



Supplementary Guidance on **Interpreting an Audiogram for Indications of Occupational Noise-Induced Hearing Loss (NIHL)**



Introduction

All workers whose exposures are equal to or higher than an eight-hour time-weighted average of 85dBA must be under a health surveillance programme which involves audiometric testing as described in HSE's guidance document L108 (The Control of Noise at Work Regulations 2005). Health Surveillance may also be needed below the action value of 85dB (ref paragraph 103, page 24 of L108)

In 2021, the HSE revised L108, which included clarification on advice provided to health professionals in Table 12, where a new column was added regarding review for 'NIHL seen on audiogram?'. Paragraph 24 of the guidance goes on to make clear that an initial step will be for the audiogram to be assessed for the presence of NIHL.

Another update relates to referral requirements; where NIHL is newly identified or progressive, the worker should be placed in Category 3 and be referred for medical assessment by an appropriately trained doctor, e.g., an occupational physician.

Due to these recent edits, the SOM special interest group (SIG) was set up to provide further guidance as to how an "assessment" of the audiogram can be undertaken in a consistent, validated, and practical manner. This SIG reviewed the different criteria available across the evidence base and in use by other government agencies and regulatory bodies internationally.

To improve consistency, the SIG has developed a stepwise approach incorporating some of the alternative approaches to interpretation of 'NIHL as seen on audiogram'. This guidance is not obligatory, and occupational health providers are free to use any preferred means to interpret the audiogram, so long as they can justify that this is a valid and trusted methodology for these purposes.

In publishing this supplementary guide, the SOM will continue to review the practicality and relevance of this advice through a pilot scheme, where we will engage a group of providers to give feedback on its application in real-life health surveillance scenarios.

This guide should be read in conjunction with the SOM position statement.¹

This stepwise approach does not necessarily represent the views of any individual member of the group, and the SIG makes no assumption that its recommendations represent the views of all the members of the SIG.

While this stepwise approach is presented in good faith, it is the responsibility of the reader to ensure their approach to matters relating to 'audiometric interpretation and NIHL' accords with current best practice and legal requirements, and the SOM will accept no responsibility resulting from the failure of any reader to do so.

This guide lays out the structure for a tiered approach to noise health surveillance, where the initial health surveillance check as outlined in the HSE's L108 guidance is considered a first-tier screening test.

There is also a Symptom Questionnaire in Appendix A, and notes to the Questionnaire at Appendix B.

REFERENCES

1. https://www.som.org.uk/sites/som.org.uk/files/SOM_UKHCA_Position_Statement_Noise_Health_Surveillance_Guidance_May_23.pdf



Step 1: Screening for Occupational Noise-Induced Hearing Loss

Assessing individuals for occupational noise induced hearing loss

- Clarify that the individual is frequently noise exposed in the workplace (above 85dB LEPd) and has completed a noise and health questionnaire as provided in L108 Appendix 5 or equivalent. Note that health surveillance may also be needed below the action of 85dB (ref. paragraph 103, page 24 of L108).
- Sum hearing levels obtained at 1, 2, 3, 4 and 6 kHz, for each ear separately. Compare the summation with the values given for age and sex in Table 13 of Appendix 4 (L108). You should also sum hearing levels at 3, 4 and 6 kHz to detect any rapid hearing loss as defined in L108 Appendix 4.
- Observe the audiogram for a notch. There are a number of criteria available to define what a noise-induced hearing loss notch looks like. These are summarised below and may be helpful in making an initial interpretation of the audiogram for possible indications of noise-induced hearing loss.

Whose notch is it anyway?

