

Noise-Induced Hearing Loss

of Occupational Origin

A Guide for Medical Practitioners

This booklet was compiled by Dr Chris Walls (Departmental Medical Practitioner, OSH) from technical material prepared by: Mr John Avery (Otolaryngologist); Mr. George Bellhouse (Senior Occupational Health Scientist, Noise, OSH); Ms Ann Greville and Mr Jeremy Rosser (National Audiology Centre) and Dr David Black (Penrose Clinic).

The information on noise control was contributed by Nigel Lloyd, Acoustic Consultant, Acousafe Consulting and Engineering Ltd., Wellington.

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Foreword

The Occupational Safety and Health Service of the Department of Labour (OSH) is committed to providing health and safety information to everyone in the workplace. Our aim is to enable managers and their employees to control the risks to their health and wellbeing that arise in the workplace.

This booklet is one of a series of OSH publications highlighting important occupational health problems. It is aimed at providing general practitioners and other primary health care practitioners with diagnostic information and practical solutions to the occupational health problems they face.

Noise is a well-recognised and ubiquitous hazard in the workplace. It has been a problem for New Zealand industry for the last 100 years. Despite several campaigns and considerable attention to the issue, the effects of noise on hearing remain an enormous problem. Because of the pervasive extent of noise throughout the modern day, OSH hopes that this booklet will have application both within and outside of work.

General practitioners act as the occupational health advisers for most of New Zealand's industry. They play a crucial role in the diagnosis of hearing loss and in advising their patients of the best means to control noise. I hope that this booklet will make your task easier and contribute towards preserving the hearing of all those at work.



R. J. M. Hill

General Manager

Summary

Diagnostic criteria have been formulated to enable general practitioners to diagnose occupational noise-induced hearing loss and notify these patients to the Occupational Safety and Health Service (OSH) of the Department of Labour. General practitioners should be better equipped after reading this booklet to offer practical advice to employers and employees on how to avoid hearing loss.

1. Two baseline audiometric measurements are recommended at the following frequencies: 500, 1000, 1500, 2000, 3000, 4000, 6000 and 8000Hz. Surveillance and diagnosis should use these frequencies also.
2. People in workplace environments that exceed the Workplace Exposure Standard for an 8-hour working day (85 dB(A)) must have hearing surveillance at least every 2 years at the above frequencies.
3. People can be considered to have an occupational noise-induced hearing loss:
 - (a) If the hearing surveillance shows an occupational history consistent with exposure to excess noise.
 - (b) If the *shape* of the hearing threshold curve obtained from the surveillance audiograms shows a characteristic notch at 4 to 6 KHz, with recovery at the higher frequencies.

The magnitude of the hearing loss is diagnosed by noting the depth of the notch from an established baseline.

4. The criteria adopted for notification to OSH is that the threshold at 4KHz is at least 30dB Hearing Loss (HL) and is at least 15dB worse than the 2KHz threshold. The hearing loss should be symmetrical in each ear.
5. Hearing surveillance and the diagnosis of noise-induced hearing loss is only half of the solution. General practitioners and other primary health care professionals must advise affected people and their managers on the need for prevention of hearing loss by means of noise control.
6. The importance is emphasised of considering all sources of noise (both occupational and non-occupational) when offering advice to people (both in the industrial or the general practice setting).
7. A discussion of noise control measures is presented, together with a summary of the employer's obligations under the new Health and Safety in Employment Act.

Introduction

The Costs of Hearing Loss

In the 1991-92 year, the ACC received over 9000 noise-induced hearing loss (NIHL) claims from New Zealanders, at a cost to the corporation of \$38 million. The cost to the sufferers of this hearing loss cannot be measured in monetary terms alone. Deafness is a major source of social isolation for the middle-aged and elderly, the two age groups with the greatest incidence of NIHL. General practitioners are familiar with the handicaps that retired workers with deafness suffer and the extent to which this handicap detracts from their enjoyment of retirement.

NIHL is the most common cause of acquired hearing loss and is totally preventable¹. It has been accepted for years that many New Zealand industries have a noise problem. Numerous campaigns have been mounted to combat this problem but little long-term improvement seems to have occurred.

The Occupational Safety and Health Service of the Department of Labour (OSH) believes that all primary care practitioners have a role in diagnosing those who have already suffered irreversible damage and, more importantly, in offering education and advice to prevent further deterioration of the affected person's hearing and the occurrence of NIHL in unaffected people.

A Notifiable Disease

NIHL has been targeted as a priority disease under the Notifiable Occupational Disease System (NODS), operated by the Occupational Safety and Health Service. This system has three goals:

1. To collect statistical data on occupationally related illness and disease.

This data is used to help formulate government policy and will serve as the ultimate check on the effectiveness of occupational safety and health interventions by employers, employees and their representatives and government agencies.

2. To educate general practitioners about a small number of important occupational diseases.

General practitioners care for most of New Zealand's small businesses and receive little undergraduate or postgraduate training in occupational health.

3. To identify at-risk occupations and workplaces so that OSH can focus interventions on preventing further occupational illnesses at that site in the future.

Scope of this Booklet

This booklet reviews the factors that combine to create the problem of NIHL. It is designed to familiarise doctors with terminology used in measuring and controlling noise (which can be confusing) and to provide a framework for accurate diagnosis and prevention. It deliberately takes an uncomplicated approach to what is a highly technical subject.

NIHL has implications outside the workplace. In this age of “Heavy Metal” and the ubiquitous “Walkman”, the general practitioner needs to consider the individual’s recreational pursuits as well as the hazards at work. To control the hazard of noise, in both the occupational and the recreational setting, doctors, teachers and parents need to target the young with strategies to reduce their noise exposure.

An Overview of the Physics of Sound, Physiology of the Normal Ear and the Pathology of NIHL

What is Noise?

Noise has been defined as unwanted sound that may adversely affect the health and wellbeing of individuals or populations².

Some dispute now exists as to whether “unwanted” should be still included in the definition, given the impact in modern times of “wanted” recreational noise.

Characteristics of Sound

Sound is a form of energy, generated when a surface vibrates and sets the adjacent air molecules into vibration, creating pressure fluctuations above and below atmospheric pressure.

The rate at which these pressure fluctuations (or waves) occur determines the frequency (or pitch) of the sound and is normally measured in Hertz (one Hertz or Hz equals one cycle per second).

The velocity with which the pressure fluctuations move away from the vibrating surface is the speed of sound. This changes slightly with air temperature and pressure, but is normally taken to be approximately 340 metres per second. The velocity of sound in materials other than air depends chiefly on the properties of that material. It is, for example, about 1,400 metres per second in fresh water and 5,200 metres per second in steel.

Sound and Human Hearing

A young person with normal hearing can hear a wide range of frequencies of sound, from about 20 to 20,000 Hz.

Frequencies below 20 Hz are felt as vibrations rather than heard as sound. The effect of these infrasonic vibrations on the hearing mechanism is not well understood, although they can cause adverse health effects such as nausea and headaches if present at a high enough intensity.

Frequencies above 20,000 Hz, called ultrasonic frequencies, are not normally heard by humans but can cause hearing impairment if they are present at a high enough intensity.

A normally hearing person is capable of responding to an enormous range of sound pressures, from about 20×10^{-6} Pascals (Pa) to about 200 Pa, a range of 10,000,000 to one. The ear responds in a logarithmic rather than a linear manner to changes in the sound pressure it receives.

This minimum level of sound pressure change of 20×10^{-6} Pa is used as a baseline or reference for comparative measurements. Normal atmospheric pressure is about 100 KiloPascals (KPa) so it can be seen that the hearing mechanism is exquisitely sensitive.

Measuring Noise

Measuring Sound Intensity

It is sound intensity at the ear over a period of time which has been shown to correspond to the degree of NIHL.

Intensity is defined as the rate of energy flow per unit area, which is difficult to measure but has been shown to be directly proportional to the square of the sound pressure. This can be measured relatively simply so that instruments usually detect the change in air pressures induced by sound.

These changes in air pressures are measured using a comparative unit called the “Bel” (a unit which is not confined to noise measurement). The unit is associated with *ratios* of “power” and “intensity” and needs a reference value. In the case of sound measurement, this reference value (level) is the minimum audible sound pressure (20×10^{-6} Pa). A tenfold change in the intensity of sound is called 1 Bel. Because of its large size, the Bel is usually divided into decibels (dB = one tenth of a Bel) and this is the international convention for the measurement of sound levels.

A table of decibel levels and their approximate effect on a person’s hearing mechanism is presented in Table 1, together with some examples of typical noise sources.

Table 1 Decibel Levels and their Effects on the Hearing Mechanism.

| Sound Level (dBA) | Physiological Response | Example of Noise Source |
|-------------------|---|--------------------------------------|
| 150 | Instantaneous damage. | An explosion, heavy-calibre weapon |
| 140 | Damage over a brief period of time | A rifle being fired |
| 130 | Threshold of pain | A jet aircraft taking off |
| 115 | Some hearing damage after approximately 30 seconds | A power saw or a chain saw operating |
| 100 | Some hearing damage after approximately 15 minutes. | Grinding metal, noisy lawn mower |
| 85 | Some hearing damage after 8 hours. | Noise in a very busy street. |
| 70 | Damage to hearing is unlikely to occur | Assembly work without noisy tools |
| 60 | Difficulty understanding conversation on telephone | Busy office |
| 50 | Hearing with comfort | Urban noise level away from roads |
| 30 | Undisturbed sleep | Average bedroom |
| 0 | Threshold of hearing | Anechoic chamber |

Because of the logarithmic decibel scale used to measure sound, a 3dB increase in sound level represents a doubling of the power of the sound reaching the ear. However, a 3dB increase is subjectively only just noticeable. A 10dB increase in sound level represents a tenfold increase of the power of the sound reaching the ear but subjectively it will “sound” only about twice as loud to the exposed person.

Effects of Frequency on Hearing

In addition to the logarithmic response to sound pressure, the human ear responds in a non-linear fashion to sounds of different frequencies.

This non-linear response has been measured by asking a large number of young people with normal hearing to adjust the levels of pure tones at different frequencies until these tones are judged to be of equal loudness as a 1KHz reference tone at various sound levels.

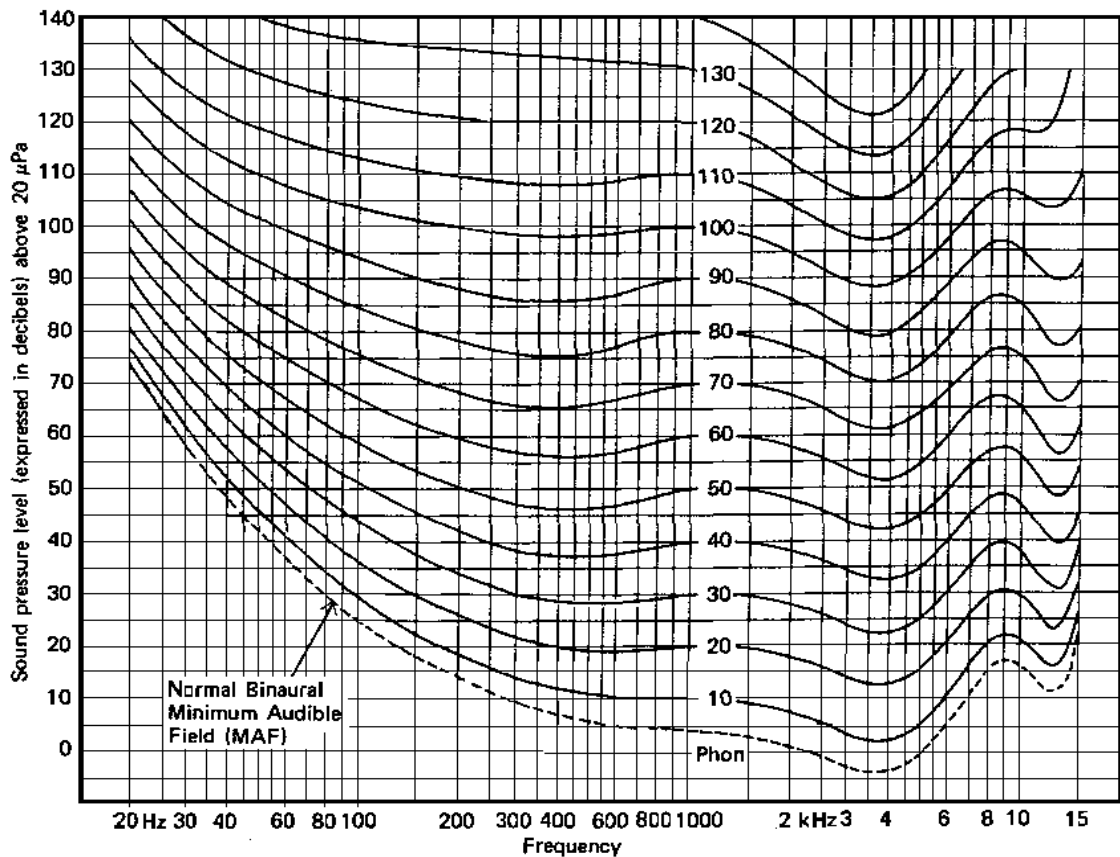


Fig. 1 Equal Loudness Curves.

