Assessment of occupational noise-induced hearing loss for ACC

A practical guide for otolaryngologists

NZSOHNS
THE NEW ZEALAND SOCIETY OF OTOLARYNGOLOGY, HEAD AND NECK SURGERY

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Introduction

Welcome to this 2018 version of the guideline[1] for assessing occupational noise-induced hearing loss (ONIHL) for Accident Compensation Corporation (ACC) clients. This evidence- and consensus-based guideline will help you to make fair and consistent decisions on ACC cover for occupational noise-induced hearing loss.

The guideline includes summaries of ACC-commissioned systematic literature reviews on key aspects of ONIHL, and references to resources to assist you to provide robust, evidence-based reports. Background information on relevant legislation and specific details of the New Zealand context, including useful guidance on carrying out assessments for third parties, are also included. See Appendix A for the 2018 Otolaryngologist Report (ACC723).

How the guideline was developed

Several people have shared their expertise and support in developing this guideline. The first version was developed and published in 2011. ACC, occupational medicine specialists and otorhinolaryngologists (ORLs) collaborated to provide practical guidance on how to assess whether noised-induced hearing loss (NIHL) was caused by occupational exposure.

ACC's Audiology Advisor requested that the 2011 guideline be updated. We convened an expert advisory group and, alongside evidence-based research updated since 2011, provided expert consensus knowledge in this area. This 2018 version of the guideline is now presented to you to inform your specialist assessments of ACC ONIHL clients.

The New Zealand Society of Otolaryngology, Head and Neck Surgery endorsed the guideline on 5 October 2018.

Acknowledgements

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[1] The guideline is located online at *https://www.acc.co.nz/assets/provider/acc7917-assessment-hearing-loss.pdf*

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Relevant legislation in New Zealand

Accident Compensation Act 2001

ACC provides comprehensive, no-fault personal injury cover for New Zealand residents and visitors to New Zealand. The Accident Compensation Act 2001 precludes litigation for personal injury in New Zealand, except for exemplary damages.

Everyone in New Zealand is eligible for comprehensive injury cover, even if the person contributed to the injury. A claim can be lodged regardless of the person's age or whether they're still working.

Physical injuries covered by ACC can include: fractures induced by external trauma; work-related gradual process injuries (such as deafness caused by work noise); infections and diseases caused at work by performing a task or being exposed to a particular environment (this excludes any congenital conditions); and poisoning.

As physical injury requires actual damage to the body from the injury, the mere presence of symptoms, such as pain or tinnitus, will not be sufficient to establish cover in the absence of a diagnosed physical injury.

ACC does not cover:

- illness (apart from certain defined occupational diseases)
- injuries related mainly to ageing
- injuries that develop gradually and are not caused by work tasks or exposure (i.e. non-occupational gradual process injuries).

Under normal circumstances, the injury must have occurred in New Zealand.

Specific legislation relating to hearing loss

ACC can provide cover for hearing loss when it is caused in the following ways:

- an accident
- a gradual process condition (but only if related to work exposure), or
- medical treatment (known as treatment injury).

Work-related hearing loss

The Accident Compensation Act 2001 allows cover for NIHL as a work-related gradual process injury.

To be eligible, the client needs to establish that they were resident and working in New Zealand, or working temporarily abroad as a New Zealand resident for a New Zealand agency or company, when the noise exposure occurred.

For hearing loss to be accepted for cover:

- the hearing loss must have been caused by noise
- exposure to noise needs to be identified as having occurred at work and
- exposure to injurious noise must not have occurred to a material extent away from work (material extent meaning that the non-work exposure acting alone could not have been sufficient to cause the NIHL)
- workers exposed to such workplace noise must be at a significantly greater risk of suffering NIHL than others not exposed to that environment. The comparison of risk is between people who generally perform work with such noise exposure and people in other work environments, not between the client and the general population. The fact that a client may be more at risk of suffering NIHL is not relevant to this consideration
- the work must be for pecuniary gain or profit – unpaid work, or work that involves only an allowance that is not subject to taxation (such as volunteer firefighters and prisoners involved in work schemes), is not covered.

Self-employed workers, e.g. farmers and often their family members, are included under the scheme.

Accidents

Hearing loss can result from head injuries caused by accident. This generally requires specialist assessment, and is outside the scope of this guideline.

Occasionally hearing loss results from a single exposure to an extremely loud noise or explosion. The assessment for these cases will differ from the assessment for gradual process because it will be limited to evidence relating to the date on which the hearing loss developed.

Treatment injury

Treatment injury cases include those with hearing loss caused either by a) failure to provide treatment or b) by treatment provided by a registered health professional, when hearing loss is not a necessary part or ordinary consequence of the treatment. This provision means that hearing loss from chemotherapy would not be considered for cover, since it is an expected outcome of treatment. However, hearing loss caused by inappropriate treatment may be covered e.g. unmonitored gentamicin or incorrect dosages of chemotherapy.

The determination of treatment injury involves a consideration of all the circumstances of the treatment, including the person's underlying health condition at the time of the treatment, and clinical knowledge at the time of the treatment.

A failure of treatment to achieve the desired result is not considered a treatment injury. An injury from a clinical trial is not eligible unless the trial was approved by an ethics committee and the trial was not performed for the benefit of a distributor or manufacturer.

Cover

For clients who lodged a claim on or after 1 July 2010, a 6% binaural hearing loss threshold for cover applies. That is, the amount of hearing loss attributed to ONIHL (or another covered cause) must exceed 6% for ACC to accept cover. This does not apply to clients with existing claims lodged before July 2010. The figure of 6% was selected on the basis of 500 consecutive entitlement (i.e. hearing aid funding) recommendations by Ear, Nose and Throat (ENT) specialists. Where there are several claims (such as for trauma), cover may be given if the total injury-related hearing loss exceeds 6%.

Entitlement(s)

Before the introduction of the 6% threshold for cover, not all clients who were eligible for cover were also eligible for entitlements (i.e. rehabilitative assistance such as hearing aids and associated services). Under current legislation this is less likely; instead, regulations control the extent of entitlement. However, for clients with claims lodged prior to July 2010 who are being reassessed, recommendations as to whether the clients' coverable hearing loss would justify hearing aid provision may be requested.

ACC regulations

Specific details relating to the assessment of hearing loss are contained in the Accident Insurance (Occupational Hearing Assessment Procedures) Regulations 1999 (1). Under these regulations, the percentage loss of hearing (PLH) scale is defined, together with corrections for age-related hearing loss. Note that the age correction table was updated in 2010. A new version of the standard on which the age corrections are based (ISO 7029) was published in January 2017. The new age corrections may be introduced into the assessment regulations.

The PLH scale was developed by John Macrae at the National Acoustic Laboratories in Sydney, Australia, and a discussion of the development of the scale is available (2).

The Accident Compensation (Apportioning Entitlements for Hearing Loss) Regulations 2010 (3), which were updated in 2014, specify maximum payments towards the cost of hearing aids and associated service fees under an apportionment model; that is, the amount paid reflects the proportion of the total hearing loss attributed to the covered injury. In addition, the Ministry of Health subsidy is reverse apportioned. Payments on behalf of both the Ministry of Health and ACC are administered by ACC for clients with hearing loss of mixed causation. In nearly all cases the funding is sufficient for a free-to-client product to be offered by audiology services, although other options involving co-payments may be presented for the clients' choice.

Health and Safety at Work Act 2015 (HSWA)

The purpose of the HSWA is to provide a balanced framework to secure the health and safety of workers and workplaces, with the guiding principle that workers and other persons should be given the highest level of protection against harm to their health, safety, and welfare from hazards and risks arising from work. THE HSWA shifts the focus from monitoring and recording health and safety incidents to proactively identifying and managing risks. Under the HSWA, the primary obligations are on the people who create risk and are best placed to manage it.

The Health and Safety in Employment Regulations 1995 contain specific workplace noise exposure limits. Regulation 11 requires employers and those in control of workplaces to ensure, as far as is reasonably practicable, that no worker is exposed to noise above 85 dB(A) over an 8-hour day and a peak noise level of 140 dB, whether or not they are wearing hearing protection. If it is not possible to eliminate the risk of noise exposure above these levels, the employer must clearly communicate that noise levels are likely to be hazardous and specify what hearing protection is required (and where to obtain it). Provision of hearing protectors does not imply that no dangerous noise exposure has occurred – various reports have outlined the limitations of hearing protection (4, 5).

Assessment issues

You can see from the legal framework that aspects of your clinical assessment are vital. They include, for example, your:

- careful elicitation of the history of hearing loss, past illness, injury, treatments and noise or explosion exposure
- understanding of the literature relating to the work risk of NIHL in various worker groups and occupation types
- your expert analysis of the:
  - severity of the noise exposure
  - relative risks of work and non-work exposure
  - your expert opinion of the:
- pattern of hearing loss and examination findings, and whether these are typical of NIHL
- risk to hearing from a client's medical, surgical, pharmacological or trauma history.

Medical Council of New Zealand

The Medical Council of New Zealand has developed guidelines for doctors carrying out medical assessments for third parties (6) (see Appendix B).

The guidelines cover issues such as the need to provide an impartial opinion for the third party, and the differences in the relationship between the doctor and the patient (notwithstanding the requirement to provide a professional standard of care). The doctor must communicate with the patient in a manner that enables the patient to understand the information provided and the role of the doctor as an assessor. The assessment report is sent to the third party (but in the knowledge that the report will be provided to the client on request).

A consideration of ethical behaviour and the appropriate management of financial relationships (such as ownership of audiology services) is also provided by the Medical Council (7).

Undertaking the assessment

There are specific clinical and ethical considerations to remember when undertaking a clinical assessment as a non-treating doctor.

The specialist must be suitably qualified to undertake the assessment

The report you provide will be suitable for determining ACC cover and entitlement(s) only if you have the skills and knowledge to undertake the assessment. You need to have a New Zealand vocational registration with ORL qualification that provides an assurance of your skills in history and examination at a specialist level. This is a baseline qualification.

As well as this, you should ideally have pursued an interest in hearing loss and be adept at analysing the hearing effects of illness, injury, medical treatment and noise exposure. It is also very helpful to be familiar with the literature on the occupational and recreational risks of NIHL, including an understanding of the medico-legal aspects of these conditions. In a situation where you feel your knowledge and qualifications are not sufficient to enable you to undertake an assessment confidently, it may be better to decline to do so, or at least to express some reservations when writing the report.

Patient communication, informed consent and explanation remain very important. Although you are not the treating doctor, as an assessing doctor you still have obligations to the patient. The Medical Council provides guidance on this subject and emphasises the approach to informed consent, checking that the patient has a good understanding of the nature of the assessment and giving the patient some sense of what will happen next.

There will be only limited situations where it is reasonable and expedient to carry out treatment (e.g. to remove wax to facilitate an assessment). However, if you need to have a procedure such as MRI carried out to explore a medical condition, ACC would not normally fund it.

The assessment must be impartial

Your assessment needs to be impartial. This means you should ensure that your evaluation of the patient and weighing up of the findings are based on a sound clinical approach and methodical analysis. In doing this, you are putting aside an advocacy role for either the client or ACC to give an objective assessment.

It is not appropriate to conduct an assessment where there is a perceived conflict of interest

The report you provide influences both ACC cover and entitlement for ONIHL. Considerable expert and impartial clinical judgement and synthesis of information are expected of you. A conflict of interest arises when the outcome of an assessment may be perceived as *significant for the doctor as well as the patient*.

It would not be appropriate for you to undertake an assessment if:

- you have a relationship with the patient through family, business or social links
- you, or a family member or close associate (or your/their beneficial entity), have a controlling or significant interest in the provision of hearing aids, hearing rehabilitation or other services likely to be affected by ACC cover or entitlement decisions.

If you think there *may* be a conflict of interest:

- inform the patient that you cannot proceed; or

If you consider that, despite a perceived conflict, you do not have any personal interest in whether the patient does or does not have a diagnosis of ONIHL:

- declare the conflict of interest in the assessment report
- confirm that you remain impartial to the outcome
- indicate how you manage the conflict of interest.

Table 1: Conflicts of interest

Situation	Conflict of interest	Possible action
You are asked to complete an ONIHL assessment of a patient who is a family friend/relative/close business associate.	Potential conflict of interest.	Decline the assessment request, or at the very least declare your conflict of interest.
You (or your family's beneficial entity, trust or company) have a financial interest in the company that leases rooms to an audiologist but no "interest" in the audiologist's business, i.e. a commercial arm's-length transaction.	Probably not a conflict of interest or *can be managed* so as not to be a conflict of interest.	Ensure that you have guidelines in place (e.g. fair ways of letting clients know about other audiology practices in the area) so the audiology practice does not receive undue advantage through its association with you.
You (or your family's beneficial entity) have income, shares or directorship in an audiology service that provides hearing aids.	Clear conflict of interest.	Decline the assessment request, or declare your conflict and: • ensure objectivity in your apportionment • refrain from advocating for or preferentially referring clients to any service in which you have a commercial interest.

Status of your opinion

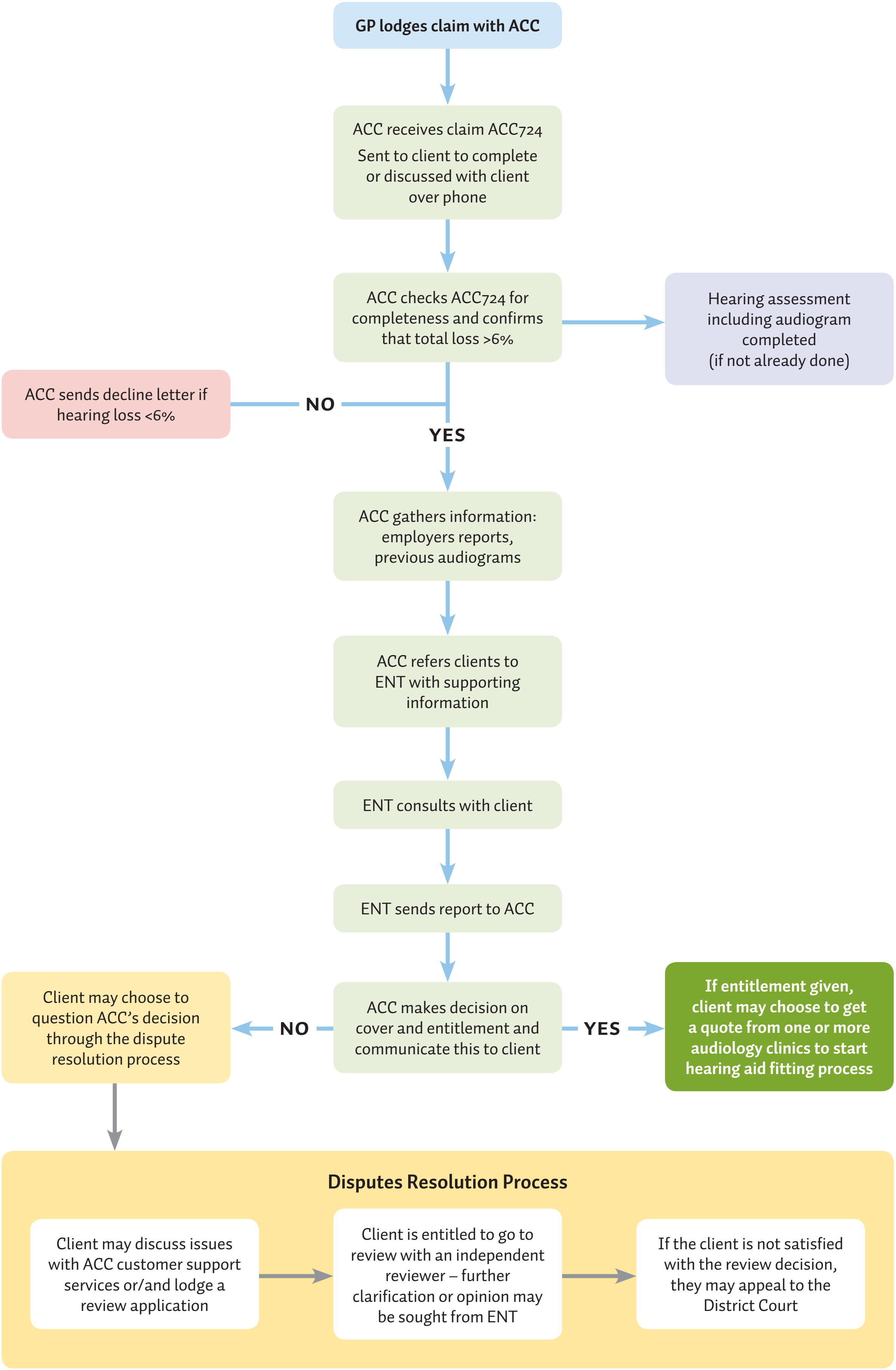
Your role is to assess the gathered information, including objective and clinical findings, in the light of your professional knowledge to reach an opinion. You are not required to decide on the claim, but your opinion will be considered by ACC in its decision-making.

Requirement for a further audiogram during ORL hearing loss assessment

By and large an audiogram at or close to the date of an ORL hearing loss assessment may be regarded as best practice. The acceptability of an older audiogram is ultimately at the discretion of the ORL carrying out the assessment, but the following points may be kept in mind:

- Where a client has long since ceased noise exposure, an older audiogram (say six months or more) may well be perfectly adequate. Old audiograms from around the time the client ceased work may be useful for tracking the progression of the client's hearing loss.
- Individuals working in ongoing noise should have more up-to-date audiograms (e.g. within three months).
- Where the most recent audiogram is inadequate (poor test conditions, incomplete, unreliable patient responses etc it should be repeated.
- A client with active non-occupational ear disease may well require contemporary audiometry, especially if there has been a recent clinical event (e.g. barotrauma, sudden deafness).
- Inconsistent previous audiograms (query non-organic loss) would benefit from contemporary audiometry.
- Where the age-adjusted loss is very close to the threshold for cover, it may be prudent to arrange an independent contemporary audiogram.

Figure 1: Hearing loss claim process



GP lodges claim with ACC

ACC receives claim ACC724
Sent to client to complete or discussed with client over phone

ACC checks ACC724 for completeness and confirms that total loss >6%

Hearing assessment including audiogram completed (if not already done)

ACC sends decline letter if hearing loss <6%

ACC gathers information: employers reports, previous audiograms

ACC refers clients to ENT with supporting information

ENT consults with client

ENT sends report to ACC

ACC makes decision on cover and entitlement and communicate this to client

Client may choose to question ACC's decision through the dispute resolution process

If entitlement given, client may choose to get a quote from one or more audiology clinics to start hearing aid fitting process

Disputes Resolution Process

Client may discuss issues with ACC customer support services or/and lodge a review application

Client is entitled to go to review with an independent reviewer – further clarification or opinion may be sought from ENT

If the client is not satisfied with the review decision, they may appeal to the District Court

Subsequent to your report

ACC will send a copy of your report to the client if the case is declined for cover and/or entitlement(s). If the client chooses to seek a review of the decision by ACC, ACC would normally ask the assessing doctor for further details if there are any remaining questions following the assessment report.

The client may seek a second opinion from another specialist, and ACC may also ask this specialist for further information. ACC would normally refer the second opinion back to the first assessor for comments.

It would normally not be necessary (or desirable) for the assessor to attend the review hearing since this is a quasi-legal environment, and reports on the client's file will generally be taken at face value.

The review would be carried out by a reviewer employed by FairWay Resolution Ltd, an independent company. The client may choose to appeal any review decision to the District Court in Wellington.

Rehabilitation and entitlements

Rehabilitation is defined by ACC as a process of supporting a person with an injury covered by ACC so that they can live an everyday life. An everyday life relates to establishing the person's independence to the maximum extent practicable, given their strengths and abilities following an injury.

Depending on the client's needs, they may be entitled to one or more social rehabilitation options provided under the Accident Compensation Act 2001. The relevant options for hearing injury are:

- equipment (aids and appliances)
- training for independence.

In general, ACC has two options for providing hearing rehabilitation. ACC can:

- contribute to the cost of the support (e.g. equipment such as hearing aids and assistive devices)
- fund and arrange rehabilitation support (e.g. hearing therapy or tinnitus counselling).

Clients with accepted cover and entitlements are sent information on the amount of financial assistance that ACC and the Ministry of Health will contribute towards the cost of hearing aids and associated services. The clients are then free to approach any audiology practice registered with ACC for a quote for hearing aids as the beginning of the hearing aid fitting process.

For clients with severe covered hearing loss (usually those with hearing loss from treatment injury or major accidents), cochlear implantation may be considered.

If a client is declined cover and entitlements, they may be eligible for funding assistance towards hearing aids from other sources.

Information about funding sources is given at:

- New Zealand Audiological Society. Funding for hearing aids. Retrieved from *https://www.audiology.org.nz/hearing-aid-funding.aspx*

Lists of public and private audiology services are provided at:

- New Zealand Audiological Society. Find your nearest MNZAS audiologist. Retrieved from *https://www.audiology.org.nz/find-an-audiologist.aspx*

Evidence reviews

As part of the project to develop this guideline, ACC commissioned a series of evidence reviews to summarise the current state of knowledge in a range of related areas. The 2011 and 2018 evidence reviews are described in Table 2 below which is followed by summaries of their findings and our recommendations.

Table 2: ONIHL evidence reviews

Evidence updates on risk factors for ONIHL.

Report	Summary
Update 1: Exposure to solvents with or without noise (2018). Amanda Bowens, Information Specialist, ACC, NZ. (8)	Reviews recent evidence on occupational exposure to organic solvents, with or without noise, as a risk factor for hearing loss. It takes a pragmatic, "best evidence" approach and is a partial update of ACC's 2010 epidemiological review of hearing loss risk factors.
Update 2: Review of impact and impulse noise evidence (2018). David McBride, Occupational Medicine Specialist, University of Otago, NZ. (9)	Reviews evidence on NIHL and impact or impulse noise since the McBride (2010) evidence review. Describes some new findings for complex noise effects and no updates for impulse noise.
Update 3: Genetic factors (2018). Amanda Bowens, Information Specialist, ACC, NZ. (10)	Briefly reviews the literature on genetic risk factors associated with both NIHL and susceptibility to hearing loss more generally. It is a partial update of ACC's 2010 epidemiological review of risk factors for hearing loss.
Part 1: Noise effects and duration (2010). David McBride, Occupational Medicine Specialist, University of Otago, NZ. (11)	Describes the development of the international standards that summarise epidemiological data on hearing loss and noise exposure. It also includes information on types of noise, their effects on hearing loss, and typical noise exposures.
Part 2: Epidemiological review – some risk factors of hearing loss (2010). Zhi-ling Zhang, Senior Research Adviser, ACC, NZ. (12)	Covers the risks of developing hearing loss associated with agents other than noise.
Part 3: Audiometric standards (2010). Suzanne Purdy, University of Auckland, NZ and Warwick Williams, National Acoustic Laboratories, Sydney, Australia. (13)	Reviews appropriate standards for carrying out audiometric assessments in terms of key issues such as test conditions, test equipment and tester qualifications.

2018 Update 1: Exposure to solvents with or without noise

Amanda Bowens, Information Specialist, ACC, New Zealand

This review update concludes that evidence from systematic reviews/meta-analyses and, to a lesser extent, cohort studies published during the period 2009-2018 indicates that occupational exposure to certain organic solvents, with or without noise, is a risk factor for hearing loss. These findings are in alignment with ACC's 2010 review and with major international reviews.

Of the three main solvents discussed in this update, evidence of ototoxicity is strongest for styrene and toluene. It is weaker and more limited for xylene. There is evidence that styrene and particularly toluene have synergistic effects with noise. Occupations associated with high solvent exposure are discussed in the ototoxicity section of this guideline.

No validated clinical tools for or guidelines on assessing hearing loss associated with solvent exposure were identified. However, international agencies have released guidance on assessing and monitoring the hearing of people exposed to ototoxic solvents in the workplace.

RECOMMENDATION

Workers exposed to chemicals should have this reflected in their assessment.

The order of magnitude attributable to solvents/heavy metals is in the range of 2-6%, dependent on years of exposure.

2018 Update 2: Review of impact and impulse noise

David McBride, University of Otago, New Zealand

Since the 2011 ONIHL guideline was published, two studies of Chinese workers exposed to complex noise Xie (14) and Davis et al (15) have given additional insights into the effect of complex noise. Davis et al (15) have shown that ISO 1999 underestimates the noise induced permanent threshold shift to be found at 2, 4 and 6 kHz by at least 10-15 dB HL (hearing loss).

