition rate could be made later. In general, one would expect that for slow repetition rates the ISLM will be able to record single impacts and that where the repetition rate is too fast for this to be possible, the noise should be measurable with a conventional SLM using the techniques of measurement normally adopted for continuous noise. The BOHS Hygiene Standard for Wide Band Noise (3) suggests that repetition rates greater than 10 ips can be measured in this way. However, if the decay times of the pulses which occur more slowly than 10 per second can be estimated from tape recordings, a relatively simple and economic technique for the evaluation of recurrent impact noise should become available.

<u>References</u>

1) Robinson, D W (1970). In 'Hearing and Noise in Industry' (edited by Burns, W and Robinson, D W), Appendix 10, HMSO, London.

2) Atherley, G R C and Martin, A M. (1971). Equivalent Continuous Noise Level as a measure of injury from impact and impulse noise. Ann Occup Hyg, vol 14, 11.

3) Committee on Hygiene Standards. 'Hygiene Standard for Wide Band Noise' British Occupational Hygiene Society, 1971. Pergamon Press, Oxford.

fig 1 Single Impulse Parameters

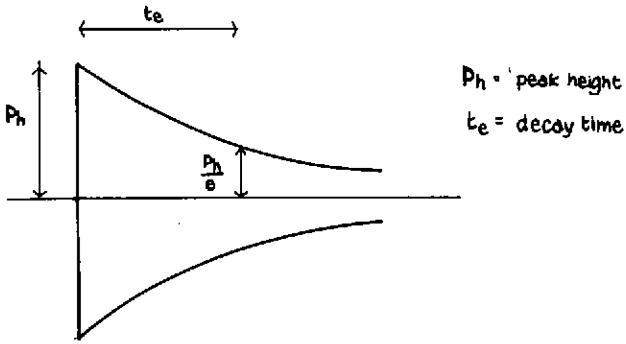

fig 2 Meter reading and Energy Law for Single impacts

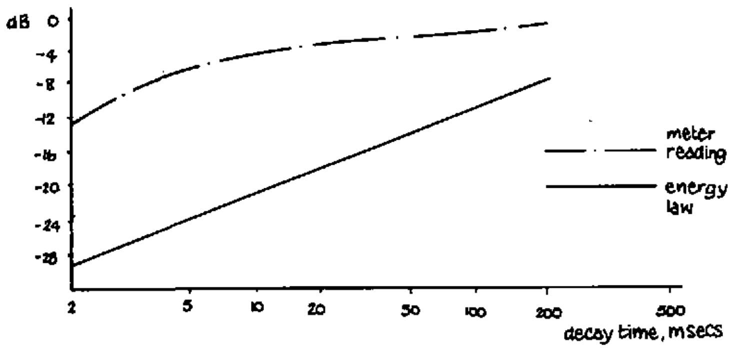

fig 3 Meter reading and Energy Law for pulses of varying decay times