A series of curves results, the so called “equal loudness curves” illustrated above (Fig.1).

It can be seen from these curves that hearing has the greatest sensitivity over the middle range of frequencies, which are those contained in human speech. At high and low frequencies, a much higher sound pressure level is required to sound as loud as a middle-frequency sound.

If a sound level meter is given approximately the same response characteristics as the 40 phon curve on the graph above (phons are subjective units of loudness), the characteristic is called an “A-weighting”. The A-weighting is internationally used to assess occupational noise and such a measurement is identified by (A), e.g. 85 dB(A).

The C-weighting is derived from the 100 phon curve and is used in some countries to determine whether a particular type of hearing protection will sufficiently reduce the noise being measured to a “safe” level.

Workplace Exposure Standards: the Terminology of “Acceptable” Noise Levels

Workplace Exposure Standards

Noise occurs throughout the day and has a damage-dose effect on hearing. Industrial noise exposure standards are set for an average 8-hour working day and assume that noise exposure throughout the rest of the 24 hours will not cause the total noise exposure for that day to exceed the exposure standard.

The risks of noise (or any workplace hazard) cannot be considered in isolation from that person’s social or recreational environment. For example, noise levels at discos have been reported as 97db(A)³. A person who experienced a noise dose which equalled the “acceptable” level for an 8-hour working day and then spent 4 hours at a disco has exceeded their daily dose, despite having had an “acceptable” exposure during work.

Equivalent Continuous Noise Level

To quantify an acceptable level of noise, the term “Leq” is normally used. Leq is short for Equivalent Continuous Noise Level, and is an imaginary constant noise level which contains the same amount of sound energy as the actual fluctuating or intermittent noise over a stated interval.

The extent of damage caused to hearing is dependent on the amount of noise energy that the ear has been exposed to over a period of a day. This total noise energy for the day can be determined by adding up all the separate exposures of different levels for various periods of time. This total exposure is normally expressed in terms of an Equivalent Level of sound over a period of 8 hours, called the Leq(8hrs), and can be directly compared with an exposure standard to determine whether the noise is likely to be damaging to a person’s hearing.

In New Zealand, the exposure standard is set at 85dB(A) Leq (8hrs). That is, the limit for the acceptable level of noise in the workplace is taken to be the sound level for the period of exposure that is equivalent to a constant 85dB(A) for an 8-hour period.

For every 3dBA increase in measured sound levels (a doubling of the sound power) the acceptable time of exposure must be halved (see Table 2).

Table 2 Noise Levels and Maximum Exposure Times.

| Constant Noise Levels | Maximum Exposure Time |
|-----------------------|-----------------------|
| 85 dBA | 8 hours |
| 88 | 4 hours |
| 91 | 2 hours |
| 94 | 1 hours |
| 97 | 30 mins |
| 100 | 15 mins |
| 103 | 8 mins |
| 106 | 4 mins |

Leq is the same class of measurement as other Workplace Exposure Standards (WES), or as they are referred to in other countries, Threshold Limit Values (TLVs). These values are based on a mixture of scientific evidence and economic practicability and accept that at the specified level of hazard some people will go on to suffer harm. *They are not and should never be used as demarcating a safe from an unsafe workplace.*

For example, the risk of a person who has been exposed to noise of 85dB(A) for 8 hours every working day for 40 years suffering a 30dB(A) loss on audiometric testing is 35% (i.e. one third of people working in a “safe” environment are at risk from suffering a significant degree of hearing loss over their working life). If the exposure increases to 90dB(A), the risk rises to 51%.³

The Workplace Exposure Standard is:

- Leq (8hrs) 85 dB(A)
- Maximum Level 115 dB(A)
- Peak Level 140 dB

Effects of Noise on Hearing

Symptoms and Signs

There is a great variability in the amount of NIHL suffered between people exposed to the same levels of noise. This may be due to a number of different mechanisms but two people doing the same work in the same environment can have quite different degrees of hearing loss from their exposures.

Excess noise produces a number of effects on the hearing mechanism. NIHL is by far the most common result of excess noise over a period of time and is preceded by a number of warning signs. These warning signs do not have to be present for NIHL to occur.

Temporary Threshold Shift This is a temporary raising in the threshold of detection of sound. The person notices a dullness or a difficulty in hearing (speech discrimination in noisy environments, etc.) over this period of time. The time taken for recovery to the normal hearing threshold depends on the intensity and duration of the noise and may exceed 48 hours.

A Temporary Threshold Shift (TTS) is the reason why audiometry is recommended after a suitable quiet period (16 hours). Frequently this is achieved by organising the tests at the beginning of a shift or working day.

The exact pathology of the effects of noise has not been fully established. TTS may include subtle intracellular changes in the sensory cells (hair cells) of the cochlea and swelling of the auditory nerve endings. Other factors such as metabolic exhaustion of the cells have been implicated⁴.

When insufficient time is allowed for the TTS to recover, and further excess noise levels are encountered, this threshold shift can become permanent and is called a Permanent Threshold Shift (PTS). The extent of PTS for a given set of conditions varies significantly from one subject to another and is unpredictable. An exposed person does not have to have suffered a TTS to develop a PTS.

If TTS occurs frequently, then PTS can develop and become NIHL, leading to an “occupational deafness”.

Tinnitus Tinnitus is a subjective sensation of noise in the ears or head. There are various descriptions of tinnitus, either as a high-pitched ringing, hissing or whistling, or a low-pitched rushing or buzzing. Short periods of high-pitched whistling can be experienced before TTS or PTS is established and can be taken as a warning sign of impending hearing damage⁵.

NIHL can occur without the person ever having noticed tinnitus.

Tinnitus is an important warning sign, prompting patients and their general practitioners to consider the possibility of impending NIHL and should never be dismissed lightly.

Recruitment Where the loudness of a sound increases beyond a threshold, the person with recruitment notices a sudden increase in their perception of the loudness of the sound.

Recruitment has many causes and is of great importance as a limiting factor in the fitting and use of hearing aids to overcome a hearing disability.

Recruitment occurs when there is a high hearing threshold. Since the threshold is elevated, the effect is that the equal loudness contours (illustrated on page 10) are compressed upwards, causing the growth of loudness of a sound as its sound pressure increases to be greater than for normal subjects. A consequence of recruitment is that the range between the threshold of hearing and the threshold of pain is reduced.

Masking Masking occurs when the background sounds render the distinction of speech unintelligible. Masking plays a major part in the inability of someone with NIHL to distinguish speech in a crowded room. In contrast, they are usually able to distinguish telephone speech more clearly.

NIHL and Presbycusis NIHL is a sensorineural hearing loss of gradual onset and is usually irreversible. Commonly, degeneration of the hair cells of the organ of Corti in the 4 to 6 kHz region occurs first. Superimposed on this noise-induced damage is presbycusis, the sensorineural hearing deterioration associated with age. The combination of NIHL and presbycusis requires some compensation agencies to differentiate between the “normal” loss of function associated with aging and the excess loss caused by noise. There are accepted tables and formulae for this calculation (see Appendix 9).

Whether hearing loss is an inevitable consequence of aging is controversial. Nevertheless, the consensus at the moment is that hearing deteriorates with age (presbycusis) and NIHL occurs in addition to this.

Surveillance in the Workplace

Hearing surveillance has three aims:

1. To identify those people with hearing impairment or tinnitus and to prevent further hearing loss developing.

2. To monitor the effectiveness of noise control measures in that person's workplace.
3. To provide an important contact with noise-exposed employees who may require an education programme.

Hearing surveillance is a form of biological monitoring as it measures the impact of a hazard on the individual. As with all types of biological monitoring, the person being tested must understand the reasons for the monitoring, give their agreement and be informed of the results of the test. It is most useful if the employee agrees to allow their manager to be informed of these results, even though it constitutes personal health information. Managers need to be able to identify people at risk when planning to control the risks in the workplace.

Any surveillance should be part of the health and safety management plan for the workplace and have the commitment of everyone involved.

The Audiogram

As with most biological monitoring, it is important to obtain a "baseline" by performing an initial audiogram. This identifies hearing loss present before the current employment began and allows a more accurate assessment of the effects of noise in the current workplace. The Accident Rehabilitation and Compensation Insurance Act (1992) mentions the need for two such baseline audiograms and OSH would support this recommendation.

OSH recommends that baseline testing of a patient be composed of two audiograms at the following frequencies:

0.5kHz 1 kHz 1.5 kHz 2 kHz 3 kHz 4 kHz
6 kHz 8 kHz

These are the same frequencies requested by the ACC when considering compensation for NIHL. (Some audiometers are unable to measure at the 1.5kHz frequency. The absence of this frequency would not invalidate an audiogram.)

After the initial audiogram:

1. Audiograms should be performed regularly for all people working in an environment which has an established or suspected noise hazard, defined as an exposure level greater than 85 dB(A) Leq (8 hrs).
2. The baseline audiograms should be performed within 3 months of initial employment, after a period of at least 16 hours quiet. This could follow a period of absence

from work or the wearing of high-grade hearing protectors to ensure that the exposure is no higher than 75dB(A). The beginning of a shift is often used to perform hearing surveillance. A pre-employment assessment may not be the ideal time because of the pressures on the applicant during this process, although many baselines are obtained in this way.

Ideally two audiograms, performed a couple of months apart, will provide a good baseline of that person's hearing ability.

These baseline audiograms provide the occupational health practitioner (occupational health nurse, occupational physician, general practitioner or practice nurse) the opportunity to:

- (a) Educate the person;
 - (b) Discuss the noise hazards in their particular area of work;
 - (c) Discuss the programmes to control this noise; and
 - (d) Explain the company's or the practice's policy on hearing surveillance.
3. Audiograms should be repeated no further apart than 2-yearly. They should be done more frequently in a particular workplace where:
- (a) There is evidence of hearing loss occurring;
 - (b) New processes have been introduced which pose a greater noise hazard; or
 - (c) When requested by the OSH occupational health nurse, medical officer or inspector.
4. Audiograms should be carried out in an environment where background noise is not more than 40 dB(A). Where ambient noise is greater than this, noise-excluding head sets or a testing booth should be used. Ideally, audiograms should be performed in specially designed booths which enable some individuals to detect sounds at the threshold of hearing. They will provide sensitive baselines against which to measure any subsequent deterioration.
5. Technical equipment to measure noise, hearing and the environment in which these tests take place should all meet accepted standards and be calibrated regularly. If these standards are not met, agencies such as ACC may not accept the results as valid. The appropriate standards are listed in Appendix 6.

The Diagnosis of NIHL

OSH in common with international practice has adopted pure tone measurements to diagnose NIHL. However, it is the inability of a person to discriminate speech, particularly against a background of noise, that produces the greatest impairment to their lives.¹

The use of pure tone testing results for diagnosis reflects the fact that the measurement of the ability to communicate is inexact and that the diagnosis of NIHL often has more to do with compensation than with improving the person's ability to communicate.

The following criteria have been chosen to make the diagnosis as straightforward and as reproducible as is possible. As with all occupational health problems, the diagnosis must include the following:

Occupational History

There should be a clear history of sustained exposure to loud noise at work. The practitioner should ask the person what industries they have worked in and for how long in each industry. An attempt to identify the approximate noise levels at each task (e.g. was speech possible without shouting? were the ears ringing at the end of the day or week?) should be made and the control measures employed (hearing protection, engineering control, hearing surveillance) should be assessed.

Comment should be made concerning the degree and type of recreational noise exposure.

Results of the Screening Audiogram

Audiometry should not be a stand-alone function but be part of an industry-based hearing conservation programme. OSH recommends that the testing of a person be at the same frequencies as the baseline testing, namely; 0.5kHz 1 kHz 1.5 kHz 2 kHz 3 kHz 4 kHz 6 kHz 8 kHz.

In order to make the diagnosis of NIHL, the following are necessary:

1. The shape of the hearing threshold curve should show a characteristic notch at 4-6 kHz, with a recovery at high frequencies usually required. A normal audiogram is shown in Fig. 2. This is contrasted with a "typical" noise-induced hearing loss audiogram shown in Fig. 3.

