Proceedings of the Institute of Acoustics

NOISE AND HEARING CONSERVATION IN THE BRITISH ARMY

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1. INTRODUCTION

Noise and its effect on hearing were traditionally not thought of as a problem in the Army until the present century; although there must have been some noise-induced hearing loss ever since the invention of gunpowder. More recently, the problem has been increased by the development of the tracked armoured fighting vehicle.

The First World War produced a spate of reports of noise-induced hearing loss from gunfire. These reports were largely forgotten; from a technical point of view, they were seriously limited in that the technology of the day could measure neither noise nor hearing acuity. A similar spate of reports followed the Second World War, but in this case some early pioneers were able to measure both the noise and its effect on hearing. The most detailed, and also the most accessible, of this work was that by Murray and Reid (1).

Murray and Reid described noise, and resulting temporary and permanent hearing loss, from a variety of weapons, from rifles to howitzers. They included some weapons which were more noisy than anything in current service.

After the Second World War, interest in noise-induced hearing loss dwindled again. Interest was re-kindled with the introduction of the 7.62mm Self Loading Rifle, and very much more so by the gradually increasing use of audiometry. For instance, Livesey (2) found that 54 out of a sample of 100 Infantry showed evidence of noise-induced hearing loss. Brasher (3) found a similar incidence in Infantry soldiers, but a lesser incidence in medical personnel, presumably reflecting the lesser noise exposure of the latter. Coombe (4) found a similar state of affairs in 1979.

At this time, the most used form of protection was a soft plastic ear plug which had been shown to be effective when properly worn. This device was issued to all Army personnel in 1966, but hearing loss continued to occur. Clearly, a more formal programme for hearing conservation was needed. The Army Hearing Conservation Programme (with equivalent programmes in the other Services) was developed to meet this need, and issued as a general administrative instruction. Routine screening audiometry was formally introduced in 1979 (4).

The Army Hearing Conservation Programme is designed to preserve combat effectiveness, preserve health, and meet statutory obligations. The hearing conservation measures available at unit level are the detection, measurement and evaluation of hazard; reduction of noise hazard; use of personal hearing protection; monitoring of hearing acuity; and health education.

In many respects, therefore, hearing conservation in a military context is broadly similar to its civilian equivalent. However, there are also some marked differences:

- exposures, even during routine training, vary greatly from day to day;
- there is a great variety of noise sources, including impulse noise from gunfire;

- soldiers need to have reasonably good hearing in order to be able to do their jobs - hence the requirement to preserve combat effectiveness.

This last point is in marked contrast to civil life where noise-induced hearing loss rarely has a direct effect on employability. Soldiers are generally well aware that noise-induced hearing loss can affect or in some cases terminate their careers.

The UK Noise at Work Regulations (1989) (5) apply to the Armed Services in peacetime in the same way as to industry, but their application is not always straightforward. They are really framed around continuous noise from machinery and are clearly not designed to take account of irregular exposures, nor of impulse noise from gunfire. The concept of a "daily personal noise exposure", for instance, does not accord with a job where each day is different from the next. The obvious solution in this case is to assume the worst reasonably credible exposure.

2. IMPULSE (GUNFIRE) NOISE

Impulse noise from gunfire has few civil equivalents. It is characterised by very high peak pressures over a very brief duration. Typically, small arms produce, at the user's ear, peak pressures around 2 kPa with a duration around 5 ms. Other weapons can be more noisy, especially infantry support weapons and artillery where peak pressures can be 20 kPa or more with durations in the range 10 - 50 ms. The majority of weapons require use of hearing protection; the most noisy weapons can, in susceptible individuals, cause severe hearing loss after a very small number of rounds where protection is not used..

Evaluation of impulse noise from gunfire is based on a UK Defence Standard (6), which is generally similar in intent and effect to standards used in other armed forces (7). There is evidence to show that it is over-cautious when applied to exposures where hearing protection is used (8).

Hearing protectors are generally very effective (provided, of course, that they are used carefully on all occasions of exposure). Typically an ear muff will reduce peak pressure at the ear by about 15 - 20 dB, as measured by miniature microphones at the ear position; but the reduction in peak pressure is, by itself, an inadequate measure of protection of hearing and will under-estimate the effectiveness of protection. Although the Noise at Work Regulations (1989) are correct in stating that peak pressures above 200 Pa at the ear may be hazardous, the assertion that they are necessarily hazardous in all cases is flatly contradicted by the evidence, especially as so far as levels at the protected ear are concerned.