A study by Roberts et al (16), using a mixed model in which baseline hearing status was entered as an additional covariate, also predicted worse thresholds than the ISO standard, more marked at the high frequencies for the higher percentiles of hearing loss, being at least 5 dB HL and as much as 21 dB HL (90th percentile, 6 kHz).

RECOMMENDATION

Assessors should be mindful that ISO 1999 is likely to underestimate the effect on hearing when impact noise is present. It is probably appropriate to add 3-6 dB of noise exposure when assessing the audiometric profile.

There has been little additional data for impulse noise and the earlier advice should remain extant.

2018 Update 3: Genetic factors

Amanda Bowens, Information Specialist, ACC, New Zealand

The report focuses on three areas:

1. Recent research on genetic factors associated with NIHL – the evidence base has grown since 2010. Meta-analyses suggest possible associations between susceptibility to NIHL and variants in several genes, e.g. heat shock protein 70.
2. Non-syndromic hearing loss – there are four main types depending on inheritance pattern. Age of onset, severity and progression vary between and within types. Autosomal recessive forms are more common, but autosomal-dominant forms may be more likely to arise in adulthood and progress with age.
3. Other inherited conditions associated with hearing loss – a range of syndromes, e.g. mitochondrial disorders, are characterised by hearing loss alongside other signs and symptoms. In addition, research suggests that some other disorders that may have an inherited component, e.g. diabetes, may be associated with an increased risk of hearing loss.

2010 Part 1: Noise effects and duration

David McBride, Occupational Medicine Specialist, University of Otago, New Zealand

The basic principle in diagnosis and assessment is that there must be a "suitable and sufficient" history of noise exposure to cause the degree of hearing loss at hand. Although the audiometric notch is a sign of ONIHL, it is not pathognomonic.

Fundamental to the assessment procedure is knowledge of the quantitative relationship between noise and hearing loss, and how age and noise interact: one must know the degree of hearing loss that would be expected from noise exposure to a given level and duration – the noise "dose". NIHL may develop from both occupational and non-occupational sources, but these need to be distinguished because of the requirements imposed by ACC's legislation.

In this guideline, the relationships between noise exposure (level and duration) and hearing loss are looked at with regard to the two main types of noise – continuous noise and impulse noise.

Continuous noise

Continuous noise was examined in large cross-sectional studies in Europe and the United States in the 1960s, with subjects who had been exposed to the same level of steady noise throughout their careers without the use of hearing protection. This allowed mathematical modelling of the relationship between noise and hearing level, shown to conform (within constraints) to an "equal energy theory", with equal amounts of "A-weighted" sound energy causing equal amounts of hearing loss.

The model was refined and incorporated into ISO 1999, which allows the calculation of the hearing loss to be expected from any given noise exposure in a range of percentiles of the population, from the 5% least sensitive to the 5% most sensitive to its effects. Age has also been incorporated into the model, the two effects being combined in the populations actually under study, but allowed to be additive in their effects. The model does suffer from a number of assumptions and constraints, and is therefore not perfect, but at present it is the best available for the purpose.

RECOMMENDATION
In order to make a diagnosis of NIHL, the level and duration of noise should be elicited (actual noise-level data from the employer, or estimates). These noise estimates should then be used to predict the range of hearing impairment that might be expected from such noise exposure, referring to tables derived from ISO 1999. The client's hearing should then be compared to these levels and to the amount of hearing loss to be expected from age alone. This will allow an assessment of the probability of causation.

Impulse noise

Impulse noise has been even more difficult to study. As the cumulative exposure dose is almost impossible to ascertain over a period of time, the human studies have relied on a temporary effect on the ear – a temporary threshold shift (TTS) – to evaluate probable long-term effects on hearing.

There is much ongoing debate about the relationship between permanent hearing loss and TTS, but studies have shown that equal noise energy causes equivalent amounts of TTS (a corollary to the equal energy hypothesis). In the absence of further insights, there are "energy measures", including A and B durations of an impulse, that allow the hazard to be estimated, albeit with less precision than for steady noise. There is also growing knowledge about C weighting as an energy measure.

RECOMMENDATION
An assessment of exposure to firearms is important. The type and calibre of weapon need to be known, along with the number of rounds (or cartridges) fired on each occasion, and how often exposure takes place. Exposure of less than 100 rounds per year may not pose a significant risk to hearing. Individuals shooting more than 10 rounds on each occasion, with monthly exposure, may be exposed to another 2-3 dB(A) of noise in addition to their occupational exposure. The additional hearing loss, depending on dose, may vary, on average, from around 3 to 9 dB HL.

Noise levels

Most noise in New Zealand probably lies in the range of 85-90 dB(A), with some industries having noise exposures up to 100 dBA and a very few occupations being exposed in excess of this level.

Effect of hearing protectors

The noise dose is moderated by noise control measures in the workplace. Although noise management should focus on reducing the noise at source, there is a heavy reliance on hearing protection. For behavioural and other reasons, this is often much less effective than supposed, reducing the noise exposure by much less than the 20-30 dB values often quoted, and sometimes in the region of only 2-3 dB(A).

RECOMMENDATION

- The type of hearing protection (type of plug and grade or class of earmuff) should be elicited.
- It is essential to form a clear idea of how often hearing protection has been worn.
- The highest-grade earmuffs will have an assumed protective factor of up to 30 dB. However, to be effective, hearing protectors must be worn always when noise is present; otherwise their effectiveness is greatly reduced. The resulting protection can be as low as 2-3 dB.

Non-occupational factors affecting hearing

Noise occurs not only at work, but also at home and at leisure. From the information available, it seems that the average person with a noisy job would have little extra material noise exposure added by leisure noise. However, perhaps 10-20% of people do have material exposure to non-occupational noise.

RECOMMENDATION

- Firearms and shooting are probably the most hazardous types of exposure, and the frequency and intensity of such exposure must be evaluated (see the impulse noise section above).
- Exposure to music, both live and through music systems, may be hazardous for the few who listen for long periods at excessive levels.
- Regular attendance at nightclubs (i.e. weekly or more) poses a risk to hearing.
- People listening to personal music players may be at risk if exposure to excessive levels exceeds seven hours per week.
- People heavily involved in motor sports may experience some effect on their hearing.

Lastly, other important factors in the assessment of hearing loss are mentioned, including best practice and guidance in the use of questionnaires (both self-completed and clinician-led) to elicit a full noise and otological history.

2010 Part 2: Epidemiological review: some risk factors of hearing loss

Amanda Bowens, Information Specialist, ACC, New Zealand and Zhi-ling Zhang, Senior Research Adviser, ACC, New Zealand

Noise is the most important risk factor for occupational hearing loss at present. However, exposure to other risk factors (e.g. solvents and smoking) should not be ignored.

Age

Evidence that supports a synergistic effect of ageing and noise exposure appears to be very weak. Compared with those without historical noise exposure, older adults previously exposed to occupational noise do not have a higher rate of threshold changes and may even have a lower rate.

These findings support the conclusion that noise exposure in working age is very unlikely to be an attribute of hearing deterioration in older people who are no longer exposed to noise. In other words, previous noise exposure is very unlikely to cause older people to be more prone to age-related hearing loss, even though hearing loss caused by the previous noise exposure will still exist.

An additive effect model of ageing and noise exposure on hearing loss is much more acceptable than the assumption of synergistic effect. Nevertheless, the model is not always in agreement with data from available studies. An additive effect model with modification is the best approach available.

RECOMMENDATION

The impact of ageing must be considered in the diagnosis of NIHL. Hearing deterioration (threshold changes) after people leave occupational noise exposure cannot be attributed to occupational noise exposure.

Exit audiograms (for those leaving employment or noise-exposed jobs) appear to be critical in assessing the maximum amount of occupation-attributable hearing loss in an individual. However, any historical records of hearing tests can be relevant and helpful and should be tracked and considered for hearing impairment assessments.

Carbon monoxide

The findings from animal studies and human case reports are different. No hearing impairment has been found in animal studies even with significantly high concentration exposure to carbon monoxide (up to 1,500 ppm). However, human cases of hearing loss have been reported after carbon monoxide poisoning.

Exposure levels of carbon monoxide are not available in the accidental poisoning reports. It is reasonable to assume that the poisoning levels are higher than the exposure levels in most workplaces.

Based on the case reports, carbon monoxide poisoning-related hearing loss could be described as bilateral sensorineural impairment and is at least partly reversible. It is unclear whether the hearing loss is related to the potential ototoxicity and/or neurotoxicity of carbon monoxide.

There is only a very limited number of epidemiological studies on the link between occupational exposure to carbon monoxide and hearing impairment in the working-age population. More studies are needed. Both the risk of hearing loss in association with long-term occupational exposure to carbon monoxide in the working environment and the possible interaction between the exposure, noise and other risk factors remain unclear at this stage.

RECOMMENDATION

A patient's medical history of carbon monoxide poisoning should be investigated and recorded during the diagnosis of NIHL. Audiometric testing results (if available) following the poisoning need to be considered in the assessment.

Smoking

Smoking can be considered a risk factor of hearing loss. However, all reviewed studies have significant weaknesses in methodology, especially in the measurement of noise exposure and in controlling for the exposure as a relevant confounder. Even though most of the included studies indicate that smoking is associated with hearing loss, more well designed studies with appropriate controls on relevant confounders are needed.

RECOMMENDATION

Patients with NIHL can be advised to stop smoking to prevent related adverse health effects, including possible further hearing impairment. In some studies, ex-smokers have had either a lower risk of hearing impairment than current smokers or an insignificant risk when compared to non-smokers. For long-term heavy smokers, it is possible that smoking could contribute to hearing loss.

Applications of evidence to hearing assessment

It is relatively difficult to use these findings for clinical assessments of individual patients. The effects of the risk factors are assessed at population or group level in epidemiological studies, so there are limitations in generalising the findings for an individual. Moreover, the exposure “dose” of the risk factors (apart from age) for an individual is usually unclear and difficult to obtain quantitatively.

Exposure to multiple risk factors makes the decision-making more difficult. As mentioned previously, there is also a lack of high-quality cohort studies for some risk factors reviewed.

Internationally, there is an absence of clinical tools to determine quantitatively how much of an individual’s hearing loss is caused by smoking.

However, these limitations do not hinder the findings being used in a “qualitative approach” in a clinical assessment. For example, if hearing impairment in a yacht-building worker does not match the level of noise exposed, information in relation to other risk factors (e.g. exposure to styrene, smoking and other non-occupation-related exposure) should be considered when interpreting the hearing impairment. In these cases, historical audiometric records are particularly valuable.

It will be a rare case where the apportionment is materially affected by these factors, given the current state of knowledge. If substantial exposure has occurred, a separate ACC claim for gradual process injury might be expected.

2010 Part 3: Audiometric standards

Suzanne Purdy, University of Auckland, New Zealand and Warwick Williams, National Acoustic Laboratories, Sydney, Australia

This document considers standards relating to the audiometric assessment of clients presenting with a history of noise exposure.

Acoustical test environment

Maximum permissible ambient sound pressure levels or noise levels in the test area should meet the requirements of ISO 8253-1 Acoustics – Audiometric test methods, Part 1: Pure-tone air and bone conduction audiometry for hearing threshold levels down to 0 dB HL.

The ability to determine bone conduction thresholds accurately to a hearing level of 5 dB HL is required. The maximum permissible background sound pressure levels to test to threshold levels of 5 dB for air and bone conduction with a +5 dB uncertainty over the range 500-8,000 Hz are provided in Table 3 below. All test environments used for diagnostic audiology should meet the ambient noise requirements for bone conduction testing, and hence test environments should comply with the ambient noise levels specified in the right-hand column in the table.

Maximum permissible ambient noise levels (LS, max) for air and bone conduction audiometry for hearing thresholds to 5 dB, with 5 dB uncertainty over the range 500-8,000 Hz, using typical supra-aural earphones such as the Telephonics TDH39 with MX 41/AR cushions or the Beyer DT48 (adapted from ISO 8253-1 Tables 2 and 4).

Table 3: Maximum permissible background sound pressure levels

Ls, max (dB re 20 μPa), Adapted from ISO 8253-1

	Test tone frequency range (Hz)	
Octave band	**Air conduction audiometry**	**Bone conduction audiometry**
125	55	34
250	46	24
500	31	21
1,000	33	20
2,000	40	19
4,000	47	15
8,000	46	22

An assessment of test spaces used for ACC hearing assessments is required every five years, or earlier if there has been activity (e.g. seismic, building work) affecting the space in which the clinic/booth is located.

Calibration

A formal calibration of all audiometric test equipment should be carried out on an annual basis for equipment that moves between testing locations, or biennially for equipment kept in fixed testing locations. The calibration should be undertaken by an accredited testing laboratory with full, documented traceability to national standards. Formal calibration should be carried out in accordance with the relevant ISO and IEC standards (IEC 60318, IEC 60645 and ISO 389). Daily listening checks are very important. A brief listening check should be carried out on a daily basis.

Training and qualifications of person undertaking audiometry

The current guidelines pertain to diagnostic audiometry for the purpose of diagnosing NIHL, and hence the person undertaking audiometry requires a high level of training and skill. Audiologists have the highest level of training, so are the preferred professionals for audiometric testing.

Audiometric test procedures

Rather than leaving earphones in place during bone conduction testing, it is preferable that testers use audiometric testing facilities that allow accurate bone conduction audiometry to at least 5 dB HL without the test ear being occluded.

Immittance audiometry (tympanometry and acoustic reflex testing) is recommended as a cross-check procedure for pure-tone audiometry to determine if there is a conductive component to the hearing loss.

Because of the errors that can potentially affect air and bone conduction thresholds, and the possibility of incorrectly identifying middle-ear pathology using tympanometry alone (without acoustic reflexes), speech audiometry and acoustic reflex testing are recommended as core elements of the diagnostic audiometry test battery.

Other research

In addition to the evidence reviews, several major bodies of research on hearing loss were commissioned by ACC in conjunction with the Health Research Council in 2010 (5, 17, 18).

How to complete your assessment

Your report should be on the ACC723 form (see Appendix A), which is available for electronic use, or use the same headings and order as form ACC723. The assessment report should be sent to ACC in the knowledge that the report will be provided to the client on request.

Potential conflicts of interest

If any conflict of interest exists (see page 1 of ACC723), please declare it and describe any mitigating action you have taken.

Hearing loss records

This section is the place to record any information ACC has sent you, or you have yourself unearthed, about:

- the client's earlier claim(s) relating to hearing loss
- any previous ENT assessment(s) and/or treatment
- historical audiometric information. Bear in mind the Privacy Act 1993 (specifically the purpose for which the information was collected in the first instance) in pursuing such data. Ensure the client's permission is recorded.

If you have new information available, you should send a copy with your report. If you find during your assessment that further information may be available (e.g. copies of previous audiograms or measures of occupational noise levels), please forward this information to ACC with your report.

Exposure history

This section is for recording the client's history – incorporating information from the completed work history provided by ACC, which may have been completed directly by the client or by ACC staff conversing with the client, together with your own verbal history. It is expected that you will ask questions of the client based on information provided on the work history form so that you can identify relevant noise exposure. If the quality of information provided is less than desirable, indicate this in your report.

Detail is requested relating to different aspects of noise exposure and experiences of other factors that might affect hearing loss.

History of hazardous noise exposure

This is of paramount importance in providing an evidence-based opinion. In all cases, other than the most obvious, it is essential to extract details of the client's work environment to enable you to establish the probable exposure levels.

Based on the questionnaire, together with your verbal history and other sources, you are asked to identify whether there is a history consistent with exposure to hazardous levels of noise within New Zealand. ACC does not cover ONIHL developed outside New Zealand (see the "Relevant Legislation" section, p.7).

You should specify the period when, and the location where, relevant exposure occurred, and if there is likely to have been adequate hearing protection used, including the proportion of the time such protection was used. This will lead to a summary of the duration and probable equivalent intensity level of total exposure the client is likely to have experienced.

If the client has been exposed to impact/impulse noise, their risk of hearing loss is higher than for continuous noise (see David McBride's literature review summary on p.19). Workplaces associated with exposure to impact or impulse noise are indicated in Table 4.

Table 4: Non-continuous noise exposure across occupational groups

Sectors	Workplaces where impact/impulse noise might be encountered
Impact noise	
Manufacturing	Metals and metal products Wood products e.g. sawmill, joinery glass and glass products printing press, paper production Brewery / bottling areas Pottery Food products including knocking areas of abattoirs Packaging
Maintenance of metal products	Panel beating Aircraft maintenance Railway track maintenance
Construction	All trades in construction sector may be exposed. Ship/boat construction Earth moving equipment Mining (drilling)
Impulse noise	
Firearms	Defence forces, police, agriculture, pest control, sports officials
Mining	Any form of mining involving blasting

ACC staff will have sought information relating to work records of hearing loss and/or noise levels, and forwarded any found to you. Many employers, particularly employers of large workforces, have very detailed information available. If there is insufficient information available, and you suspect that more information may be able to be located, any effort you or your staff can put in to locating such information, or requesting that ACC do so, may provide more solid evidence to underpin your opinion.

Useful resources to complete this section are:

- David McBride's evidence review of the types of noise (steady state or impact/impulse) and their effects on hearing (9, 11)
- summary of noise levels Greville (19).

Information on the impact of hearing protection is given in:

- David McBride's evidence review of the types of noise and their effects on hearing (11)
- the University of Auckland/Massey University report on prevention of hearing loss (5).

Military noise exposure

If the client has a history of involvement with the armed forces, you are asked to comment on the role they played and their status, that is, unpaid, such as a cadet or, if regular forces, which arm of defence and in which role and environment. In particular, you should focus on the exposure to noise – the types of noise and the duration of any exposure.

Information about impulse noise and firearms in particular is given by McBride (9, 11). Questions to the client should include whether there were auditory symptoms at the time, whether help was sought for hearing problems, and whether any records exist. The armed forces are an invaluable source of audiometric records, so if these exist they should be accessed. Dobie (20) has useful information on military noise exposure. Occupational noise levels are summarised in Greville (19).

Non-work-related noise exposure

You are asked to comment on any significant exposure to non-work-related noise. Details should be recorded. If there is significant exposure to non-occupational noise, you may need to consider reducing the apportionment of the hearing loss to ONIHL accordingly. Information about typical recreational noise encountered in New Zealand is given by McBride (9).

Head injury or traumatic ear injury

Is there a history of head injury or trauma to the ear(s) that is a contributing factor in the current level of hearing loss? To be considered, the injury should have resulted in noticeable hearing symptoms at the time. Normally, medical records of the injury would be expected to exist.

If there is a significant history of trauma, please specify details (including whether an ACC claim was lodged, and sources of further information).

Family history

If there is any family history of hearing loss, this should be described. Note that the absence of a family history does not exclude genetic hearing loss – in New Zealand, as elsewhere, non-syndromic sensorineural autosomal recessive deafness is the most common form of genetic hearing loss.

Seventy-five percent of the genetic types of hearing loss are related to recessive conditions. Most of these conditions relate to mitochondrial inheritance, and some are responsible for susceptibility to hearing loss under certain conditions (e.g. development of diabetes, exposure to aminoglycosides). Non-syndromic hearing loss is the most genetically heterogeneous trait known. More than 80 loci and 30 genes have been identified. An excellent summary of the current state of knowledge is presented at: *ghr.nlm.nih.gov/condition/nonsyndromic-deafness*.

Ototoxicity

This is in two sections – exposure to ototoxic drugs, and exposure to chemicals in the workplace that may have an ototoxic or neurotoxic effect or may potentially interact with noise. If there is a history of exposure to drugs that might have caused or contributed to hearing loss, this should be explored to identify the likelihood of its contributing to the hearing loss.

Table 5: Ototoxic drugs

Ototoxic drugs (21)	
Aminoglycoside antibiotics (22)	Particularly streptomycin, neomycin, kanamycin, gentamycin, vancomycin and tobramycin. Note that a known genetic mutation determines susceptibility to aminoglycoside ototoxicity. There may be changes to vestibular function in addition to or instead of cochlear hearing loss. There is no safe dosage for these antibiotics.
Anti-neoplastics for cancer treatment (23)	Particularly those containing platinum (e.g. cisplatin, vinblastine, vincristine, carboplatin – 62% of people develop high-frequency hearing loss, which is usually permanent). A recent paper has shown that children treated with cisplatin and who develop high-frequency hearing loss are likely to show further deterioration in thresholds 10-15 years later. Drugs broad in application are more likely to be ototoxic than those with a narrow focus.
Salicylates (24)	Aspirin – more than 12 325 mgm tablets per day can cause mild to moderate (usually flat) hearing loss, but effects may be reversible if treatment is discontinued. May also have CNS effects.
Quinine (25)	Effects multifactorial, primarily via vasoconstriction of the cochlear blood flow. Usually reversible, but on rare occasions permanent. As with salicylates, may also affect the CNS.
Loop diuretics (26)	Ethacrynic acid and furosemide, when given in large doses or in cases of renal failure, can cause hearing loss. This may be reversible.

This high incidence means that hearing loss linked to platinum-based treatments would not normally be considered a treatment injury under ACC legislation.

If there is a history consistent with exposure to other ototoxic agents that might have caused or contributed to hearing loss, this needs to be identified. Information about ototoxic agents in the workplace is given by Zhang (12).

A review in 1997 (27) concluded that "the data currently available indicate that at high levels of exposure, which of themselves are capable of tissue insult, interactions between noise and hazardous substances may occur." (p.464). The information currently available indicates that workplace exposure to chemicals has small but significant effects on occupational hearing loss.

Workers exposed to high levels of metals, solvents and noise over a period of 11 years recorded a hearing change on average 2.1 dB higher than a reference group of workers with low chemical and high noise exposure. The biggest difference was at 1 kHz, followed by 2-4 kHz. These data are equivalent to about 4% additional loss related to chemical exposure (28).

Chang (29) reported that an average audiometric difference between noise alone and noise + toluene exposure equates to a difference of 3.5% for workers with an average age of 40 years (i.e. 20-25 year's exposure).

Table 6: Chemicals in the workplace that affect hearing

Substances	Workplaces where these might be encountered
Organic solvents (30)	
Toluene	Manufacture of chemicals; paint and lacquers; pharmaceuticals; rubber products; fibreglass products; food containers; carpet; oil refining; aircraft operation; boat building.
Styrene	
Xylene	
Dimethylformamide	Manufacture of clothing and textiles.
Dinitrobenzene	Dry cleaning; paint manufacture; manufacture of rubber items.
Gases	
Carbon monoxide	Combustion; fuel gas mixtures; chemical manufacturing; mining and metal processing.
Heavy metals	
Cadmium	Manufacture of alkaline batteries; pigments, coatings and platings; and plastics.
Lead	Construction; mining; manufacturing (batteries, ammunition); paint (historically); ceramics, pipes.
Mercury	Fluorescent light bulbs; dental amalgam; solder; thermometers; detonators.

Clinical examination details

Please describe your clinical observation of the client's hearing function.

Please describe the results of your clinical examination (e.g. R ear, L ear, nasal function, hearing and balance if appropriate).

If your clinical examination identifies any factors that might cause or contribute to the client's hearing loss, specify the findings, the possible cause(s) and the most likely cause(s).

Audiometric report details

Please specify the date(s) of the audiometric report(s) on which your assessment is based.

If you have commissioned a new hearing loss assessment, please forward it to ACC with your report. See page 13 above for a discussion of the conditions under which it might be appropriate to refer for another assessment.

If you have access to previous audiometry, comment on similarities or differences between this and the most recent findings.

Please specify if you believe other tests are required, and the reason(s) for this. Note that if the recommended investigation is for a condition(s) that would not be covered by ACC, ACC would not pay for it.

Summary and recommendations

Please summarise the client's noise exposure.

Summary of hearing loss

Please summarise the client's audiometric results.

Comment on any asymmetry in the audiogram. Note that some asymmetry in the frequencies normally affected by noise may be associated with firearm use, with worse hearing expected in the ear opposite to the side on which rifles were shouldered (31). Where this is not the case, you may need to investigate further, or include this component of the hearing loss in the percentage attributed to "other causes".

Where there is a significant asymmetry, some cause other than occupational noise exposure might be expected, unless there is clear evidence of consistent unilateral exposure in the workplace (very rare because of reverberation, apart from shooting and headphone use).

Apportionment of causes

In this section, you are asked to apportion the percentage hearing loss for each relevant possible cause of ONIHL, presbycusis and other factors.