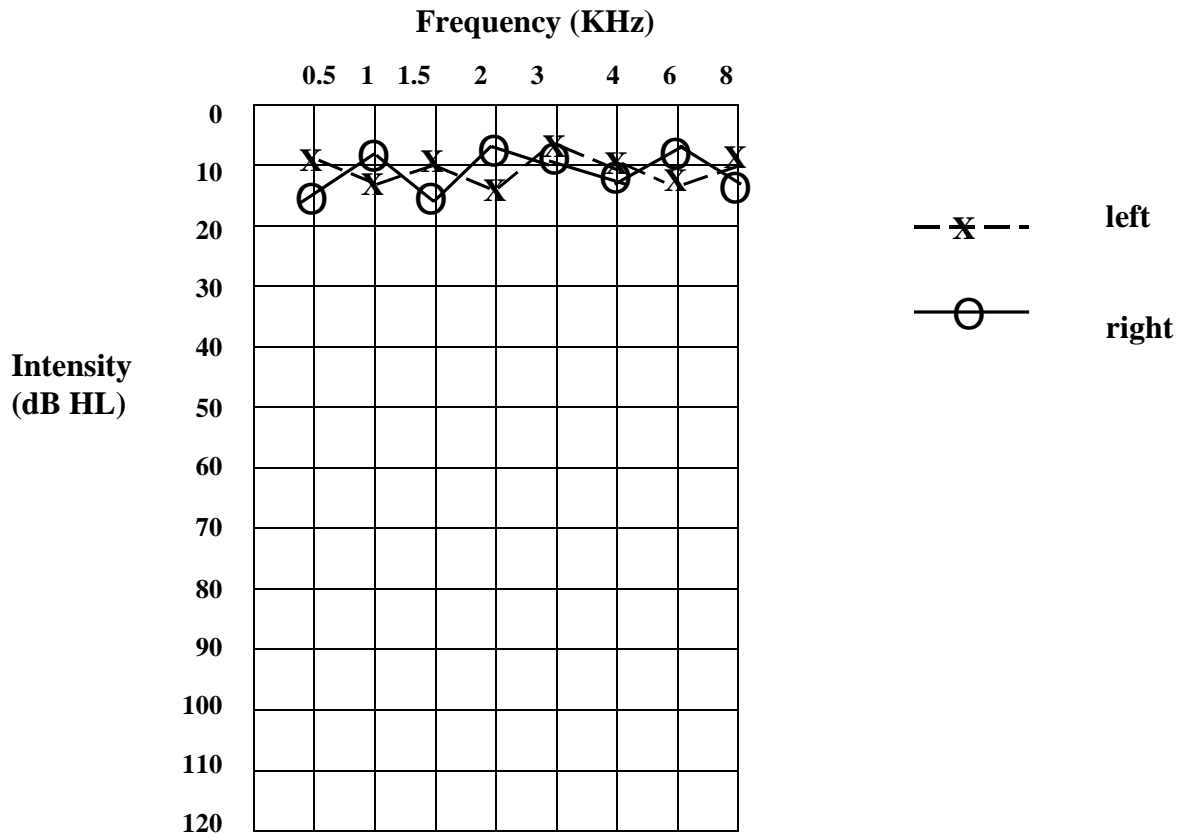


Fig. 2 Normal Audiogram.

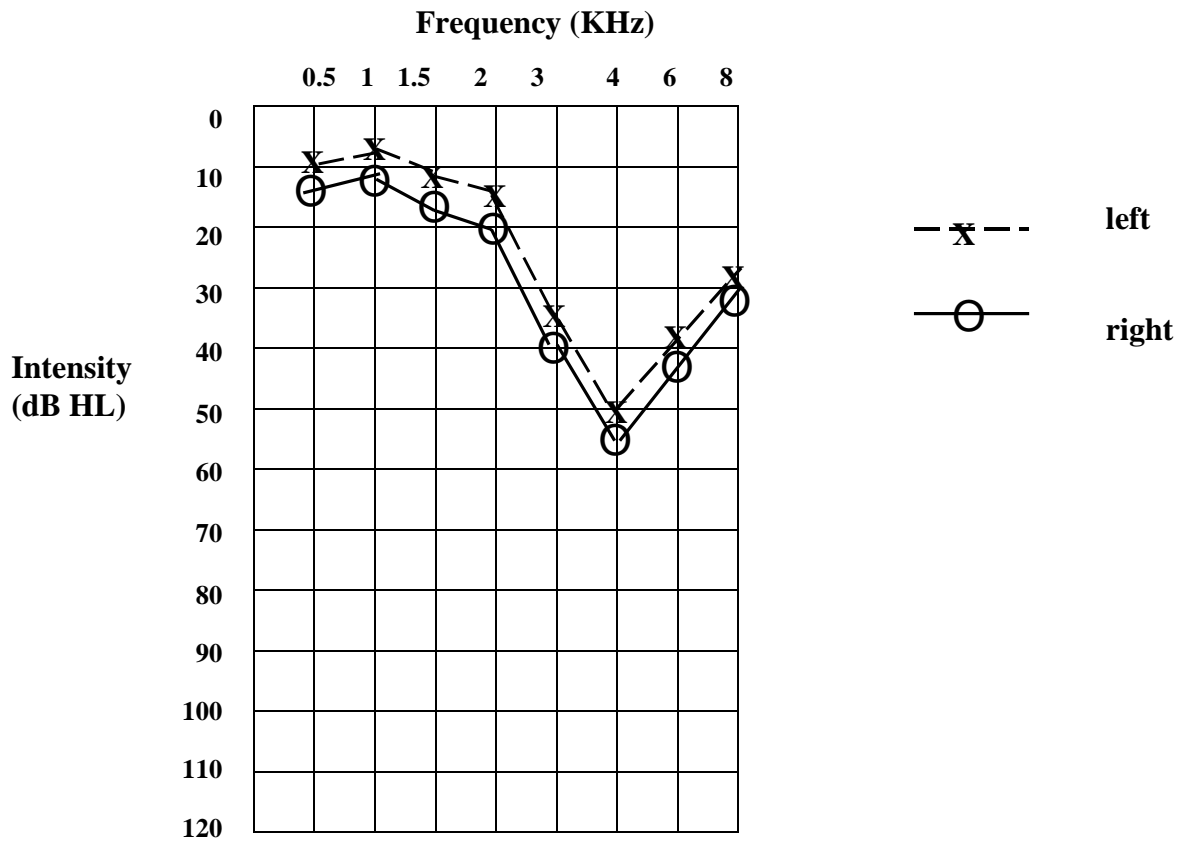


Fig. 3 Noise Induced Hearing

(Because an audiogram does not match this pattern, a noise-induced hearing loss cannot be excluded. As the NIHL increases, the notch widens and is lost. In fact, general practitioners should ask themselves with any hearing loss whether noise has played a part in the resultant clinical picture.)

2. A symmetrical loss is expected in each ear, or there should be an explanation for asymmetry on the basis of exposure history or other factors. Such an explanation for asymmetry could be that the person has a hobby involving rifle shooting (where the leading ear is subject to much higher levels of sound). If there is no convincing explanation for this asymmetrical loss, referral to an otolaryngologist should be considered.
3. For the purposes of notification to the NODS, the audiogram must measure the magnitude of the hearing loss by noting the depth of the notch from an established baseline.

The criteria adopted for notification is that the threshold at 4KHz is at least 30dB Hearing Loss (HL) and is at least 15dB worse than the 2KHz threshold.

Loss of Recovery above 6 kHz

It is usual for the audiogram to show a recovery in both ears for frequencies above 6 kHz. If this recovery is not present, the diagnosis of NIHL should be reconsidered. It is accepted that many severe cases of NIHL do not show such a recovery (sometimes this recovery is absent because of tinnitus) and NODS will accept a case without high-frequency recovery, accompanied by an explanatory note by a referring or reviewing specialist.

Notification Procedure

OSH will accept notification without further validation from otolaryngologists, occupational physicians or other health professionals who have undertaken and passed the National Audiology Centre's 2-day hearing conservation introductory course. (NAC, 98 Remuera Road, Auckland 5, Tel (09) 520 4009, Fax (09) 522 1622). This is made available around the country on a regular basis and enquiries should be directed to the NAC.

It should be noted that the Accident Rehabilitation and Compensation Insurance (Occupational Deafness Assessment Procedures) Regulations 1992 require that diagnostic audiometry for compensation assessment to be performed by a full member of the NZ Audiological Society or an otolaryngologist.

Differential Diagnosis

Otosclerosis An autosomal dominant disorder effecting both men and women, otosclerosis causes a progressive conductive deafness from early adulthood on. A “typical” audiogram is presented in Fig.4.

The primary practitioner can gain some indication in their rooms by means of the Rinne and the Weber tests (see Appendix 5).

Barotrauma Barotrauma can affect the middle and inner ear. Persistent or fluctuating tinnitus, vertigo and sensorineural hearing loss are symptoms of inner ear damage, most frequently following a diving episode or less often following flying. Cases should be referred to an otolaryngologist immediately.

Menieres Disease A disorder of swelling in the endolymphatic space. Classically, the patient develops a low-tone sensorineural loss followed by a symptom of low-pitched tinnitus. Patients describe aural fullness and then become acutely vertiginous. Attacks last between 15 minutes and several hours in duration. The disease fluctuates over long periods of time.

A typical audiogram for Menieres disease is shown in Fig.5. If there is any doubt concerning diagnosis, referral or discussion with an otolaryngologist should take place.

Brain Tumours The most common inner ear tumour causing hearing loss is an acoustic neuroma, which is a benign tumour of the Schwann cells covering the eighth nerve. The usual course of an acoustic neuroma is that the patient develops a unilateral sensorineural hearing loss. This loss progresses slowly in most cases and rarely patients may develop vestibular symptoms. Occasionally, acoustic neuromas can cause a sudden hearing loss and Menieres-type symptoms.

An audiogram typical of an acoustic neuroma is shown in Fig.6. Any patient who is suspected of having this diagnosis should be referred to an otolaryngologist.

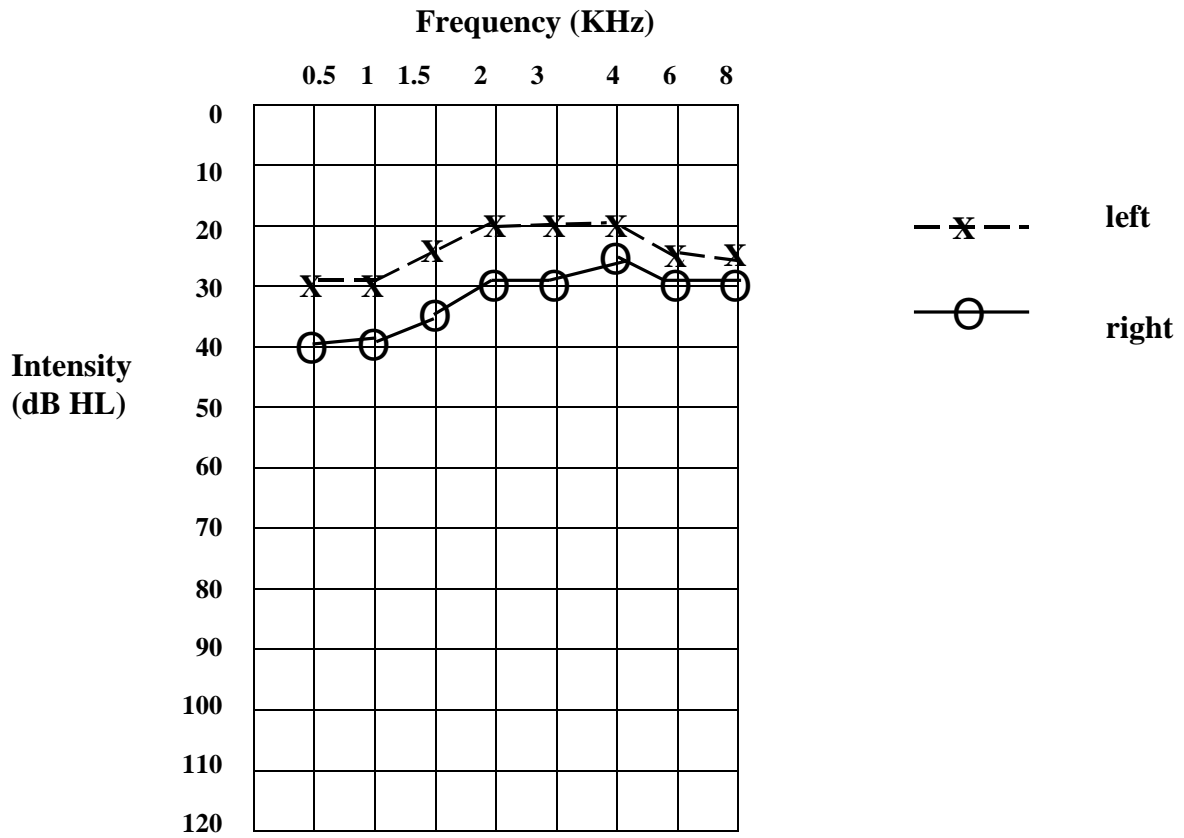


Fig. 4 Osteosclerosis.