Problems associated with the use of hearing protection include ergonomic factors such as fitting, comfort and compatibility with other headgear such as helmets. The reduction in volume of speech can also be perceived as a problem, particularly with a quiet background; it is possible to construct hearing protectors with an acoustical or electroacoustic element which will transmit speech in quiet conditions but cut out intense noise, and some of these are in service in small numbers.

3. VEHICLE (CONTINUOUS) NOISE

Continuous noise inside tracked armoured vehicles such as tanks can reach 120 - 130 dB SPL, the worst case being fast movement on roads. Much of the noise arises from impact between

track link pads and the road; noise tends to be slightly less during movement across country since the ground is softer. Most of the sound energy is concentrated at low frequencies corresponding to track link passage. Noise from wheeled vehicles tends to be less than in tracked vehicles, but can still exceed 90 dB(A). In practice, the duration of noise exposure tends to be restricted by the high cost of running these vehicles, but some groups (such as driving instructors or test drivers) have consistently long noise exposures.

Protecting hearing in such an environment presents quite a challenge, especially when the soldier is listening to speech over a communications network. If the speech is contaminated with noise picked up by live "noise-cancelling" microphones, the noise at his ears will be further increased.

The use of active noise reduction can improve the attenuation of a communications headset, while improved microphones and a voice operated switch can reduce the ambient noise transmitted through the communications network (9). It is now possible, at least in principle, to reduce noise at the ear to 90 dB(A) even in the most noisy vehicles, so the requirements of the Noise at Work Regulations (5) can be met.

4. SURVEYS OF HEARING LEVEL

Hearing levels in the British Army are monitored during routine medical checks, on intake and at intervals thereafter, using conventional pure-tone air-conduction audiometry. The results form part of normal medical records and are permanently attached to the soldier's other medical documents. They are not collated centrally, except in a very abbreviated form showing the proportion of soldiers below minimum entry standards. The primary intention of medical records generally is to assess fitness for service. Results are expressed as a hearing "degree" as follows, with the "low" frequencies being 0.5, 1 and 2 kHz, and the "high" frequencies 3, 4 and 6 kHz:

Degree	Sum of hearing level at low frequencies in dB	Sum of hearing level in high frequencies in dB	"General Description" (from Service medical classification)
H1	Not more than 45	Not more than 45	Good hearing
H2	Not more than 84	Not more than 123	Acceptable practical hearing for Service purposes
H3	Not more than 150	Not more than 210	Impaired hearing. The hearing level at which most personnel are unfit for entry to the Services
H4	Greater than 150	Greater than 210	Very poor hearing. Below entry standard to the Services

Results are recorded for right and left ears separately, and an overall degree awarded on the basis of the *worse* ear.

H4 indicates unfitness for front-line service. A further degree, H8, indicates unfitness in any capacity, inevitably resulting in medical discharge; the distinction between H4 and H8 is the responsibility of the ENT specialist and may include non-audiological factors.

Most hearing loss occurs at 4 or 6 kHz, with the other frequencies important for hearing speech being less affected. As a result, and since the assessment is made on the hearing of the worse ear, it is possible for a soldier's hearing to be unsuitable for front-line (or any) service without his being deaf in the social meaning of the term.

In principle, it would be possible to conduct a survey of hearing levels by extracting results from individual medical records, which normally include the hearing level at each frequency as well as the overall degree. In practice, it is more satisfactory to obtain fresh audiograms, since existing audiograms will have been obtained at various times so that most will not be up-to-date; also, the quality of routine audiometry can vary.

Figure 1 shows the results of a small survey of hearing in tank crew, using audiograms freshly obtained for the purpose. This was conducted in 1987 (10) after the introduction of a new Main Battle Tank (Challenger 1) which produced higher levels of continuous noise than the Chieftain which it replaced (in this regiment). Tank crew use a noise-excluding headset/helmet (Crewguard), but noise at the ears could still exceed 90 dB(A). It can be seen that the majority of tank crew are H1 with most of the rest H2. There were very few H3 and no H4. These results are not greatly different from the audiometric returns for the Army as a whole. It appears probable that the noise from the tank is not an undue risk to hearing, although it was recommended that the measurements be repeated after an interval to ensure that no deterioration was occurring.

The Gulf conflict involved movement in armoured vehicles at high speeds over long distances, both during the land battle and during the training which preceded it; for most of the soldiers involved, the noise exposure would be much greater than during peace-time. In addition to tank crew using Challenger 1, there were mechanised infantry units using the Warrior Armoured Personnel Carrier which is also very noisy (up to 120 dB, 112 dB(A)). Warrior, like Challenger, is equipped with noise-excluding headsets (in some cases, with active noise reduction), but their use may not have been universal. There was therefore some apprehension of a high incidence of hearing loss in Gulf veterans.