Information about the PLH scale used in ACC's hearing regulations is provided in a paper by Greville (2), and the National Acoustic Laboratories supply a spreadsheet to facilitate calculations, which can be ordered from:

> NAL SHOP – Products
> *https://shop.nal.gov.au/epages/nal.sf/en_AU/?ObjectPath=/Shops/nal/Categories/Products/Hearing_Loss_Measurement_Tools*

A key resource for carrying out apportionment is the British "Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes" (32), to which you are strongly advised to refer, and which is reprinted in Appendix D.

The three main requirements identified are:

- high-frequency hearing loss, in the presence of
- a potentially hazardous amount of noise exposure, and
- an identifiable high-frequency audiometric notch or bulge.

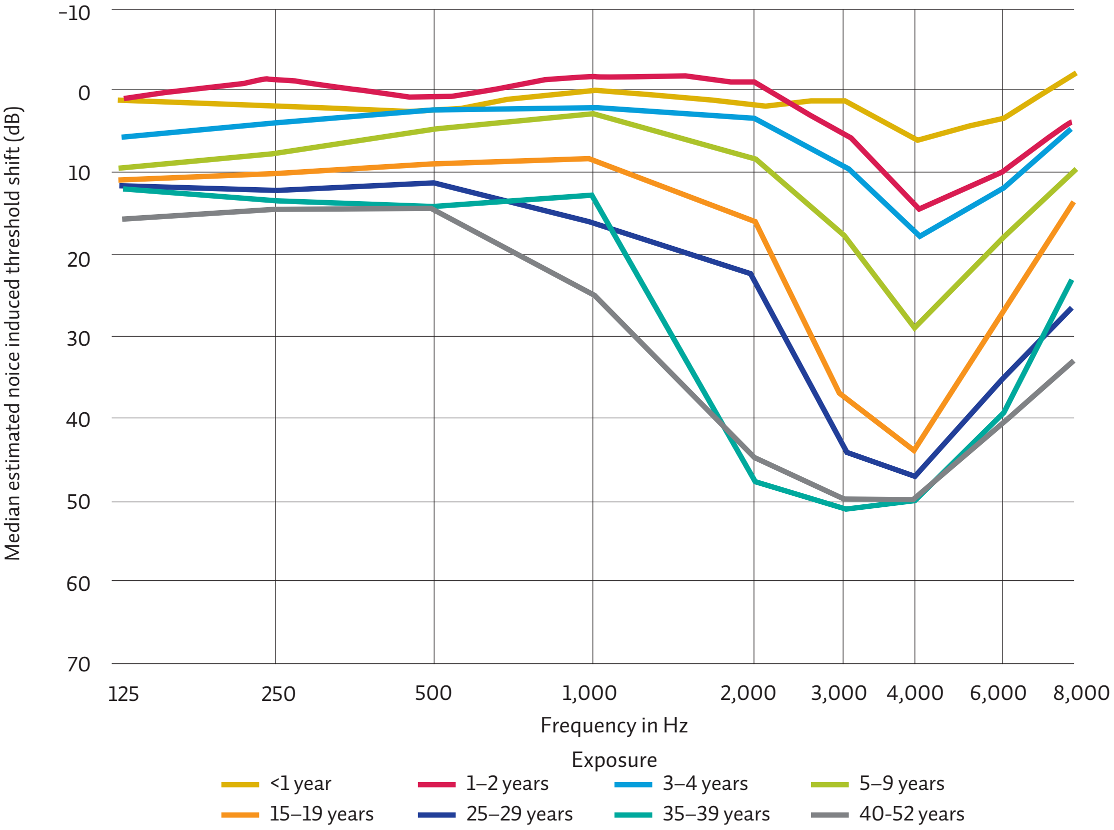
As can be seen in Figure 2, it is expected that in the early years of exposure to occupational noise, a symmetrical notch at around 4 kHz will typically be observed, but as the person ages, a "bulge" affecting lower frequencies (typically down to 2 kHz) appears.

In addition, four other factors need to be considered:

1. The clinical picture
2. The compatibility of the degree of observed hearing loss with population data on hearing loss associated with age and the probable level and duration of noise exposure (see Figures 3 and 4, and Appendix C)
3. If the diagnosis of NIHL is borderline, whether an alternative or additional diagnosis is appropriate
4. Complicated cases such as asymmetrical or conductive hearing loss. In the latter case, bone conduction thresholds may be used (with allowance for known interactions between conductive and cochlear conditions). The paper by Purdy and Williams (13) discusses issues such as bone conduction reliability.

More recently, Lutman, Coles and Buffin (33) have developed a system of quantifying NIHL from the audiogram. This formulation has promise, but it was developed for the United Kingdom system of threshold averages and there are complications converting it to the percentage loss of hearing system used in New Zealand. There are no doubt cases where it is helpful, but where there is significant other pathology present, its applicability is limited.

Figure 2: Audiograms showing onset and progression of NIHL in female jute weavers (34) exposed to noise levels averaging 100 dB(A)



Note the date of onset of auditory symptoms and refer to information, where available, about the development of hearing loss, noting that the rate of increase of NIHL at specific frequencies (e.g. 4,000 Hz) typically decelerates after 10 years' exposure (see Figure 2). In other pathologies, hearing loss at individual frequencies may accelerate, which is frequently the case in age-related hearing loss.

However, because of the built-in low fence of the PLH scale, together with the spread of hearing loss from 4,000 Hz to lower frequencies, which are weighted more highly in the PLH scale, the development of percentage hearing loss with years of exposure tends to be linear – see Figure 3 which is derived from the data in Figure 2.

Figure 3: Progression of hearing loss, expressed as a percentage, as a function of years of exposure for female jute weavers as in Figure 2 – linear trend superimposed

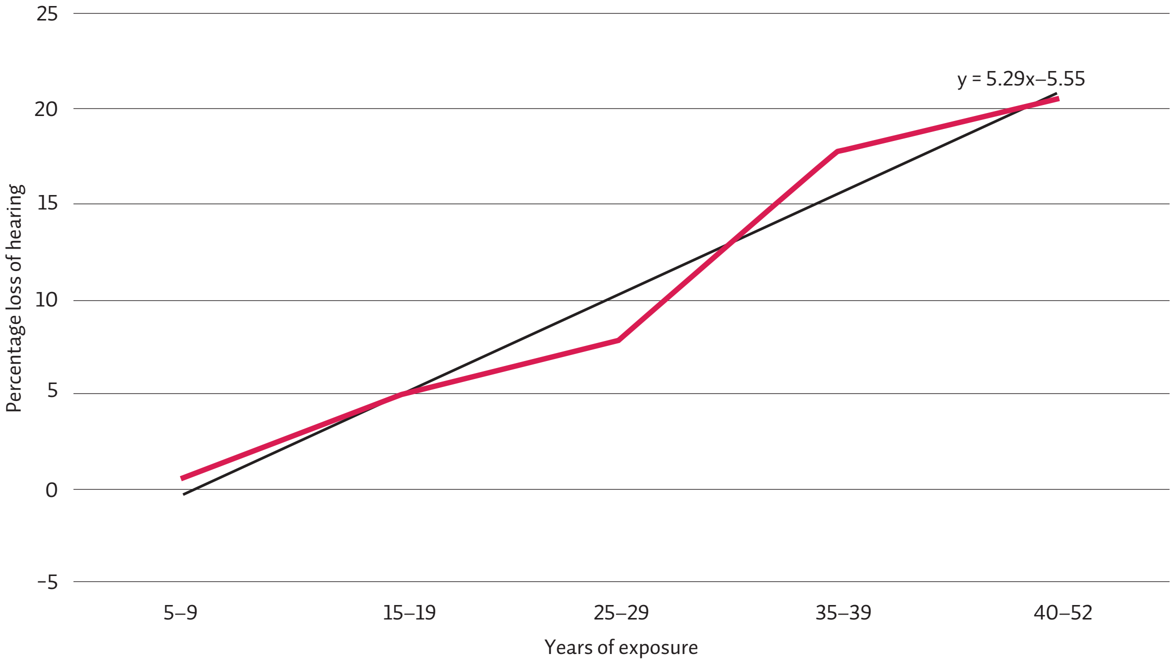
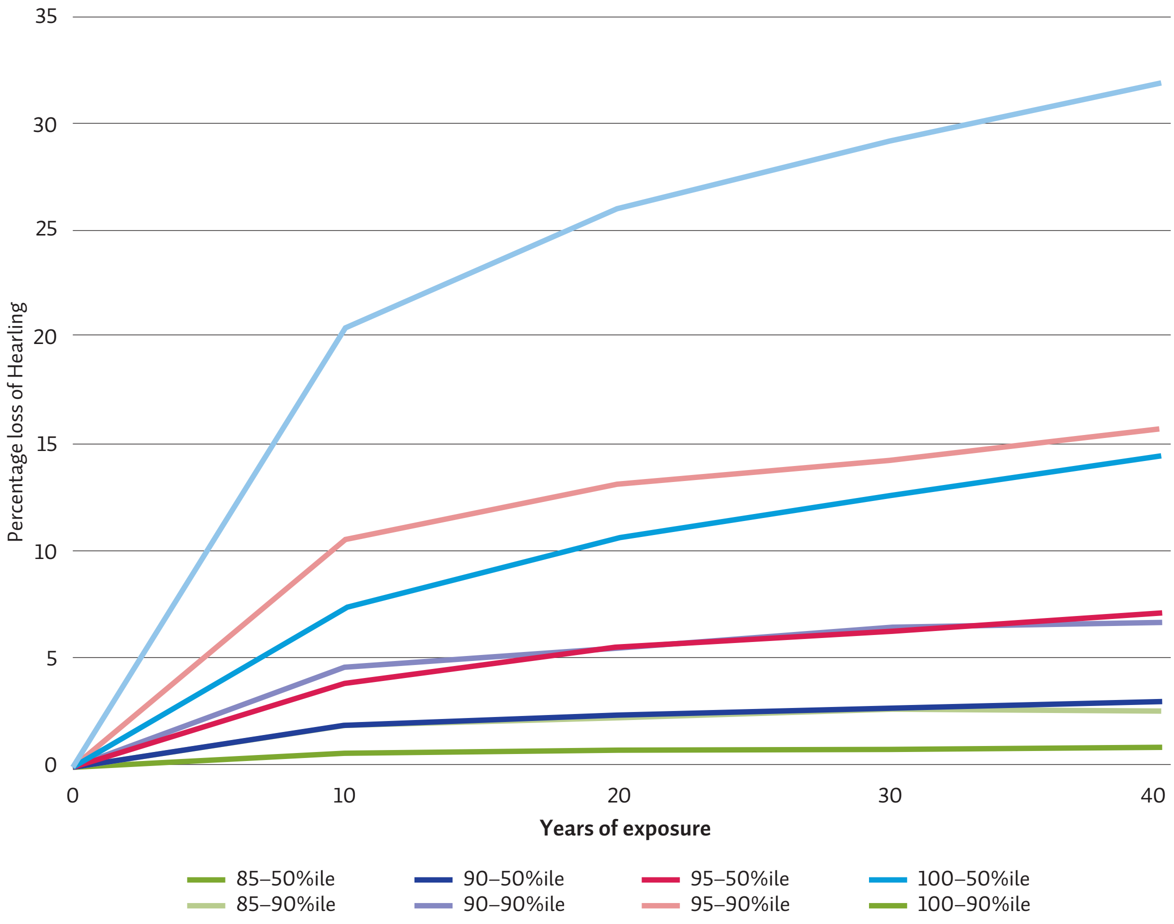


Figure 4 shows a similar pattern for grouped data for men (taken from thresholds derived from ISO 1999 – see Appendix C).

Figure 4: **Progression of hearing loss, expressed as a percentage, as a function of years of exposure at various noise levels for mean data for 60-year-old men with standard age adjustments, calculated from ISO 1999 (see Appendix C)**



The age-related percentage hearing loss (where the client is over 55 years for men or 68 years for women) should come from the age corrections defined in the regulations. It is acknowledged that individual susceptibility to presbycusis may vary widely. Refer to ISO 7029 for guidance. If you do not use the corrections defined under the regulations, you must explain why you have chosen not to. Any such recommendation would be subject to peer review.

OTHER FACTORS

Where other factors exist, you should identify the percentage you attribute to them and explain which factors, in your opinion, contribute to the hearing loss in the summary section. However, you are not required to quantify their relative contribution if there is more than one.

OCCUPATIONAL NOISE-INDUCED HEARING LOSS

The remaining hearing loss is therefore the percentage binaural loss attributed to ONIHL. Note that non-occupational NIHL should be included in the "other factors" apportionment.

Useful additional resources in making this apportionment include:

- McBride (11)
- Dobie (20)
- ISO 1999 – see sample calculations in Appendix C.

ISO 1999 provides statistical data on the effects of noise (and time) on a large population of workers. It cannot be used to make an accurate prediction of any individual's hearing loss and, indeed, in the standard there is a warning not to do so. However, in the introduction it also states that "in doubtful individual cases, the data in this international standard might provide an additional means for estimating the most probable cause and audiological diagnosis" (p. v). Coles et al (32) state that "the hearing impairments measured should be checked for compatibility with the client's age, sex and estimated total amount of noise exposure, including military and non-occupational, using ... some appropriate source such as ISO 1999" (p.268). Dobie (20) expresses the view that "the ISO model can be quite helpful in supporting (or undermining) a diagnosis of noise-induced hearing loss" (p.283).

In summary, ISO 1999 provides statistical data that can be helpful in assessing difficult cases. These data should not stand alone but should be considered along with all the other information relevant to the individual case.

Hearing loss pattern

If you believe the client's hearing loss to be work related – but the pattern is not consistent with the "distinguishing features of occupational noise induced hearing loss" (see Appendix E), please explain your reasons.

Your rationale for apportionment

In this section you should summarise your view of the case, where necessary explaining and providing justification for your apportionment between ONIHL and other causes. In simple cases little justification will be necessary, but in more complex cases you should provide a full rationale.

You have been asked to give an expert opinion. Attribution and particularly quantification of causation is, in essence, an inexact science. Your opinion should be based on the balance of probabilities.

Remember that other opinions may be sought and it will be helpful if you clearly identify how you have arrived at your opinion. Where conflicting opinions are presented, the final decision will be made based on the quality of the supporting arguments.

Where there have been earlier claims for hearing loss, please describe your findings in the context of these.

If you think any other information or expert opinion would be beneficial in further assessments of this case, you should provide details. An example would be referral for investigation of asymmetrical hearing loss.

You will be expected to provide the client with advice on the prevention of further hearing loss, but it is not necessary to report on this.

Hearing rehabilitation

If the client's claim was lodged prior to 2010, i.e. before the 6% threshold was introduced into legislation, you may be asked by the claim manager to comment on the client's need for rehabilitative devices based on the amount of hearing loss you've recommended that ACC cover.

Cases

A number of real cases from ACC's files follow. Because they are genuine cases, they do not necessarily include complete histories, nor, indeed, accurate apportionments. They are presented with comments included from expert reviewers, and it is hoped that they will be a useful starting point for discussion and development.

Case 1 Example of ONIHL as primary cause of hearing loss

History

62-year-old male. He was brought up on a farm and has continued farming since he left school. He reports driving tractors from age 8 or 10 years.

Past history

Nil of note.

Non-work noise

Lawn mowing for one or two hours per week. Chainsaw use for firewood (hearing protection used since 1990s).

Occupational history

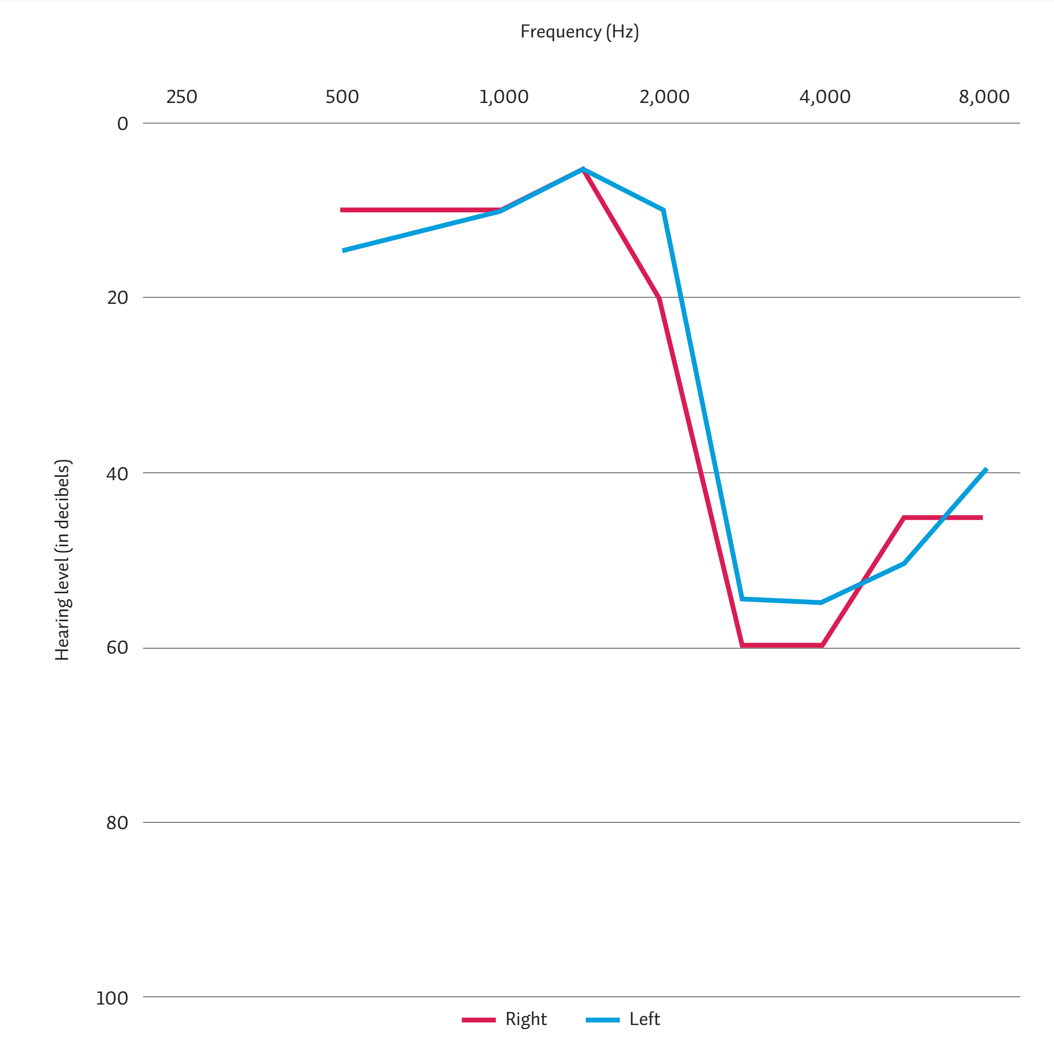
Forty years farming. Exposure to tractor noise, farm implements, chainsaws and shooting to control deer (shot off the right shoulder). There was also rock and tree stump blasting. McBride found that typical noise exposure for farmers is 85-87 dBA. Hearing protection was not used until the 1990s.

Audiogram

The features are:

- 10.5% binaural hearing loss (R: 11.7%; L: 10.2%)
- notch bilaterally with recovery at 8 kHz
- no air-bone gaps.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	10	10	5	20	60	60	45	45	11.7
Left	15	10	5	10	55	55	50	40	10.2
Binaural									10.5



Conclusion

Total hearing loss	10.5
Age	1.3
ONIHL apportionment	9.2

Comments

- Pattern typical of NIHL.
- Anchor points at 1 and 8 kHz very similar to median levels for normative data, supporting standard age adjustment.
- ISO 1999: 50th percentile for 60-year-old male exposed to 90 dB: 3% (age-adjusted)
  90th percentile for 60-year-old male exposed to 90 dB: 7% (age-adjusted)
  Additional hearing loss above that predicted by ISO 1999 predicted from exposure to shooting/blasts.
- Noise surveys of rural families support the thesis that the years of actual exposure could have exceeded 40 years. Adherence to the legislation would mean that a small deduction might be made because any childhood NIHL would not be occupational.

Case 2 Example of ONIHL as primary cause of hearing loss

History

56-year-old male who displays behaviour consistent with high-frequency hearing loss.

Past history

Nil of note.

Non-work noise

Regular use of noisy machinery at home, including chainsaws, for more than 40 years.

Occupational history

Forty years' occupational noise exposure in the building industry. Ten years' military service with heavy guns (no hearing protection allowed).

Examination

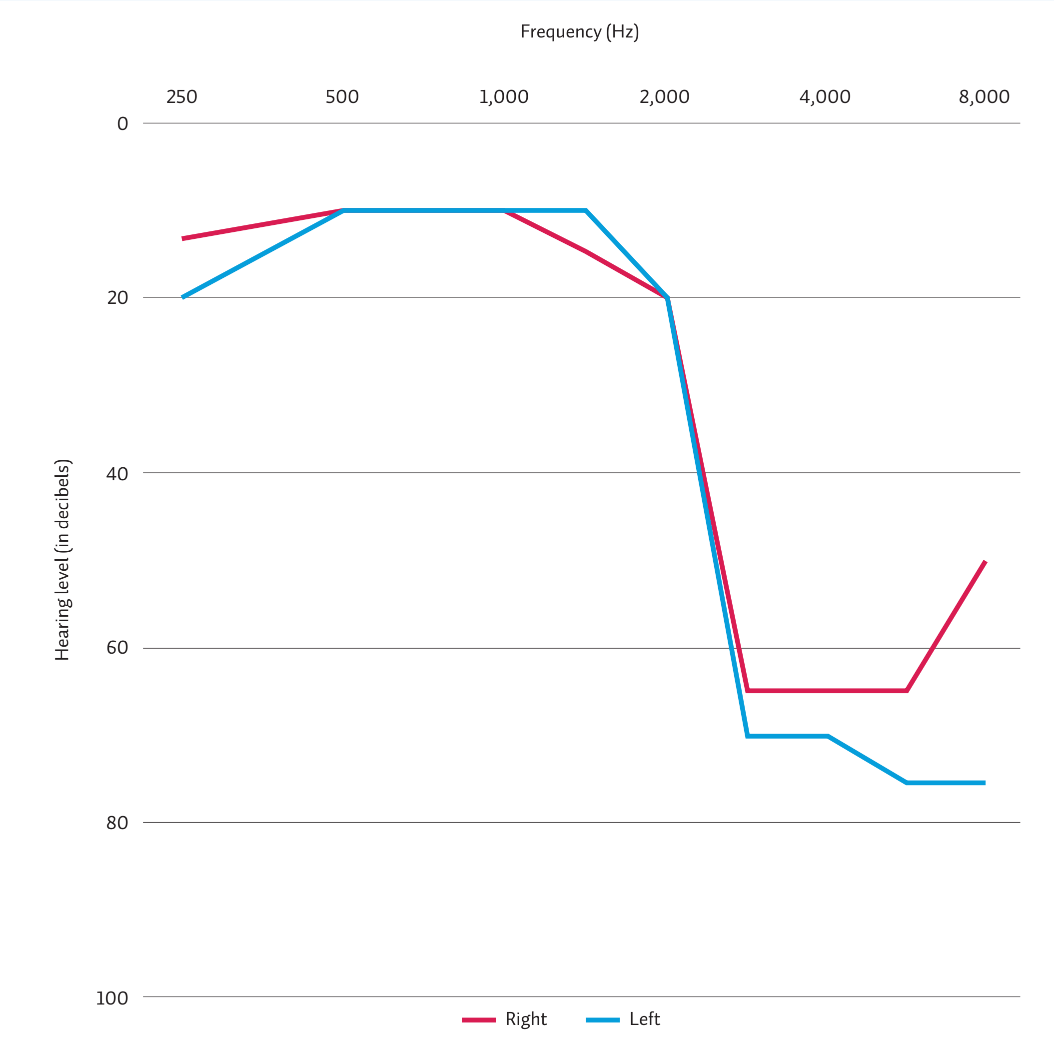
Minor scarring of the L tympanic membrane, which has no impact on hearing thresholds.