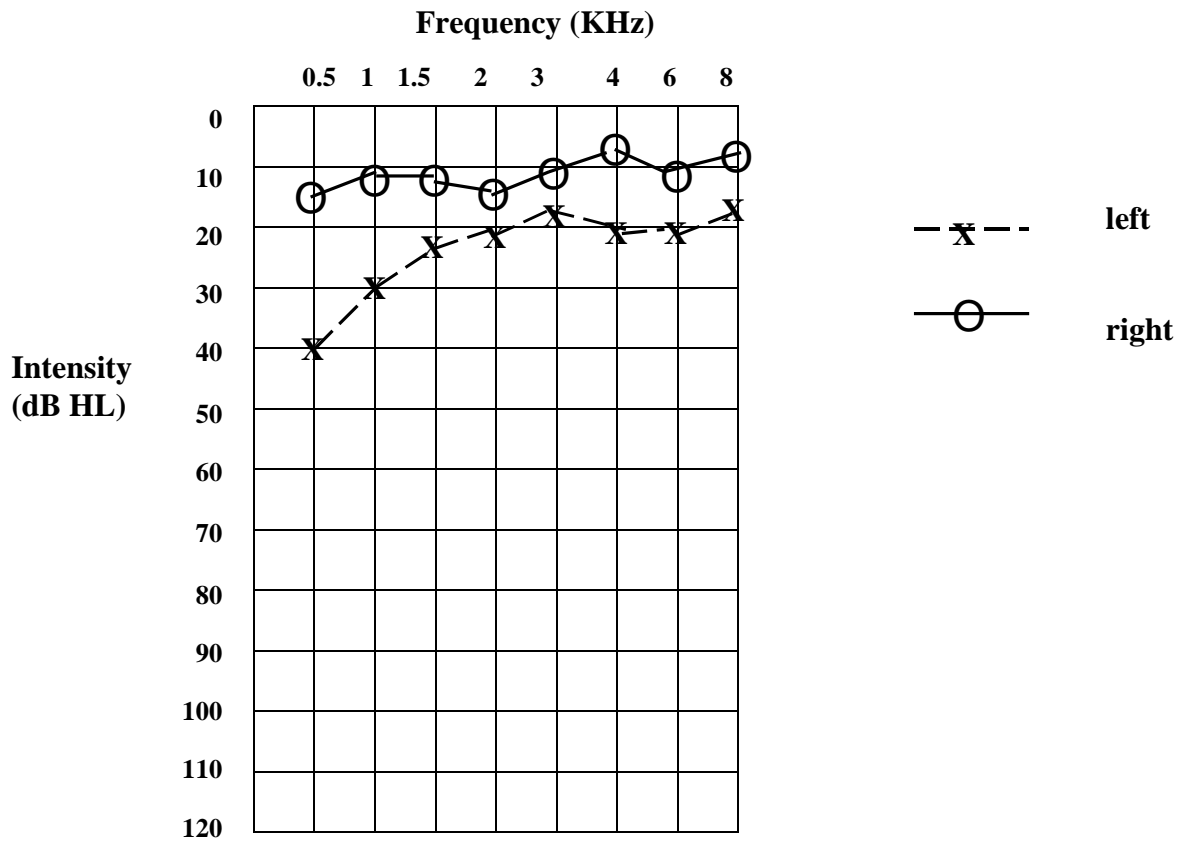


Fig. 5 Menieres Disease.

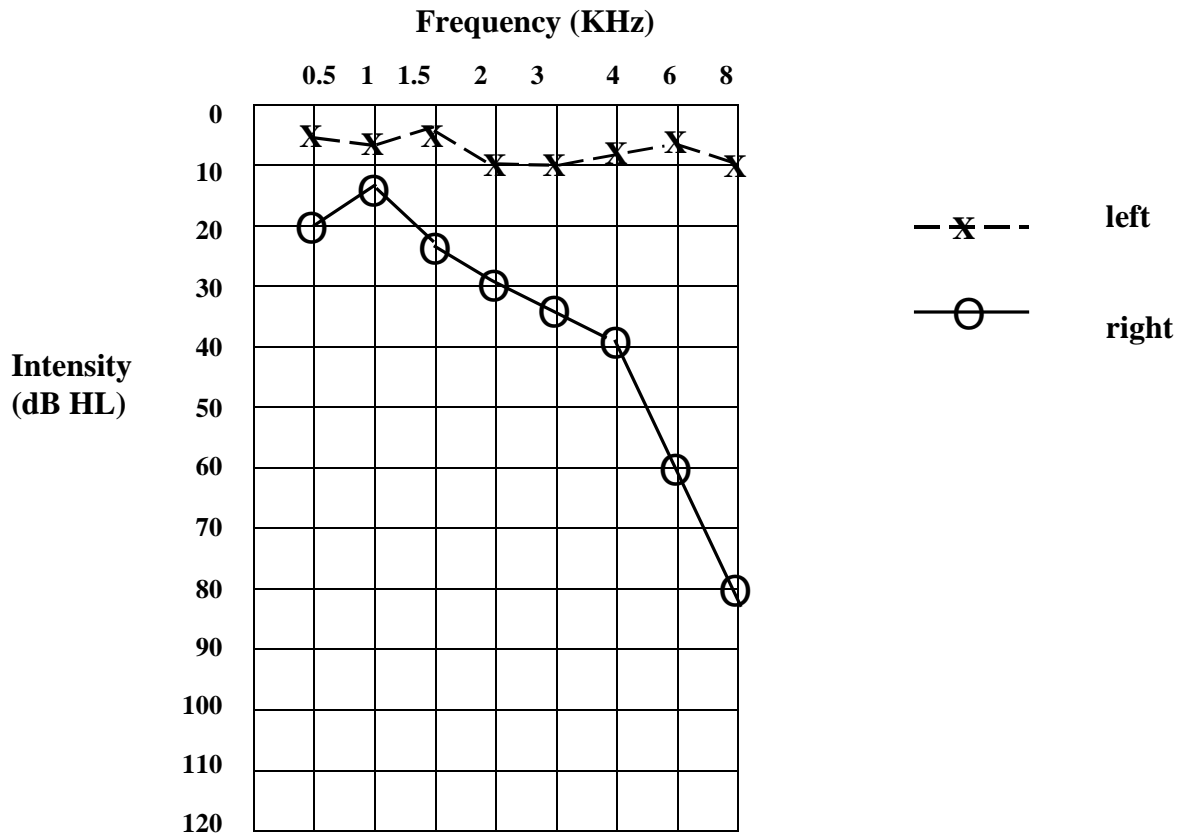


Fig. 6 Acoustic Neuroma.

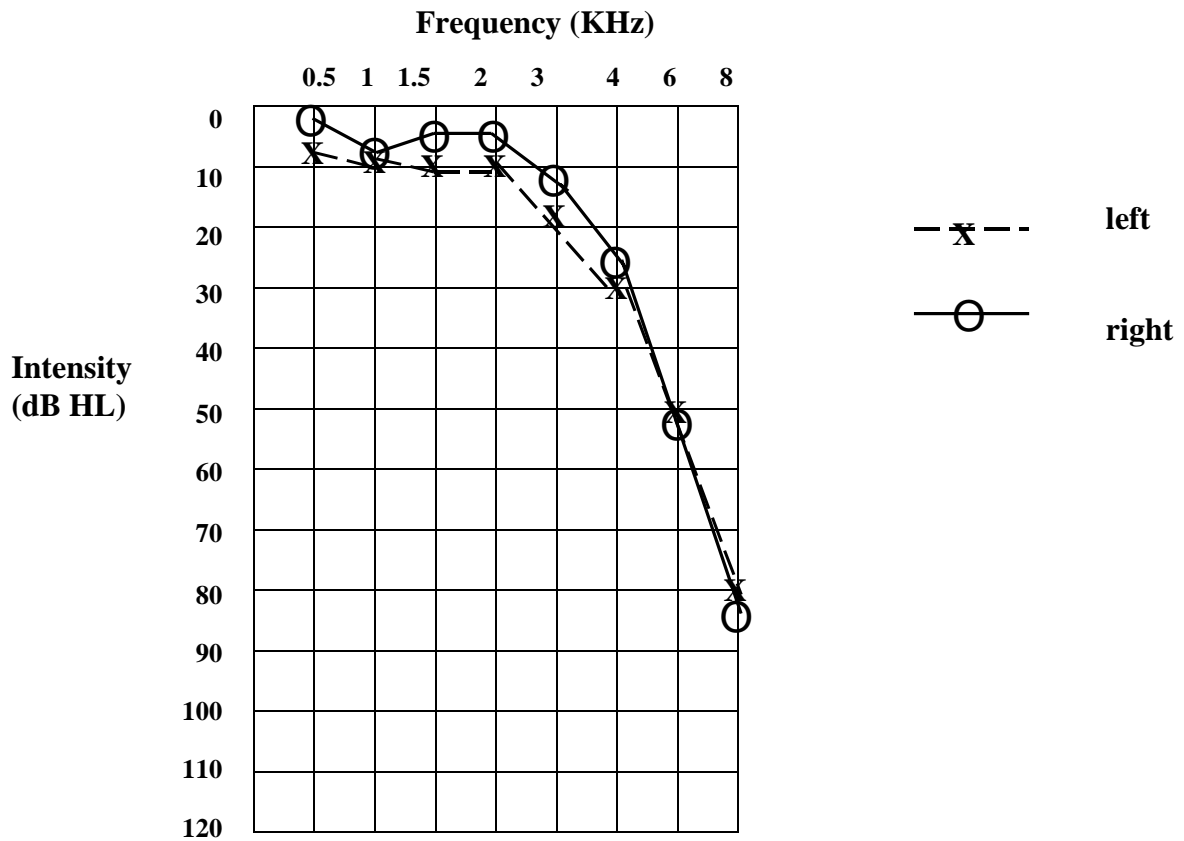


Fig. 7 Otoxicity.

Ototoxic Drugs Many drugs are recognised as affecting the inner ear and the hearing mechanism. Boies⁶ generalises that any drug or chemical that can cause renal toxicity can cause some ototoxicity. Most of the medications that cause ototoxicity do so in an irreversible fashion, one of the exceptions being the salicylate group.

Ototoxic drugs can interact with noise to compound its effects on hearing. Implicated medications are listed in Appendix 7. A typical audiogram is shown in Fig. 7.

Trauma Basal skull fractures can lead to a total loss of hearing on the affected side.

Management Guidelines

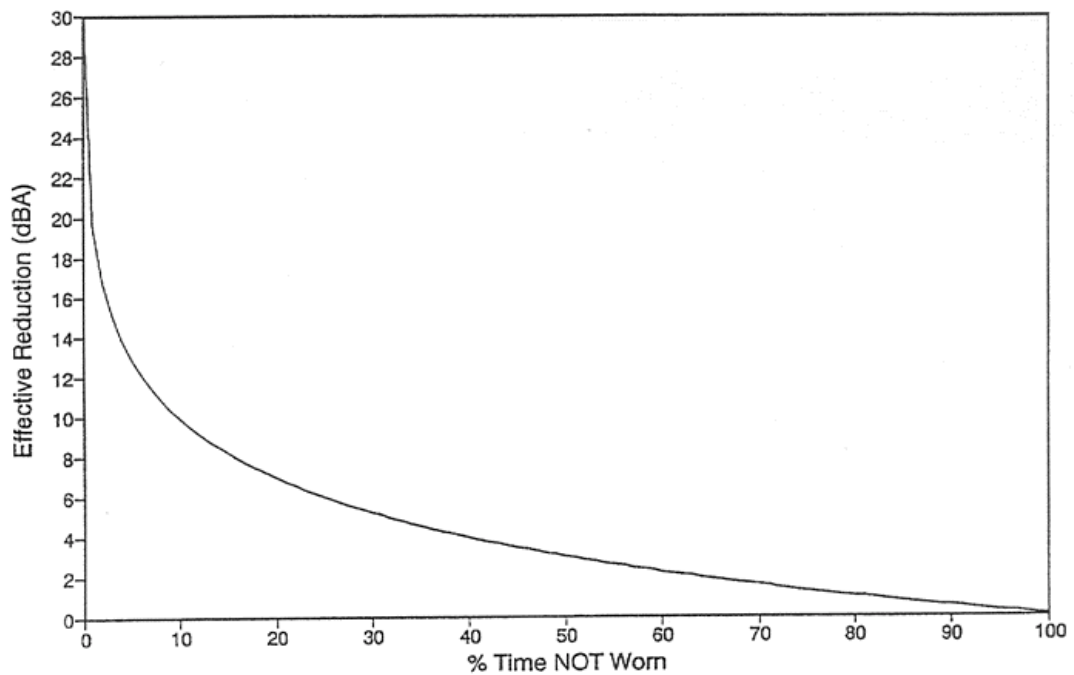
NIHL is not reversible at present and management consists of preventing further hearing loss.

