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ASSESSMENT OF RISK OF HEARING LOSS DUE TO IMPULSE NOISE

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The measurement and evaluation of impulse noise has been the largest area of uncertainty in knowledge and insufficiency in guidance in hearing conservation matters, although in recent years the situation has improved considerably. It is appropriate therefore to collate recent data and the methods that are either used in practice or are recommended, and thereby to look at the impulse noise problem as a whole.

There are two principal methods of dealing with impulse noises (i) with an ordinary sound level meter followed by comparison with damage-risk criteria intended for steady-state noises, or (ii) with a cathode ray oscilloscopic display and evaluation by criteria such as those recommended by Coles, Garinther, Hodge and Rice (1968). A third method, not to be discussed further because of lack of data connecting physical measurements and auditory hazard, is to use an impact sound analyser of some kind.

In discussing the two methods mentioned, it is helpful to classify impulses into three main types, according to the pressure/time histories of the impulse wave envelopes.

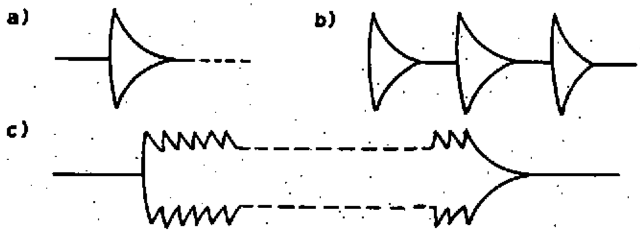

Fig.1 Envelope patterns of impulse noises.

First, Type (a), there are occasional widely-separated impulses, typified by gunfire and other very intermittent explosive noise sources. In Type (b) there are repetitive but discrete impulses covering ratios of peak to background level in the wave envelope pattern of not less than 6 dB and impact rates of about 0.5 to 10 per second; examples would be blanking processes, manual hammering of metal plates, etc. Finally, Type (c), there are highly repetitive noises, in which the repetition rate is greater than about 10 per second and the ratio of peak to minimum level in the wave envelope pattern is less than about 6 dB; this is the commonest impulse noise type found in industry and is typified by pneumatic chippers or hammers, e.g. in fettling and rivetting.

An ordinary sound level meter can only cope with Type (c) noises without difficulty. Either on the dBA scale or with full octave-band analysis, the results can be related to current damage risk criteria with little or no correction for impulsive components, i.e. where the striking rate is high and/or the peak to background level ratio is low.

However, in considering the use of a sound level meter, it should be noted that in standardisation groups it has recently been suggested that some impulsive noises (of insufficiently defined type) can be assessed by comparison with steady-state noise criteria, with the proviso that dBA values are obtained using the meter's slow response characteristic and a figure of 10 dBA is added in respect of the noise's impulsiveness. Whilst such a procedure may have its place with certain types of noise, perhaps Type (b), the 10 dBA correction and/or the measurement technique is quite unsuitable for other impulse noises. This will be discussed further.

For a start, it is not clear how this 10 dBA figure has been derived; whether this is because of a possible exceptional hazard of impulsive components in a noise (which is contrary to the evidence of Cohen, Kylin and LaBenz, 1966), whether it is to compensate for the inability of the meter to respond to the short-duration peaks of sound pressure (Dieroff, 1966), or whether it is a general safety factor covering both of these points. Whatever the rationale, 10dBA must in fact be the wrong figure for many of the noises, because there is no sharp dividing line in degree of impulsiveness between Types (a), (b) and (c) noises; thus any correction factor should range over a continuum from 0 to 10 dBA (or perhaps more) between, respectively, an almost steady-state noise and a noise repeated, say, once per second.

It is interesting to look at figures for some Type (b) impulse noises, as measured by my colleague Dr. J.G. Walker with a Bruel and Kjaer (B & K) type 2203 precision sound level meter, see Table I. It would appear from these that the slow response setting is the more appropriate one, giving, as it does, some form of temporal integration which is at least in the right general direction; that is, there is greater loudness and production of temporary threshold shifts (TTS) of hearing with the higher impact rates.

Noise	Impact Rate	Setting	15 msec*	50 msec*
130dB peak	Single impact	Fast,dBA	90+6 ∅	100+3
level, 15	1.6 per sec		90+6	100+3
and 50	3.2 per sec		90+5	100+2
msec	6.4 per sec		90+8	100+5
durations*	Single impact	Slow,dBA	80+3	90+1
	1.6 per sec		80+5	90+4
	3.2 per sec		90+3	90+8
	6.4 per sec		90+8	100+4

TABLE I. B & K SOUND LEVEL METER RESPONSES TO IMPACT NOISES
*"Duration" refers here to the time taken for the wave envelope to fall by 20dB from its peak level. ∅ "90" = range selected, "+6" = reading of the meter needle.

Moreover, TTS studies (Walker, 1969) using these particular noises have indicated degrees of potential hazard of the same general order of magnitude as those to be expected of steady-state noises having the same dBA values plus 10 dBA. Thus, the use of such a simplified technique does in fact seem, as far as this sound level meter and these Type (b) noises are concerned at any rate, to yield a general guide as to potential auditory hazard. Where the noise is less than, say 15dB above or below the borderline of hazard however, it would probably be advisable to supplement the investigation by means of oscillographic techniques.