Audiogram

The features are:

- notched sensorineural hearing loss on the R; no recovery at 8 kHz on the L
- assessor's opinion: hearing loss consistent with occupational noise history
- minimal age adjustment necessary.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	10	10	15	20	65	65	65	50	13.9
Left	10	10	10	20	70	70	75	75	16.0
Binaural									14.3



Conclusion

Total hearing loss	14.3
Age	0.1
ONIHL apportionment	14.2

Comments

- There is a substantial history of noise exposure and a typically notched audiogram on the right, although this has flattened at the higher frequencies on the left.
- The extent of the hearing loss is compatible with the noise history.
- There is no evidence of any other likely contributing cause of hearing loss with hearing within the normal range at and below 2 kHz.
- The age effect is minimal in terms of PLH.

Case 3 Example of ONIHL with overseas exposure

History

65-year-old male.

Past history

He has been aware of hearing loss for about 10 years.

Non-work noise

Has used a 0.22 rifle with a silencer for possum hunting in the past.

Occupational history

Five years UK sheet-metal work involving metal grinding and hammering, and other power tools.

New Zealand exposure 43 years in various roles with different companies involved in metal construction. He was frequently exposed to noise from others' use of power tools, although he uses earmuffs when working.

Examination

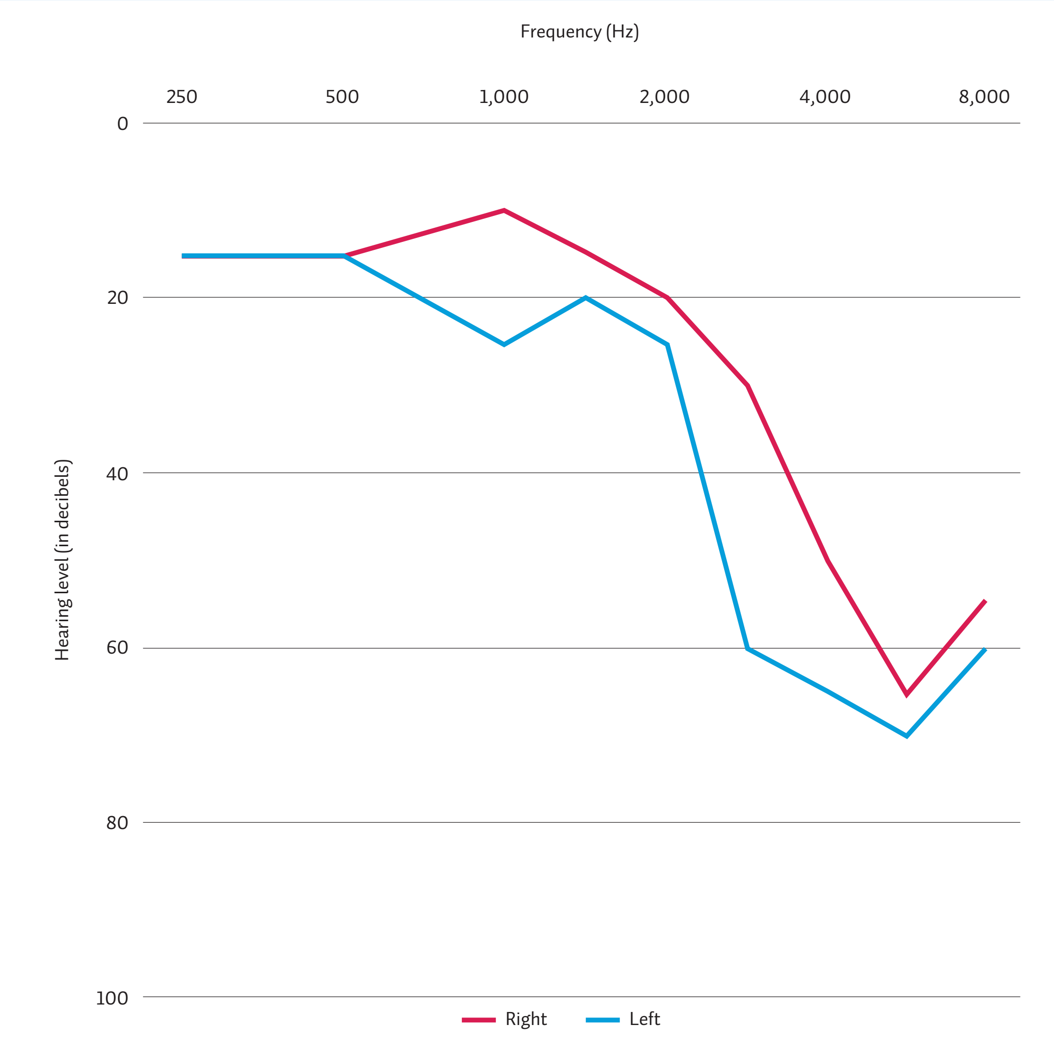
No history of ear infections, surgery or trauma.

Audiogram

The features are:

- notched sensorineural hearing loss
- asymmetrical, worse on the left.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	15	10	15	20	30	50	65	55	7.0
Left	15	25	20	25	60	65	70	60	16.6
Binaural									9.8



Conclusion

Total hearing loss	9.8
Age	2.4
ONIHL apportionment	6.0

Comments

- Typical NIHL and presbycusis pattern.
- 1.4% deduction for UK exposure.

Case 4 Example of ONIHL together with solvent exposure

History

45-year-old male.

Past history

Nil of note.

Non-work noise

Occasional recreational hunting when younger. Chainsaw use for firewood, but always uses ear protection.

Occupational history

24 years as a diesel mechanic exposed to air tools, power tools and hammering. Usually wore protection, but often experienced noise around him when not protected. Noisy rattle guns seemed loud even with ear protection. For the last three years he has been doing office work with no noise exposure.

Examination

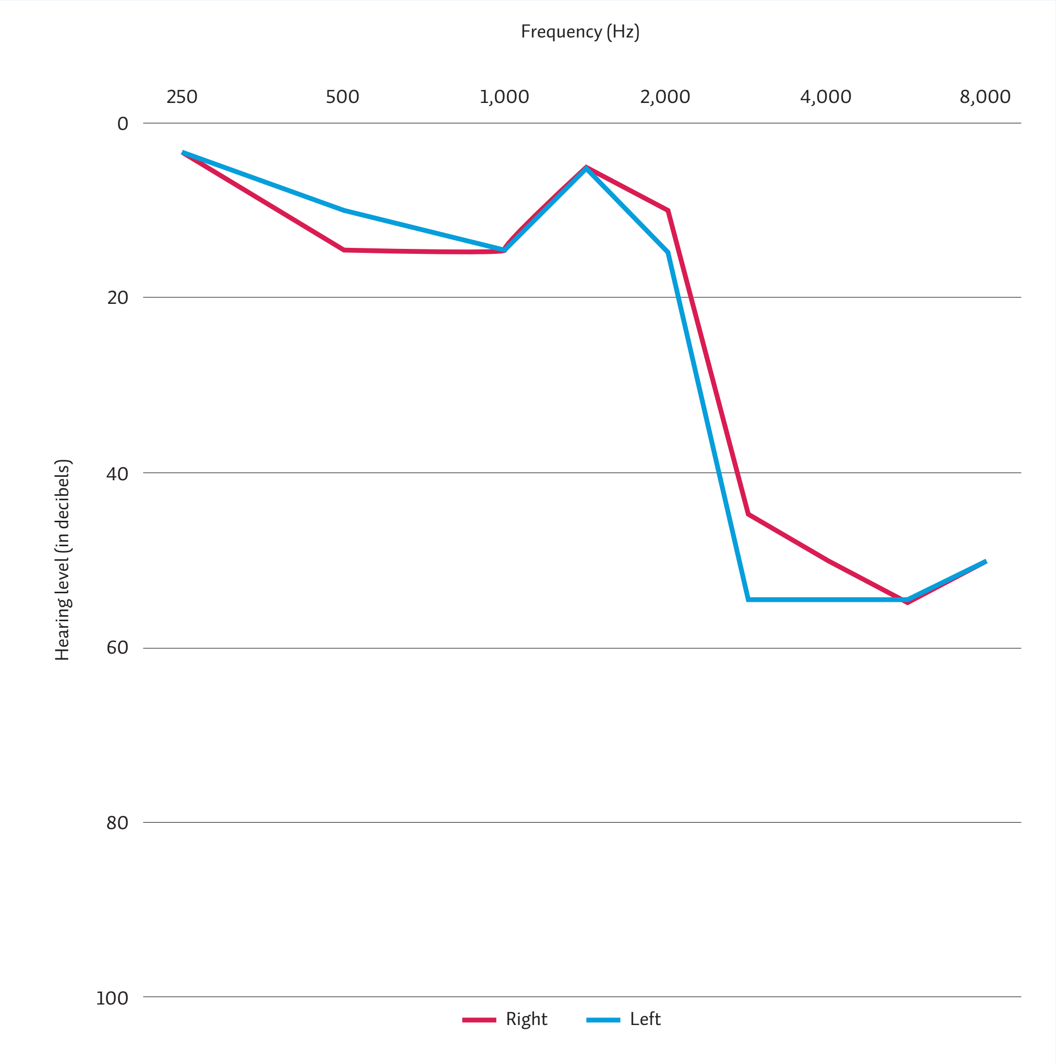
Normal.

Audiogram

The features are:

- wide notch bilaterally, with slight recovery at 8 kHz
- slight but repeatable drop at 1 kHz, although still within the normal range
- normal immittance and speech audiometry.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	15	15	5	10	45	50	55	50	8.6
Left	10	15	5	15	55	55	55	50	10.6
Binaural									8.9



Conclusion

Total hearing loss	8.9
Age	0.0
ONIHL apportionment	8.9

Comments

Mechanical engineering noise levels probably around 85 dBA unless body work is involved.

Diesel contains toluene and xylene, known to have a measurable impact on hearing.

Solvents/heavy metals typically affect hearing most around 1 kHz, but also affect the high frequencies.

Case 5 Example of asymmetrical loss in high frequencies

History

56-year-old male.

Past history

Nil of note.

Non-work noise

Mowing lawns, chainsaw, power tool use.

Occupational history

Mixed job history: 26 years' noise exposure from panel beating; logging; milk factory; auto engineering; and forestry. For the last 15 years there has been no noise exposure.

Examination

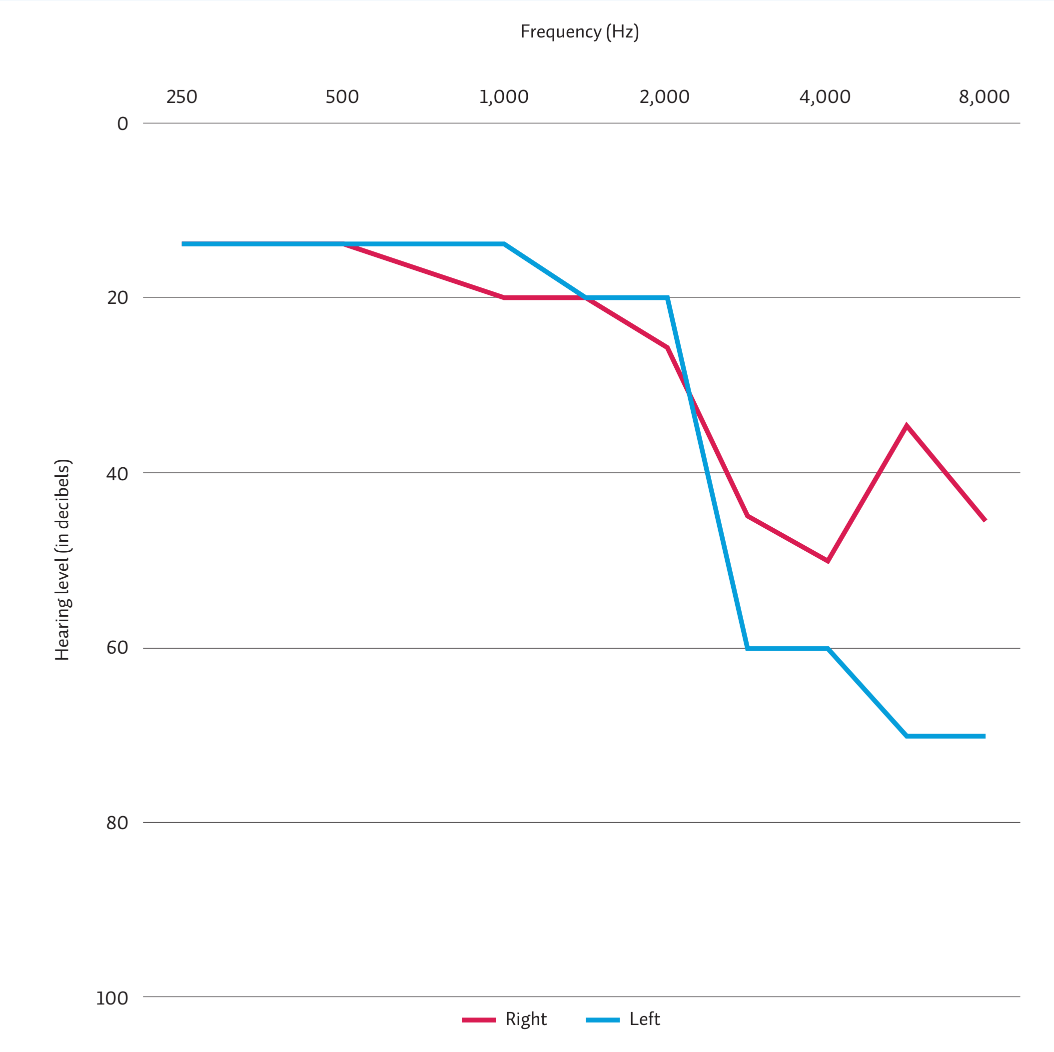
N/A

Audiogram

The features are:

- bilateral sensorineural hearing loss
- atypical notch
- asymmetrical, worse on the left.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	15	20	20	25	45	50	35	45	9.9
Left	15	15	20	20	60	60	70	70	13.9
Binaural									10.1



Conclusion

Total hearing loss	10.1
Age	0.1
ONIHL apportionment	8.9

Comments

- The audiologist had miscalculated the PLH at 13.2%. Checking of calculations is advised.
- ISO 1999 was used to support the apportionment.
- 1.1% was attributed to idiopathic factors.
- Previous audiograms 1 and 3 years earlier showed similar hearing on the right, but less asymmetry. Assessor recommended an MRI on the L.
- The client declined his hearing aid entitlement.

Case 6 Example of atypical hearing loss

History

62-year-old male.

Past history

Gradual deterioration in past 20 years.

Non-work noise

Lawnmower, chainsaw, power tools. Motor sport observer.

Occupational history

23 years with army engineers followed by four years' aircraft engineering and eight years' port work (half of which was office-based).

Examination

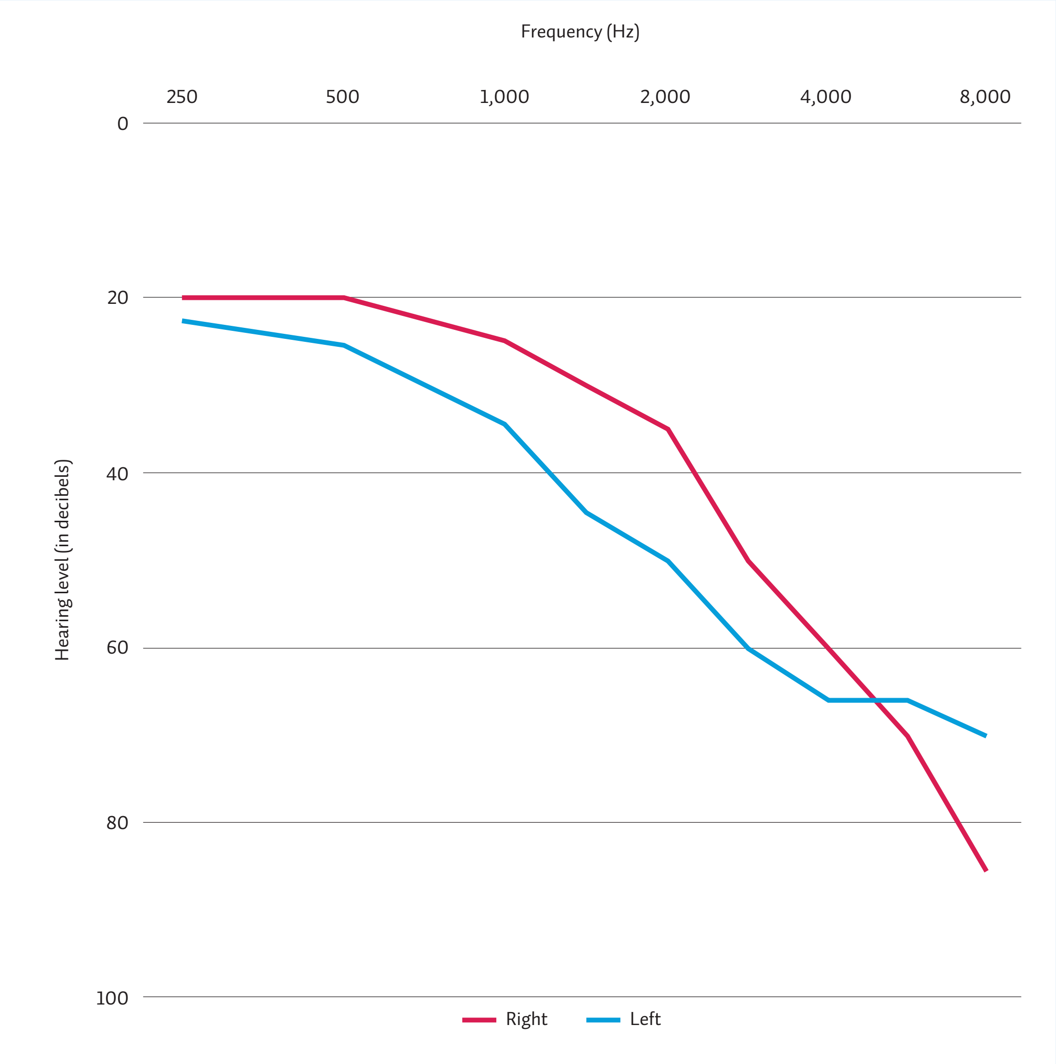
Normal.

Audiogram

The features are:

- sloping sensorineural hearing loss bilaterally
- asymmetrical, worse on L.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	20	25	30	35	50	60	70	85	20.1
Left	30	35	45	50	60	65	65	70	36.9
Binaural									24.6



Conclusion

Total hearing loss	24.6
Age	0.8
ONIHL apportionment	4.3

Comments

- A previous audiogram after 20 years in the army showed 2.0% hearing loss.
- The assessor calculated that the annual hearing loss over 20 years was 0.1%. However, this failed to take into consideration the deviation from 0 dB prior to the hearing loss reaching the low fence of the PLH scale. A more reasonable prediction of future NIHL would be 0.3% per annum, given the same noise exposure levels. The four years of aircraft maintenance could well have caused an increase in the rate of deterioration.
- Given that the hearing loss below 2 kHz is unlikely to be related to noise exposure, a final attribution of 6% would not be unreasonable.

Case 7 Example of atypical hearing loss

History

77-year-old male.

Past history

Nil of note.

Non-work noise

Small amount of hunting with high-velocity rifles.

Occupational history

Three years in manufacturing; 23 years in power schemes – welding and boiler making. No effective ear protection used. 25 years employed by a steel maker.

Examination

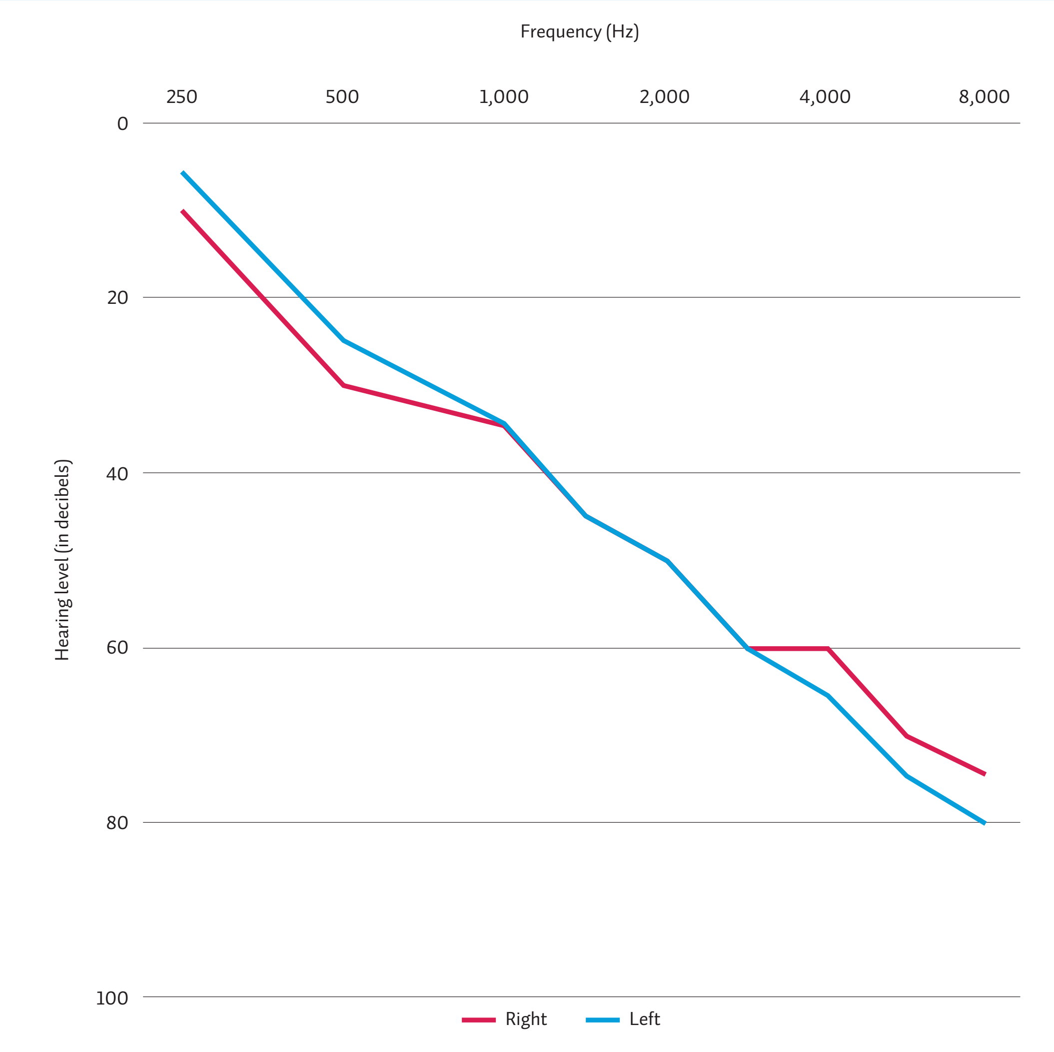
Normal.

Audiogram

The features are:

- sloping sensorineural hearing loss
- symmetrical.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	30	35	45	50	60	60	70	75	36.8
Left	25	35	45	50	60	65	75	80	36.2
Binaural									36.1



Conclusion

Total hearing loss	36.1
Age	9.8
ONIHL apportionment	16.0

Comments

- Previous audiometry in 2001 showed 9.2% hearing loss.
- In 2007, four years before retirement, audiometry showed a binaural loss of 7.3%.
- An attribution closer to 8% would probably be more appropriate given the information from the serial audiometry. The increase in hearing loss since this date is primarily in the lower frequencies (which contribute proportionally more to the PLH measure).

Case 8 Example of atypical hearing loss

History

69-year-old male.

Past history

Nil of note.

Non-work noise

History of some recreational hunting, but the majority of his shooting has been for the control of deer and other animals on the land.

Occupational history

50 years as self-employed farmer exposed to noise from tractors, bulldozers, chainsaws, dogs and the shooting of deer and rabbits. He developed 1,400 hectares from bush and estimates at least 2,500 hours on crawler bulldozers and in addition worked with tractors. He says protection was used in later years.