The person must be informed of the hazards of further excess noise exposure. Both their occupational and recreational activities should be explored to identify noise hazards and appropriate advice given to the person and their employer.

From 1 April 1993, the Health and Safety in Employment Act has required employers to identify and control hazards such as noise. NIHL is defined as “Serious Harm” in the Act. An employer who knowingly causes “serious harm” is liable to fines of up to \$100,000 and/or 12 months’ imprisonment. General practitioners need to emphasise to employers that occupational health is good business.

The doctor should advise the employer of the basis of a good hearing conservation policy. Many managers assume that a hearing conservation policy entails buying (and occasionally getting their staff to wear) hearing protection. In fact, in the very loud environments commonly encountered in industry, the person needs only to be unprotected for a short time to exceed the exposure standard. This is illustrated in Fig. 8.

OSH has undertaken cost-benefit studies of the various means of controlling excessive noise. The studies indicate that hearing protection, properly worn and maintained is a more expensive option in the long term than isolation of the noise source and engineering controls.



Assistance for those with Hearing Loss

All those with any significant degree of hearing loss should be referred to a specialist for an hearing assistance review. Some differentiation of the roles played in providing hearing assistance is useful. Otolaryngologists determine the cause of the hearing loss and decide whether anything medically can be done to treat this loss.

Audiologists (defined as members of the New Zealand Audiological Society) are able to perform audiometry to satisfy compensation requirements and carry out an hearing aid trial to provide the hearing disabled person with the optimum assistance. Hearing aids are helpful to most people but require expert advice on choosing the most appropriate device for the type of hearing loss.

The Hearing Association has a role in rehabilitation, including teaching lip reading and training in other aids to communication. Such communication training should involve other members of the person's family.

Although these areas are properly the domain of their respective experts, they are mentioned here because of their importance for the affected person and for completeness in this booklet.

Prevention through Education

Prevention is the key to a successful reduction in the incidence of NIHL in the community. General practitioners have an important part to play, both in their own role and in complementing the activities of occupational physicians. Chief of these initiatives must be education.

1. Awareness should be raised among children in schools and their parents that noise damages hearing. Parents, teachers and children should be aware of the risks of excess noise and the means of combating this risk.
2. This awareness of noise dangers should be reinforced during trade training. Elementary noise control measures should be introduced into trade skills training during this critical period when people are learning the work practices they will use for the rest of their working lives.
3. In the workplace, at the time of the initial audiogram, the employee should leave with an understanding of their baseline audiogram result, of the hazards in their workplace, and of the methods employed to control these hazards.

At subsequent audios, and during in-service training, the occupational health nurse or safety officer can employ such techniques as wall posters, crew meetings, and signage noting hazards in particular areas to promote awareness about the risks of noise. In some workplaces, however, the Leq of 85 dB(A) poses a problem in that the entire area would be so marked, making the signs seem commonplace and decreasing their impact.

NOTE: Signage by itself quickly becomes part of the “wallpaper” of the workplace environment and is often obscured by grime. Signs should be accompanied by other information indicating that control plans have been developed and a planned completion date when the hazard will be controlled. Signage by itself is not a solution to a hazard.

Health and Safety in Employment Act and the Noise Regulations

The Health and Safety in Employment Act and the accompanying Noise Regulations (in preparation at the time of writing) require hazards to be identified and controlled. The hierarchy of control stipulated by the Act requires employers to take all practicable steps to protect employees by:

1. Controlling the noise at source.
2. Isolating or insulating the processes that cause excessive noise.

This could be achieved by:

- (a) Increasing the distance between the source and exposed person;
- (b) Placing barriers between the source and the exposed person;
- (c) Decreasing the time the at risk person is exposed to the noise source;
- (d) The use of protective devices.

Controlling noise is a complex and specialised business and cannot be covered in great depth here. There is a useful section in Waldron's book *Occupational Health Practice*⁵. However, certain basic rules can be used in most cases and a short summary of the basics of noise control follows.

Identify the Hazard

Fundamental to controlling the risks posed by noise is to undertake a noise survey. This can range from a sophisticated mixture of personal and environmental monitoring (available from several providers) to a simple rule of thumb assessment in the smaller workplace.

It is generally accepted that a noise hazard exists if:

1. There is difficulty in communication while in the noise. (A more formal statement of this is that if the voice has to be raised to carry out a conversation with a person about 1 metre away, then the noise level is higher than 85dBA); or
2. There is ringing in the ears (tinnitus) after exposure to the noise; or
3. Hearing seems muffled after leaving a noisy area⁴.

If the practitioner is going to advise the employer about

measures to control the risks of noise, this advice should be based on proper measurements which could be repeated after control measures have been instituted to ensure that the risks have been lessened.

OSH departmental medical practitioners (listed in Appendix 10) can advise general practitioners about noise tests and the providers able to perform these tests in their area.

Monitoring should always consist of environmental monitoring (of certain noisy areas in the workplace) and personal monitoring (i.e. measuring the personal noise dose of people in specific jobs). The environmental monitoring identifies certain areas and machinery in the workplace that need attention, and the personal monitoring identifies people (or tasks) at particular risk.

Specialised monitoring can identify which particular octaves or bands of noise are contributing to the problem and allow engineering solutions to be developed.

Noise Control Plans

To give effective noise control advice, the manager of the enterprise needs to identify the source and nature of the noise and develop a control plan². Trial and error are a common way of achieving control but can result in unnecessary expense. Sutton's Law* would suggest that identifying the chief noise source and controlling it will be the most cost-effective in the long term.

Noise control can be an expensive business. Managers often need to plan and budget these control measures over a period of time as well as beginning with immediate, temporary control measures. OSH would not expect the employer to solve all noise control measures overnight at an expense that would bankrupt the company. A control plan spanning some years that provided immediate protection to the employees and accompanied by a financially practical plan to control the excess noise by engineering controls in a series of steps would be acceptable.

Control of noise can be by active or by passive means.

Active Noise Control

Active noise control requires considerable expertise and is applicable to certain situations. The principle of active noise control is based upon transmitting noise at the same frequency as

* Mr Sutton was an American who robbed banks. When arrested and asked why, he replied: "Because that's where the money is." Noise control is best aimed at the greatest noise source.

the offending noise but at opposite phase, thus effectively cancelling that noise's energy.

There are some active noise controlled personal protective devices available now which analyse the noise and produce out of phase noise. They are used, for example, by some armed services to control the relatively constant low-frequency noise generated in helicopter cockpits. These hold great potential but are, at this stage of their development, the domain of the acoustic engineer rather than a general recommendation for all circumstances.

Passive Noise Control

Passive noise control is far more common and incorporates the principles detailed at the start of this section. Essentially these control methods are based on:

1. Attenuation (providing a barrier to the flow of noise energy. Attenuation requires mass to be effective).
2. Absorption of the sound.
3. Decreasing the "body burden" of noise by work practices.

Noise control planning can be achieved by paying attention to a number of basic steps. These steps are:

1. Planning and budgeting to lower excess noise output over several years' business plans.
2. Persuading management to purchase equipment with the lowest noise output. If there is no equipment with a low enough noise output, does the process have to be carried out in this manner?
3. Ensuring equipment is installed properly, and where possible, installed with the aim of reducing the generation and propagation of noise. For example, where practicable, machinery should be installed with vibration isolators (to reduce low-frequency noise).
4. Ensuring that the equipment is properly maintained and is being operated according to proper procedures (e.g. guards and panels are in place).
5. As part of maintenance, a number of means can be tried to reduce the noise generation. Excessive noise implies mechanical problems that might be corrected by maintenance. For example:
 - (a) Modifying the speed of the machinery can have a large impact on noise production.

- (b) Reducing the impact noise of plant or product by the use of resilient materials.
 - (c) Stopping panels from resonating or amplifying sound by the use of dampening material, stiffening the panels or increasing their bulk. If the panels themselves are not acting as noise attenuators, they can be manufactured from mesh or perforated sheet to prevent resonance or amplification.
 - (d) Sound enclosures present around noise sources should be scrupulously sealed against noise leakage and the noise source should be isolated from surrounding structures to prevent sympathetic vibration.
 - (e) The height through which components fall into bins or onto chutes can be reduced and the impact on resonant surfaces eliminated.
6. Equipment can be sited in the workplace to minimise the reflection and propagation of noise from surrounding walls, roofs and surfaces. Many machines are installed surrounded by sound-reflecting surfaces (smooth concrete walls and iron roofs) which add to the initial noise load generated by reflection of sound waves back towards those in the area. Other machines allow resonance to occur between various noise sources, compounding the problem. Where possible, the distance between an operator and the sound source should be as large as practicable.
7. If engineering controls are not likely to reduce the noise exposure to an acceptable level, a change in work practices should be undertaken to reduce the person's noise dose over the whole day. These include reducing the exposure time by removing those people not directly involved with the operation of the noisy machinery from the vicinity, as well as instituting the use of appropriate hearing protection.

Hearing protection is the last of the hierarchy of control methods. It is only acceptable as a temporary measure while other, more permanent measures are introduced.

Hearing Protection In New Zealand, hearing protection is graded according to its ability to reduce or attenuate the noise exposure levels experienced down to a level no higher than the Leq of 85 dBA. Therefore, to be confident in recommending this particular

solution or a particular type of hearing protection, a knowledge of the noise level is required.

Hearing protection suffers from the same problems as other personal protective equipment. Problems commonly encountered are:

1. People often neglect to use the protection for small jobs.
2. The person finds the devices hot and sweaty and uncomfortable to wear.
3. The use of other protective equipment (e.g. respirator masks) makes their wearing impracticable.
4. In high-noise areas, the hearing protection need only be dispensed with for a very brief period of time for the exposure standard to be exceeded, as illustrated in Fig. 8 (page 24).

Protective equipment has design limitations. For example, low frequencies are not well-excluded. Also, most personal protective equipment seems to be designed for northern European males. This means that Asians, Polynesians and women often have difficulty in getting equipment that fits correctly.

People using personal protective equipment, including hearing protection, must be trained in its correct use, and adequate supplies must be available to ensure cleanliness and proper maintenance.

Personal protection will only provide the expected result if it fulfils the design specifications. In the case of hearing protection, this means that ear plugs must be firmly placed in and occlude the external auditory meatus. In the case of ear muffs, the ear pads must seal around the ear and the tension band must clamp the muffs onto the head at the designed pressure to ensure an effective seal.

Hearing protection is categorised in New Zealand as shown in Table 3.

In addition, in situations where the peak level exceeds 140 dB, or the maximum “slow” response level exceeds 115 dB(A), grade 5 protection is required.

The Workplace Exposure Standard is:

- Leq (8hrs) 85 dB(A)
- Maximum Level 115 dB(A)
- Peak Level 140 dB

As with all personal protection, it is better to err on the side

Table 3 Types of Approved Hearing Protection.

| Grade | Leq (8 hr) dBA | Types |
|-------|----------------|----------------------|
| 1 | 86 - 91 | Earmuffs or Earplugs |
| 2 | 92 - 97 | Earmuffs or Earplugs |
| 3 | 98 - 103 | Earmuffs |
| 4 | 104 - 109 | Earmuffs |
| 5 | 110 - 115 | Earmuffs |

of a generous margin of protection and go to the next higher grade of protection.

All hearing protection has to be labelled either on the device itself (ear muffs) or its packaging (ear plugs) and this label must show the appropriate grade. There have been some imports of substandard equipment which have not been graded and do not offer any practical protection. People advising managers about hearing protection should ensure that any hearing protection purchased has been graded to criteria acceptable to the Secretary of Labour.

Conclusion

This booklet has been written to provide general practitioners with practical information concerning NIHL. General practitioners are important opinion leaders in their communities and it is hoped that interested practitioners will progress beyond the identification of NIHL to persuade employers and employees to adopt effective control measures rather than accepting deafness as an inevitable part of working life.

OSH would welcome any feedback concerning this publication, especially if the practitioners find areas that need expansion or clarification. Comments should be addressed to:

The General Manager,
Occupational Safety and Health,
Department of Labour,
PO Box 3705,
WELLINGTON

Appendix 1: References

- 1 Alberti P. Noise Induced Hearing Loss. *BMJ* 1992, 304-522.
- 2 *Environmental Health Criteria 12*. World Health Organisation, Geneva, 1980.
- 3 Godlee F. Noise, Breaking the Silence. *BMJ* 1992, 304, 110 -113.
- 4 Noise and Hearing Loss: Consensus Conference. *JAMA* 1990, 263, No. 23, June 20, 3185-3190.
- 5 Waldron H. A. *Occupational Health Practice*. 3rd. Edition, Butterworths, London, 1989.
- 6 Adams G. L. *et al. Boies Fundamentals of Otolaryngology*. W. B. Saunders & Co, Philadelphia, 1989.

