INTEGRATED NOISE REDUCTION HEADSETS

Elizabeth A. Goodfellow
Army Personnel Research Establishment, Ministry of Defence,
Farnborough, Hampshire, GU14 6TD, United Kingdom.

INTRODUCTION

In many work environments, the noise levels to which workers are exposed exceed those which are considered to be safe (Health and Safety, 1989 and EEC, 1986). Inadequate hearing protection causes hearing loss which may prejudice the safety and efficiency of the crew, as well as leading to possible medical downgrading or discharge. Conventional circum-aural hearing protectors will, if worn correctly, provide adequate protection against many noise hazards except when a large low frequency component is present in the noise spectrum eg in military vehicles, agricultural and farm equipment and quarrying, mining and construction industries.

Communications intelligibility is affected by both signal-to-noise ratio and hearing acuity. Intelligibility is reduced if the incoming signal is distorted by the system and/or the ear. Noise transmitted through the communication's system from microphones and radios (communications load) will increase the A-weighted sound pressure level (SPL) at the listener's ear by 6 dB or more.

Headsets incorporating Active Noise Reduction (ANR) - to reduce the noise at the ear electronically, and a voice operated switch (VOS) plus a noise cancelling microphone - to reduce the additional noise at the ear from the communications load, have been developed for the United Kingdom Ministry of Defence for use in armoured personnel carriers. The headsets also had to fulfil essential requirements such as keeping noise levels at the protected ear below 90 dB(A), compatibility with existing personal equipment, robustness, comfort and usability in tactical situations.

Three manufacturers submitted headsets, labelled A, B and C, against this requirement and each showed interesting contrasts in their approach. Headset A had large, rounded earshells which were held in place by clips attached to the helmet. The neckband did not adjust and extended beyond the rim of the helmet. The boxey earshells of Headset B were slimmer at the top to allow fitting under the helmet. The non-adjustable neckband was bulky and extended beyond the helmet rim. The neckband of Headset C was adjustable and did not protrude beyond the rim of the helmet. Headsets B and C were fitted with adjustable velcro-faced straps which when placed over the top of the helmet secured the headset over the ears.

This paper shows that although the problem areas in the technical performance were improved by the manufacturers between the first and second assessment, other important factors such as comfort and robustness will have a considerable influence on equipment acceptability for use by military forces.

METHODS

Two assessments were conducted, the second on headsets re-submitted after the manufacturers rectified problems highlighted in the first. During each assessment several objective tests were made.

Near field and far field measurements of microphone performance were used to calculate its noise discrimination characteristics.

Active and passive attentuation was measured in a static high noise facility in which an armoured personnel carrier noise spectrum was reproduced. Ten male volunteers (aged between 19 and 32 years) were individually fitted with miniature microphones - one inside and one outside each earshell of the headset. The attenuation of the headset was calculated from the difference in the noise spectra between the microphones.

Because laboratory measurements of headset performance always over-estimate the protection afforded when they are used in the work place (Hemstock and Hill, 1990), the A-weighted SPLs at the ear were measured on the same group of subjects in an armoured personnel carrier travelling on a 'tarmac' surface.

Laboratory intelligibility assessment used a Speech Transmission Index using Artificial Signals (STIDAS) device which produces a known signal. This signal passes through the communications system and the computer analyses the return signal. (Steeneken and Agterhuis, 1983.)

Visual inspection of the compatibility of headsets with helmets were made, and during all parts of the assessment other problems were noted as seen by the staff or when reported by the subjects.

RESULTS

First assessment: Headsets B and C were similar in their compliance with the requirement although there were many areas where improvement was needed. Headsets B and C achieved acceptable passive protection, although in both cases the inclusion of speech and vehicle noise through the communications system increased the A-weighted sound pressure level to above 90 dB(A). Headset A, whose passive attenuation was poor, appeared to have an acoustic leak, possibly due to the way in which the headset was attached to the helmet. The attachment caused the top of the earshell to lift from the head. The ANR worked well in headsets B and C in the static tests but were less good when the headsets were tested in the vehicle. The acoustic leak in headset A caused its ANR to perform badly. This highlights the need for good passive protection for the ANR to work well. All the microphones had adequate noise cancelling properties and better speech quality than the present in-service microphone but none of the VOSs had suitable response times. Compatibility was shown to be adequate although it was difficult, but not impossible, to fit headset A with nuclear, biological and chemical individual personal equipment (NBC/IPE); all the headsets' attenuation was bady degraded in this situation.

Some mechanical features of the headsets gave problems in the fitting and fixing of the headsets and the positioning of the microphones. Headset A had the microphone and its wiring mounted on a half circle wire-framework which was difficult to adjust. The clips on the helmet rim were not always stable. The rather large and heavy neckband for Headset B was attached to the earshells by a ball joint which did not always allow the headset to seat properly on the head and which also extended the neckband beyond the helmet rim. Although the neckband of Headset C was adjustable, it did not always close evenly which created an uneven pressure around the seal.

All the headsets were modified before being returned for the second assessment. Headset A was re-designed with an improved microphone boom with a single arm and a neckband, but it still retained the clips for securing the earshells over the ears. The ball joint on Headset B was replaced by a flatter swivel joint. The over-helmet straps were widened on Headset C and the swivel joint on the earshell was prevented by small lugs from turning through 180 degrees. All the manufacturers tried to optimise the electronic performance of the ANR, the microphone and the VOS.

The second assessment showed that the attenuation had been improved in all cases, but only Headset C performed well in the vehicle. The VOS of only Headset B gave acceptable response times. The microphones on Headsets A and B gave improved speech intelligibility compared to the in-service headset microphone. Headset A failed in many areas such as robustness, suitability of fixings and ability to fit all head sizes. Headsets B and C were robust but failed on comfort and suitability of fixings - factors which are paramount if maximum protection is to be achieved at all times with least effort and discomfort to the wearer.

CONCLUSIONS

In all of the headsets ANR was satisfactory. The practical implications of innovative ideas which had been used for such problems as retaining the headset securely whilst wearing the helmet, had not been fully thought out.

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