Figure 2 (taken from data reported by Richardson (11)) shows hearing levels in Challenger crew before and after the Gulf conflict. The "pre" results were taken from routine medical audiograms as described above. It is immediately apparent that hearing appears to have improved due to noise exposure. On closer examination, this unusual finding is seen to be due to the quality of the audiometry, which was done rather more carefully after the Gulf conflict than for the routine medical checks beforehand. Comparison of hearing levels between those who had served as tank crew, and controls who had not, showed that there was no apparent loss due to exposure to Challenger noise. There is a suggestion of some deterioration at 6 kHz in both populations, probably due to small-arms noise exposure.

In the case of Warrior crew, results averaged across 0.5, 1 and 2 kHz also show a slight improvement, again attributable to more careful audiometry. Figure 3 shows results for Warrior crew averaged across 3, 4 and 6 kHz, and expressed in this case as a histogram. The use of a histogram is more revealing than use of mean values since deterioration in hearing of a small proportion of men can be seen more clearly. The results show no apparent change in the right ear, but a slight movement in the direction of worse hearing in the left ear. Comparison in

terms of "H" degrees shows that roughly as many men appear to have improved as have deteriorated. It appears that some deterioration at high frequencies in the left ear may have actually occurred, but that it is quite small; since the left ear is most affected this may well have been a consequence of small-arms noise where the left ear is closest to the muzzle. Effects from vehicle noise are more likely to have been bilateral. Some of the loss could have been due to routine training (or indeed have been unrelated to military noise exposure).

These results are in contrast to those from the Falklands campaign (12) where substantial deterioration in some men was found following exposure to gunfire noise.

On the whole these more recent results give some grounds for optimism, in that the incidence of hearing loss is not great. On the other hand, any hearing loss at all represents an injury which (in peacetime at least) could have been avoided. It is also rather unsatisfactory that obtaining accurate data on hearing status requires a survey; an improved standard of routine audiometry, and centralised recording of results, are urgently required so that problems can be identified. These matters are being addressed.

It may be of interest to note that a survey of hearing impairment among adults in Great Britain (Davis (13)) showed, when the results were interpreted in terms of "H" degrees, hearing somewhat worse than that normally found in Regular Army samples. The reason for this is not clear, since the number of potential recruits refused entry to the Army on hearing grounds is not great and the number of soldiers prematurely discharged for poor hearing is relatively small. Possibly some element of self-selection is operating. Most of the hearing impairment reported by Davis is probably not noise-induced, and there will be an obvious difficulty, when hearing levels are measured for hearing conservation purposes, of distinguishing whether losses are or are not due to noise exposure.

5. THE WAY AHEAD

The preferred way of reducing noise-induced hearing loss is to reduce noise exposure; at first sight, weapons and armoured vehicles would not appear to offer much scope for this. However, in a few cases, new equipment has been less noisy than its predecessor, so some progress is being made. The use of hearing protection can also be improved; not just by improving attenuation (although this has been done, in the context of vehicle headsets, by the use of active noise reduction), but by making it more compatible with other equipment (seen as especially important, with the possibility of an integrated approach) and more comfortable during prolonged use. Providing hearing protection against gunfire or intermittent noise, while retaining normal hearing for speech, is another possibility to be explored for more widespread use.

6. REFERENCES

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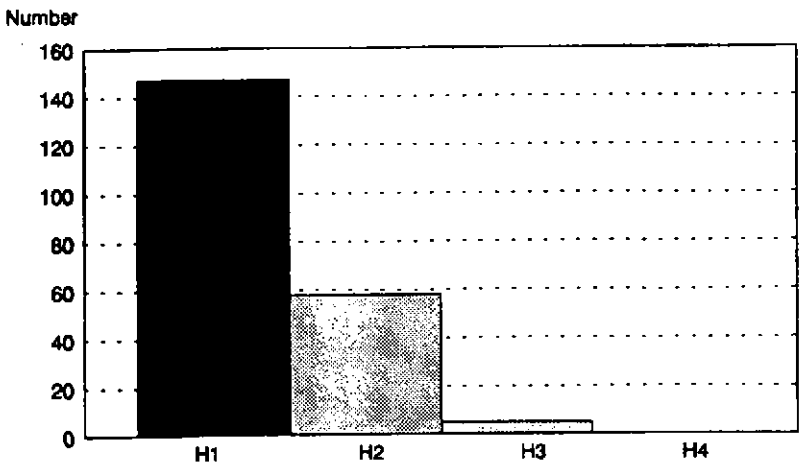

Figure 1. Hearing degrees in a Challenger tank regiment (10)