Examination

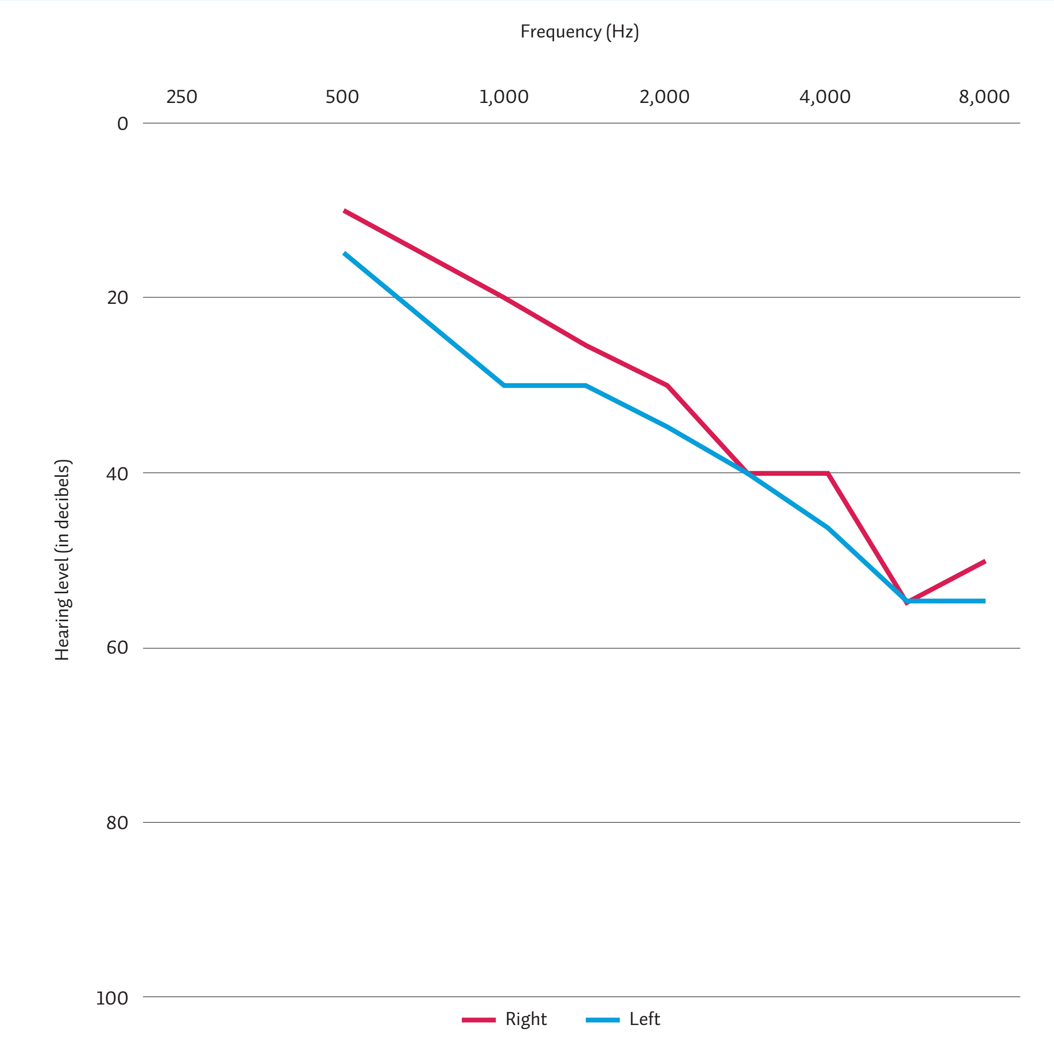
Non-contributory.

Audiogram

The features are:

- sloping hearing loss
- notch at 6 kHz only in the R ear
- slight asymmetry.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	10	20	25	30	40	40	55	50	10.9
Left	15	30	30	35	40	45	55	55	17.0
Binaural									12.9



Conclusion

Total hearing loss	12.9
Age	4.4
ONIHL apportionment	6.5

Comments

- Previous audiometry showed 6.1% hearing loss at 62 years and 9.2% at 68 years.
- This increase over six years is considerably more than would be expected from occupational noise – age-related hearing loss increases at a higher rate.
- The configuration is atypical of NIHL, but there is a reasonable history of occupational noise exposure.

Case 9 Example of flat hearing loss

History

73-year-old male.

Past history

Experience in mechanical engineering workshop in the military. No regular use of armaments.

Non-work noise

Car restoration work over many years – ear protection used only rarely.
Recreational hunting over 20 years with a .22 rifle. Approximately 50 rounds/year. Right-handed.

Occupational history

23 years' work with metal manufacturing, nine years in paper manufacturing.

Examination

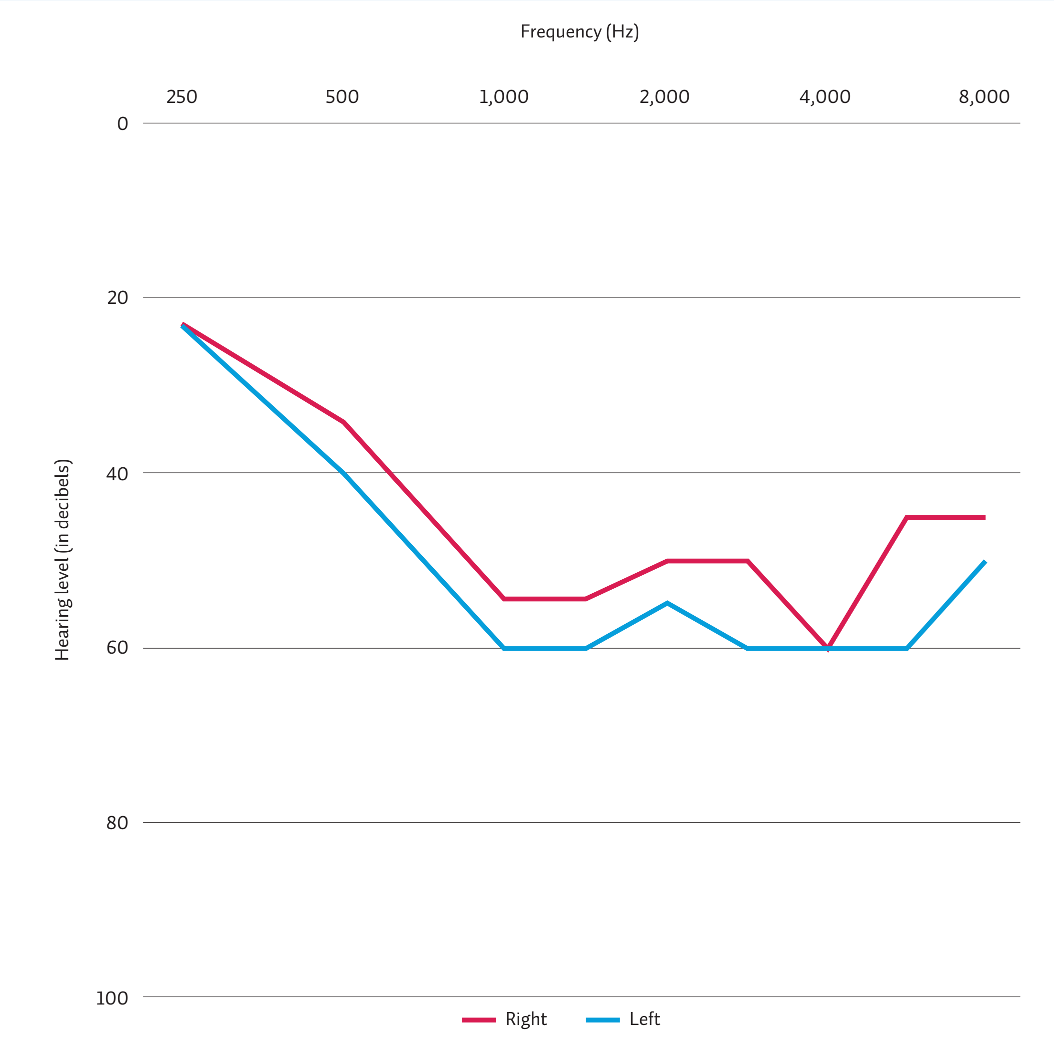
Normal.

Audiogram

The features are:

- flat sensorineural hearing loss over the frequency range 1-8 kHz.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	35	55	55	50	50	60	45	45	46.7
Left	40	60	60	55	60	60	60	50	55.2
Binaural									48.0



Conclusion

Total hearing loss	48.0
Age	6.8
ONIHL apportionment	8.6

Comments

- The assessor calculated that 31.6% hearing loss was below 2 kHz, and attributed this to idiopathic hearing loss.
- This may be an underestimation of the idiopathic component, because some component would also be expected within the high frequencies.
- 1% was attributed to recreational noise exposure.
- 6% may be a more realistic attribution.

Case 10 Example of impact noise together with LF loss

History

67-year-old male.

Past history

Diabetes and hypertension.

Non-work noise

Nil of note.

Occupational history

Nine years as panel beater and coach builder; 40 years as sheet-metal worker.

Examination

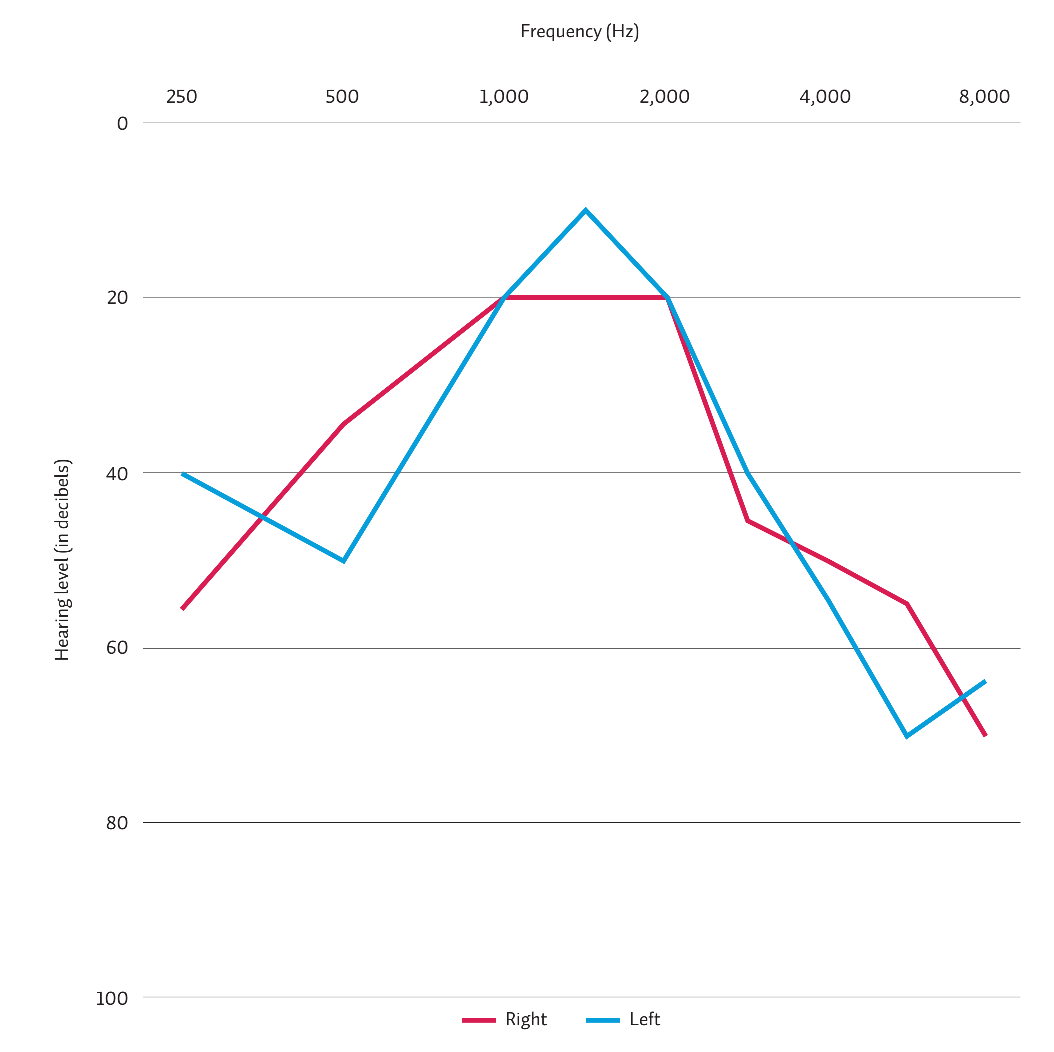
Normal.

Audiogram

The features are:

- high-frequency loss, with notch present on the L only.
- low-frequency mixed hearing loss.
- air-bone gap at .5 kHz, 35 dB on the R and 25 dB on the L.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	35	20	20	20	45	50	55	70	15.3
Left	50	20	10	20	40	55	70	65	20.2
Binaural									15.9



Conclusion

Total hearing loss	15.9
Age	3.3
ONIHL apportionment	8.9

Comments

- The assessor recommended that the hearing loss above 1.5 kHz be fully attributed to NIHL.
- However, this ignores the age-related hearing loss that also affects these frequencies. A more realistic NIHL apportionment using this reasoning would be 6%.
- The conductive part of the hearing loss, depending on when it developed, would have had a protective effect, reducing the effective noise exposure.

Case 11 Example of conductive hearing loss

History

56-year-old male.

Past history

Three months in army – rifle use. Right-hand shooter.
Unilateral tympanic membrane perforation reported.

Non-work noise

Mowing lawns, chainsaw, power tool use.

Occupational history

30 years' sawmill exposure.

Examination

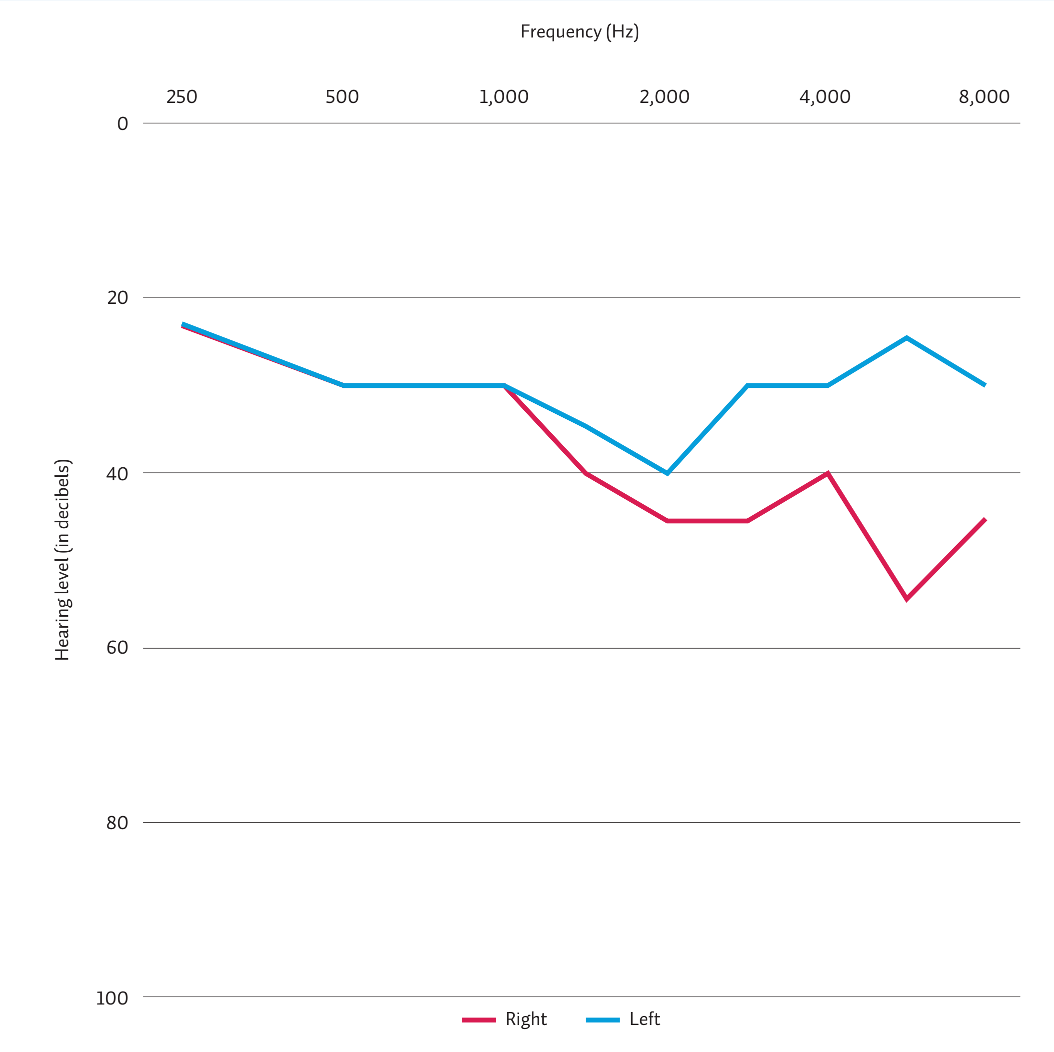
Normal.

Audiogram

The features are:

- mild, fairly flat, mixed loss
- conductive component bilaterally from healed perforations (high immittance recorded bilaterally). 15-20 dB air-bone gap (including at 4 kHz)
- small notch at 6 kHz on R only.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	30	30	40	45	45	40	55	45	26.2
Left	30	30	35	40	30	30	25	30	17.5
Binaural									20.0



Conclusion

Total hearing loss	20.0
Age	0.1
ONIHL apportionment	5.0

Comments

- The conductive component of the hearing loss means that this case is difficult to apportion.
- From the bone conduction thresholds at 4 kHz (R: 20 dB; L: 5 dB) there does not appear to be any evidence of a typical NIHL.
- Considering the air conduction thresholds for 3-8 kHz, the PLH is 3.5%. The ONIHL attribution could not exceed this level.
- The long-standing conductive hearing loss would tend to provide effective hearing protection, despite the considerable noise exposure.

Case 12 Example of unilateral conductive loss and overseas experience

History

71-year-old female.

Past history

L: perforation since childhood, for which no treatment has ever been sought.

Non-work noise

Gym classes three or four hours per week for 26 years.

Occupational history

Eight years in the UK sewing soft furnishings with 6 other machinists in same room.

In New Zealand: she spent 10 years counting bank notes by machine. She worked 5-10 metres from four guillotines. She could speak to people nearby without raising her voice.

Examination

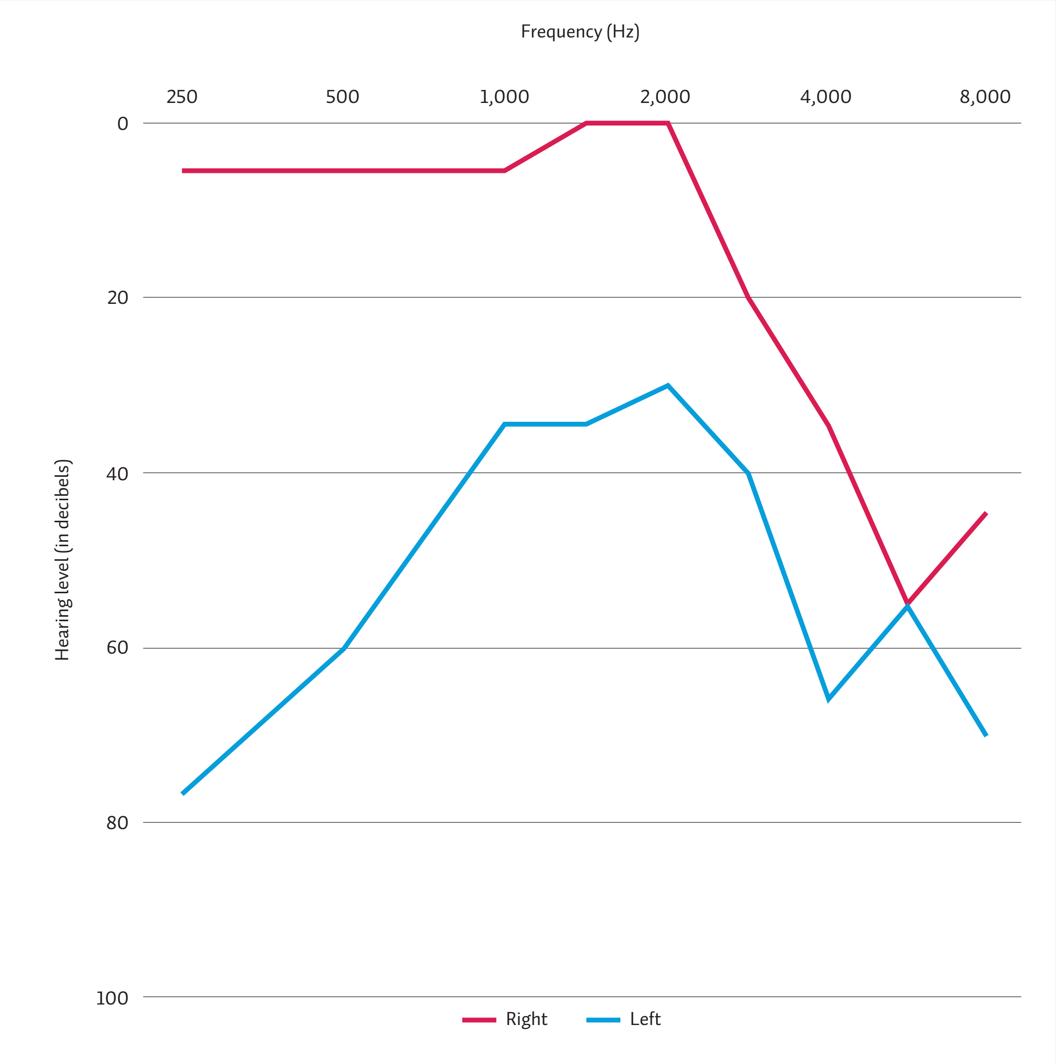
L: large, dry, central perforation. Middle ear mucosa not inflamed.

Audiogram

The features are:

- conductive loss on L (air-bone gap 45 dB at 0.5 kHz, 35 dB at 4 kHz)
- HF sensorineural notch on R.

	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000	PLH
Right	5	5	0	0	20	35	55	45	3.0
Left	60	35	35	30	40	60	55	70	33.9
Binaural									10.9



Conclusion

Total hearing loss	10.9
Age	0.6
ONIHL apportionment	2.4

Comments

- Sewing machines have been measured at 78-79 dBA. The combined effect of nearby machines would increase exposure to 85-90 dBA.
- The noise levels in the banknote factory are unlikely to have been more than 85 dBA.
- The assessor attributed 7.9% to the L conductive loss.
- The ONIHL apportionment was calculated as 2.4%, and this was related entirely to the UK exposure.
- The New Zealand ONIHL attribution was therefore 0%.

Appendix A: ACC723 Otolarygologist Report

ACC 723

Otolaryngologist report

Fill in this form if you're an otolaryngologist and we've asked you to assess our client's work-related hearing loss.

Section 1 – Your details

Your name:

Your provider number:

Section 2 – Client details

Client's name:

Claim number:

Client's date of birth: D M Y

Section 3 – ACC details

ACC staff member:

ACC office:

Section 4 – Assessment details

Date you assessed oour client: D M Y

Purchase order number:

Section 5 – Potential conflicts of interest

A conflict of interest is where someone's personal interests conflict (or have the potential to conflict) with the responsibilities of their role. If carrying out this assessment presents any conflict(s) of interest for you, please list the conflict(s) together with any action you have taken to mitigate it.

I declare the following conflict(s) of interest:

The action(s) I have taken to mitigate any conflict(s) of interest is:

Section 6 – Hearing loss records

Please attach to this form any recent hearing loss test results you have for our client.

Please tell us about any hearing loss claims, assessments or treatment our client has had:

Section 7 – Hearing loss questionnaire review

You'll need to review all the information in our client's hearing loss questionnaire before you answer the questions in this section.

Have you reviewed our client's hearing loss questionnaire answers? ○ Yes ○ No

Is the work history provided (either prior to or during your client interview) adequate for your purposes? ○ Yes ○ No

Does our client have a history of being around hazardous noise levels at their work in New Zealand? ○ Yes ○ No

If so, tell us how long our client was exposed to the noise, what kind of noise it was and how intense the noise was, thinking about any hearing protection they were wearing and the likely effects on their noise exposure:

Does our client have a history of exposure to military noise that's likely to cause hearing loss? ○ Yes ○ No

If so, tell us how long our client was exposed to the noise, what kind of noise it was, and how intense the noise was, thinking about any hearing protection they were wearing and the likely effects on their noise exposure:

Does our client have a history of taking part in noisy activities outside work? ○ Yes ○ No

If so, tell us how long our client was exposed to the noise, what kind of noise it was and how intense the noise was, thinking about any hearing protection they were wearing and the likely effects on their noise exposure:

Has our client ever had a head injury or trauma to the ear(s) that has contributed to their hearing loss? ○ Yes ○ No

If so, please tell us about any head injury or trauma that has contributed to our client's hearing loss:

Does our client have a family history of hearing loss? ○ Yes ○ No

If they have, please tell us about the hearing loss in their family:

Has our client taken any drugs that may have contributed to their hearing loss? ○ Yes ○ No

If they have, please tell us the name of the drugs, the dates our client took them, and the reason(s) they were prescribed:

Has our client been exposed to anything else ototoxic that might have contributed to their hearing loss? ○ Yes ○ No

If they have, please tell us what they've been exposed to, when they were exposed to it and any hearing loss it caused:

Section 8 – Clinical examination details

What's your clinical observation of our client's hearing loss?