From both theoretical considerations and the I.E.C. specifications (1961, 1965) and from the results of some recent observations (Table II), it is obvious that ordinary sound level meters are unsuited for measurement of Type (a) noises. The table shows gross discrepancies between the actual levels of noise and the meter readings, and also a non-linearity in response between the 136 and 160 dB noises. The latter is hardly surprising since the upper limit for the B & K instrument is quoted at 134dB with its usual 1-inch microphone.

Noise	Setting	B & K meter	Dawe meter
136dB peak level, 300 μsec duration*	Fast,dBA	110-oO 100, 100-1, 100-2 90+9, 90+9, 90+8 80 +over 10	
	Slow,dBA	100-oO 90-1, 90-2, 90-2 80+5, 80+4, 80+4, 80+3 70+10, 70+10, 70+10, 70+9	
160dB peak level, 300 μsec duration*	Fast,dBA	120-oO 110-1, 110-2 100+9 90 +over 100	120-oO 110-2, 110-3 100+4, 100+3 90 +over 10
	Slow,dBA	110-oO 100-1 90+6	100-oO 100-4 90-1, 80+4 70+7, 60+10

TABLE II. SOUND LEVEL METER RESPONSES TO EXPLOSIVE NOISES

*Duration refers here to the time taken for the single large pressure wave to return to ambient pressure

In spite of this, it is interesting to note that the handbook of the Dawe sound level meter quoted 100 to 120 dB as being "deafening" and to be found in "gunfire"; in fact, the hazardous 160 dB peak-level noise gave maxima of 107 to 109 dBA (on both the Dawe and the B & K meter), whilst the safe 136 dB peak-level noise gave only 98 to 100 dBA (on the B & K meter). Therefore, for some noises of Type (a) even, sound level meters of the types quoted appear to give results that may have some, though minimal, quantitative value, provided certain rules are applied as follows: (i) that the highest relevant 10 dB unit in the range selector be used in order to minimise the effect of needle inertia (i.e. the needle has to move through a shorter distance for 100+2 dB than for 90+8 dB), and (ii), that readings of 90 dBA or more should be regarded only as an indication of possible hazard needing more comprehensive analysis.

Moreover, as Type (a) noises are separated by intervals that do not allow any integration of energy between impulses and as the fast response gives results nearer to the actual noise level and is less dependant on the range selector setting, the fast response would now seem to be more appropriate. But, being no sharp division between noise Types (a) and (b), no rule can yet be made as to when a fast and when a slow response should be employed. In short, in the present state of knowledge, sound level meters cannot be regarded as suitable instruments for impulse noise assessment, except with those noises that are so rapidly repetitive (Type c) that correction factors for impulsiveness are barely needed anyway. It is hoped that these limited observations illustrate this point, and will also act as a spur towards study of the subject in greater depth.

Coming now to the oscillographic measurement technique and method of auditory evaluation described by Coles et al (1968), it would seem that this is the method of choice for noises of Type (a), helpful for Type (b), but inappropriate for Type (c). In this, the pressure/time history of the impulse is displayed on a cathode-ray oscilloscope. This is then analysed in terms of peak-level and of duration (either as described beneath Table I or as beneath Table II, whichever is appropriate). Potential hazard is evaluated by reference to a graph whose axes are peak level and duration. Various correction factors are applicable, notably for number of impulses. Since the original paper in 1968, however, a modification has been proposed (Colès and Rice, 1969) with respect to the correction factor for number of impulses per exposure.

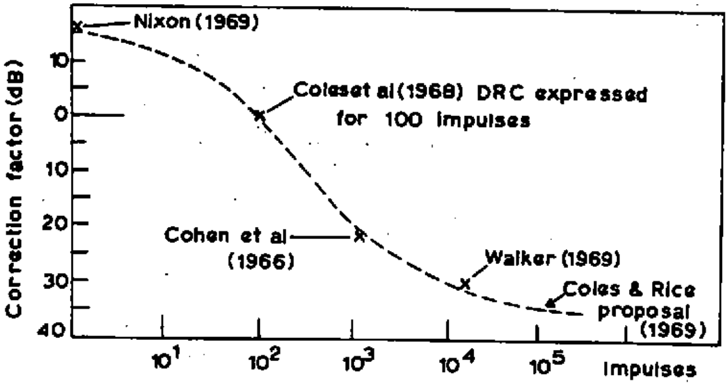

Fig. 2 Proposed corrections for number of impulses.

Explanation of how the new proposal was arrived at will not be repeated here, but it is gratifying to note that this now leaves no major discrepancy between impulse-noise TTS studies and the auditory hazard predictable from details of the noise, or between impulse and steady-state noises with regard to specification of auditory hazard.

Probably, in course of time, the modification itself will prove to need some adjustment as, so far, it can only be claimed to be an approximation. Likewise, with respect to impulses having rise times that are substantially greater than the 0.3 to 0.5 msec upper limit referred to in the original paper, the permitted noise levels referred to in the Coles et al damage risk criterion may need elevating somewhat (by an estimated 0 to 8 dB in the rise-time range 0.5 to 5 msec). However, in the majority of industrial and experimental impulse noises the rise times come well within this upper limit.

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