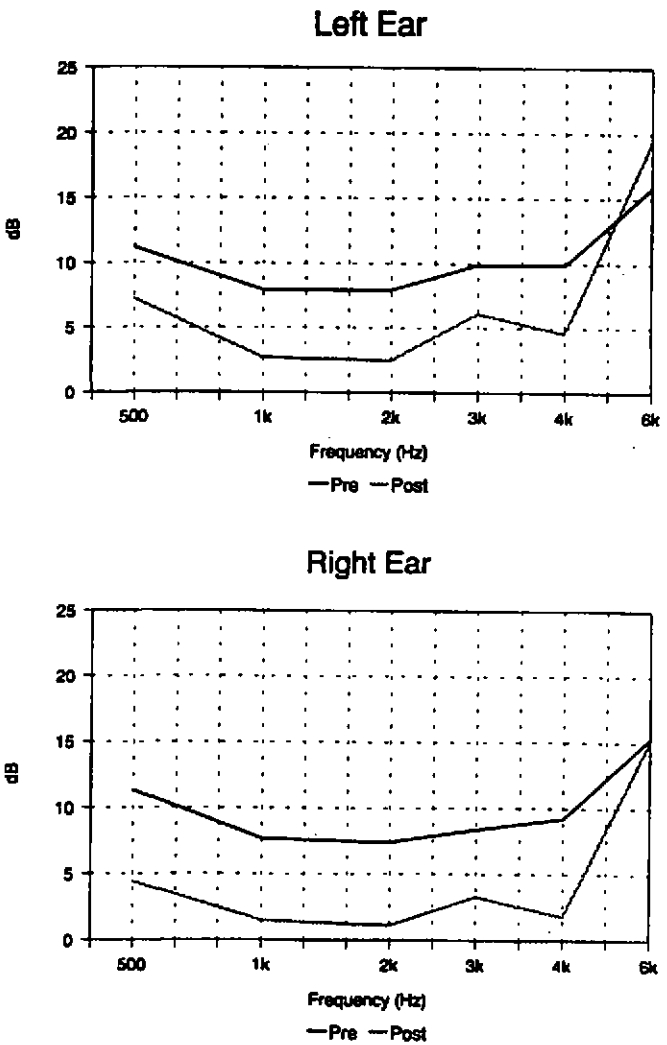

Figure 2. Hearing levels in Challenger tank crew, pre and post Gulf conflict (11)

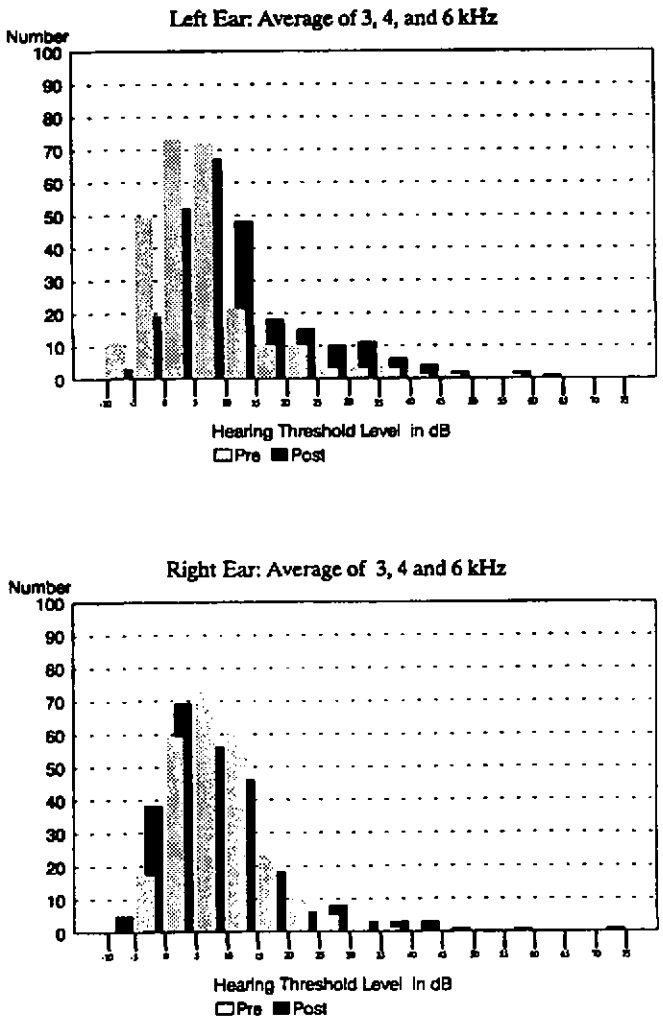

Figure 3. Hearing thresholds in Warrior crew, pre and post Gulf conflict