



Department of Occupational Safety and Health
Ministry of Human Resources



GUIDELINES ON MANAGEMENT OF OCCUPATIONAL NOISE-RELATED HEARING DISORDERS

2021



DEPARTMENT OF OCCUPATIONAL SAFETY AND HEALTH
MINISTRY OF HUMAN RESOURCES MALAYSIA

GUIDELINES ON MANAGEMENT OF OCCUPATIONAL NOISE-RELATED HEARING DISORDERS

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PREFACE

These are the Guidelines on Management of Occupational Noise-Related Hearing Disorders.

The purpose of these Guidelines is to assist Occupational Health Doctors (OHDs) in managing occupational noise-related hearing disorders following the Occupational Safety and Health (Noise Exposure) Regulations 2019 and the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

OHDs are also required to read these Guidelines in conjunction with the Occupational Safety and Health (Noise Exposure) Regulations 2019 and the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019. This move facilitates them in fulfilling the relevant requirements in a comprehensive and integrated approach.

All OHDs are expected to adopt and adapt these guidelines as a source of reference in managing noise-related hearing disorders.

These guidelines are reviewed from time to time. OHDs and other occupational health practitioners are encouraged to give their comments in writing to DOSH Malaysia so that these guidelines can be continuously improved.

I thank and acknowledge those who have contributed to the development of these guidelines.

Director-General
Department of Occupational Safety and Health,
Malaysia
2021

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Special thanks to the Department of Otolaryngology-Head & Neck Surgery (ORL-HNS), International Islamic University Malaysia (IIUM) for allowing us to use their facilities for photographic session for these Guidelines.

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This guidelines has been endorsed by the Department's Policy Review Committee chaired by the Director General of the Department of Occupational Safety and Health (DOSH).

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TERMS AND DEFINITIONS

TERM	DEFINITION
abnormal audiogram	An audiogram that shows a Hearing Loss, Hearing Impairment, or permanent Standard Threshold Shift (STS)
approved	Approved in writing by the Director-General of Occupational Safety and Health
attenuation	A reduction in the amplitude of a sound
audiogram	A graphical record obtained from the results of hearing tests with an audiometer which charts, among others, the threshold of hearing at various frequencies against sound intensity in decibels
audiometric report	A report that contains, but is not limited to, the employee's personal and employment particulars, test date, employee's noise exposure level, relevant medical history and hobbies, audiogram, interpretation, medical examination report, and recommendation as necessary
audiometric test (or testing)	The measurement of the hearing threshold levels of a person employing monoaural pure tone air conduction threshold tests
audiometric test centre	A facility to determine an employee's hearing threshold
baseline audiogram	The audiogram against which future audiograms are compared to
daily noise exposure level $L_{ex, 8h}$	The equivalent continuous sound pressure level corrected for a typical working day of 8 hours
decibel (dB)	A dimensionless unit for expressing sound levels. It is based on the logarithm of the ratio between a measured and referenced sound level
dB(A)	A-weighted decibel a unit of measurement of sound pressure level corrected to the a-weighted frequency scale utilizing an electrical network having the characteristics specified accordingly by the International Electrotechnical Commission (IEC) using a reference sound pressure level of 20 micropascals
dB(C)	C-weighted decibel a unit of measurement of sound pressure level corrected to the c-weighted frequency scale employing an electrical network having the characteristics specified accordingly by the International Electrotechnical Commission (IEC) using a reference sound pressure level of 20 micropascals
Diagnostic Pure Tone Audiometry	For these guidelines, this term refers to the measurement of the hearing threshold levels of a person through air and bone conduction threshold test with or without masking
Director-General	The Director-General of Occupational Safety and Health appointed under subsection 5(1) of the act
Employee	An employee comes within the definition of 'employee' under the Occupational Safety and Health Act 1994 [Act 514]
Employer	Employer comes within the definition of 'employer' under the Occupational Safety and Health Act 1994 [Act 514]
Excessive Noise	Daily noise exposure level exceeding 82 dB(A) or daily personal noise dose exceeding fifty percent or maximum sound pressure level exceeding 115 dB(A) at any time or peak sound pressure level exceeding 140 dB(C)
Hearing Conservation Administrator	A person appointed by an employer to administer and supervise a hearing conservation program
Hearing Conservation Program	A program structured to the specific needs of the organization to prevent occupational noise-related hearing disorders
Hearing Impairment	The arithmetic average of the permanent hearing threshold level of an employee at 500, 1000, 2000, and 3000 hz, which is shifted by 25 dB or more compared to the standard audiometric reference level
Hearing Loss	Partial or total inability to hear marked by a hearing threshold worse than 25 dB at any audiometric test frequency. Hearing loss may be mild (26 to 40 dB), moderate (41 to 70 dB), severe (71 to 90 dB), or profound (equal or more than 91 dB)



