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"IMPULSIVE NOISE: UNIVERSITY OF NEWCASTLE UPON TYNE".

HEARING PROTECTION AGAINST IMPULSIVE NOISE

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The obvious question to ask on the title of this lecture (given that the need for hearing protection against impulsive noise exists) is "why discuss protection specifically against impulsive noise? Isn't it just the same as that against continuous noise?". It is certainly true that protective devices effective against continuous noises can also be used with impulsive noise; but the measurement of the degree of protection thus afforded is far from straightforward. Another reason for considering protection against impulsive noise as a separate entity is that the properties of impulsive noise make possible the design of defenders with relatively little effect on the hearing of speech, as will be described later.

Impulsive noise can be defined as having a very high peak level and short duration, as for instance in an explosion or the report of a gun. Another class of impulsive noise sometimes called impact noise, can be produced by mechanical means, as for instance in a drop forge. Nearly all the author's experience, however, has been with gunfire-type noises. The peak pressures may be very great, about 159 dB (ref 2×10^{-5} N/m^2) from a self-loading rifle, at the ear of the firer, with a duration about 5 milliseconds; very much greater pressures and slightly longer durations may be encountered with weapons of larger calibre.

The effect of impulsive noise on hearing has been fairly extensively studied and most of the work has been summarised in two damage risk criteria (1, 2), relating peak level, duration and number of impulses for a stated risk to hearing, although some uncertainties still exist. The methods of analysing the noise, being dependent on peak levels (measured, usually, with an oscilloscope), and not being explicitly dependent on frequency, are quite different from those used with continuous noise.

Measurement of the attenuation of impulses offered by hearing protection is thus far from straightforward. The attenuation for continuous noise is usually assessed by a real-ear attenuation at threshold (REAT) method, such as that given by the current American standard (3); but the attenuation so measured is dependent on frequency, and therefore cannot be used in conjunction with a criterion which does not take account of frequency. Another drawback is that the levels used in the REAT test are very much smaller than those encountered with impulsive noise, and it does not necessarily follow that the attenuation is independent of sound pressure level over the whole of this range - indeed for some devices it can be shown that the attenuation increases with sound pressure level.

It is probably not possible to assign a single value for the attenuation of a device to all different impulsive noises. However, over a restricted range of noise types, scatter appears small enough to be of practical use. Most of the practical work centres round a "temporary threshold shift reduction" (TTSR) technique, using small reversible hearing losses as an indicator of potential hazard. If the hazard can be estimated with and without ear protection the effective attenuation can be estimated, although the method obviously has its difficulties. Much work has been carried out in this way on the ubiquitous V-51R ear plug, and it appears that, for gunfire-type noises at least, an effective attenuation in excess of 20 dB can be expected, although as always this is dependent on the fitting of the device (1, 4, 5). The attenuation provided by good ear muffs appears to be greater, as one would expect, although it is difficult to give exact figures.

Although the above work has the merit of being intensely practical, more precise figures would obviously be desirable, and one is tempted to use some form of artificial ear in an effort to provide them. Unfortunately the use of artificial ears present problems which have not entirely been solved, and so the results therefrom, although possibly instructive, cannot be used to give an absolute value of attenuation. A compromise solution, at least with circumaural devices, would be to use a microphone at the ear canal entrance and compare its readings with the pressure outside, although this would place severe demands on both the microphone and its associated equipment; despite its attractions the method does not yet seem to have been employed for impulsive noise.

Something of a "half-way house" towards an artificial ear is provided by the use of cadaver ears, suitably instrumented, which have been used by the author in conjunction with Dr R R A Coles (6) to examine the properties of various types of ear plugs, both with pure tones and impulses. It is not claimed that results so obtained are quantilatively exact, but they do seem to show much of interest. One of the findings was the increase in attenuation with sound pressure level in ear plugs having some form of deliberately introduced leak; this increase was quite masked at levels in excess of 140 dB and was due to the breakdown of laminar flow in the air passages. While the resulting increase in attenuation was most noticeable in a plug ("Gundefender") designed with the effect in mind, it also occurred with other commercial types. The effect would obviously increase the protection available at very high levels, a point which will be elaborated later.

It will be obvious that the assessment of the efficiency of hearing protective devices against impulsive noise is very far from easy, and as far as conventional devices are concerned it is difficult to progress beyond the estimate of 20-35 dB, depending on the type of protector used, given by Coles et al (1)*. The assumption that the protection is related to pure-tone attenuation, although plausible, cannot be strictly justified. The problem is acute since, in some circumstances, a risk of damage to hearing exists even where the best available protection is used.

Impulsive noise does have one mitigating feature in that it is possible for the attenuation provided by hearing protection to be greater for the noise than for wanted sounds, such as speech. As the noise consists of very intense short-duration bursts on a quiet background, it is necessary only to arrange that the attenuation is much greater at high than at low levels. There are several possible mechanisms by which this could be achieved; one is the "Gundefender" ear plug already described, which appears to work well in the situations for which it was designed (7, 8) and has the merit of simplicity. A rather more complicated solution is provided by the Cosmocord A9000 headset, which consists essentially of a normal pair of ear muffs, with a microphone, peak limiting amplifier and telephone mounted on each shell to transmit low-level sound. As the duration of each impulse is very short and the amount of speech lost therefore small, it is possible (given a sufficiently quiet background) to hear almost normally while retaining a useful degree of hearing protection.

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