Hoffman	<ul style="list-style-type: none">• any threshold at 3, 4 or 6 kHz exceeds by 15 dB HL the average threshold in the low/middle frequencies, 0.5 and 1 kHz, and the threshold at 8 kHz is at least 5 dB HL better (lower) than the maximum threshold at 3, 4 or 6 kHz.
Coles	<ul style="list-style-type: none">• high-frequency notch when the hearing threshold level at 3 and/or 4 and/or 6 kHz is at least 10 dB HL greater than the thresholds at 1 or 2 kHz and at 6 or 8 kHz
The 4-kHz notch	<ul style="list-style-type: none">• hearing thresholds at 2 and 8 kHz that are both at least 10 dB HL lower than (better than) the threshold at 4kHz.
Wilson	<ul style="list-style-type: none">• thresholds at 2 and 8 kHz that are both at least 10 dB HL lower than (better than) the threshold at the notch frequency of interest (3, 4 or 6 kHz).

- Assess the audiogram for possible presence of occupational NIHL. The SOM recommend occupational health professionals use the OSHA criteria to conduct this assessment. If there is a change in hearing threshold relative to the baseline audiogram of an average of 10dB or more at 2000, 3000 and 4000 Hz in either ear², then this can be classed as indicative of occupational NIHL, considered to reflect a notch in the audiogram, and in accordance with HSE guidance may be classified as Category 3. This should be considered alongside the noise and health questionnaire information completed by the individual.
- The outcome of the above assessment may not default to a Category 3 if the NIHL detected can be considered a 'stable' situation or condition. Stable NIHL (Category 2) can only be judged in comparison with previous audiogram results (if available). If there is no change from previous test results or it has progressed consistently across all frequencies or the audiometric pattern is indicative of age related hearing loss. If this is in doubt, you may wish to retest at up to six months in the future to ensure this is a real newly identified or progressive hearing loss or whether this is 'stable' (and therefore remains a Category 2 if assessed as such using the HSE categorisation criteria).
- If no indications of occupational NIHL are detected and no other hearing health conditions suspected, then the individual will revert to ongoing regular reassessment whilst they remain noise exposed. The occupational physician (OHP) will receive a referral if the individual is categorised as 3 or 4 in the HSE categorisation scheme including all relevant information and advice gleaned from the Step 1 assessment.

REFERENCES

2. <https://www.osha.gov/laws-regs/standardinterpretations/1989-11-17#:~:text=An%20STS%20is%20defined%20at,threshold%20values%20in%20the%20baseline>



Step 2: Occupational Health Physician Review

- Where a Category 3 or 4 is identified, there must be referral to an occupational physician. Where other non-occupational hearing health concerns are identified, you may refer directly to Step 3. This should include suspected unilateral hearing loss as defined in L108 Appendix 4 paragraph 27 (*Sum the hearing levels at 1, 2, 3 and 4 kHz for both ears. If the difference between the ears is greater than 40dB, the individual should be advised of the findings and referred for medical advice.*).
- The OHP may use the Coles/Brewster criteria for further assessment of the audiogram for indication of occupational noise-induced loss³.
- If they have access to the individual, they may also use the further question set outlined in Appendix A of this guide to explore evidence for occupational NIHL and other non-occupational causes.
- A judgement is made, and advice collated for the employer, on whether there are indications of occupational NIHL in order to allow adaptations in the workplace for general control improvement, and the trigger of specific legal duties as outlined in Reg 9(4) of the Control of Noise at Work Regulations, or for the individual if they are deemed particularly susceptible, and on fitness for continued exposure to noise in the workplace. Feedback is also provided to the individual.
- The OHP may require that the individual has further testing or clinical support for their health status via step 3.

REFERENCES

3. Noise induced hearing loss - An examination of the methods of assessment in a cross-sectional study of 87 industrial workers. Das S., Mulhearn, M., Brewster M. & Banerjee A.R. Clinical Otolaryngology. 2017; 1-7. <https://pubmed.ncbi.nlm.nih.gov/29119679/>



Step 3: Further testing or clinical support

An occupational health provider or OHP may decide that the individual requires further specific audiological or clinical examination and support. This may be via audiology, ENT or other specific specialist referral. (Note this section and access to further support needs development with other specialists such as the British Society of Audiology).