Please tell us about your clinical findings for the client's right ear, left ear, nasal function, hearing and balance that relate to their hearing loss:

Was there anything else apart from noise exposure that contributed to our client's hearing loss? ○ Yes ○ No

Please tell us about anything else that contributed to our client's hearing loss:

Section 9 – Audiometric report details

Please tell us the date(s) of the audiometric report(s) for hearing loss (ACC612) on which you based this report:

Please comment on anything important from any of our client's earlier audiograms:

Is the audiometric evaluation complete for diagnostic purposes? ○ Yes ○ No

If not, please explain why:

Please tell us about any other tests you think are needed and the reasons for them:

Section 10 – Your summary and recommendations

Please refer to our 'Assessment of occupational noise-induced hearing loss for ACC: a practical guide for otolaryngologists' to apportion our client's hearing loss.

Your assessment of noise exposure:

Please describe our client's hearing loss based on your findings:

Our client's total binaural loss is: %

Our client's binaural loss correction for presbycusis is: %

Our client's net age-corrected hearing loss is: %

Our client's binaural loss attributed to factors other than occupational noise is: %

Our client's binaural loss attributed to occupational noise-induced hearing loss (ONIHL) is: %

Please comment on how much of this is a result of exposure in New Zealand:

Is our client's pattern of hearing loss typical of noise-induced hearing loss? ○ Yes ○ No

If the hearing loss pattern isn't typical of ONIHL and you think the hearing loss is occupational, please explain why:

Please explain your rationale for apportioning our client's hearing loss between ONIHL and other causes:

Do you think there's any other information we should get, or expert we should consult to help us assess our client's case? ○ Yes ○ No

If yes, please give us your recommendation(s):

Do you recommend a hearing aid trial for the client based on the amount of ONIHL as you've assessed it? ○ Yes ○ No

If yes, tick the aid configuration our client needs: ○ Binaural ○ Right ○ Left ○ Other

If no, please explain why:

Section 11 – Declaration and signature

I confirm that, to the best of my knowledge, the information I have provided in this report is true and correct. I confirm that I have discussed the information in the form with the client and they have authorised me to submit this information to ACC for the purposes of assessing their claim.

Name:

Signed:

Date: D M Y

When we collect, use and store information, we comply with the Privacy Act 1993 and the Health Information Privacy Code 1994. For further details, see ACC's privacy policy, available at ***www.acc.co.nz****. We use the information collected on this form to fulfil the requirements of the Accident Compensation Act 2001.*

- ***Scan and email the completed form to:***
  hamilton.hearingloss@acc.co.nz or dunedin.hearingloss@acc.co.nz or
- ***Photocopy and post to:***
  ACC Hamilton Service Centre, PO Box 952, Waikato Mail Centre, Hamilton 3240 or
  ACC Dunedin Service Centre, PO Box 408, Dunedin 9054
- ***For assistance email: AudiologyAdvisor@acc.co.nz***

Appendix B: Medical Council of New Zealand: Non-treating doctors performing medical assessments of patients for third parties

(Reprinted with permission from the Medical Council of New Zealand, 2018)

Doctors who are employed by a third party to perform medical assessments of patients are required to maintain a professional standard of care within the framework of the assessing relationship and are expected to meet the standards of practice outlined in this statement.

Introduction

1. Medical assessments for third parties fall within the definition of the practice of medicine[1] and are a common feature of medical practice. The purpose of a medical assessment varies depending upon the role of the third party. Examples include assessment for employment suitability, and eligibility for health services or compensation. You may perform medical assessments as the patient's own doctor (also referred to as the treating doctor) or as a non-treating doctor.
2. In some circumstances, you may be asked as the patient's own doctor to provide a medical assessment of the patient for a third party. Insurance companies and employers tend to use this form of assessment. You may also be employed or contracted as a non-treating doctor when a third party requires an independent assessment or second opinion. Examples include expert advisors (used in legal proceedings), doctors employed by organisations like ACC, insurance companies or the patient's employers.
3. As a non-treating doctor your assessment may take several forms, including a consultation with the patient, physical examination or a file review of the patient's medical history.

The role of the non-treating doctor

4. As a non-treating doctor your role is to perform a medical assessment and provide an impartial medical opinion to the third party who has employed or contracted you.

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[1] As defined by the Council pursuant to sections 11 and 12 of the Health Practitioners Competence Assurance Act 2003. A copy of the definition of the practice of medicine can be found at www.mcnz.org.nz under Resources >> Medical Registration >> Definition of the practice of medicine.

As the title indicates, your role does not include providing any form of treatment to the patient.

5. Decisions made by a third party will be influenced by your opinion and this may affect the outcome for the patient. Therefore, the Council considers that in making a recommendation you have a responsibility to ensure that your professional opinion and recommendations are accurate, objective and based on all the available evidence.

Performing medical assessments

6. If you do not consider yourself suitably qualified to conduct an assessment, or identify a conflict of interest, you must decline the referral. You do not have to provide the third party with an explanation.

7. If the third party considers that a physical examination is not required, you must be satisfied (and be able to justify) that you have all the information necessary to make an accurate assessment without performing a physical examination or speaking with the patient.

The non-treating doctor and patient relationship – the standard of care within the framework of the assessing relationship

8. The basis of the relationship between the patient and you as an assessing doctor is not the same as that within an established doctor-patient relationship (even when you are also the patient's usual doctor), however patients being assessed are often vulnerable and you are still required to maintain a professional standard of care.

   The Council requires that non-treating doctors adhere to the principles in the Code of Health and Disability Services Consumers' Rights.

9. As such, you should treat the patient with respect, and ensure that they are free from coercion, discrimination, harassment and exploitation. If there is a meeting with the patient, you are required to respect the patient's dignity and communicate with the patient in a manner that enables him or her to understand the information provided and your role.

Effective communication and consent

10. The Council has identified some recurring problems in medical assessments performed by non-treating doctors. The common issue is poor communication with the patient. This leads to unmet expectations, misunderstandings and confusion about the non-treating doctor's responsibility to the patient. Therefore, if you are required to consult the patient:

You must ensure he or she understands the purpose of the medical assessment and your role. Although the patient will usually be informed of this by the third party before seeing you, you should confirm this and, if necessary, provide further explanation.

This explanation should include discussion about the differences between your role and the role of the patient's own doctor.

You must explain what will happen during the assessment and also ensure that the patient is aware of what you are doing throughout the consultation.

This includes explaining the scope of the consultation and any tests that the assessment may require.

You must obtain the patient's informed consent. You should ensure the patient understands that any aspect of the medical assessment may be included in the report to the third party. You should not proceed with the assessment if the patient does not provide his or her consent. You should also advise the patient that he or she has the right to withdraw from the assessment at any time, and inform him or her of any relevant policy held by the third party in relation to withdrawal of consent and the process he or she should follow to organise another assessment with a different doctor. In either of these circumstances you should record in your report to the third party at what point the assessment was terminated and why.

You must explain and ensure that the patient understands what will happen after the consultation. Specifically, you must ensure the patient understands that the report will be the property of the third party. Any questions or requests for information should be directed through the third party.

Recording a consultation

11. A patient may want to record the consultation by video or audio tape. You should consider such a request carefully and, if you do not consent, ask the third-party to arrange for another doctor to conduct the assessment[2].

Reports for the third party

12. Once the medical assessment has been completed it is standard practice for the doctor who performed the assessment to provide a written report to the third party with his or her medical opinion. The report must be accurate and objective. You should not speculate or base recommendations on insufficient or flawed evidence and if you are not satisfied that a medical opinion can be accurate, based on all the information provided in the file, you must clearly state this in the report. You may choose to recommend further methods of investigation if appropriate (i.e. medical tests, x-rays etc.).

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[2] **Jackson v ACC** (Wellington District Court, Decision No. 168/2002 dated 25 June 2002).

A doctor has the "privilege" to decide in what lawful way a medical examination will be conducted and the patient also has the "privilege" to ask for a tape-recorded consultation. It is then a question of balancing the reasonableness of the exercise of the mutual privileges. In this particular case the doctor had not put forward any worthy arguments to refuse to tape the consultation and given the patient's perception of her dealings with ACC and specialists appointed by it, her request to tape the examination was a reasonable exercise of her privilege to do so.

13. If you have been provided with any documentation or information from the third party this should be listed as part of your report. This ensures that this information can be referred to again if there are any issues or questions in the future.

14. If the third party has requested that you make recommendations (such as suitability for an employment position) these recommendations must not compromise the patient's safety.

15. It is the role of the third party to make the decisions for which they sought your advice. This includes decisions about eligibility for compensation and other benefits, and compliance with legislation. You should therefore restrict your comments to an assessment of medical issues.

16. The results of any tests or investigations you have ordered should be copied to the patient's usual doctor.

17. If you become aware of another medical condition as a result of your assessment, you should inform the patient and refer him or her back to his or her usual doctor for further investigation. You should notify the patient's usual doctor in writing. You should not notify the third-party unless your finding is relevant to their enquiries.

Medical assessments by the patient's usual doctor

18. In some circumstances, you may be asked as the patient's usual doctor to perform a medical assessment that would otherwise be performed by a non-treating doctor. This is usually because the patient lives in an isolated area where a non-treating doctor is unavailable or in instances where it would be inappropriate to refer to an unknown treating doctor (such as where the patient has experienced sexual abuse). In this situation, you should clearly explain the difference in your role, so that the patient understands that the usual dynamics of the doctor-patient relationship are different.

19. You must ensure that any medical assessment of a current patient for a third party is accurate, objective and based on all the available evidence.

File assessments by non-treating doctors

20. You may be employed or contracted as a non-treating doctor to perform a medical assessment based solely on information in the patient's file. In such circumstances, and as with any other form of medical assessment, you must be satisfied that you have all the information necessary and a physical examination is not required before providing your professional opinion or recommendation.

21. You should remember that the documented findings of another health practitioner have been based on physical examinations and direct communication with the patient. If you conclude that the documented cause of a medical condition or diagnosis is incorrect, you need to be confident that your conclusion can be supported with relevant evidence and is based on all the necessary information. It

is not acceptable to include such conclusions in the report to the third party unless you are confident and can justify that consulting with the patient or the health practitioner who made the initial diagnosis is not necessary.

Financial influences for the non-treating doctors

22. You must not allow the financial interests of either the patient or the third party to influence your assessment, opinion or recommendations.

Review of medical assessment opinions

23. The Health and Disability Commissioner has concluded that complaints about the contents of an assessment report and complaints about purely paper-based reviews are usually not within the Commissioner's jurisdiction. The Commissioner cannot look into complaints about these matters, and you should direct such complaints directly to the third party, as the party best placed to address these concerns.

24. Concerns about the conduct of a non-treating doctor during a face-to-face assessment may fall within the Health and Disability Commissioner's jurisdiction, and such concerns should be directed to the Commissioner's office. However, concerns about a non-treating doctor providing an opinion on a matter outside his or her scope of practice, or a non-treating doctor's competence should be directed to the third party or the Medical Council.

Other relevant resources:

- The Medical Council of New Zealand has released a statement on *Medical certification* that outlines the general requirements and duties of a doctor when signing any form of certificate or medical report. This is available from the Council's website (*www.mcnz.org.nz*).
- There are several publications available from occupational groups that may assist doctors to understand the role of the independent or third party assessment. Both the Australasian and the United Kingdom Faculties of Occupational Medicine have released guidelines on this issue – guidelines are available on *www.racp.edu.au/fellows/resources/occupational-and-environmental-medicine-resources* or *www.facoccmed.ac.uk*
- The NZMA Code of Ethics
- The Code of Health and Disability Services Consumers' Code of Rights

December 2010

This statement is scheduled for review by December 2015. Legislative changes may make this statement obsolete before this review date.

Appendix C: Sample ISO 1999 calculations

The following tables are calculated from tables in ISO 1999. The example used is that of a person 60 years of age, with 10-40 years' (in decades) exposure at each of four noise levels.

The tables are presented separately for men and women. Note, however, that only the age-related hearing losses vary by gender.

The age-related components are derived from ISO 7029 (included as Database A in ISO 1999), which summarises data from people without otological abnormalities – the result being that the calculated figures represent the total hearing loss to be expected from age and noise exposure. Both mean (i.e. 50th percentile) and 90th percentile calculations are presented.

In addition to showing the total hearing loss in dB HL, the PLH for both the hearing loss as indicated and the age-corrected PLH are presented – using the same percentile age data.

It is recommended that the age-adjusted PLH for men be used as an estimate of the PLH attributable to noise-induced hearing loss for both genders, since any gender difference between age-corrected estimates of NIHL is merely an artefact of the PLH scale.

Figure 3 in the main body of the guideline is a graphical representation of the age-adjusted PLH for men.

Table 7: Combination of noise and age only for men (at 60 years) 50th percentile age and noise data

		10 years’ exposure; thresholds in dB; 50th percentile data							PLH	
Men		500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
Average daily noise exposure dBA, 8 hours/day, 5 days/week, 50 weeks/year	85	6	7	10	13	23	32	34	2	1
	90	6	7	11	14	27	37	37	3	2
	95	6	9	13	17	34	44	42	5	4
	100	10	13	16	20	42	52	49	8	7
		20 years’ exposure; thresholds in dB; 50th percentile data								
		500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
	85	6	7	10	13	24	33	34	2	1
	90	6	7	12	16	29	38	38	3	2
	95	6	10	15	20	36	46	44	6	6
	100	11	16	21	27	47	56	52	12	11
		30 years’ exposure; thresholds in dB; 50th percentile data								
		500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
	85	6	7	10	13	24	33	34	2	1
	90	6	7	12	17	29	39	38	4	3
	95	7	10	17	23	39	47	45	7	6
	100	12	16	24	31	49	58	53	14	13
		40 years’ exposure; thresholds in dB; 50th percentile data								
		500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
	85	6	7	11	14	24	34	35	2	1
	90	6	7	12	18	30	40	39	4	3
	95	7	10	18	25	39	48	46	8	7
	100	13	17	26	34	52	60	54	15	15

Table 8: Combination of noise and age only for men (at 60 years) 90th percentile age and 90th percentile noise data

Average daily noise exposure dBA, 8 hours/day, 5 days/week, 50 weeks/year

	10 years' exposure; thresholds in dB; 90th percentile data							PLH	
Men	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
85	18	19	24	30	45	59	64	14	2
90	18	19	26	34	50	63	68	17	5
95	19	22	31	39	58	70	73	23	11
100	25	29	38	46	69	78	80	33	20

	20 years' exposure; thresholds in dB; 90th percentile data								
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
85	18	19	25	31	46	59	64	15	2
90	18	19	27	35	52	65	69	18	6
95	19	23	33	42	62	72	75	25	13
100	26	32	42	53	75	80	82	38	26

	30 years' exposure; thresholds in dB; 90th percentile data								
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
85	18	19	25	31	47	60	65	15	3
90	18	19	28	36	54	65	69	19	6
95	19	23	34	44	64	73	76	27	14
100	27	33	45	56	78	84	84	42	29

	40 years' exposure; thresholds in dB; 90th percentile data								
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
85	18	19	25	31	47	60	65	15	3
90	18	19	28	37	54	66	69	19	7
95	19	24	35	46	66	75	76	28	16
100	27	35	47	59	81	85	85	44	32

Table 9: Combination of noise and age only for women (at 60 years) 50th percentile age and noise data

Average daily noise exposure dBA, 8 hours/day, 5 days/week, 50 weeks/year

	10 years' exposure; thresholds in dB; 50th percentile data							PLH	
Women	**500**	**1,000**	**1,500**	**2,000**	**3,000**	**4,000**	**6,000**	**Total HL**	**Age-adjusted**
85	6	7	9	12	16	20	23	0	0
90	6	7	10	13	20	26	27	1	1
95	6	9	12	16	27	33	33	2	2
100	10	13	15	18	36	43	40	5	5

	20 years' exposure; thresholds in dB; 50th percentile data								
	500	**1,000**	**1,500**	**2,000**	**3,000**	**4,000**	**6,000**	**Total HL**	**Age-adjusted**
85	6	7	9	12	17	21	23	0	0
90	6	7	11	15	22	27	28	1	1
95	6	10	15	19	30	36	34	3	3
100	11	15	21	26	42	47	43	9	9

	30 years' exposure; thresholds in dB; 50th percentile data								
	500	**1,000**	**1,500**	**2,000**	**3,000**	**4,000**	**6,000**	**Total HL**	**Age-adjusted**
85	6	7	9	12	17	21	23	0	0
90	6	7	11	16	23	28	28	1	1
95	7	10	16	22	33	38	36	4	4
100	12	16	23	30	44	50	45	11	11

	40 years' exposure; thresholds in dB; 50th percentile data								
	500	**1,000**	**1,500**	**2,000**	**3,000**	**4,000**	**6,000**	**Total HL**	**Age-adjusted**
85	6	7	10	13	17	22	24	0	0
90	6	7	12	16	24	29	29	1	1
95	7	10	17	24	34	39	37	5	5
100	13	17	25	33	47	52	46	13	13

Table 10: Combination of noise and age only for women (at 60 years) 90th percentile age and 90th percentile noise data

Average daily noise exposure dBA, 8 hours/day, 5 days/week, 50 weeks/year

	10 years' exposure; thresholds in dB; 90th percentile data							PLH	
Women	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
85	18	19	22	26	34	40	48	8	3
90	18	19	24	30	40	46	53	11	6
95	19	22	29	35	49	54	59	18	12
100	25	29	36	43	61	65	68	28	23

	20 years' exposure; thresholds in dB; 90th percentile data								
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
85	18	19	23	27	35	41	48	9	3
90	18	19	25	31	42	48	54	12	7
95	19	23	31	38	53	58	61	20	15
100	26	32	41	50	68	68	71	35	29

	30 years' exposure; thresholds in dB; 90th percentile data								
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
85	18	19	23	27	35	41	49	9	3
90	18	19	26	32	44	48	54	13	8
95	19	23	32	41	56	59	63	22	17
100	27	33	43	53	72	73	74	38	32

	40 years' exposure; thresholds in dB; 90th percentile data								
	500	1,000	1,500	2,000	3,000	4,000	6,000	Total HL	Age-adjusted
85	18	19	23	27	35	41	49	9	3
90	18	19	26	33	44	49	54	14	8
95	19	24	33	42	58	61	63	23	18
100	27	35	46	56	75	75	75	41	36

Appendix D: Coles, Lutman & Buffin: Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes

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Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes

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Guidelines on the diagnosis of noise-induced hearing loss for medicolegal purposes

These guidelines aim to assist in the diagnosis of noise-induced hearing loss (NIHL) in medicolegal settings. The task is to distinguish between possibility and probability, the legal criterion being 'more probable than not'. It is argued that the amount of NIHL needed to qualify for that diagnosis is that which is reliably measurable and identifiable on the audiogram. The three main requirements for the diagnosis of NIHL are defined: R1, high-frequency hearing impairment; R2, potentially hazardous amount of noise exposure; R3, identifiable high-frequency audiometric notch or bulge. Four modifying factors also need consideration: MF1, the clinical picture; MF2, compatibility with age and noise exposure; MF3, Robinson's criteria for other causation; MF4, complications such as asymmetry, mixed disorder and conductive hearing impairment.

Keywords *noise-induced hearing loss* *diagnosis* *medicolegal*

A probable diagnosis of noise-induced hearing loss (NIHL) is easy where there is a history of unprotected noise exposure of high level and long duration, a typical audiometric notch maximal at 3, 4, or 6 kHz and no evident complicating factor or diagnostic competitor. In many other cases though, the diagnosis is much less certain. In medicolegal work, the diagnosis may also be subject to challenge in correspondence, by instructing solicitors and those for the other party or parties, and under cross-examination in court.

In such cases, NIHL is usually accompanied, and often obscured, by age-associated hearing loss (AAHL) and sometimes by other additional forms of hearing impairment. The diagnostic task then reduces to that of defining the likelihood of the presence of a component of NIHL in the overall hearing impairment.

In defining likelihood, we are helped by the legal requirement in civil proceedings–namely to give an opinion on 'balance of probabilities' or whether it is 'more probable than not'. In practice, keeping that legal criterion in mind can be an enormous help. The expert witness is required only to differentiate between probability and possibility, with the onus of proof of probability on the claimant. Nevertheless, a semi-quantitative opinion on the degree of probability can assist the court, by indicating how close to or distant from the borderline it is considered to be.

Another major issue is how much noise damage has to be present before it counts. The following statements encompass the range of criteria that might be used for this:

1. The risk of noise-induced destruction of at least some cochlear hair cells.
2. The slightest degree of damage that is likely to cause some minimal but finite degree of loss of hearing ability either now, or later when augmented by ageing effects.
3. The likelihood of causation of some specified degree of reduced hearing ability, below which the effect is regarded as of no importance.
4. The presence of a degree of noise-induced hearing loss that is large enough to be measurable reliably and identifiable on the audiogram.

Our opinion and decision on this matter is as follows. Statement (1) defies demonstration in living human beings and is therefore only of theoretical interest. Statement (2) borders on the concept of 'de minimis non curat lex', roughly translated as 'the law does not concern itself with

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trifles.' With respect to hearing, this is for the courts to define when and if they wish to do so. For us to attempt a definition would be to invite disagreement and criticism from within the professions of otology and audiology, as well as being an incursion into legal prerogative where it might be seen to be usurping the role of the judiciary. Statement (3) is arbitrary, and medical and scientific opinions already vary widely on this. Statement (4) is the only practicable criterion for the amount of noise damage necessary for the diagnosis of NIHL; that is, a reliably measurable and identifiable degree of damage. This statement is also compatible with the legal requirement where the test is whether or not, on the balance of probabilities, noise has made a material contribution to the claimant's overall hearing impairment. This criterion is therefore the one on which the following diagnostic guidelines are based.

Historical background to these guidelines

The authors are not aware of any previously published quantitative guidelines for the diagnosis of NIHL. Operational criteria for diagnosis of the condition were therefore not included in the material presented in our annual 1-day course on 'Medicolegal aspects of noise-induced hearing loss', until 1998. Our change in policy on this issue arose from requests by participants, in the evaluation questionnaires for the 1997 course, for more information on how to diagnose NIHL. In fact, one of us (R.R.A.C.) had already been using his own rough set of criteria for medicolegal work for about 2 years. These then became the basis for our development of the first draft of these guidelines, which were then presented to the 1998 course.

They were then piloted through about 200 medicolegal cases during 1998, amended in places as a result, and then presented as a second draft set of guidelines to the 1999 course. With some further modifications, mostly of an editorial nature, they have now been finalised.

The guidelines are considered by the authors to be well-founded, practicable and useful. It is hoped that they will assist otologists and audiologists in making diagnoses in those many borderline cases that are troublesome. They may also assist the courts in adjudicating on these issues.

Guidelines on the diagnosis of noise-induced hearing loss

In order to keep the text of these guidelines as concise as possible, notes of explanation or further guidance have been placed in Appendix A and a worked example, comparing audiometric measurements with the most likely pattern and extent of AAHL, is given in Appendix B.

1. AIM

1.1. The aim of these guidelines is to assist expert medical witnesses in considering evidence for the diagnosis of NIHL in a medicolegal setting. They do not relate to hearing loss due to acute acoustic trauma, nor to noises having unusual frequency spectra (see para. 2.2), nor do they quantify how much of any hearing impairment is due to noise.

2. SCOPE

2.1. For the most part, the guidelines refer to uncomplicated cases of NIHL; that is, cases of 'typical' NIHL together with presumed 'normal' AAHL.

2.2. In the present context, 'typical' NIHL refers to the form of hearing impairment that gradually accrues in a proportion of those who have repeated exposures to hazardous levels of one or more of the common types of broad-band sound. Sounds not fitting this description include those predominantly of tonal nature or of low-frequency or very high-frequency spectrum. Examples of such unusual spectra would be where the sound level is > 10 dB greater in the 0.25, 0.5 or 8 kHz octave band than in each of the 1, 2 and 4 kHz octave bands.

