Measurements of impulsive noise

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Excessive noise exposure is a cause of hearing loss. The hearing loss normally gets worse over time as repeated excessive exposures occur. However, extreme high level short duration sounds (bangs) can also present an immediate risk of hearing damage.

Risk of immediate damage is indicated by the C-weighted maximum instantaneous peak sound pressure level of the event. There is also a risk associated with the overall A-weighted noise exposure. The Control of Noise at Work Regulations require a risk assessment when anyone is likely to be exposed to instantaneous peak sound pressure levels at or above 135 dB(C). The Supply of Machinery (Safety) Regulations requires the manufacturer to report the C-weighted workstation peak sound pressure level of a noisy machine if it exceeds 130 dB(C).

I've spent many years making measurements of noise exposure from high level impulsive sound including firearms and explosions to assess the risk to hearing. What I've included here are some tips based on my own experience of high level impulsive noise measurements, and measurements of hearing protector performance.

Instrumentation

The right sound level meter

Your sound level meter or instrumentation should meet IEC 61672-1, or be at least Type 2 to the older standards IEC 60804 and IEC 60651. This is important. Instruments not meeting these standards may give errors of over 15 dB in impulsive sound. Unfortunately sometimes meters are falsely specified as meeting these standards so look for an additional guarantee. Use a sound level meter that has also passed a standard verification test (IEC 61672-3, or BS 7580 are the standards for this) or check with the manufacturer that the instrument model or a similar model in the range has passed pattern evaluation.

Close-to sounds can be dominated by high frequencies, creating more of a crack than a bang. Here a Class 1 or Type 1 instrument should be preferred as it has a tighter specification at higher frequencies.

If you are using a device that has a variable sample rate ensure this is sufficient to capture frequencies up to 20 kHz.

Low sensitivity microphones

Most sound level meters are designed to measure sound pressure levels within our normal environment. They typically overload on the least sensitive range around 140 dB. The capability to measure higher sound pressure levels can be achieved by using a microphone that has lower sensitivity and a dynamic range to higher sound pressure levels. Typically the use of a ¼ inch microphone in place of a ½ inch microphone will allow measurements to around 160 dB, and there are also microphones specified to measure above 190 dB. The manufacturer of your sound level meter should be able to advise on a suitable microphone.

Alternative transducers for extreme conditions

Peak levels over 170 dB(C) occur from stun grenades, military weaponry and explosions. In these extreme sound pressure levels your choice of microphones is limited, and expensive. In addition, if you are working outdoors and with explosive events you might prefer something rugged.

Hydrophones are a traditional and often recommended alternative to a microphone for the measurement of high sound pressure levels. Another relatively inexpensive and tough alternative is dual purpose microphone/pressure sensors designed to measure pressure fluctuations in both air and fluid environments.

If you use alternative transducers you may have no specification of the overall measurement accuracy of your instrumentation. Laboratory tests or comparative measurements in the field may be required to confirm the performance of your chosen equipment combination.

Other practical issues

There are some further practical considerations:

- You will need a sound calibrator that provides a suitable sound pressure level for the field checks of sensitivity. For example, a device providing a nominal level of 114 dB at 1 kHz or a pistonphone providing a level of 124 dB at 250 Hz are readily available. You will also need to confirm the actual level provided by the calibrator at your microphone or transducer.
- Low sensitivity devices can have a comparatively high sensitivity to vibration. You may need to provide vibration isolation for the microphone supports.
- In high level noise you can get a gradual deterioration of the sprung contacts between the microphone, preamplifier, and any adaptors. This can result in a low frequency vibration signal superimposed on the impulse event sound.

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What should you measure?

To assess exposure

If you are assessing personal noise exposure you will need to measure the maximum C-weighted peak sound pressure level over one or more impulse events. In addition, you will need to measure the sound exposure level (L_{AE}) over a number of events. You can then calculate the daily personal noise exposure ($L_{EP,d}$) for the number of events a person is exposed to in the working day. (Guidance on how this is done is provided in HSE publication L108 *Controlling noise at work*).

To select hearing protection

EN 458 Appendix B gives a method to make a crude estimate of the hearing protector attenuation in impulsive noise without the use of measurements. This method is informative, leaving it open for alternative methods to be used.

The Health and Safety Laboratory has recently validated a measurement method. The results confirm it is possible to use a variation of the H, M, L method given in the EN 458 Appendix A.3 to predict protector attenuation in impulsive sound.

In this alternative method the measured C and A-weighted Fast maximum values of the impulse event (L_{CFmax} and L_{AFmax}) are used to obtain an essential L_C minus L_A value that characterises the impulse spectrum. (Ideally the A and C-weighted measurements should be made simultaneously at the same location. And just a word of warning: don't calculate weighted maximum values from a spectrum. You will get the wrong answer.)

The H, M and L values for the protector correspond to spectra with L_C - L_A values of -2, 2 and 10 dB respectively. If you plot the H, M and L values against the L_C - L_A values you can simply read across from your measured L_C - L_A value to obtain the estimated attenuation (as shown in Figure 1 for an L_C - L_A value of 6dB). This estimated attenuation can be subtracted from the measured C-weighted peak sound pressure level and the A-weighted sound exposure level to obtain an estimate of the effective level at the ear when the protector is worn. Note that it is also recommended practice in the UK to reduce an estimated attenuation by 4 dB to account for a reduced attenuation in use.

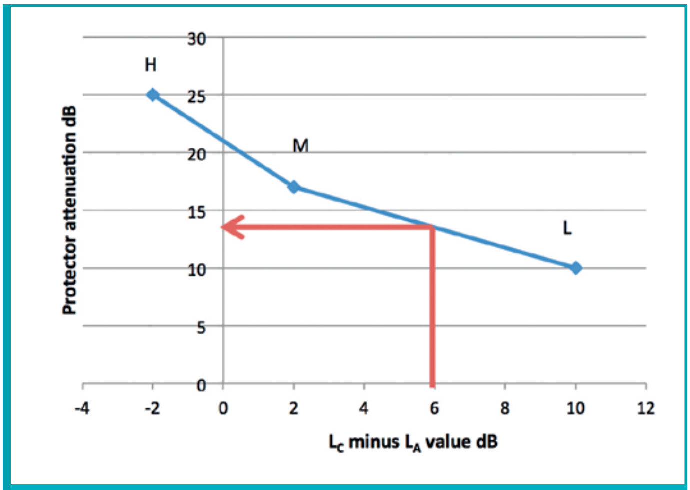

Figure 1. Protector attenuation estimate

References

- **Controlling Noise at Work** HSE publication L108 available as a free download from www.hse.gov.uk
- **Hearing protectors – Recommendations for selection, use, care and maintenance – Guidance document** EN 458:2004

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An example of things that go bang here at the Health and Safety Laboratory (provided by HSL Visual Presentation Services team)