Flow Chart of testing and referral

The flow chart below outlines a possible process for testing and onward referral of individuals.





Appendix A: Symptom Questionnaire

Appendix 5 of L108 has a sample noise and health questionnaire for use prior to audiometry with the purpose of gathering personal, medical, family and military history including tinnitus and potential exposure to ototoxins. However pure tone audiometry, on its own, is a poor predictor of disability experienced with everyday activities that involve hearing. An additional symptom questionnaire including specific questions on hearing loss and associated disability is outlined here. These additional questions are not intended to replace the L108 questionnaire but to supplement it: any cross-over issues relating to past medical and family history are highlighted where relevant. To assist the practitioner's understanding on the specific purpose of these questions some background, clarification notes and references are included.

There are numerous detailed questionnaires often accompanied by studies in the literature specific to individual auditory symptoms such as hyperacusis and tinnitus. It is not the intention to list or repeat these here but to focus on answers to key questions the practitioner may find helpful when receiving a referral with 'NIHL seen on the audiogram'. Taken in the context of workplace health surveillance, which may involve a significant volume of audiograms, these questions are by necessity relatively brief and targeted towards a putative attribution to noise and the exclusion of other causes – as such it is a referral exercise and not a diagnostic one and none of the questions are unique to NIHL. Whilst a lot of symptoms listed will be reflective of significant hearing deficits some such as speech in noise identification and sensitivity are also potential early indicators of damage – a primary aim of health surveillance. A benefit from the collection of these symptoms is they provide a snapshot of overall personal disability in a health surveillance setting without recourse to more extensive questionnaires.

1. Do you consider your hearing to be normal?

Left ear	YES	NO
Right ear	YES	NO

2. If not, how long has that been?

Date of onset:

If answer to Q1 is NO*, please complete the following additional questions (*see note 1):

- | | | | |
|---|----------|-----------|---------|
| 3. Did the loss come suddenly or gradually? (Please circle.) | Suddenly | Gradually | |
| 4. Do you hear better or worse in a noisy environment? (Please circle.) | Better | Worse | Neither |
| 5. Do you have difficulty perceiving speech in a crowded room? | YES | NO | |
| 6. Do everyday sounds seem louder to you? | YES | NO | |
| 7. Do you notice difficulty adjusting between quiet and loud sounds? | YES | NO | |
| 8. Do you have difficulty perceiving pitch? | YES | NO | |
| If you answered yes, is it different between your ears? | YES | NO | |
| 9. Do you avoid or feel fatigued by everyday sounds? | YES | NO | |



Appendix B:

Notes to Symptom Questions

1. Individuals are sometimes unsure regarding whether and how long they have had hearing loss, and it can be advantageous, if practicable, to verify this with a spouse, partner or family member.¹ Paradoxically, it can be a partner's description of their hard-to-hear soft speech which might point to otosclerosis (particularly if accompanied by a Carhart notch at 2 kHz on the bone conduction audiogram reflecting the impaired resonant frequency of the ossicles).² Any indication of a unilateral audiometric hearing loss, whether symptomatic or not, should be investigated to exclude an acoustic neuroma prior to attributing to atypical/asymmetrical occupational noise exposure..
2. Whilst the majority of cases of NIHL will develop over many years (notably the first 10 years), symptoms of hearing loss are often not noticed until they involve speech frequency identification.

However, otosclerosis and presbycusis similarly develop slowly. A number of conditions can develop suddenly, such as Ménière's disease or bacterial and viral infections. A temporal association with head injury or acoustic trauma from very loud noise exposure should be self-evident in sudden causes.