Appendix 2: Glossary

| | |
|----------------------------------|--|
| Attenuation | A reduction in sound. |
| Audiometry | The measurement of the hearing threshold level of a person by means of a bilateral pure tone air conduction threshold test. |
| A-weighting | The A-frequency weighting specified in the International Standard IEC 651:1979. (Note: A-frequency weighting is used because it approximates the response of the human ear.) |
| dB | An abbreviation for decibel (see decibel). |
| dB Slow | The time-weighting applied to noise averaged over 1 second to give a composite reading of the noise. |
| Decibel | A dimensionless unit used to compare the magnitudes of powers, intensities or pressures. |
| Engineering controls | Any engineering procedure that reduces the sound level, either at the source of the noise or in its transmission, but does not include the use of any hearing protection device. |
| Exposure standard | A noise level greater than either $L_{eq}(8)$ 85dBA , a maximum noise level of 115dBA or a peak noise level of 140dB. |
| Hearing protection device | A device or pair of devices worn by a person or inserted in the ears of a person to reduce that person's noise exposure. |
| Impulse noise | Noise consisting of a single pressure peak, or a sequence of such peaks, or a single burst with multiple pressure peaks, or a sequence of such bursts. |
| $L_{eq}(8)$ | That steady sound level measured in A-weighted decibels referenced to 20 micropascals which, when present for 8 hours, causes the same A-weighted noise energy to be received as that due to the actual noise over the actual working day. |

| | |
|-----------------------------|--|
| Maximum noise level | The highest A-weighted sound pressure level in decibels referenced to 20 micropascals determined by sound measuring equipment with “Slow” time-weighting, as specified in the International Standard IEC 651:1979. |
| Noise exposure | The amount of sound energy a person is exposed to during a representative day, stated as the Leq(8) in dBA. |
| Peak noise level | The highest linear (unweighted) peak sound pressure level in decibels referenced to 20 micropascals determined by sound measuring equipment with “Peak” time-weighting, as specified in the International Standard IEC 651:1979. |
| Pure tone audiometry | The basis for hearing evaluation. Hearing thresholds are measured for pure tones at different test frequencies. |

Appendix 3: Notification Letter to OSH

Date

The Registrar
 NODS
 OSH GMO
 PO Box 3705
 WELLINGTON

Notifiable Occupational Disease System Noise-Induced Hearing Loss

I wish to notify a case of occupationally related noise-induced hearing loss. The details are as follows:

Person's Name: _____ Date of Birth: _____
 Current Occupation: _____ Years in Occupation: _____
 Employer's Name and Address: _____
 Telephone: _____

I have:

attached a photocopy of the audiogram with this letter

or:

written the measured hearing levels for the frequencies nominated below.

Audiogram Results

| | 500Hz | | 1000 | | 1500 | | 2000 | | 3000 | | 4000 | | 6000 | | 8000 | |
|------------|-------|---|------|---|------|---|------|---|------|---|------|---|------|---|------|---|
| | R | L | R | L | R | L | R | L | R | L | R | L | R | L | R | L |
| Baseline 1 | | | | | | | | | | | | | | | | |
| Baseline 2 | | | | | | | | | | | | | | | | |
| Diagnostic | | | | | | | | | | | | | | | | |

| Diagnostic Test | Type of Audiometer | Date Calibrated | Date of Test |
|-----------------|--------------------|-----------------|--------------|
| | | | |

Yours faithfully,

Doctor's Name and Address:

Appendix 4: Model Industrial Hearing Conservation Programme

Vision

This company is successful because of its commitment to excellence in its product and its people. This is a healthy and safe workplace as part of our commitment to excellence.

Goals

Health and safety are part of the day-to-day issues that the workforce deals with. The company is fully committed to managing issues to achieve excellence in all aspects of its operations.

There is full knowledge, information and involvement by this company's people in health and safety issues. Noise has been identified by all as a priority hazard requiring control.

Health and safety hazards are dealt with at the source by elimination of the hazard, or where that is impracticable by substitution or by isolation, or where that is impracticable by means of personal protection.

Strategies

The company works to achieve its goals through:

1. Written policies concerning occupational safety and health.
2. A commitment to reducing noise at source.
3. Education and involvement by means of all people on site by means of "train the trainer" programmes.
4. Identification and prioritisation of hazards.
5. Personal monitoring and appropriate treatment.
6. Planned and budgeted strategic plan concerning noise control.

Tactics

1. The company has a written commitment from senior management to a health and safety programme.
2. All new equipment and machinery bought into the organisation will have the lowest noise rating of the equipment on offer.
3. Noise measurement will be undertaken to identify and prioritise noise hazards in the enterprise (environmental, personal and by biological monitoring).

4. Information and education will be given to employees about noise and its effects.
5. Noise control measures will be introduced according to priority areas and budgetary allocations.
6. Appropriate audiometric monitoring will be undertaken to identify those people who are beginning to suffer some deterioration of hearing. This audiometric surveillance will include:
 - (a) Pre-employment or immediate post-employment baseline audiometry.
 - (b) Routine audiometry every two years or sooner if the processes at the workplace change.
 - (c) Audiometric tests at the employee's request.

The results of these measurements will be conveyed to the people at the workplace, together with adequate explanation and information.

7. All the above measures will be audited regularly.

Appendix 5: Basic Tests of a Person's Hearing

Rinne's Test

This test indicates whether conductive deafness is present or not. A tuning fork is sounded and held in front of the ear, with the points close to the external auditory meatus. As the vibrations of the fork diminish, the patient is asked to identify the point of time at which the tuning fork can no longer be heard. At this point, the heel of the tuning fork is held against the mastoid process. If it is not heard there, the above procedure is reversed. If the tuning fork is heard by air conduction *after* it is heard by bone conduction, as is the case for a person with a normal healthy middle ear, Rinne's test is said to be positive and a conductive deafness is not present.

Weber's Test

A tuning fork is sounded and placed on the vertex of the skull. If a conductive deafness is present in one ear, the patient will indicate the ear with the conductive deafness as that in which the sound is the clearest. (If both ears have a conductive deafness, the sound will be clearest in that ear which is more affected).

If a *sensori-neural* deafness is present, the test reveals an opposite finding. Presuming the person's middle ear is normal, the application of the tuning fork will be heard more loudly by the ear with the better functioning nerve and cochlea, i.e. the lesser degree of sensorineural deafness.

Appendix 6: Suitable Screening Audiometers and International Standards

| Agent | Models | Approximate Price |
|--|-----------------------|--------------------|
| Electronics for Hearing PO Box 80046 Green Bay, AUCKLAND Phone: (09) 827 4457 | Beltone 109 | \$1,000 to \$2,000 |
| | Hansaton AS7 | \$1,000 to \$2,000 |
| | Hansaton BA20 | \$8,300 |
| | Hansaton AT22 | \$7,600 |
| Langdon Hearing Instruments PO Box 1367, TAUPO Phone: (07) 377 0711 | Maico MA25 | \$1,000 to \$2,000 |
| Oticon NZ Ltd. PO Box 9128 Te Aro WELLINGTON Phone: (04) 385 3943 Toll-Free: 058 200 200 Fax (04) 384 5212 | Interacoustics AD27 | \$4,000 to \$5,000 |
| | Interacoustics AD25 | \$3,000 to \$4000 |
| | Interacoustics AS7M | \$1,000 to \$2,000 |
| | Interacoustics AD10HF | \$1,000 to \$2,000 |
| | Interacoustics AS15 | \$4,000 to \$5,000 |
| | Interacoustics AT22 | \$7,000 to \$8,000 |
| Pulsedata International Ltd PO Box 11362 Mt Wellington, AUCKLAND Phone: (09) 525 4217 | Grason Stadler GSI17 | \$1,000 to \$2,000 |
| | | |
| Reid Technology PO Box 1898 Birkenhead, AUCKLAND Phone: (09) 379 6011 | Micromate 304 | \$1,000 to \$2,000 |

As the prices and distributors of equipment frequently change, up-to-date advice should be sought from the National Audiology Centre, 98 Remuera Road, Auckland 5.

New Zealand agencies involved in the measurement of noise and its effects on people are agreed that:

1. Standard screening audiometers conforming to IEC 645 (1979) are acceptable, and should be calibrated at least every 2 years.
2. Noise-excluding head sets used in non-booth conditions are acceptable, but their use should be noted on the recording.

3. Where audiometry booths are used, these should conform to a standard, currently AS 1269 or ANSI S3.1 (1977).
4. The international standard ISO 6189: *Acoustics - Pure tone air conduction threshold audiometry for hearing conservation purposes* is used for carrying out pure tone audiometry and should be followed.

These standards are held in common with practice in Australia.

Calibration (the frequency depends on the equipment used) can be carried out by the Institute of Environmental Science and Research Ltd. (ESR), 17 Kelly Street, Mt. Eden, Auckland. Tel: (09) 815 3670 Fax: (09) 630 9619.

Appendix 7: Ototoxic Drugs

| | | |
|------------------------------------|--|--|
| Antibiotics | Aminoglycosides Streptomycin Dihydrostreptomycin Neomycin (in high dose & given IV) Gentamycin Tobramycin Amikacin Viomycin Colistin | Other Antibiotics Vancomycin Erythromycin Chloramphenicol Ristocetin Polymyxin B |
| Diuretics | Furosemide Ethacrynic acid Bumetanide Acetazolamide Mannitol | |
| Analgesics and Antipyretics | Salicylates Quinine Chloroquine | |
| Antineoplastic | Bleomycin Nitrogen mustard cis-Platinum | |
| Miscellaneous | Pentobarbital Hexadine Mandelamine Practolol | |
| Chemicals | Carbon monoxide Oil of Chenopodium Nicotine Aniline dyes Alcohol Potassium bromate | |
| Heavy Metals | Mercury Gold Lead Arsenic | |

Appendix 8: Audiogram Record for Industrial Use

OSH 007



OCCUPATIONAL AUDIOMETRY RECORD

CONFIDENTIAL

DEPARTMENT OF
LABOUR
TE TARI MAHI

SURNAME: _____ FIRST NAMES: _____ DATE OF BIRTH: _____ M/F: _____
HOME ADDRESS EMPLOYER WORK LOCATION

FAMILY DOCTOR: _____ HEARING PROTECTION GRADE (Please tick appropriate grade)
0 1 2 3 4 5

NOISE EXPOSURE HISTORY

Present occupation: _____
Secondary employment: _____
Previous employment: _____

Military service: _____
Noisy hobbies: _____

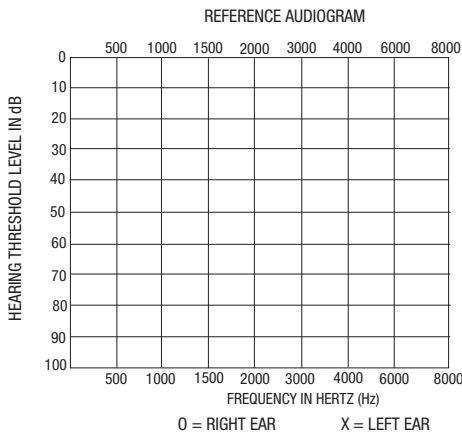
| Period (Years or months) | |
|-----------------------------|--|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

| Hearing Protectors | |
|--------------------------|--------------------------|
| YES | NO |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |

Comments: _____
Date: _____ Initials: _____

Please indicate by ticking appropriate boxes

FIRST ASSESSMENT



OTOSCOPIC EXAMINATION

| | RIGHT EAR | | LEFT EAR | |
|-----------------|--------------------------|--------------------------|--------------------------|--------------------------|
| | YES | NO | YES | NO |
| CANALS CLEAR | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| NORMAL EARDRUMS | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| ANY PERFORATION | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

COMMENTS _____

HEALTH HISTORY

| | YES | NO |
|--------------------------------|--------------------------|--------------------------|
| Diseases affecting hearing | <input type="checkbox"/> | <input type="checkbox"/> |
| Ear or head injuries | <input type="checkbox"/> | <input type="checkbox"/> |
| Family history of hearing loss | <input type="checkbox"/> | <input type="checkbox"/> |
| Recent earache or discharge | <input type="checkbox"/> | <input type="checkbox"/> |
| Any other health problem? | <input type="checkbox"/> | <input type="checkbox"/> |
| Have you a hearing loss? | <input type="checkbox"/> | <input type="checkbox"/> |

Other comments _____

DETAILS

ACTION TO BE TAKEN: _____
Signed: _____ Designation: _____ Date: ___ / ___ / 19__

MEDICAL OFFICER'S COMMENTS (where applicable): _____

Signed: _____ Date: ___ / ___ / 19__

Appendix 9: Method of Calculating Hearing Loss with Age

The Accident Rehabilitation and Compensation Insurance (Occupational Deafness Assessment Procedures) Regulations 1992 require the following procedure to be followed in order to determine the percentage hearing loss of a claimant due to exposure to occupational noise.