2.3. 'Normal' AAHL here implies consistency with the range of age-associated hearing data in ISO 7029 (1984)[1] for the appropriate age and sex, and also having the most common audiometric configuration of AAHL in which the hearing loss increases progressively with test frequency and with age, the progression having an accelerating character.

3. GENERAL REMARKS

3.1. Inevitably, guidelines are a matter of judgement. They should be interpreted as guides, not rigid rules. Nevertheless, these guidelines have been derived after careful consideration of the data available and keeping in mind the legal criterion that the diagnosis should be likely 'on balance of probabilities' or 'more likely than not'.

3.2. It is not possible from case law or from scientific research to specify the minimum degree of NIHL that may be considered significant in terms of compensatability (see Note 1 in Appendix A). Consequently, guidelines on the minimum amount of noise exposure that might be significant must depend on the smallest hearing loss that can be measured in an individual with a reasonable degree of reliability. At 4 kHz, this is considered to be about 10 dB.

3.3. The guidelines presented here comprise three Requirements R1, R2 (a) or (b), R3(a) or (b) and four Modifying Factors MF1, MF2, MF3, MF4.

3.4. For the diagnosis of NIHL, requirements R1, R2(a) and R3(a) should be met; or if appropriate R1, R2(b) and R3(b). The diagnosis may then be strengthened or weakened according to how modifying factors MF1, MF2, MF3 and MF4 apply to the individual.

Diagnostic requirements

4. REQUIREMENT R1: 'HIGH-FREQUENCY IMPAIRMENT'

4.1 R1 comprises audiometric evidence of a high-frequency sensorineural hearing impairment. For the present purposes, 'high-frequency' is defined relative to the threshold levels at middle frequencies. It is when a single measurement of hearing threshold level (HTL) at 3, 4 or 6 kHz, after any due correction for earphone type (see Note 2), is at least 10 dB greater than the HTL at 1 kHz or 2 kHz. If an average of two or more measurements in that ear can be used, the 10 dB guideline figure may be slightly reduced (see Note 3).

5. REQUIREMENT R2(a): 'NOISE EXPOSURE'

5.1. If R2(a) is met, at least 50% of individuals exposed to this known or estimated amount of noise would be likely to suffer a measurable degree of hearing loss. This noise estimate includes allowance for proper use of hearing protection (see Note 4) or for any in-built protection from a conductive hearing loss believed to have been present in the relevant noise-exposure years (see Note 5).

5.2. From an assessment of the various sets of epidemiological data and predictive formulae available (see Note 6), the lower limit of noise exposure meeting this requirement is considered to be an equivalent daily 8-h continuous noise exposure ($L_{EP,d}$) of not less that 85 dB(A) (see Notes 7 and 8) for a sufficient number of years to lead to a cumulative exposure of at least 100 dB(A) NIL, the so-termed Noise Immission Level.[2–4]

5.3. The medical examiner may not be able to make an estimate of the total noise exposure, even in terms of whether it meets R2(a) or (b). If a diagnosis of NIHL would be made if these noise exposure requirements were met, then it is recommended that in absence of a noise exposure estimate a conditional diagnosis be made.

6. REQUIREMENT R2(b): 'NOISE EXPOSURE'

6.1. Substantial amounts of NIHL can be caused in a minority of persons exposed to < 100 dB(A) NIL; that is, in those who are more than averagely susceptible. To allow for such cases, a less stringent noise exposure requirement is applicable provided the audiometric evidence of noise damage is stronger. The lower level of total noise exposure for such cases is reduced to 90 dB(A) NIL (see Notes 7 and 8), although the lower limit on $L_{EP,d}$ remains at 85 dB(A). Where the estimated total exposure is in the range 90–99 dB(A) NIL, thereby meeting noise exposure guideline R2(b) but not R2(a), the audiometric guideline R3(b) must be met instead of R3(a).

7. REQUIREMENT R3(a): 'AUDIOMETRIC CONFIGURATION'

7.1. Evidence of probable presence of NIHL is considered to be present if there is a downward notch in the audiogram in the 3–6 kHz range that is large enough to be identifiable with a reasonable degree of confidence; see para. 7.5. An example of such a notch is shown in Fig. 1.

7.2. Evidence for NIHL is also provided on the audiogram by a sufficiently large relative bulge downwards and to the left in the 3–6 kHz range; see para 7.6. In a considerable proportion of NIHL cases, especially after the age of about 50 years, the characteristic high-frequency notch is missing. This is usually due to the additional presence of high-frequency hearing impairment of other causation, either pre-existing or developing concurrently or subsequently, such as associated with ageing. Typically that has the effect of converting a noise-induced audiometric notch into a bulge, an example of which is shown in Fig. 2 and also in Fig. 3 later. In other cases it may reduce the notch to a size (e.g. 5 dB) that is not significant as a notch. Nevertheless, it will add to the size of a potential bulge and should be examined closely to see if it qualifies as a bulge (see para. 7.6 and Note 10).

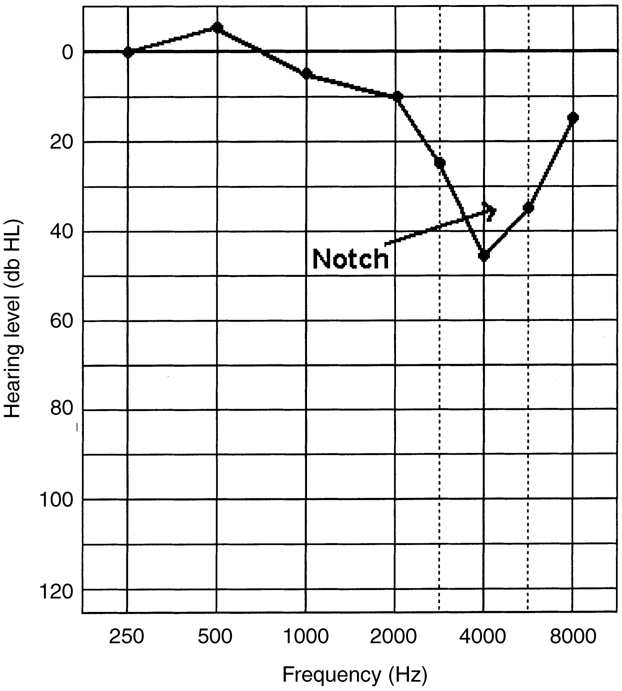

Figure 1. A high-frequency notch in the audiogram, typical of noise-induced hearing loss.

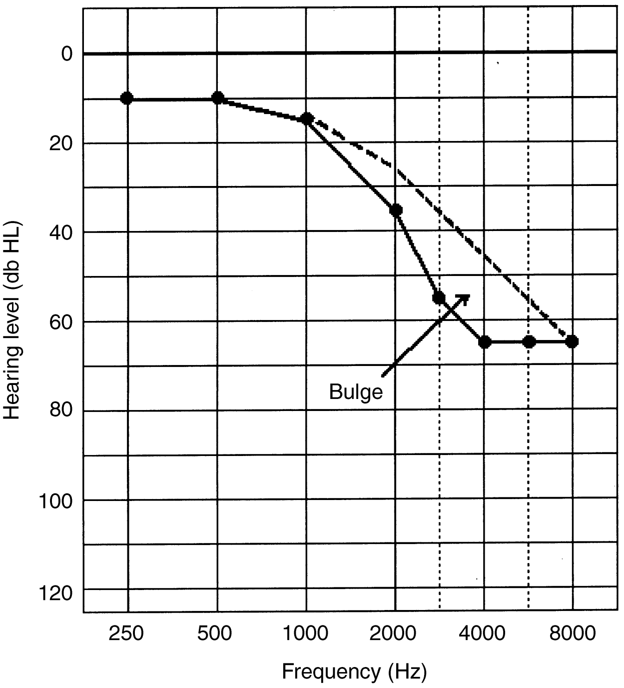

Figure 2. A bulge downwards and to the left in the audiogram, typical of noise-induced hearing loss plus presumed age-associated hearing loss (AAHL). (The dashed line indicates the median AAHL for men aged 70).

7.3. It should, however, be noted that the presence of such a notch or bulge is not pathognomonic of NIHL, as it is sometimes found or can be seen to develop in people with no significant noise exposure. Nevertheless, such a notch or bulge means a high probability of the presence of a substantial amount of NIHL if there has also been sufficient noise exposure and there is no strongly adverse or precluding other factor or diagnosis.

7.4. Likewise, the absence of a notch or bulge of sufficient size to meet R3(a) or (b) does not preclude the presence of some NIHL hidden in hearing impairments having other causation, or of NIHL having an atypical audiometric configuration. But such possibilities would generally be below the balance of probabilities. An exception might be where the size of the notch or bulge only just fails to meet the guideline, but the noise exposure had been particularly high (over 110 dB(A) NIL, for example).

7.5. Definition. A high-frequency *notch* in the air-conduction audiogram (see Note 9) that is sufficiently large to be indicative of the probable presence of NIHL is where the hearing threshold level (HTL) at 3 and/or 4 and/or 6 kHz, after any due correction for earphone type (see Note 2), is at least 10 dB greater than at 1 or 2 kHz and at 6 or 8 kHz. If an average of two or more HTL measurements can be used, the 10 dB figure may be slightly reduced (see Note 3).

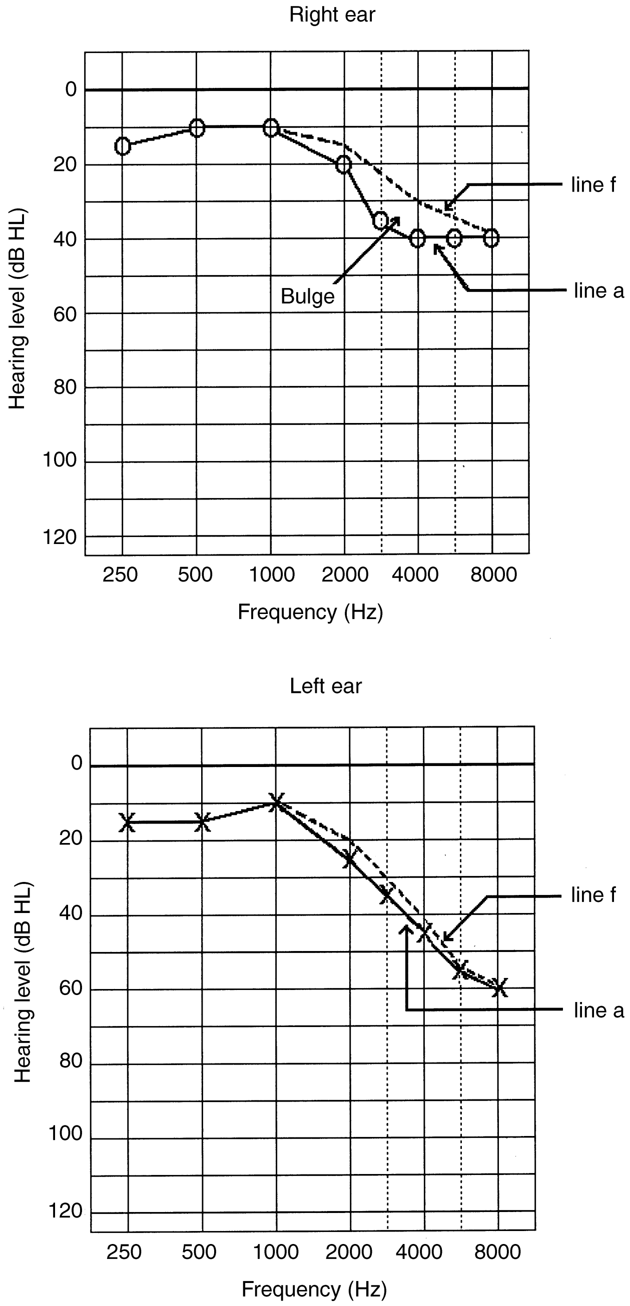

Figure 3. The worked example. (Measured hearing thresholds are shown in line a, and comparison figures of age-associated hearing loss in line f).

7.6. Definition. A high-frequency *bulge* in the air-conduction audiogram (see Note 9) that is sufficiently large to be indicative of the probable presence of NIHL is defined as follows. Such a bulge is present if the HTL at 3 and/or 4 and/or 6 kHz, after any due correction for earphone type (see Note 2), is at least 10 dB greater relative to the comparison values for age-related hearing loss (see Note 10) at corresponding frequencies. If an average of two or more HTL measurements can be used, the 10 dB figure may be slightly reduced (see Note 3). Occasionally the bulge extends to involve 2 kHz, or even 1 kHz.

7.7. Note that the extent of the notch or bulge as defined here for diagnostic purposes does not indicate the full extent of the hearing loss caused by noise damage. For instance, the HTL values at 1 and 8 kHz are most commonly used here as the 'anchor points' for estimating the AAHL comparison values against which the measured HTLs are compared in order to identify a probable noise-induced bulge. But in fact in many cases of noise damage there is probably a component of NIHL in any hearing impairment at 1 and 8 kHz.

8. REQUIREMENT R3(b): 'AUDIOMETRIC CONFIGURATION'

8.1. If the noise exposure requirement in R2(a) is met, then audiometric requirement R3(a) is sufficiently stringent. But if the noise exposure only meets R2(b), and not R2(a), then the corresponding requirement R3(b) has to be met instead of R3(a).

8.2. Requirement R3(b) is similar to R3(a), except that the notch or bulge has to be at least 20 dB to qualify.

Modifying factors

9. MODIFYING FACTOR MF1: 'CLINICAL PICTURE'

9.1. The mode, nature and age of onset and progression of auditory symptoms, especially if prominent temporary post-exposure auditory symptoms are recalled, and the fitting and use of any hearing aid(s) should be compatible with hearing loss resulting from recurrent noise exposure. 'Prominent' here is regarded as recollection of temporary tinnitus and/or dullness of hearing lasting an hour or more. These symptoms are particularly relevant if their duration gradually increased until they were present permanently. Account needs also to be taken of any probable diagnostic competitors or additional diagnoses or noise-protective factors, although any other diagnosis may well be an additional cause of hearing loss rather than an alternative to NIHL. The examiner should indicate the extent to which any such modifying factor supports, modifies or perhaps countermands the diagnosis of NIHL.

10. MODIFYING FACTOR MF2: 'COMPATIBILITY WITH AGE AND NOISE EXPOSURE'

10.1. The hearing impairments measured should be checked for compatibility with the claimant's age, sex and estimated total amount of noise exposure, including military and non-occupational, using the 'NPL Tables' (Robinson and Shipton, 1977)[4] up to the 5th percentile values of susceptibility, or other appropriate source, such as ISO 1999: 1990.[5] By definition, 5% of the population are even more susceptible than that, but the other evidence for the hearing impairment being due to noise and age alone should be strong for more extreme percentiles of susceptibility to be acceptable.

10.2. However, if the amount of hearing impairment is excessive in relation to the age and noise exposure (occupational, military and non-occupational), this does not necessarily negate a diagnosis of NIHL. The extra hearing impairment may well be due to a third causation, additional to NIHL and AAHL.

11. MODIFYING FACTOR MF3: 'ROBINSON'S CRITERIA'

11.1. If the diagnosis of NIHL seems borderline, the audiometric data should be checked for compatibility with Robinson's[6] probability tests to uncover other causation. These comprise a scheme of statistical tests leading to eight criteria, each of which is expressed at two levels of probability based on the 95% and the 98% limits of normal distribution. The criteria relate to the degree of conformity of the measured audiometric configuration with the Burns and Robinson[2] model of NIHL, the degree of left/right asymmetry both in amount of hearing impairment and in audiometric configuration, and the calculated degree of noise susceptibility.

11.2. Where two of these criteria are exceeded, it is probable that there is some alternative or additional diagnosis present, accounting for at least part of the measured hearing impairment. Exceptions occur however, and should be argued on their merits. Where three or more of these criteria are exceeded, an alternative or additional causation becomes highly probable. Note, however, that Robinson's criterion no. 2 for asymmetry, can on its own be very helpful in defining whether measured left/right differences are to be considered acceptable or excessive, or perhaps having some particular explanation such as asymmetrical noise exposure.

11.3. Where a case passes Robinson's criteria, this only means that the data are compatible with a diagnosis of NIHL combined with presumed AAHL, without needing to postulate an additional or alternative diagnosis. They are not criteria for a diagnosis of NIHL.

12. MODIFYING FACTOR MF4: 'COMPLICATED CASES'

12.1. In some cases, there may be considerable left/right differences in the amount of hearing impairment and only one ear complies with the above-stated requirements for a diagnosis of NIHL. In such instances, the user is referred to

Note 11 for recommendations on how the guidelines should be interpreted in asymmetrical cases.

12.2. Various other aural disorders in addition to NIHL and AAHL may be present and be contributing to the hearing impairments measured. In such cases, the guidelines should not be applied rigidly. Where a person is thought to have suffered a material degree of noise-induced threshold shift, but yet does not fully qualify for that diagnosis under these guidelines, the reasons for making an exception to them should be explained in detail.

12.3 Conductive hearing loss. This is likely to affect the assessment of effective noise exposure and/or estimation of the amount of sensorineural hearing loss (see Notes 5 and 9).

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Appendix A. Explanatory and further guidance notes

Note 1. Consideration of noise exposure in terms of negligence by the defendant is a separate issue, and should not be confused with diagnosis. Quantification of the amount of NIHL, disability and similar issues are also outside the scope of these guidelines.

Note 2. When Telephonics TDH-39 audiometer earphones have been used, subtract 6 dB from the measured HTL values at 6 kHz. This is to take account of the calibration artefact associated with use of those earphones.[7] (TDH-39 earphones are the most commonly used in the UK: amongst others, they are used in most Amplivox, Bilsom (CA 850), Inter-Acoustics, Kamplex, Madsen and Peters audiometers. On the other hand, Grason-Stadler audiometers use TDH-49 or TDH-50 earphones that are free of this artefact).

Note 3. If an average of two, several or many hearing threshold measurements at the relevant frequencies in a particular ear can validly be used, the 'at least 10 dB or greater' guideline may be reduced slightly, by up to about 3 dB. In borderline cases, an average of all the audiograms available and acceptable for averaging should be used in assessing the evidence for or against the presence of a high-frequency hearing impairment, notch or bulge. To this end, if when testing the hearing of a case that seems borderline in any of these respects, it will usually help to carry out one or more re-tests at the defining frequencies with repositioning of the earphones between tests. The results of each re-test should be plotted on the audiogram and/or tabulated in the report.

Note 4. Corrections for reported use of hearing protection. In order to estimate the noise reaching the internal ear, allowances have to be subtracted from the levels of noise at work during the years in which hearing protection was understood to have been properly used. Such allowances should only be made where it is believed that the hearing protection had been used virtually all the time (in those years or for a stated proportion of them) that the individual was exposed to hazardous levels of noise.

If the particular protector used can be identified, its attenuation characteristics may be obtainable either from published data (e.g. Martin[8]) or from information provided by its manufacturer. Account has then to be taken of the evidence that hearing protectors are less effective as worn in industry than as measured in the laboratory,[9] their real-world attenuation being about 16 dB less for earplugs and 8 dB less for earmuffs.

Where the actual protector used cannot be identified with certainty, or its attenuation characteristics are not known, recourse may be necessary to the figures in Table 1. This gives values for the mean real-world attenuation of A-weighted noise levels likely to be achieved for various classes of hearing protector.

Table 1. Realistic sound attenuation data for hearing protectors

Class of hearing protector	Real-world attenuation (dB)
Music headphones	0
Cotton wool (dry or waxed)	5
Soft plastic earplugs	10
Canal caps (suprameatal plugs on headband)	10
Personalised earmoulds	10
Glass down earplugs (e.g. Bilsom range)	15
Plastic foam earplugs (e.g. EAR range)	15
Earmuffs	20

Note 5. The presence of a conductive hearing loss may require corrections to be made to the external noise levels in order to estimate the effective levels likely to reach the internal ear (see para. 5.1.). Subtractions from the air-conduction thresholds may also be needed in order to estimate the sensorineural hearing impairment (see Note 10). Due to measurement variability and distortions, air-bone gaps may seem to differ widely (and unrealistically) between frequencies, and may also be markedly small at 2 kHz. Therefore, the best estimate of the conductive component is the air-bone gap averaged over 0.5, 1, 2 and 3 or 4 kHz, providing: (1) that in any bone-conduction tests at 4 kHz the ipsilateral ear is occluded sufficiently to prevent hearing of air-conducted sound radiated from the bone-conduction transducer; and (2) that the bone-conduction thresholds at 2 kHz are excluded from the average if the apparent air-bone gap at 2 kHz is smaller that at all the other frequencies. If the average air-bone gap is $<$ 10 dB, corrections for conductive hearing loss should not be made.

Note 6. Various formulae[2,4,5,10,11] predict, from the estimated noise exposure and subject's age and sex, the extent of hearing impairment to be expected in various percentiles of susceptibility.

At face value these formulae predict that even the most extremely noise-resistant percentiles would suffer some degree of NIHL. They also suggest that noise exposures of low level (e.g. low 80 s in decibels) and duration (e.g. only a few years) would cause small but finite degrees of NIHL in some of those so exposed.

However, their original data sources were limited to cross-sectional studies, and the evidence for such effects is weak, being extrapolations from effects measured mostly in people with around average degrees of susceptibility and large amounts of noise exposure. The earlier work also exaggerated the apparent effect of small noise exposures. Moreover, epidemiological studies involving low level and/or short-duration and/or intermittent exposures (e.g. in forestry workers, marine engine room personnel, miners, underground railway workers, navy divers, aircraft handlers, and exposure of young persons to amplified music) seem to indicate an occurrence of less than the expected degree of hearing loss and in smaller proportions of those exposed.

These scientific considerations have to be judged also in relation to the legal criterion of 'balance of probabilities', and to what can be regarded as a reasonably reliable single measurement in an individual ear. At 4 kHz this is considered to be about 10 dB (see para. 3.2.). According to International Standard 1999 (1990),[5] noise exposure at 90 dB(A) for 10 years, which equates to a NIL value of 100 dB(A), causes a median NIHL of 11 dB at 4 kHz (and, incidentally about 3.5 dB in the 1, 2 and 3 kHz average). Hence, our use of the 100 dB(A) NIL value in R2(a).

Note 7. $L_{EP,d}$ noise levels below 85 dB(A) in fact cause very little NIHL. With low noise levels, the noise immission calculations tend to over-estimate the potential auditory hazard. For example, a virtually safe noise level of 80 dB(A), if heard for 20 years, would yield an apparently unsafe NIL of 93 dB(A). Therefore, it is recommended that $L_{EP,d}$ levels below 85 dB(A) should not be taken into account in estimating the total noise exposure.

Note 8. Noise exposure estimates are often rounded to the nearest whole decibel. Noise level values of 84.5–84.9 dB(A) and NIL values of 99.5–99.9 dB(A) or 89.5–89.9 dB(A) should therefore be regarded as being 85 dB(A), 100 dB(A) or 90 dB(A), respectively.

Note 9. Bone-conduction measurements are very variable and prone to calibration artifacts and distortions, such as the Carhart effect which occurs in most forms of conductive hearing loss. They should not therefore be used for judging the shape of audiograms for diagnostic purposes, although they are of course useful for identification and quantification of a conductive hearing loss. The possibility of a noise-induced notch or bulge should therefore be judged only from the shape of the air-conduction audiogram.

Note 10. Derivation of comparison values of age-associated hearing loss (AAHL). In order to obtain comparison values of AAHL in an individual ear the following procedures are recommended. See also the worked example shown in Table 4, lines a–g.

First, correct the measured hearing threshold level (HTL) values for any conductive hearing loss of $\geq$ 10 dB (see Note 5) and, if appropriate, for the use of TDH-39 earphones (see Note 2). Then, look at the corrected HTL values (line a) at the audiometric frequencies just above and below those most usually affected by noise. At the high frequency end of the range this is usually 8 kHz. Occasionally though, e.g. where there is a precipitous fall-off above 6 kHz, that frequency is a better indicator of the upper end of the probable AAHL pattern affecting the rest of the frequency range. The HTL at 8 kHz is therefore usually taken as the 'upper anchor point' for estimating the likely extent of AAHL in an individual ear.

