Hearing protection is vital for many people in a wide range of industries around the world. In fact, in many situations it is critical in protecting an individual’s hearing. Worldwide, approximately 900 million people suffer with some form of hearing loss. Many of these cases could have been prevented with the correct use of adequate hearing protection.

Most industrialised nations have some form of occupational noise legislation. For instance, in the UK the ‘Control of Noise at Work Regulations’, based on a European directive, provides minimum health and safety requirements. These regulations set out the action values and exposure limit values at which employers must act. At a daily or weekly exposure level of 80dB(A)/135dB(C)peak or more, the employer must provide information and training to staff and make hearing protection devices available. At 85dB(A)/137dB(C)peak and above, the employer must take reasonable action to try to reduce the noise in the workplace by using engineering controls or administrative methods. If the noise cannot be reduced in this way, hearing protection devices become mandatory. There is also an exposure limit value of 87dB(A)/140dB(C)peak, above which no worker can be exposed to.

However, it is not only in the workplace where people are exposed to harmful noise levels. Music venues, nightclubs and shooting ranges are just a few of the places at which noise levels are regularly exceeded. Hearing protection can be found in many different forms, whether standard ear-muff or ear-plug designs (known as ‘passive devices’) or more complex models incorporating electronic systems which react differently in varied noise environments, known collectively as ‘active devices’.

The performance of models in their passive state is dependent on several factors. The depths of the cups which enclose the ears, the headband force and the acoustic absorption of liners are just a few of the variables contributing to the effectiveness of earmuffs, while size, fit and construction material generally govern the performance of earplugs. However, the protection provided by any device will be compromised if it is poorly fitted or incorrectly worn – even the slightest break in a seal around an earplug or the cushion of an earmuff will reduce the ‘attenuation’ (noise reduction) provided by the hearing protection. Because of this, it is important that wearers are shown how to correctly use their hearing protection.

Testing
Before a hearing protection product can be placed on the market in Europe, it must be tested and certified. This is because it falls under the scope of the Personal Protective Equipment Directive 89/686.

The wide range of hearing protection types available is reflected by the number of...
European Standards governing this testing. The EN 352 series of standards is made up of eight parts, which cover the general requirements of each type of hearing protector. For example, parts one and two relate to passive earmuffs and earplugs respectively. Part three sets out the requirements of earmuffs attached to industrial safety helmets, and the final five parts cover active devices – including level-dependent, active noise reduction and audio input devices.

The testing scheme differs for each type of device. However, each of them must undergo chemical, physical and acoustics testing, as well as a review of product marking and wearer information.

Chemical testing
In terms of chemical testing, any materials used in the manufacture of the device which will come into contact with the skin must be confirmed as being non-staining, and not likely to cause skin irritation, allergic reaction or any other adverse effect on health. The physical testing schedule is designed to replicate the day-to-day physical demands which will be put upon the hearing protection, and to ensure that the device is fit for purpose.

Physical testing
One of the first physical tests undertaken in the testing scheme is a materials and construction assessment. This confirms that the device is free from sharp edges, is safe for use and that any cleaning and disinfection methods specified cause no damage or impairment to the hearing protection.

A sizing assessment is also required, to ensure that the product is suitable for the range of head sizes designated by the manufacturer. The majority of devices are classified as ‘medium’ size range, which should fit the vast majority of the population. However, products can be classified as ‘small’ or ‘large’, and must be clearly labelled so before they are placed on sale. During this test, a range of fitting rigs, moulded headforms and size gauges are used to ensure that the products can meet specified test dimensions and so provide an adequate fit for the consumer.

For earmuffs, cup rotation, headband force and cushion pressure are assessed to confirm that the cups can be rotated sufficiently. This will indicate if wearers can adjust the device for the best fit and ensure that there is no excessive pressure upon the head from the combination of cushions and headband.

Resistance to damage is evaluated by dropping the hearing protection from a specified height onto a solid steel plate. If any part of the sample cracks or breaks, the device will fail the test, and will most probably require redesign and resubmission for testing. This testing can also optionally be conducted at -20°C for devices which are designed for use in colder environments.

The durability of headbands or standby mechanisms, which allows helmet-mounted earmuffs to be returned to the position which they occupy while not in use, are also tested if they are incorporated into the device. This is gauged by placing the cups of the product onto a pair of plates which oscillate between a minimum and maximum separation distance. The process continues for 1,000 cycles to replicate the action of a wearer fitting and removing the device or activating the standby mechanism.