The Regulations state, amongst other things, that:

3. Application—

Subject to these regulations, these regulations shall apply to the assessment of the degree of deafness in respect of any claim that a person has suffered deafness caused by gradual process arising out of and in the course of employment.

4. Procedures to be followed in assessment—

(1) The claimant shall undergo a pure tone audiometry test of binaural loss of hearing conducted by an otolaryngologist or audiologist.

(2) A test of the hearing of any claimant shall not have any status if the claimant has been exposed to a noise level that is likely to result in a temporary threshold shift being present during the test (such as an Leq (8-hour) level greater than 85 dBA within 16 hours before testing); and the person conducting the test shall ask the appropriate questions to determine whether any such exposure has occurred.

(3) During each test, the air conduction HTL of the claimant shall be measured with an audiometer at audiometric frequencies 500, 1000, 1500, 2000, 8000, 4000, 6000, and 8000 Hz.

(4) During each test the HTL of both the better ear and the worse ear must be measured at each audiometric test frequency.

(5) The binaural percentage loss of hearing at each audiometric frequency shall be calculated in accordance with the tables specified in the First Schedule to these regulations using the HTL of the better ear and the worse ear as co-ordinates.

(6) The percentage loss of hearing calculated at each of the 8 audiometric frequencies shall be added together to obtain the overall percentage loss of hearing.

(7) Every pure tone audiometry test undertaken under these regulations shall comply with the technical and procedural standards of ISO 6189.

5. Adjustment for hearing loss due to presbycusis—

The overall percentage loss of hearing calculated under regulation 4 (6) of these regulations shall be adjusted for presbycusis by reducing the overall percentage loss of hearing by the percentage specified in the Second Schedule to these regulations.

6. Report of assessment—In making a report of an assessment of degree of deafness, the otolaryngologist or audiologist shall specify—

- (a) The tests undertaken; and
- (b) The results of those tests; and
- (c) The make and model of the audiometer used in those tests; and
- (d) The date of the last basic calibration of the audiometer and the name of the laboratory that conducted the calibration; and
- (e) The age of the claimant, and whether an adjustment has been made under regulation 5 of these regulations; and
- (f) Any other comments relevant to the assessment.

FIRST SCHEDULE

Values of Percentage Loss of Hearing Corresponding to Given Hearing Threshold Levels in the Better and Worse Ears at 500 Hz

| | | HTL — BETTER EAR | | | | | | | | | | | | | | | | | |
|--|-----------|------------------|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|
| | | ≥15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | ≥95 | |
| | HTL | ≥15 | 0 | | | | | | | | | | | | | | | | |
| | Worse Ear | 20 | 0.4 | 0.6 | | | | | | | | | | | | | | | |
| | (dB) | 25 | 0.6 | 1.0 | 1.4 | | | | | | | | | | | | | | |
| | | 30 | 1.0 | 1.4 | 2.0 | 2.8 | | | | | | | | | | | | | |
| | | 35 | 1.3 | 1.8 | 2.5 | 3.4 | 4.5 | | | | | | | | | | | | |
| | | 40 | 1.7 | 2.2 | 3.0 | 3.9 | 5.1 | 6.4 | | | | | | | | | | | |
| | | 45 | 2.0 | 2.6 | 3.4 | 4.3 | 5.5 | 6.8 | 8.1 | | | | | | | | | | |
| | | 50 | 2.3 | 2.9 | 3.7 | 4.7 | 5.8 | 7.1 | 8.4 | 9.7 | | | | | | | | | |
| | | 55 | 2.5 | 3.2 | 4.0 | 5.0 | 6.1 | 7.3 | 8.6 | 9.9 | 11.2 | | | | | | | | |
| | | 60 | 2.7 | 3.4 | 4.2 | 5.2 | 6.3 | 7.5 | 8.8 | 10.0 | 11.3 | 12.6 | | | | | | | |
| | | 65 | 2.8 | 3.5 | 4.4 | 5.4 | 6.5 | 7.7 | 8.9 | 10.2 | 11.5 | 12.7 | 14.0 | | | | | | |
| | | 70 | 2.9 | 3.7 | 4.5 | 5.5 | 6.6 | 7.8 | 9.1 | 10.3 | 11.6 | 12.9 | 14.2 | 15.5 | | | | | |
| | | 75 | 3.0 | 3.8 | 4.7 | 5.7 | 6.8 | 8.0 | 9.2 | 10.5 | 11.8 | 13.1 | 14.5 | 15.7 | 16.9 | | | | |
| | | 80 | 3.1 | 3.9 | 4.8 | 5.8 | 6.9 | 8.1 | 9.3 | 10.6 | 12.0 | 13.3 | 14.7 | 16.0 | 17.2 | 18.2 | | | |
| | | 85 | 3.2 | 4.0 | 4.9 | 5.9 | 7.0 | 8.2 | 9.4 | 10.7 | 12.1 | 13.5 | 14.9 | 16.2 | 17.4 | 18.4 | 19.1 | | |
| | | 90 | 3.4 | 4.1 | 5.0 | 6.0 | 7.1 | 8.3 | 9.5 | 10.8 | 12.2 | 13.6 | 15.0 | 16.3 | 17.6 | 18.5 | 19.2 | 19.7 | |
| | | ≥95 | 3.4 | 4.2 | 5.1 | 6.1 | 7.1 | 8.3 | 9.5 | 10.8 | 12.2 | 13.6 | 15.0 | 16.4 | 17.6 | 18.6 | 19.3 | 19.7 | 20.0 |

Values of Percentage Loss of Hearing Corresponding to Given Hearing Threshold Levels in the Better and Worse Ears at 1000 Hz

| | | HTL — BETTER EAR | | | | | | | | | | | | | | | | | |
|--|-----------|------------------|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|
| | | ≥15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | ≥95 | |
| | HTL | ≥15 | 0 | | | | | | | | | | | | | | | | |
| | Worse Ear | 20 | 0.5 | 0.8 | | | | | | | | | | | | | | | |
| | (dB) | 25 | 0.8 | 1.2 | 1.8 | | | | | | | | | | | | | | |
| | | 30 | 1.2 | 1.7 | 2.5 | 3.5 | | | | | | | | | | | | | |
| | | 35 | 1.7 | 2.3 | 3.1 | 4.3 | 5.7 | | | | | | | | | | | | |
| | | 40 | 2.1 | 2.8 | 3.7 | 4.9 | 6.3 | 8.0 | | | | | | | | | | | |
| | | 45 | 2.5 | 3.3 | 4.2 | 5.4 | 6.9 | 8.5 | 10.2 | | | | | | | | | | |
| | | 50 | 2.8 | 3.6 | 4.7 | 5.9 | 7.3 | 8.8 | 10.5 | 12.1 | | | | | | | | | |
| | | 55 | 3.1 | 3.9 | 5.0 | 6.2 | 7.6 | 9.1 | 10.7 | 12.4 | 14.0 | | | | | | | | |
| | | 60 | 3.3 | 4.2 | 5.3 | 6.5 | 7.9 | 9.4 | 11.0 | 12.6 | 14.2 | 15.7 | | | | | | | |
| | | 65 | 3.5 | 4.4 | 5.5 | 6.7 | 8.1 | 9.6 | 11.2 | 12.8 | 14.4 | 15.9 | 17.5 | | | | | | |
| | | 70 | 3.7 | 4.6 | 5.7 | 6.9 | 8.3 | 9.8 | 11.3 | 12.9 | 14.6 | 16.2 | 17.8 | 19.4 | | | | | |
| | | 75 | 3.8 | 4.7 | 5.8 | 7.1 | 8.5 | 10.0 | 11.5 | 13.1 | 14.8 | 16.4 | 18.1 | 19.7 | 21.1 | | | | |
| | | 80 | 3.9 | 4.9 | 6.0 | 7.3 | 8.6 | 10.1 | 11.7 | 13.3 | 15.0 | 16.7 | 18.4 | 20.0 | 21.5 | 22.7 | | | |
| | | 85 | 4.1 | 5.0 | 6.2 | 7.4 | 8.8 | 10.3 | 11.8 | 13.4 | 15.1 | 16.9 | 18.6 | 20.3 | 21.7 | 23.0 | 23.9 | | |
| | | 90 | 4.2 | 5.2 | 6.3 | 7.5 | 8.9 | 10.3 | 11.9 | 13.5 | 15.2 | 17.0 | 18.7 | 20.4 | 21.9 | 23.2 | 24.1 | 24.6 | |
| | | ≥95 | 4.3 | 5.3 | 6.4 | 7.6 | 8.9 | 10.3 | 11.9 | 13.5 | 15.2 | 17.0 | 18.7 | 20.5 | 22.0 | 23.3 | 24.2 | 24.7 | 25.0 |

Values of Percentage Loss of Hearing Corresponding to Given Hearing Threshold Levels in the Better and Worse Ears at 1500 Hz

| | | HTL — BETTER EAR | | | | | | | | | | | | | | | | |
|--------------------------|-----|------------------|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|
| | | ≥15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | ≥95 |
| HTL Worse Ear (dB) | ≥15 | 0 | | | | | | | | | | | | | | | | |
| | 20 | 0.4 | 0.6 | | | | | | | | | | | | | | | |
| | 25 | 0.6 | 1.0 | 1.4 | | | | | | | | | | | | | | |
| | 30 | 1.0 | 1.4 | 2.0 | 2.8 | | | | | | | | | | | | | |
| | 35 | 1.3 | 1.8 | 2.5 | 3.4 | 4.5 | | | | | | | | | | | | |
| | 40 | 1.7 | 2.2 | 3.0 | 3.9 | 5.1 | 6.4 | | | | | | | | | | | |
| | 45 | 2.0 | 2.6 | 3.4 | 4.3 | 5.5 | 6.8 | 8.1 | | | | | | | | | | |
| | 50 | 2.3 | 2.9 | 3.7 | 4.7 | 5.8 | 7.1 | 8.4 | 9.7 | | | | | | | | | |
| | 55 | 2.5 | 3.2 | 4.0 | 5.0 | 6.1 | 7.3 | 8.6 | 9.9 | 11.2 | | | | | | | | |
| | 60 | 2.7 | 3.4 | 4.2 | 5.2 | 6.3 | 7.5 | 8.8 | 10.0 | 11.3 | 12.6 | | | | | | | |
| | 65 | 2.8 | 3.5 | 4.4 | 5.4 | 6.5 | 7.7 | 8.9 | 10.2 | 11.5 | 12.7 | 14.0 | | | | | | |
| | 70 | 2.9 | 3.7 | 4.5 | 5.5 | 6.6 | 7.8 | 9.1 | 10.3 | 11.6 | 12.9 | 14.2 | 15.5 | | | | | |
| | 75 | 3.0 | 3.8 | 4.7 | 5.7 | 6.8 | 8.0 | 9.2 | 10.5 | 11.8 | 13.1 | 14.5 | 15.7 | 16.9 | | | | |
| | 80 | 3.1 | 3.9 | 4.8 | 5.8 | 6.9 | 8.1 | 9.3 | 10.6 | 12.0 | 13.3 | 14.7 | 16.0 | 17.2 | 18.2 | | | |
| | 85 | 3.2 | 4.0 | 4.9 | 5.9 | 7.0 | 8.2 | 9.4 | 10.7 | 12.1 | 13.5 | 14.9 | 16.2 | 17.4 | 18.4 | 19.1 | | |
| | 90 | 3.4 | 4.1 | 5.0 | 6.0 | 7.1 | 8.3 | 9.5 | 10.8 | 12.2 | 13.6 | 15.0 | 16.3 | 17.6 | 18.5 | 19.2 | 19.7 | |
| | ≥95 | 3.4 | 4.2 | 5.1 | 6.1 | 7.1 | 8.3 | 9.5 | 10.8 | 12.2 | 13.6 | 15.0 | 16.4 | 17.6 | 18.6 | 19.3 | 19.7 | 20.0 |