Towards the lower end of the frequency range, 1 kHz is usually the best frequency to use as the 'lower anchor point'. Audiometry is fairly precise at that frequency. It is also relatively free from ambient and physiological noise masking effects and other factors which so often seem to cause 10–20 dB impairments at 0.25 and 0.5 kHz. Occasionally 0.5 or 2 kHz will be more appropriate, for example when the HTL there is more than 5 dB better than at 1 kHz.

Statistical data on AAHL are then consulted. Those shown in Tables 2 and 3 are recommended. For the plaintiff's sex and approximate age (up to 10 years above or below the actual age) the AAHL data that correspond best to the values at the two 'anchor points'(line b) are then selected (line c).

Next, calculate (line d) the misfit values. These are the differences between the statistical values (line c) and the measured HTLs at the two 'anchor points' (line b). Then (line e), interpolate misfit values for the intermediate frequencies. Go on to add these misfit values (lines d and e) to the statistical values (line c) to derive the adjusted AAHL values (line f). The adjusted AAHL values (line f) are the ones to compare with the corrected HTLs (line a) to estimate to what extent a NIHL-like bulge may be present (line g).

Note 11. Asymmetrical hearing impairment. Robinson,[6] in the second criterion of his scheme for identifying other causation in cases of NIHL, indicates the 'normal' limits of asymmetry in uncomplicated cases of NIHL.

In some cases of asymmetrical sensorineural hearing impairment there may be an apparent explanation. Examples include: asymmetrical noise exposure, the asymmetrical protective effect of unilateral or greater conductive hearing loss on one side or of a unilaterally poorly fitting hearing protector, asymmetrical AAHL or other asymmetrical components of the hearing impairment.

In yet other cases, there is no apparent explanation for the presence of a significant NIHL-like notch or bulge on one side only. These cases are compatible with the presence of NIHL but with varying degrees of probability. For instance if one ear meets R3(a) or R3(b), and the other ear also shows a notch or bulge but it is smal-

Table 2. Typical age-associated hearing loss (AAHL) data for men*

		Predicted hearing threshold levels (dB) at the following ages in years												
Frequency (Hz)	Percentile	20	25	30	35	40	45	50	55	60	65	70	*75*	*80*
250	75	2	2	2	3	3	4	4	5	6	7	8	*9*	*11*
	50	8	8	8	8	9	10	11	12	13	14	16	*17*	*19*
	25	14	14	15	15	16	17	18	20	21	23	25	*27*	*29*
500	75	1	1	1	1	2	2	3	4	5	6	8	*9*	*11*
	50	5	5	6	6	7	8	9	10	11	13	14	*16*	*18*
	25	11	11	11	12	13	14	15	17	19	21	23	*25*	*28*
1000	75	− 2	− 2	− 1	− 1	0	0	1	2	4	5	6	*8*	*10*
	50	2	2	3	3	4	5	6	7	9	11	13	*15*	*17*
	25	7	7	7	8	9	11	12	14	16	18	21	*24*	*27*
2000	75	− 1	− 1	0	0	1	3	4	6	8	11	13	*16*	*19*
	50	4	4	5	6	7	9	11	13	16	19	22	*26*	*30*
	25	9	10	11	12	14	16	19	22	25	30	34	*39*	*44*
3000	75	− 1	− 1	0	1	3	5	7	10	14	17	21	*26*	*31*
	50	4	5	6	7	9	12	15	19	23	28	34	*40*	*46*
	25	11	11	13	15	17	21	25	30	36	42	49	*57*	*65*
4000	75	0	1	2	4	6	9	13	17	21	27	33	*40*	*47*
	50	6	7	8	11	14	18	22	28	34	41	49	*58*	*68*
	25	14	14	16	19	24	29	35	42	50	59	70	*81*	*93*
6000	75	0	1	2	4	7	10	14	19	24	30	37	*45*	*53*
	50	7	8	10	12	16	20	25	32	39	47	56	*65*	*76*
	25	16	17	19	22	27	33	39	48	57	67	79	*92*	*105*
8000	75	0	1	2	5	8	12	17	23	29	37	45	*54*	*64*
	50	8	9	11	14	18	24	30	38	46	56	67	*79*	*92*
	25	17	18	21	25	31	38	46	56	67	80	94	*110*	*120*

*Modified from International Standard ISO 7029 (1984)[1] which gives estimates for threshold shifts as a function of age in highly screened populations and is known as Database A. The above table is modified from the standard by utilising a baseline for 18-year-olds that differs from the zero value in the standard. The baseline is from the bottom line of Table 6 in Lutman and Davis (1994)[12] after subtraction of 6 dB at 6 kHz to allow for the artificial increase in hearing threshold levels in that study attributable to the use of TDH-39 earphones. Specifically, the baseline values are 7.5, 5.0, 2.0, 3.5, 4.0, 6.0, 7.0 and 7.5 dB, respectively, at 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz. Figures in italics are derived from extrapolation beyond the age limit of 70 years used in the standard. Values > 120 dB have been truncated at 120 dB. See also Note 12.

Table 3. Typical age-associated hearing loss (AAHL) data for women*

Frequency (Hz)	Percentile	Predicted hearing threshold levels (dB) at the following ages in years												
		20	25	30	35	40	45	50	55	60	65	70	*75*	*80*
250	75	2	3	3	3	4	4	5	6	6	7	9	*10*	*11*
	50	8	8	8	8	9	10	11	12	13	14	16	*17*	*19*
	25	14	14	14	15	16	17	18	19	21	23	24	*27*	*29*
500	75	1	1	1	1	2	2	3	4	5	6	8	*9*	*11*
	50	5	5	6	6	7	8	9	10	11	13	14	*16*	*18*
	25	11	11	11	12	13	14	15	17	19	21	23	*25*	*28*
1000	75	− 2	− 2	− 1	− 1	0	0	1	2	4	5	6	*8*	*10*
	50	2	2	3	3	4	5	6	7	9	11	13	*15*	*17*
	25	7	7	7	8	9	11	12	14	16	18	21	*24*	*27*
2000	75	− 1	− 1	0	0	1	2	4	5	7	9	11	*14*	*17*
	50	4	4	4	5	6	8	10	12	14	17	20	23	27
	25	9	9	10	11	13	15	17	20	23	26	30	*34*	*39*
3000	75	− 1	− 1	0	1	2	3	5	7	9	12	15	*18*	*21*
	50	4	4	5	6	8	9	12	14	17	21	24	*28*	*33*
	25	10	11	11	13	15	17	20	23	27	32	36	*42*	*48*
4000	75	0	1	1	2	4	5	7	10	12	15	19	*23*	*27*
	50	6	6	7	9	10	13	15	18	22	26	30	*35*	*41*
	25	13	14	15	16	19	22	25	29	34	39	45	*51*	*58*
6000	75	1	1	2	3	5	7	10	13	17	21	25	*30*	*36*
	50	7	8	9	10	13	16	19	23	28	34	39	*46*	*53*
	25	15	16	17	20	23	26	31	36	43	50	57	*66*	*75*
8000	75	0	1	2	3	6	8	12	16	20	25	31	*37*	*44*
	50	8	8	10	12	15	18	23	28	34	41	48	*56*	*65*
	25	17	18	20	23	26	31	37	44	51	60	70	*80*	*92*

*Modified from International Standard ISO 7029 (1984)[1] which gives estimates for threshold shifts as a function of age in highly screened populations and is known as Database A. The above table is modified from the standard by utilising a baseline for 18-year-olds that differs from the zero value in the standard. The baseline is from the bottom line of Table 6 in Lutman and Davis (1994)[12] after subtraction of 6 dB at 6 kHz to allow for the artificial increase in hearing threshold levels in that study attributable to the use of TDH-39 earphones. Specifically, the baseline values are 7.5, 5.0, 2.0, 3.5, 4.0, 6.0, 7.0 and 7.5 dB, respectively, at 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz. Figures in italics are derived from extrapolation beyond the age limit of 70 years used in the standard. Values $>$ 120 dB have been truncated at 120 dB. See also Note 12.

ler than the 10 dB or 20 dB required, then the probability of NIHL is still high. If one ear is markedly better at high frequencies and shows a significant notch or bulge, but the worse ear shows little or no trace of such, then there is still a more-likely than-not probability of NIHL: the greater hearing impairment in the worse ear may be due to some unidentified cause additional to NIHL and ordinary AAHL, that additional disorder having hidden or obliterated the noised-induced notch or bulge. In other cases there is not much difference between the two ears at high frequencies but, without apparent explanation, only one ear shows a significant notch or bulge and the other shows little or no trace of one: such cases should be regarded as very borderline and be decided on the strength of other evidence (e.g. severity of noise exposure or of temporary postexposure symptoms). Finally, if only the worse ear at high frequencies shows a significant notch or bulge, and there is little or no trace of NIHL in the better ear, then there is only a possibility of NIHL, not a probability.

Note 12. ISO 7029[1] includes a baseline term to represent the median hearing threshold level (HTL) of 18-year-olds, although the standard suggests that for practical purposes this may be assumed to be zero. Since the publication of the standard, it has become evident that values greater than zero are appropriate for representative populations screened to exclude otological disorder and noise exposure. The formulation within ISO 7029 entails that the distribution of HTLs is not fixed, but varies according to the median value. Hence, incorporation of a nonzero baseline also increases the spread of the distribution. A revision of ISO 7029 is being prepared and is currently at a final draft stage. The revised version will remove the dependence of the spread on the baseline value. Hence, the values in Tables 2 and 3 have been calculated without this dependence, to conform to the forthcoming version of the standard.

Appendix B. Worked example of application of requirement R3(a)

Take a hypothetical claimant, aged 57. He had a total of 23 years of unprotected exposure to high levels of noise in the steel industry, which would easily meet qualifying requirement R2(a), making R3(a) the relevant guideline for looking at his audiogram. His hearing was measured with an audiometer employing TDH-39 earphones. There was no conductive hearing loss.

The calculations to see whether or not there is a high-frequency audiometric bulge that meets the NIHL diagnostic guidelines are set out in Table 4 for each ear separately.

DIAGNOSTIC CONCLUSIONS

In the table for the right ear, the better-hearing ear, in line g there is a significant bulge of +13 dB at 3 kHz and of +10 dB at 4 kHz. But there is only a small, nonsignificant trace of a bulge in the worse-hearing ear of only +5 to +3 dB from 2 to 4 kHz in line g. The pattern of asymmetry (see Note 11) is such that the probable diagnosis is of NIHL and AAHL in both ears, together with an additional hearing loss of uncertain causation on the left which has obscured most of the noise damage on that side.

The measured thresholds corrected at 6 kHz (lines a in Table 4) and the adjusted AAHL values (lines f) are illustrated in Fig. 3.

Table 4. Worked example: calculations for the identification of possible presence of noise-induced hearing loss

		Hearing threshold levels (dB) at the audiometric frequencies (kHz)							
	Line	0.25	0.5	1	2	3	4	6	8
Right ear	a HTL measured* and corrected	15	10	10	20	35	40	39†	40
	b HTL at selected 'anchor points'			10					40
	c Selected AAHL statistics‡			8	13	20	28	32	38
	d Misfit values at 'anchor points' (line b minus line c)			+2					+2
	e Interpolated misfit values				+2	+2	+2	+2	
	f Adjusted AAHL values (line c plus lines d and e)			10	15	22	30	34	40
	g Audiometric bulge (line a minus line f)			0	+5	+13	+10	+5	0
Left ear	a HTL measured* and corrected	15	15	10	25	35	45	54†	60
	b HTL at selected 'anchor points'			10					60
	c Selected AAHL statistics§			13	21	30	40	51	54
	d Misfit values at 'anchor points' (line b minus line c)			−3					+6
	e Interpolated misfit values				−1	+1	+2	+4	
	f Adjusted AAHL values (line c plus lines d and e)			10	20	31	42	55	60
	g Audiometric bulge (line a minus line f)			0	+5	+4	+3	−1	0

*Corrected for any conductive hearing loss of ≥ 10 dB (see Note 5).
†Corrected by 6 dB for TDH-39 earphone calibration artefact (see Note 2).
‡ From Table 2, age 55, median values.
§ From Table 2, age 55, 75th percentile values.

Appendix E: American College of Occupational and Environmental Medicine guidelines

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Occupational Noise-Induced Hearing Loss

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Occupational hearing loss is preventable through a hierarchy of controls, which prioritize the use of engineering controls over administrative controls and personal protective equipment. The occupational and environmental medicine (OEM) physician plays a critical role in the prevention of occupational noise-induced hearing loss (NIHL). This position statement clarifies current best practices in the diagnosis of occupational NIHL.

Noise-induced hearing loss (NIHL) continues to be one of the most prevalent occupational conditions and occurs across a wide spectrum of industries. Occupational hearing loss is preventable through a hierarchy of controls, which prioritize the use of engineering controls over administrative controls and personal protective equipment. The occupational and environmental medicine (OEM) physician works with management, safety, industrial hygiene, engineering, and human resources to ensure that all components of hearing loss prevention programs are in place.[1] The OEM physician should emphasize to employers the critical importance of preventing hearing loss through controls and periodic performance audits rather than just conducting audiometric testing. Nevertheless, audiometric testing, besides documenting the permanent loss of hearing, can be of value in the identification of hearing loss at a time when early preventive intervention is possible. The American College of Occupational and Environmental Medicine (ACOEM) believes that OEM physicians should understand a worker's noise exposure history and become proficient in the early detection and prevention of NIHL.

THE OEM PHYSICIAN AS PROFESSIONAL SUPERVISOR OF THE AUDIOMETRIC TESTING COMPONENT OF A HEARING CONSERVATION PROGRAM

The OEM physician also plays a critical role in the prevention of occupational NIHL by serving as a professional supervisor of the audiometric testing element of hearing conservation programs. The Occupational Safety and Health Administration (OSHA) defines a requirement for professional supervisors in the 1983 Hearing Conservation Amendment.[2] The responsibilities of the professional supervisor can be found in the ACOEM position statement *The Role of the Professional Supervisor in the Audiometric Testing Component of Hearing Conservation Programs*.[3] Responsibilities include interpretation of audiograms, work-relatedness determinations, referral of problem cases, quality oversight of audiometric testing, and determination of the effectiveness of the hearing conservation program.

This statement clarifies current best practices in the diagnosis of NIHL. On the basis of current knowledge, it updates the previous ACOEM statement[4] regarding the distinguishing features of occupational NIHL.

DEFINITION

Occupational NIHL develops gradually over time and is a function of continuous or intermittent noise exposure. This is in contrast to occupational acoustic trauma which is characterized by a sudden change in hearing as a result of a single exposure to a sudden burst of sound, such as an explosive blast. The diagnosis of NIHL is made by the OEM physician, by first taking into account the worker's noise exposure history and then by considering the following characteristics.

CHARACTERISTICS

The principal characteristics of occupational NIHL are as follows:

- It is always sensorineural, primarily affecting the cochlear hair cells in the inner ear.
- It is typically bilateral, since most noise exposures affect both ears symmetrically.
- Its first sign is a "notching" of the audiogram at the high frequencies of 3000, 4000, or 6000 Hz with recovery at 8000 Hz.[5]
    - This notch typically develops at one of these frequencies and affects adjacent frequencies with continued noise exposure. This, together with the effects of aging, may reduce the prominence of the "notch." Therefore, in older individuals, the effects of noise may be difficult to distinguish from age-related hearing loss (presbycusis) without access to previous audiograms.[6]
    - The exact location of the notch depends on multiple factors including the frequency of the damaging noise and size of the ear canal.
    - In early NIHL, average hearing thresholds at the lower frequencies of 500, 1000, and 2000 Hz are better than average thresholds at 3000, 4000, and 6000 Hz, and the hearing level at 8000 Hz is usually better than the deepest part of the notch. This notching is in contrast to presbycusis, which also produces high-frequency hearing loss but in a down-sloping pattern without recovery at 8000 Hz.[7]
    - Although OSHA does not require audiometric testing at 8000 Hz, inclusion of this frequency is highly recommended to assist in the identification of the noise notch as well as age-related hearing loss.[8]
- Noise exposure alone usually does not produce a loss greater than 75 dB in high frequencies and greater than 40 dB in lower frequencies. Nevertheless, individuals with non-NIHL, such as presbycusis, may have hearing threshold levels in excess of these values.[8]

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- Hearing loss due to continuous or intermittent noise exposure increases most rapidly during the first 10 to 15 years of exposure, and the rate of hearing loss then decelerates as the hearing threshold increases.[9] This is in contrast to age-related loss, which accelerates over time.
- Available evidence indicates that previously noise-exposed ears are not more sensitive to future noise exposure.
- There is insufficient evidence to conclude that hearing loss due to noise will progress once the noise exposure is discontinued.[8] This is primarily based on a National Institute of Medicine report which concluded that, on the basis of available human and animal data, it was felt unlikely that such delayed effects occur.[9,10] However, recent animal experiments indicate although there appears to be threshold recovery and no loss of cochlear cells following noise exposures to rodents, there is evidence of cochlear afferent nerve terminal damage and delayed degeneration of the cochlear nerve, thus suggesting that delayed effects could be seen in the future.[11]
- Although the OSHA action level for noise exposure is 85 dB (8-hour time-weighted average), the evidence suggests that noise exposure from 80 to 85 dB may contribute to hearing loss in individuals who are unusually susceptible. The risk of NIHL increases with long-term noise exposures above 80 dB and increases significantly as exposures rise above 85 dB.[12,13]
- Continuous noise exposure throughout the workday and over years is more damaging than interrupted exposure to noise, which permits the ear to have a rest period. At the present time, measures to estimate the health effects of such intermittent noise are controversial.
- Real world attenuation provided by hearing protective devices may vary widely between individuals. The noise-reduction rating of hearing protective devices used by a working population is expected to be less than the laboratory-derived rating.[14,15] Hearing protective devices should provide adequate attenuation to reduce noise exposure at the eardrum to less than 85 dB time-weighted average. In addition, technology is now available, which can provide an individualized attenuation rating for hearing protective devices and continuous monitoring of noise at the eardrum.[16–18]
- The presence of a temporary threshold shift (ie, the temporary loss of hearing, which largely disappears 16 to 48 hours after exposure to loud noise) with or without tinnitus is a risk indicator that permanent NIHL will likely occur if hazardous noise exposure continue.[19] Barring an ototraumatic incident, workers will always develop temporary threshold shift before sustaining permanent threshold shift.[1]

ADDITIONAL CONSIDERATIONS IN EVALUATING THE WORKER WITH SUSPECTED NIHL

The OEM physician evaluating possible cases of NIHL should consider the following issues:

- Unilateral sources of noise such as sirens and gunshots can produce asymmetric loss, as can situations in which the work involves fixed placement of the affected ear relative to the noise source. When evaluating cases of asymmetric loss, referral to rule out a retrocochlear lesion, such as an acoustic neuroma,[20] is warranted before attributing the loss to noise. The physician should consult criteria, such as from the American Academy of Otolaryngology—Head and Neck Surgery, which can assist in making referrals for further evaluation.[21,22]
- Animal exposure data suggest that the addition of very intense and frequent impulse/impact noise to steady-state noise can be more harmful than steady-state noise of the same A-weighted energy exposure. (A-weighting is the most common noise measurement scale. A-weighting best approximates the way the human ear perceives loudness at moderate sound levels and it de-emphasizes high and low frequencies that the average person cannot hear.) Nevertheless, human data are currently too sparse to derive an exposure metric, which can practically estimate such a hazardous noise risk.[23,24]
- Animal models suggest that exposure to ototoxic agents, such as solvents (notably ethylbenzene, methylstyrene, n-hexane, n-propylbenzene, p-xylene, styrene, trichloroethylene, and toluene), may act in synergy with noise to cause hearing loss. Asphyxiants (carbon monoxide and hydrogen cyanide), some nitriles (such as acrylonitrile), and metals (lead, mercury, and tin) have also been implicated as causing ototoxicity. The involvement can be seen as damage to cochlear hair cells, central nervous system, or both. Although the scientific understanding of the role of all these chemicals in human ototoxicity is still evolving, a thorough exposure history to these chemicals should be obtained and taken into consideration when evaluating sensorineural hearing loss.[25–27] Further, the hierarchy of primary prevention controls should be implemented in order to mitigate the risk of an acquired dose to workers, or others, potentially exposed to ototoxic chemicals.
- Individual susceptibility to the auditory effects of noise varies widely.[28] The biological basis for this remains unclear. In addition, the contribution of comorbid conditions such as cardiovascular disease, diabetes, and neurodegenerative disease to hearing loss is unclear.[29]
- There are a number of other causes of sensorineural hearing loss besides occupational noise. Of primary concern is non-occupational noise exposure from a variety of sources, especially recreational noise, such as loud music, weapons firing, motor sports, etc. Other causes include a wide variety of genetic disorders, infectious diseases (eg, labyrinthitis, measles, mumps, syphilis), pharmacologic agents (eg, aminoglycosides, diuretics, salicylates, antineoplastic agents), head injury, therapeutic radiation exposure, neurologic disorders (eg, multiple sclerosis), cerebral vascular disorders, immune disorders, bone (eg, Paget disease), central nervous system neoplasms, and Menière's disease. A medical history can help in determining whether any of these conditions could contribute to an individual's hearing loss.[30] Nevertheless, the Genetic Information Nondiscrimination Act in some instances precludes the OEM physician from obtaining a family history,[31] which could give insight into genetic disorders such as Alport syndrome. There is an exception for when the family medical history is collected for diagnostic or treatment purposes. In such cases, when genetic or any other non-occupational condition noted earlier is suspected, a referral to an otolaryngologist or other appropriate specialist is recommended.
- Individuals with NIHL may experience significant morbidity due to hearing loss, concomitant tinnitus, and/or impaired speech discrimination. On the job, such hearing loss can impact worker communications and safety. Other conditions associated with noise exposure and/or hearing loss are hypertension, depression, dementia,[32] social isolation,[33] increased risk of accidents,[34–36] and retrocochlear lesions.[37–41] Workers with evidence of hearing loss require an individualized evaluation that takes into account both the need to communicate safely and effectively and the need for protection from additional damage due to noise.
- Because hearing loss due to noise is irreversible, early detection and

intervention is critical to prevention of this condition. Ensure baseline audiograms are obtained for new hires and/or employees newly identified as working within a noise-laden environment. A 10-dB confirmed threshold shift from baseline in pure-tone average at 2000, 3000, and 4000 Hz (OSHA standard threshold shift or STS), while not necessarily resulting in significant impairment, is an important early indicator of permanent hearing loss.[42] A temporary threshold shift is an important early and reversible indicator that potential cochlea hair cell damage can progress to an STS, unless preventive interventions occur. Tinnitus is another early warning symptom for NIHL.[8] Other early warning flags, such a 10-dB non-age-corrected STS or an 8-dB age-corrected STS, may have a higher positive predictive value in identifying those individuals who will progress to impaired hearing.[43] Therefore, individuals in hearing conservation programs who exhibit such shifts on serial audiometric testing should be carefully evaluated and counseled regarding avoidance of noise and correct use of personal hearing protection.

- Age correction of audiograms is a method of age standardization, which allows comparisons of hearing loss rates among working populations. OSHA allows, but does not require, the use of an age-correction procedure.[2] Age-correction factors are averages for a population—some individuals will exhibit more age-related loss and some less. Therefore, the application of age correction to the surveillance audiograms of a noise-exposed population can result in fewer confirmed 10-dB shifts being reported. Thus, when applying age correction to the audiometric results of an individual who has experienced a threshold shift, the OEM physician should consider whether, in that individual, a preventable noise component of hearing loss could play a role.
- Any assessment of hearing loss requires the review of all previous audiograms, as well as noise exposure records, hearing protection data, and clinical history, to assist in the diagnosis of NIHL. A referral for a comprehensive audiology evaluation, including bone conduction testing, can assist in verifying the nature of hearing loss.[44]

THE OEM PHYSICIAN'S ROLE IN DIAGNOSING NIHL

The OEM physician plays a major role in the prevention of NIHL, and to make an evidence-based clinical diagnosis, must understand factors contributing to noise exposure in the workplace, non-occupational sources of noise, chemicals known to be ototoxic, comorbidities impacting hearing, and the pathophysiology of NIHL and its clinical and audiometric characteristics. Making a diagnosis of NIHL is an important step in preventing further hearing loss in the affected worker and for identifying the potential for NIHL in coworkers. The OEM physician must work with management and other safety and health professionals to evaluate the workplace for noise exposure, educate the workers regarding the risk of noise exposure (occupational and non-occupational), and reduce the potential for noise exposure.

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