Proceedings of The Institute of Acoustics

MEASUREMENT OF IMPULSIVE INDUSTRIAL NOISE EXPOSURE

I.R. Price and E.J. Walles

Health & Safety Executive, Occupational Medicine & Hygiene Laboratory, London

INTRODUCTION

Recent discussions of the proposed EEC Directive on the protection of workers from exposure to noise (1) have considered the need for an overriding limit for exposure to "instantaneous" high levels of noise and how these are to be measured. Sound level meters (SLMs) which conform to IEC 651 (2) have rms detection circuits with SLOW (1 s) or FAST (125 ms) or IMPULSE (35 ms rise time, 1.5 s decay time) time constants. They may optionally also have a PEAK response, typically 30 to 50 us time constant.

In the UK the 1972 Code of Practice (2) sets a limit of 150 dB (600 pascals) for instantaneous exposure of the unprotected ear. It is difficult to determine the instantaneous level and thus a more practicable measurement would be to use the PEAK or IMPULSE response provided on some SLMs.

This Paper compares the indications which a modern SLM will give for a number of "impulsive" signals applied electronically to the instrument when either PEAK or IMPULSE time constants are selected. The Leq of these signals over a number of measurement periods has been calculated and is reported.

MEASUREMENTS

General

The maximum indication, on a modern Precision Integrating Sound Level Meter, when set to either PEAK or IMPULSE time constant was noted for the same electrical input signal. Electrical test signals were applied to the SLMs through an equivalent capacitance replacing the instrument microphone.

Test Signals

The principal test signals were tone-bursts of controlled level and duration (starting and ending at a zero crossing). They were chosen because they could be accurately and repeatably produced and were of the form used in the IEC Standard for Integrating-averaging Sound Level Meters (IEC 804,(4)). Some additional measurements were made with digital tape recordings of two impulsive industrial noise sources - a drop forge and a power press.

The measurement of the level of an impulsive signal will depend on its duration and height above the normal background. This effect was tested with tone-burst signals superimposed on a continuous background signal of the same frequency and in phase with it (as in IEC 804). The measurements of the IMPULSE or PEAK level of the signals were made with tone-bursts applied from 9 dB above the background up to overload (55 dB). A 6 kHz signal was used with tone-burst durations of 6 cycles (1 ms), 60 cycles (10 ms), 600 cycles (100 ms) and 6000 cycles (1 s). The true linear and A-weighted levels of the tone-bursts with background were checked by applying the signal at the test levels as a continuous signal with the meter in the SPL mode.

The effect of frequency of the impulse was tested by applying a single tone-burst of constant level and duration at octave band centre frequencies from 63 Hz to 16 kHz. The tone-bursts were applied at a level of 45 dB(rms). No signal level compensation was made for the A-weighted response. The frequency response to continuous signals was measured with the meter operating in the SPL mode for comparison with the impulse results.

A repeated impulse was thought likely to give a higher maximum IMPULSE indication than a single impulse because of the long decay time of the response. Thus measurements were made with repeated tone-bursts. A repeated 6 kHz tone-burst of 60 cycles (10 ms) duration was applied at 45 dB on the scale. The "off" period between the tone-bursts was varied from 10 cycles to 5340 cycles (1.7 ms to 890 ms). The maximum PEAK or IMPULSE indications of the SLM were recorded.

The indications of the SLM for PEAK and IMPULSE time constants were determined for the recordings of a drop forge and a power press. The digital recording technique used to make these recordings yields a signal-to-noise ratio of 96 dB. The drop forge produces 7 impacts per cycle of operation which took 13 s to complete (three cycles were measured). The power press was operating continuously at a striking rate of 78 strokes per minute.

RESULTS

PEAK Response

The results demonstrate that the height above a background and duration of the impulse have no significant effect on the measured PEAK level (Figure 1). The tests at varying frequency show (Figure 2) a small increase in level at low frequency and a small decrease in level at high frequency but these differences are within or very close to the tolerances allowed for the frequency response in IEC 651. The tests with repeated impulses show (Figure 3) some variability in response from one SLM used in the tests but none from the other. Thus this variability was probably a characteristic of the particular instrument used.

