

FOR MANY EMPLOYEES the wearing of a headset, an earpiece, or a headphone is part of their job. Telephonists, telephone sales personnel, air traffic controllers, television cameramen, television presenters, sound engineers, staff in the control rooms of the emergency services or public utilities, audio typists, radio operators and even the occasional noise consultant all wear headphones of various designs or some or all of the time. Then there are workers in industry where headphone entertainment systems are provided, or those who (with or without their employers' consent) bring in their personal stereos.

A colleague reports a case where he was told in all seriousness "the noise here isn't a problem - if I turn my Walkman up I can't hear it".

So how does one assess the risk of hearing damage from headphones and ensure compliance with the regulations?

In principle it's simple. The noise exposure ($L_{EP,d}$) Action Levels of 85 and 90 dB(A) apply to the noise from headphones just as they do to the noise from the workers' surroundings. In practice it's a little more complicated.

The first difficulty is in measuring the sound levels from the headphones. One cannot just put the earpiece over the microphone of a sound level meter and hope for the best, though there are those who have tried! The reliable method is to use an acoustically accurate dummy head or manikin. At ISVR Consultancy Services we use a "Kemar" manikin - the Knowles Electronics Manikin for Acoustic Research. A similar manikin is produced by Brüel and Kjær. Both these manikins have average or typical human head dimensions and a realistic external ear. The ear is moulded from a rubbery flesh-like material and leads on to the ear canal. At the inner end of the ear canal, at the "eardrum" position is a microphone. To measure the noise levels from headphones we put them on our manikin. Because the manikin's ear is geometrically and acoustically similar to a real ear, a headphone placed over the manikin's ear or an insert earphone placed into the

Headphones and the Noise at Work Regulations

If headphones are worn in the course of work, whether in a noisy factory or a quiet office, then the Noise at Work Regulations 1989 apply.

Whatever the sound from the headphone, whether it be work-related or incidental entertainment, whether it be speech, rock or classical music, as far as the listener's ears and the regulations are concerned it's all noise. If the listener is an airline pilot or works on a sea-going vessel he or she may be exempt from the regulations, but not from the effects of noise on hearing. The risks are real but not always appreciated.



The Kemar manikin wearing a headset



The microphone capsule can be seen at the left eardrum

manikin's ear canal behave in the same way as on a real ear. The sound pressures produced at the manikin's "eardrum" are the same as would be produced at the eardrum of a typical, real human ear.

The second difficulty is in comparing sound levels at the eardrum with the Action Levels. The Action Levels are noise exposures derived from sound pressure levels measured with a sound level meter in an external unobstructed sound field, not sound levels at an eardrum. In a normal indoor or outdoor environment, when listening without earphones or headphones, the listener is immersed in an external sound field. The ear canal acts as a resonant tube and amplifies some sound frequencies. The noise level at the eardrum is

therefore higher than the noise level measured with a sound level meter in the external sound field, usually by between 5 and 15 dB depending upon the noise spectrum.

Before we can compare the noise levels measured on the manikin with the Action Levels we need to subtract out the amplification of the ear canal. To do this we analyse the sound spectrum at the eardrum into one-third octave bands and take away the amplification of the ear canal in each band. This gives the spectrum of the equivalent unobstructed external sound field. This is the notional or imaginary external sound field which, heard without earphones, would produce the same noise level and spectrum at the eardrum as the sound from the headphones. The A-

weighted sound level of this notional field is calculated from the one-third octave band levels. The notional external sound field, in producing the same noise level and spectrum at the eardrum, would have the same potential to cause hearing damage as the earphone. The sound level of the notional external sound field is then used, just like any sound level measured with a sound level meter, to calculate a daily personal noise exposure ($L_{EP,d}$) for comparison with the Action Levels in the Noise at Work Regulations.

We have used this technique successfully to assess the noise exposure of operators with telephonist-type headsets at a Fire Brigade control room, to assess noise exposures of TV cameramen with normal headphones and TV presenters with transparent plastic tubes connected to ear inserts. We have also assessed built-in headphone entertainment systems for a large national corporation at several of their offices, and many personal stereo or Walkman systems which some employers allow in the workplace.

Our experience so far shows that most headphone wearers listening to work-related or speech material are not exposed to excessive noise. But there is a significant minority choosing to listen at levels which are too high. With personal stereos or employer-provided entertainment headphones we are finding that roughly 50% of listeners are exposed below the First Action Level of 85 dB(A), roughly 40% are receiving exposures between the First and Second Action Levels - ie between 85 and 90 dB(A), and about 10% of listeners are exceeding the Second Action Level. These figures were obtained in environments where the background noise levels were between 70 and 80 dB(A) and take into account the proportion of the shift for which the listeners wear headphones. Clearly noise from headphones cannot be ignored.

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