3. This seemingly abstruse question may point to the eponymous phenomenon of 'paracusis of Willis' (or 'Willisii'), where the person hears better in noise than in quiet, indicating a conductive loss. Those with sensorineural loss have difficulty hearing in a noisy environment whereas those with conductive loss tend to hear better due to the raised volume of speech in others (the Lombard reflex). Whilst valuable when reported, its discriminatory value has been questioned.³
4. Sometimes referred to as the 'cocktail party effect', this symptom of speech identification in a crowded room is commonly described by those with sensorineural hearing loss. However, the assessing practitioner needs to be alert to the possibility of an auditory processing disorder (APD) sometimes a feature of those with neurodiversity.⁴
5. Hyperacusis or 'sound sensitivity' is defined as an abnormal lowered tolerance to sound, often coincident with tinnitus, both of which can occur in sensorineural hearing loss. It is unclear but generally thought to be a defect in central or neural auditory processing. Whilst relatively uncommon, it can result from prolonged exposure to noise and occur in the absence of actual sensorineural hearing loss. An inventory of hyperacusis symptoms has been developed.⁵
6. Recruitment is another phenomenon where sound is perceived to become suddenly louder with increasing sound level. This can have the paradoxical effect whereby those affected request an initial "speak louder" followed by a complaint of "stop shouting". This is a feature of cochlear damage (stereocilia damage to the outer hair cells (OHCs) of the basilar membrane; OHCs are a feature of NIHL) or, more simply, more the sensory than the neural aspect of sensorineural hearing loss. For hearing loss of up to about 45dB, audibility is the single most important factor, but as losses increase, poor discrimination of suprathreshold audible stimuli (including temporal and pitch discrimination) becomes more important.⁶

REFERENCES

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2. Carhart R. Clinical application of bone conduction audiometry. Archives of Otolaryngology 1950; 51(6): 798-808. doi: 10.1001/archotol.1950.00700020824003
3. Quinn KJ and Coelho DH. The Curious Rise and Incomplete Fall of "Paracusis Willisii". Otol Neurotol. 2022; 43(1): 137-143. doi: 10.1097/MAO.0000000000003368
4. Auditory processing disorder (APD): <https://www.nhs.uk/conditions/auditory-processing-disorder/>
5. Greenberg B and Carlos M. Psychometric Properties and Factor Structure of a New Scale to Hyperacusis: Introducing the Inventory of Hyperacusis Symptoms. Ear and Hear. 2018; 39(5): 1025-1034. doi: 10.1097/AUD.0000000000000583
6. Moore BC. Perceptual consequences of cochlear hearing loss and their implications for the design of hearing aids. Ear and Hear. 1996; 17(2): 133-61. doi: 10.1097/00003446-199604000-00007



Appendix B: Notes to Symptom Questions (cont.)

7. Pitch perception is another suprathreshold discriminatory problem, sometimes referred to as 'double hearing'. Diplacusis is a specific term describing an anomaly whereby the same tone is perceived as having a different pitch when presented to the right and the left ear of the same listener. Important for speech and music appreciation, it may manifest symptomatically as another feature of the complex noises of the 'cocktail party effect', where the individual is not able to segregate sounds that arrive from different sources, such as the punchline of a joke, because of others' laughter.⁷
8. In addition to hearing loss, tinnitus and sound sensitivity, long-term noise exposure can lead to sound-induced auditory fatigue, which results in avoidance behaviour to everyday sound and the seeking of silence. Though probably more a reflection of exposure, there has been report of statistically significant associations between occupational noise, tinnitus, and sound-induced auditory fatigue.⁸

7. Oxenham AJ. Pitch perception and auditory stream segregation: implications for hearing loss and cochlear implants. *Trends Amplif.* 2008; 12(4): 316–31. doi: 10.1177/1084713808325881

8. Fredriksson S, Hammar O, Torén K et al. The effect of occupational noise exposure on tinnitus and sound-induced auditory fatigue among obstetrics personnel: a cross-sectional study. *BMJ Open* 2015; 5: e005793. doi:10.1136/bmjopen-2014-005793



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