IMPULSE Response

The results presented in Figure 1 show the dependence of an IMPULSE time constant measurement on impulse height above background and duration. The results also show an identical response for A-weighted or Linear measurements. Impulses of 100 ms or more duration indicated 2 - 3 dB below the peak indication whereas those of 10 ms will indicate up to 8.8 dB below and those of 1 ms up to 17.6 dB below. Further variability will result if the impulses are repetetive and this variability will depend on the repetition rate (Figure 3). There was a slight increase in the measured level at 63 Hz due to the transient response of the A-weighting filter, as might be expected, but the A-weighting produced no other side-effects on the IMPULSE measurement (Figure 2). In the test with typical impulsive industrial noises the IMPULSE levels were about 11 to 13 dB below the PEAK levels (Table 1).

DISCUSSION

From the data presented in the results it is possible to calculate the Leq of the impulsive signals in a given period of measurement and the level of an impulse to give an indication of 130 dB(AI).

The 1 s, 10 s, 60 s and 8 hr Leq of tone-bursts of 1 ms, 10 ms, 100 ms and 1 s as individual bursts equivalent to a peak level of 140 dB(A) are given in Table 2. Thus it might be considered practicable to specify peak exposure in terms of 10 s Leq (for example 140 dB(A) PEAK = 100 dB(A) Leq (10 s)).

An indication of 130 dB(AI) will require an input level of about 145 dB(A) for a 1 ms impulse, 136 dB(A) for a 10 ms impulse and 130.5 dB(A) for a 100 ms impulse.

The instrument which gave wide variability in the measured PEAK level of the repeated tone-bursts met the requirements for PEAK response given in IEC 651 (2).

CONCLUSION

From the results obtained in the tests using well defined electrical signals (tone-bursts) it can be concluded that for well designed SLMs the:

- PEAK level indicated will be independent of amplitude above background, length and repetition rate;

- when using the IMPULSE setting the indication will depend on each of these factors;

The frequency of the impulse causes slight errors at low frequency for A-weighted IMPULSE measurements and at high frequencies for Linear PEAK measurements.

The data also shows that it is difficult to determine a fixed relationship between a PEAK indication and an IMPULSE indication. Over the range of signals considered the data shows that the IMPULSE measurement differs from the PEAK measurement by between 2 and 17 dB depending on impulse height above background and duration and repetition rate of the impulse.

In considering the measurement of PEAK SPL and the measurements conducted it is clear that IEC 651 does not adequately test the PEAK characteristic of SLMs and the relevant clauses should, perhaps, be revised.

REFERENCES

(1) E.E.C., 'Proposals for a Council Directive on the protection of workers from the risks related to exposure to chemical, physical, and biological agents at work: Noise.'

(2) International Electrotechnical Commission, 'Sound level meters', International Electrotechnical Commission Publication 651:1979.

(3) Department of Employment, 'Code of Practice for reducing the exposure of employed persons to noise', HMSO 1972.

(4) International Electrotechnical Commission, 'Integrating-averaging sound level meters', International Electrotechnical Commission Publication 804:1984.

Table 1. Measured response to impulsive machine noise

	Leq dB(A)	Peak dB	Impulse dB(A)	Impulse dB
Drop forge	116	146.2	133.2	134.5
Power press	125.5	142.2	131.0	133.5

Note: The levels quoted only show the relation between the measurements and bear no relation to the true noise levels.

Table 2. Leq of 140 dB(A) peak level tone burst

Tone burst duration ms	1s Leq dB(A)	10s Leq dB(A)	60s Leq dB(A)	8h Leq dB(A)
1	107.0	97.0	89.2	62.4
10	117.0	107.0	99.2	72.4
100	127.0	117.0	109.2	82.4
1000	137.0	127.0	119.2	92.4

Figure 1 Measured level of tone burst relative to rms tone burst level, for PEAK, IMPULSE, and A-weighted IMPULSE response against tone burst height.