Values of Percentage Loss of Hearing Corresponding to Given Hearing Threshold Levels in the Better and Worse Ears at 2000 Hz

| | | HTL — BETTER EAR | | | | | | | | | | | | | | | | |
|--------------------------|-----|------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|
| | | ≥15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | ≥95 |
| HTL Worse Ear (dB) | ≥15 | 0 | | | | | | | | | | | | | | | | |
| | 20 | 0.3 | 0.5 | | | | | | | | | | | | | | | |
| | 25 | 0.5 | 0.7 | 1.1 | | | | | | | | | | | | | | |
| | 30 | 0.7 | 1.0 | 1.5 | 2.1 | | | | | | | | | | | | | |
| | 35 | 1.0 | 1.4 | 1.9 | 2.5 | 3.4 | | | | | | | | | | | | |
| | 40 | 1.3 | 1.7 | 2.2 | 2.9 | 3.8 | 4.8 | | | | | | | | | | | |
| | 45 | 1.5 | 1.9 | 2.5 | 3.3 | 4.1 | 5.1 | 6.1 | | | | | | | | | | |
| | 50 | 1.7 | 2.2 | 2.8 | 3.5 | 4.4 | 5.3 | 6.3 | 7.3 | | | | | | | | | |
| | 55 | 1.9 | 2.4 | 3.0 | 3.7 | 4.6 | 5.5 | 6.4 | 7.4 | 8.4 | | | | | | | | |
| | 60 | 2.0 | 2.5 | 3.1 | 3.9 | 4.7 | 5.6 | 6.6 | 7.5 | 8.5 | 9.4 | | | | | | | |
| | 65 | 2.1 | 2.6 | 3.3 | 4.0 | 4.9 | 5.7 | 6.7 | 7.6 | 8.6 | 9.6 | 10.5 | | | | | | |
| | 70 | 2.2 | 2.7 | 3.4 | 4.1 | 5.0 | 5.9 | 6.8 | 7.8 | 8.7 | 9.7 | 10.7 | 11.6 | | | | | |
| | 75 | 2.3 | 2.8 | 3.5 | 4.3 | 5.1 | 6.0 | 6.9 | 7.9 | 8.9 | 9.9 | 10.8 | 11.8 | 12.7 | | | | |
| | 80 | 2.4 | 2.9 | 3.6 | 4.4 | 5.2 | 6.1 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 12.9 | 13.6 | | | |
| | 85 | 2.4 | 3.0 | 3.7 | 4.4 | 5.3 | 6.1 | 7.1 | 8.1 | 9.1 | 10.1 | 11.1 | 12.1 | 13.0 | 13.8 | 14.3 | | |
| | 90 | 2.5 | 3.1 | 3.8 | 4.5 | 5.3 | 6.2 | 7.1 | 8.1 | 9.1 | 10.2 | 11.2 | 12.2 | 13.2 | 13.9 | 14.4 | 14.8 | |
| | ≥95 | 2.6 | 3.2 | 3.8 | 4.6 | 5.4 | 6.2 | 7.1 | 8.1 | 9.1 | 10.2 | 11.3 | 12.3 | 13.2 | 14.0 | 14.5 | 14.8 | 15.0 |

Values of Percentage Loss of Hearing Corresponding to Given Hearing Threshold Levels in the Better and Worse Ears at 3000 Hz

| | | HTL — BETTER EAR | | | | | | | | | | | | | | | | |
|--------------------------|-----|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| | | ≥15 | 20 | 25 | 30 | 35 | ~0 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | ≥95 |
| HTL Worse Ear (dB) | ≥15 | 0 | | | | | | | | | | | | | | | | |
| | 20 | 0.2 | 0.3 | | | | | | | | | | | | | | | |
| | 25 | 0.3 | 0.5 | 0.7 | | | | | | | | | | | | | | |
| | 30 | 0.5 | 0.7 | 1.0 | 1.4 | | | | | | | | | | | | | |
| | 35 | 0.7 | 0.9 | 1.2 | 1.7 | 2.3 | | | | | | | | | | | | |
| | 40 | 0.8 | 1.1 | 1.5 | 2.0 | 2.5 | 3.2 | | | | | | | | | | | |
| | 45 | 1.0 | 1.3 | 1.7 | 2.2 | 2.7 | 3.4 | 4.1 | | | | | | | | | | |
| | 50 | 1.1 | 1.4 | 1.9 | 2.3 | 2.9 | 3.5 | 4.2 | 4.8 | | | | | | | | | |
| | 55 | 1.2 | 1.6 | 2.0 | 2.5 | 3.0 | 3.6 | 4.3 | 4.9 | 5.6 | | | | | | | | |
| | 60 | 1.3 | 1.7 | 2.1 | 2.6 | 3.1 | 3.7 | 4.4 | 5.0 | 5.6 | 6.3 | | | | | | | |
| | 65 | 1.4 | 1.8 | 2.2 | 2.7 | 3.2 | 3.8 | 4.4 | 5.1 | 5.7 | 6.4 | 7.0 | | | | | | |
| | 70 | 1.5 | 1.8 | 2.3 | 2.8 | 3.3 | 3.9 | 4.5 | 5.2 | 5.8 | 6.5 | 7.1 | 7.7 | | | | | |
| | 75 | 1.5 | 1.9 | 2.3 | 2.8 | 3.4 | 4.0 | 4.6 | 5.2 | 5.9 | 6.6 | 7.2 | 7.8 | 8.4 | | | | |
| | 80 | 1.6 | 2.0 | 2.4 | 2.9 | 3.4 | 4.0 | 4.7 | 5.3 | 6.0 | 6.6 | 7.3 | 8.0 | 8.6 | 9.1 | | | |
| | 85 | 1.6 | 2.0 | 2.5 | 3.0 | 3.5 | 4.1 | 4.7 | 5.4 | 6.0 | 6.7 | 7.4 | 8.1 | 8.7 | 9.2 | 9.5 | | |
| | 90 | 1.7 | 2.1 | 2.5 | 3.0 | 3.5 | 4.1 | 4.7 | 5.4 | 6.1 | 6.8 | 7.5 | 8.2 | 8.8 | 9.2 | 9.6 | 9.8 | |
| | ≥95 | 1.7 | 2.1 | 2.6 | 3.0 | 3.6 | 4.1 | 4.7 | 5.4 | 6.1 | 6.8 | 7.5 | 8.2 | 8.8 | 9.3 | 9.6 | 9.8 | 10.0 |

Values of Percentage Loss of Hearing Corresponding to Given Hearing Threshold Levels in the Better and Worse Ears at 4000 Hz

| | | HTL — BETTER EAR | | | | | | | | | | | | | | | | |
|--------------------------|-----|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| | | ≥20 | 25 | 30 | 3.5 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | ≥95 | |
| HTL Worse Ear (dB) | ≥20 | 0 | | | | | | | | | | | | | | | | |
| | 25 | 0.1 | 0.2 | | | | | | | | | | | | | | | |
| | 30 | 0.2 | 0.3 | 0.5 | | | | | | | | | | | | | | |
| | 35 | 0.3 | 0.4 | 0.6 | 0.9 | | | | | | | | | | | | | |
| | 40 | 0.4 | 0.5 | 0.8 | 1.0 | 1.5 | | | | | | | | | | | | |
| | 45 | 0.5 | 0.7 | 0.9 | 1.2 | 1.6 | 2.1 | | | | | | | | | | | |
| | 50 | 0.6 | 0.8 | 1.0 | 1.4 | 1.7 | 2.2 | 2.6 | | | | | | | | | | |
| | 55 | 0.6 | 0.8 | 1.1 | 1.5 | 1.8 | 2.2 | 2.7 | 3.1 | | | | | | | | | |
| | 60 | 0.7 | 0.9 | 1.2 | 1.5 | 1.9 | 2.3 | 2.7 | 3.2 | 3.6 | | | | | | | | |
| | 65 | 0.7 | 1.0 | 1.3 | 1.6 | 2.0 | 2.4 | 2.8 | 3.2 | 3.6 | 4.0 | | | | | | | |
| | 70 | 0.8 | 1.0 | 1.3 | 1.6 | 2.0 | 2.4 | 2.8 | 3.2 | 3.7 | 4.1 | 4.5 | | | | | | |
| | 75 | 0.8 | 1.1 | 1.4 | 1.7 | 2.1 | 2.5 | 2.9 | 3.3 | 3.7 | 4.1 | 4.5 | 4.9 | | | | | |
| | 80 | 0.9 | 1.1 | 1.4 | 1.7 | 2.1 | 2.5 | 2.9 | 3.3 | 3.8 | 4.2 | 4.6 | 5.0 | 5.3 | | | | |
| | 85 | 0.9 | 1.2 | 1.4 | 1.8 | 2.1 | 2.5 | 2.9 | 3.4 | 3.8 | 4.3 | 4.7 | 5.1 | 5.4 | 5.7 | | | |
| | 90 | 0.9 | 1.2 | 1.5 | 1.8 | 2.2 | 2.6 | 3.0 | 3.4 | 3.8 | 4.3 | 4.7 | 5.1 | 5.5 | 5.7 | 5.9 | | |
| | ≥95 | 1.0 | 1.2 | 1.5 | 1.8 | 2.2 | 2.6 | 3.0 | 3.4 | 3.9 | 4.3 | 4.8 | 5.2 | 5.5 | 5.7 | 5.9 | 6.0 | |

**Values of Percentage Loss of Hearing Corresponding to Given Hearing Threshold Levels
in the Better and Worse Ears at 6000 Hz**

HTL — BETTER EAR

| | | ≥25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | ≥95 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | ≥25 | 0 | | | | | | | | | | | | | | |
| HTL | 30 | 0.1 | 0.2 | | | | | | | | | | | | | |
| Worse Ear | 35 | 0.2 | 0.3 | 0.4 | | | | | | | | | | | | |
| (dB) | 40 | 0.3 | 0.4 | 0.5 | 0.7 | | | | | | | | | | | |
| | 45 | 0.3 | 0.4 | 0.6 | 0.8 | 1.0 | | | | | | | | | | |
| | 50 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 | | | | | | | | | |
| | 55 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | | | | | | | | |
| | 60 | 0.4 | 0.6 | 0.7 | 0.9 | 1.1 | 1.4 | 1.6 | 1.8 | | | | | | | |
| | 65 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 2.0 | | | | | | |
| | 70 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | | | | | |
| | 75 | 0.5 | 0.7 | 0.8 | 1.0 | 1.2 | 1.4 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | | | | |
| | 80 | 0.6 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.7 | | | |
| | 85 | 0.6 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.7 | 2.8 | | |
| | 90 | 0.6 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 | 1.9 | 2.2 | 2.4 | 2.6 | 2.7 | 2.8 | 2.9 | |
| | ≥95 | 0.6 | 0.8 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 | 1.9 | 2.2 | 2.4 | 2.6 | 2.7 | 2.8 | 2.9 | 3.0 |

**Values of Percentage Loss of Hearing Corresponding to Given Hearing Threshold Levels
in the Better and Worse Ears at 8000 Hz**

HTL — BETTER EAR

| | | ≥30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 ~ 90 | ≥95 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------|-----|
| | ≥30 | 0 | | | | | | | | | | | | |
| HTL | 35 | 0.1 | 0.1 | | | | | | | | | | | |
| Worse Ear | 40 | 0.1 | 0.2 | 0.2 | | | | | | | | | | |
| (dB) | 45 | 0.1 | 0.2 | 0.3 | 0.3 | | | | | | | | | |
| | 50 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | | | | | | | | |
| | 55 | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | | | | | | | |
| | 60 | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | 0.6 | | | | | | |
| | 65 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | | | | | |
| | 70 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | | | | |
| | 75 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.8 | 0.8 | | | |
| | 80 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.6 | 0.7 | 0.8 | 0.8 | 0.9 | | |
| | 85 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | 0.6 | 0.6 | 0.7 | 0.8 | 0.8 | 0.9 | 0.9 | |
| | ≥90 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | 0.6 | 0.6 | 0.7 | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 |

SECOND SCHEDULE

Adjustment of Percentage Loss of Hearing for Presbycusis

| MALE | Percentage Adjustment | FEMALE | Percentage Adjustment |
|------|-----------------------|--------|-----------------------|
| Age | | Age | |
| <57 | 0.0 | < 65 | 0.0 |
| 57 | 0.2 | 65 | 0.1 |
| 58 | 0.5 | 66 | 0.2 |
| 59 | 0.7 | 67 | 0.3 |
| 60 | 1.0 | 68 | 0.4 |
| 61 | 1.4 | 69 | 0.5 |
| 62 | 1.7 | 70 | 0.7 |
| 63 | 2.1 | 71 | 1.0 |
| 64 | 2.5 | 72 | 1.3 |
| 65 | 2.9 | 73 | 1.6 |
| 66 | 3.4 | 74 | 1.9 |
| 67 | 3.9 | 75 | 2.3 |
| 68 | 4.4 | 76 | 2.7 |
| 69 | 5.0 | 77 | 3.2 |
| 70 | 5.5 | 78 | 3.7 |
| 71 | 6.1 | 79 | 4.3 |
| 72 | 6.8 | 80 | 4.8 |
| 73 | 7.4 | | |
| 74 | 8.1 | | |
| 75 | 8.8 | | |
| 76 | 9.6 | | |
| 77 | 10.3 | | |
| 78 | 11.1 | | |
| 79 | 12.0 | | |
| 80 | 12.8 | | |