AN IN-EAR ACTIVE NOISE REDUCTION DEVICE

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INTRODUCTION

In working environments where high sound pressure levels are unavoidable there is a need to protect hearing by the use of an earmuff or ear plug. This protection should reduce the A-weighted sound pressure level (SPL) at the ear to below 90 dB(A) LEP(d) which is the allowable daily personal noise exposure based on an 8-hour working day (2nd action level) as stated by the UK Noise at Work Regulations 1989 and by the Commission of European Communities (1986). If this A-weighted SPL is exceeded the exposure time must be adjusted by halving the exposure time for every 3 dB increase in the A-weighted SPL. These limits minimise the risk of both temporary and permanent noise-induced hearing loss.

Military vehicles, especially tracked, armoured vehicles, often produce SPLs in excess of 120 dB, so noise-reducing bearing protectors which are compatible with vehicle and with personal equipment are required. Most circum-aural headsets do not provide the necessary level of protection from the high proportion of low frequency sound present in the noise spectra of such vehicles. However, the performance of the headsets could be improved by the use of active noise reduction (ANR) - a technique which uses an electronic circuit to produce an anti-phase signal at low frequencies and reduces the A-weighted SPL at the ear.

In most military situations the use of circum-aural headsets is practicable but when the soldier has to wear nuclear, biological and chemical individual protective equipment, the respirator straps and the material of the hood create an acoustic leak between the head and the ear cushion of the headset. This increases the A-weighted SPL at the ear which may cause a hearing loss and difficulty with communications. A solution to this problem is to use an ear-insert device which incorporates ANR. Prototypes of such devices, developed and built for the Stores and Clothing Research and Development Establishment (Cole, 1991) have been tested in the laboratory and in the field.

METHODS

Five identical prototype devices were tested (Figure 1). Ten male volunteers (aged between 19 and 32 years) were trained to fit the ear inserts.

For the laboratory tests the subjects wereseated in pairs in a static noise facility in which noise spectra previously recorded from tracked, armoured vehicles were reproduced. The spectiarecorded from the internal and external microphones, Knowles miniature microphones- EG 3000 which are an integral part of the in-ear device, were analysed on a dual-channel, real-time analyser Norsonics 830. From this information the attenuation of the device and the A-weighted SPL at the ear were calculated.

For the field tests the A-weighted SPL measurements at the ear were made using the equipment described above with the same subjects wearing operational military clothing, including ballistic protective helmets, whilst travelling in groups in a tracked armoured personnel carrier driving at 40 km/h, 50 km/h and maximum speed, around a tarmac lest track. This cycle was repealed after a break of approximately 10 minutes. The speeds and terrain chosen for this field test created noise levels between 110 and 120 dB SPL depending on crew position.

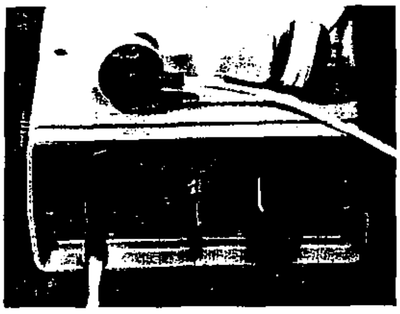

Figure 1. The prototype in-ear active noise reduction device

RESULTS

The mean total (passive and active) attenuation is shown in Figure **2.** Mean attenuation in each one third octave band centre frequency was calculated from the noise facility data from all ***5*** prototypes, in all subjects (100 data ***sets*** in **all**).

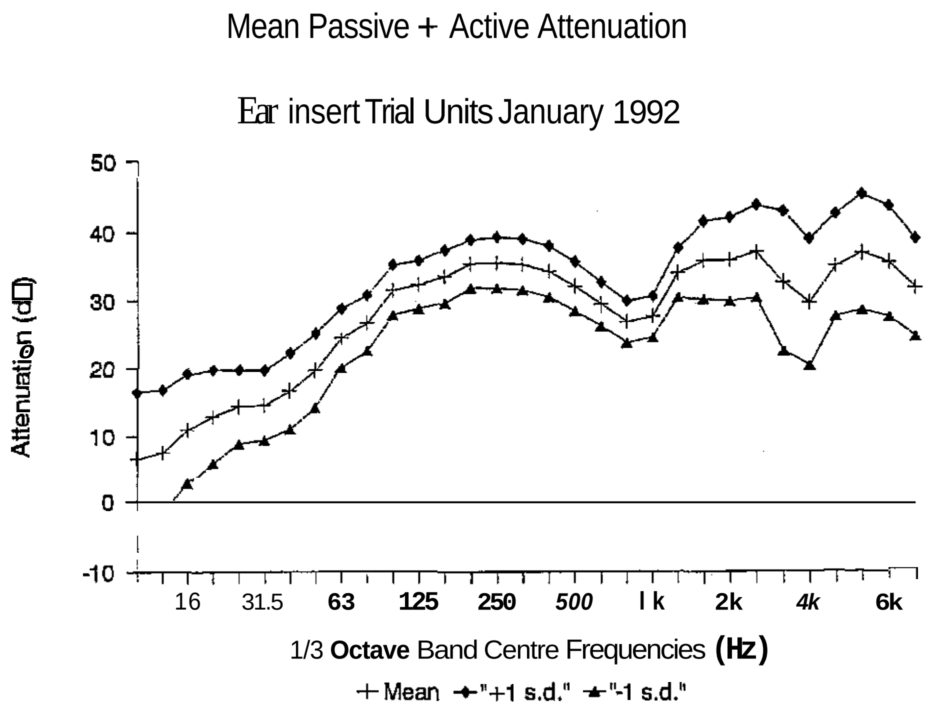

Figure 2. Mean total (passive and active) attenuation of the prototype in-ear active noise reduction device

In both static and dynamic situations, the mean SPLs at the ear with the ANR "on" were below 90 dB(A) and the device was compatible with the helmet and other military equipment.

During the field tests it was noted that some of the subjects had problems inserting the device correctly and in some cases, the less-than-gentle handling of the device, which would probably happen in routine use, gave rise to microphone, transducer and lead problems. One of the subjects complained that the multiple insertions of the in-ear insert caused soreness in and around the entrance **to** his external auditory meatus. Subjects found that during the break eating, drinking, talking and smoking caused the in-ear insert to work loose. **Because** of the discomfort, the subjects **were** reluctant to leave the in-ear insert in place when they were not travelling in the vehicle.

CONCLUSIONS

These prototype devices provided sufficient sound attenuation lo protect the subjects to a safe level whilst in an armoured personnel carrier. The problems found during the **use** of the device in the vehicle may in **part** be attributable to its prototype nature. The importance of comfort and ease of use were highlighted. Miniaturisation of the electronic circuitry would be required in any manufacturing phase, to keep weight and size to a minimum.

REFERENCES

1. Statutory Instrument 1989 No 1790: Health and Safety, The Noise ***at*** Work Regulations 1989, HMSO London.

2. EEC Council Directive 18/188/EEC 12 May 1986 on the protection of workers from the risks related to noise at work.

3. Cole S.H. 1991, The provision of hearing protection allowing for greater compatibility with the user, 9th Commonwealth Defence Science Organisation Conference, New Zealand.