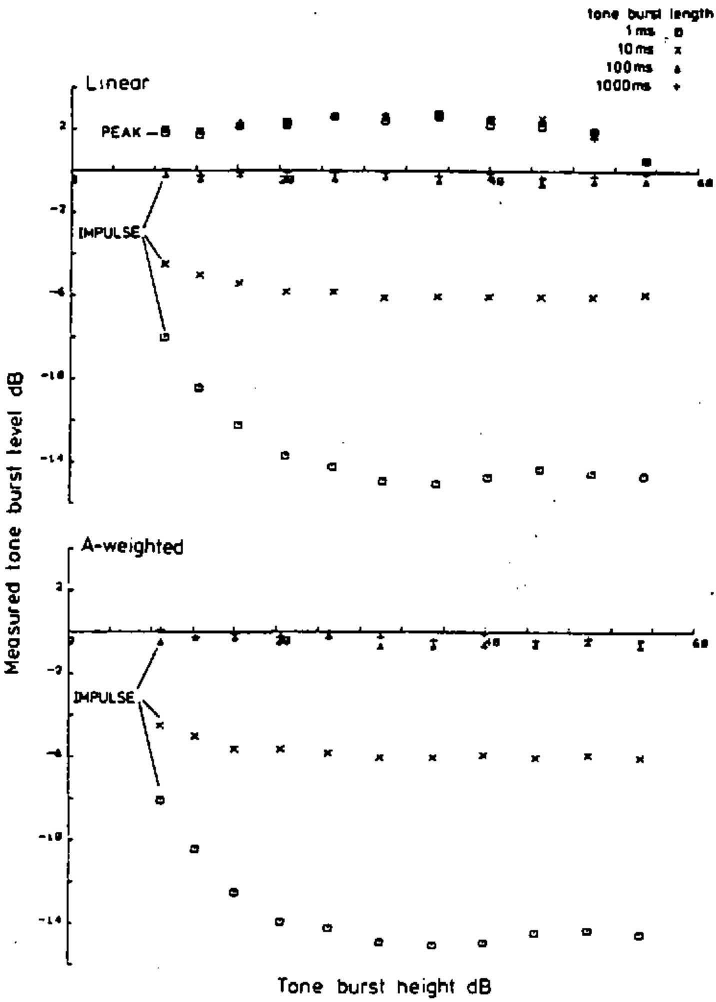

Figure 2 Measured level of tone burst relative to rms tone burst level, for PEAK, IMPULSE, and A-weighted IMPULSE response against tone burst frequency.

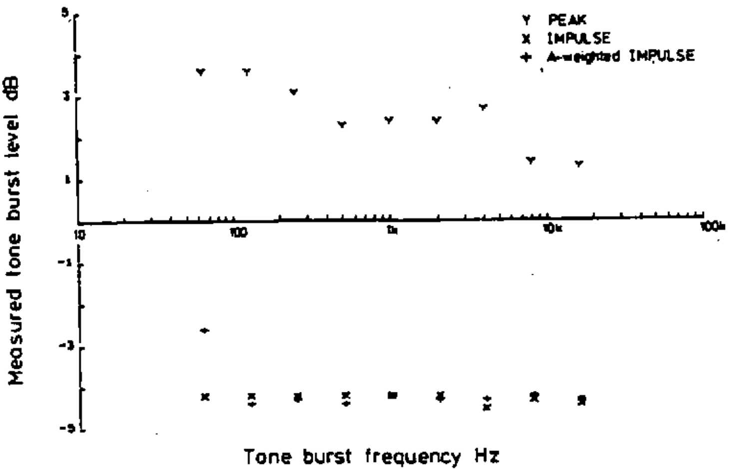

Figure 3 Measured level of repeated 10ms tone bursts, with PEAK, IMPULSE, and A-weighted IMPULSE response relative to rms tone burst level against tone burst off period.