Conditioning then takes place in the form of water immersion for 24 hours. As an option, this can be conducted with the headband under stress and with a parallel spacer placed between the cushions of the device. Once complete, the change in headband force is measured for a second time, with a maximum deviation between the two measurements providing the pass criterion.

If earmuffs with fluid filled cushions are under test, resistance to leakage must be assessed. A vertical load of 28±1 Newtons is applied to the cushion for 15 minutes, and any leakage caused will constitute a test failure.

The final physical test, which is undertaken for all types of hearing protection, is an ignitability assessment. A steel rod heated, to around 650°C is applied to the device. If any part ignites or continues to glow after the removal of the rod, the device fails the ignition test.

Acoustic testing
In terms of acoustic testing, both earmuffs and earplugs are required to undertake ‘subjective attenuation’ testing (the level of noise reduction noted by the wearer), while only earmuffs are subject to ‘insertion loss testing’. Insertion loss is the algebraic difference between the sound pressure level with and without the earmuff fitted to a test fixture. Rather than requiring human subjects, this test uses an acoustic test fixture for insertion loss assessment.
Headforms for sizing assessment

fixture which simulates the approximate dimensions of the human head.

Microphones are housed in cavities in the sides of the fixture to replicate the position of the ears. The testing is normally conducted in an acoustic tunnel, with a loudspeaker at one end, and acoustically absorbent foam at the other and along the length of the tunnel. This creates an ‘anechoic’ effect, meaning that generally sound waves striking the sides and the end of the tunnel are absorbed rather than reflected, thus allowing a ‘plane progressive sound wave’ (moving in one direction only, with no reflections from side walls or ends) to propagate along the tunnel. It is worth noting that this test sets no limit on the minimum attenuation which should be achieved. It is designed to assess the difference in the attenuation values between ten samples of the same earmuff model, in order to ensure that there is not a major variation in performance.

The subjective attenuation test uses human subjects to assess the performance of a hearing protection device, and does require a minimum attenuation value to pass the test. The results of these tests are published for the model when it is placed on sale and supplied to wearers. This test measures the ‘threshold of hearing’ – the lowest sound pressure level perceivable by the ear – of 16 human test subjects, with and without the hearing protection worn. The performance of the model is calculated from these values.

Assessing a subject’s threshold of hearing requires extremely low background noise levels. These noise levels are so low that they are expressed in negative decibels. To achieve such a quiet environment, a specially-designed location is required, such as:

- an audiometry booth (an isolated booth used to measure hearing or assess hearing protection)
- an anechoic chamber (with walls, floor and ceiling which absorb acoustic energy – sound – inside, resulting in a lack of echoes)
- a ‘hemi-anechoic chamber’ (which has a solid floor and a top hemisphere to absorb sound).

These chambers are designed to insulate against sound travelling through their walls, and use a heavy-duty construction of two independent wall structures separated by a cavity and acoustically-absorbent insulation. ‘Anechoic’ means that an extremely high percentage of sound inside the chamber is absorbed by the walls and ceiling, which are covered with foam wedges that absorb acoustic energy over a wide range of frequencies. Attenuation ratings awarded to hearing protection devices are denoted using ‘Simplified Noise level Reduction’ (also referred to as ‘Single Number Rating’, or SNR), ‘Low-Medium-High’ (HML) and ‘octave band values’. These are different ways to quantify the performance of the device in question. SNR provides a single attenuation value based on the subjective attenuation tests. Theoretically, this value can be subtracted from measured external noise levels in order to estimate the noise level at the ear, beneath the hearing protection. However, it should be noted that this method does not provide any information as to how much protection is provided in different frequency ranges, which is why the HML rating system is also required.

HML provides further detail, allowing the attenuation provided to be assessed across high, medium and low frequency ranges. This is particularly useful if a person is subjected to narrow band noise rather than broadband noise, as it allows a more accurate assessment of the noise level at the ear.

Marking of the device and the information provided to wearers also needs to be inspected. This involves a review of the supplied user manuals and an examination of the final product to ensure that the correct markings are present, and that the required information is supplied to users, as specified in the relevant European standard.

How can SATRA help?

Please email ppe@satra.com for more information on testing and certifying hearing protection for the European market.