TERM	DEFINITION
Medical Examination	An examination by an occupational health doctor which consists of medical history taking, physical examination, and other relevant investigations to diagnose or rule out any occupational or non-occupational auditory disorder
Noise Exposure	The amount of sound pressure exposed to a person's unprotected ear
Noise Exposure Limit	Noise exposure limits defined in Regulation 6 of Occupational Safety and Health (Noise Exposure) Regulations 2019
Noise Risk Assessor	Any person appointed by the employer and registered with the Director-General and possess a valid certificate to carry out a noise risk assessment
Noise-Induced Hearing Loss	Hearing loss arising from exposure to noise
Occupational Health Doctor	A registered medical practitioner under the Medical Act 1971 with a valid annual practicing certificate, who is also registered with Director -General and possesses a valid occupational health doctor certificate
Occupational Noise-Related Hearing Disorders	Occupational-related Noise-induced Hearing Loss (NIHL), hearing impairment, and permanent Standard Threshold Shift (STS)
Peak Sound Pressure Level	The highest C-weighted instantaneous sound pressure level of any impact
Personal Hearing Protector	A device put on by a person to prevent unwanted auditory effects from acoustic stimuli
Place of Work	Premises where persons work, or premises used for the storage of plant or substance
Quiet	Absence of exposure to sound levels exceeding 80 dB(A)
Screening Pure Tone Audiometry	For these guidelines, this term refers to measuring the hearing threshold levels of a person through air conduction threshold tests, as stipulated by the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.
Shall	A requirement is mandatory based on related legislations
Should	A recommendation

ABBREVIATION

ATC	Audiometric Testing Centre
BSA	British Society of Audiology
DOSH	Department of Occupational Safety and Health
HCP	Hearing Conservation Program
HI	Hearing Impairment
HL	Hearing Loss
ICOP	Industry Code of Practice
MRI	Magnetic Resonance Imaging
NEL	Noise Exposure Limit
NICE	The National Institute for Health and Care Excellence, UK
NIHL	Noise-induced Hearing Loss
NRA	Noise Risk Assessor
NRHD	Noise-related Hearing Disorders
NRR	Noise Reduction Rating
OHD	Occupational Health Doctor
ONRHD	Occupational Noise-related Hearing Disorders
ORL	Otorhinolaryngology
PHP	Personal Hearing Protector
PTA	Pure Tone Audiometry
SEG	Similar Exposure Group
SNR	Single Number Rating
SOCSO	Social Security Organization
SPL	Sound Pressure Level
STS	Standard Threshold Shift
TM	Tympanic Membrane

CHAPTER 01

INTRODUCTION

1.1 OVERVIEW OF THE RECENT OCCUPATIONAL NOISE-RELATED HEARING DISORDERS' SITUATION IN MALAYSIA

Noise-induced hearing loss (NIHL) is a public health concern, and it is the foremost preventable cause of hearing loss in the workplace. Exposure to high noise levels can cause permanent hearing damage, often without the sufferer being aware of it until it is too late. It may lead to tinnitus (ringing in the ears) or deafness. Noise can also be a safety hazard at work, interfering with communication and making warning sounds harder to hear.

Figure 1.1 shows the DOSH's statistics on occupational noise-related hearing disorders (ONRHD) from 2013 to 2019. From the chart, we can see that the trend of reported cases is progressively increasing every year. However, there are also substantial gaps between the number of cases notified to DOSH with the number of cases confirmed after DOSH's investigations. This inaccurate reporting made by employers and medical practitioners was possibly due to various factors such as difficulty in understanding the definition of Noise-Induced Hearing Loss (NIHL), Permanent STS and Hearing Impairment, and the complexity in establishing work-relatedness.

KEY HIGHLIGHTS 2018-2020¹

STATES WITH THE MOST CONFIRMED ONRHD CASES

-  Pulau Pinang
-  Johor
-  Selangor
-  Negeri Sembilan

INDUSTRIAL SECTORS WITH THE MOST CONFIRMED CASES

-  Manufacturing
-  Mining & Quarrying
-  Utilities
-  Transport, Storage & Communication

MANUFACTURING SUB-SECTORS WITH THE MOST CONFIRMED ONRHD CASES

-  Manufacturing of Food and Beverages
-  Manufacturing of Metal Product
-  Manufacturing of Rubber and Plastic Product
-  Manufacturing of Machineries and Equipments

Worldwide, 16% of the disabling hearing loss in adults is attributed to occupational noise.²

¹ Department of Occupational Safety and Health

² Nelson, D. I., Nelson, R. Y., Concha-Barrientos, M., Fingerhut, M. (2005). The Global Burden of Occupational Noise-induced Hearing Loss.

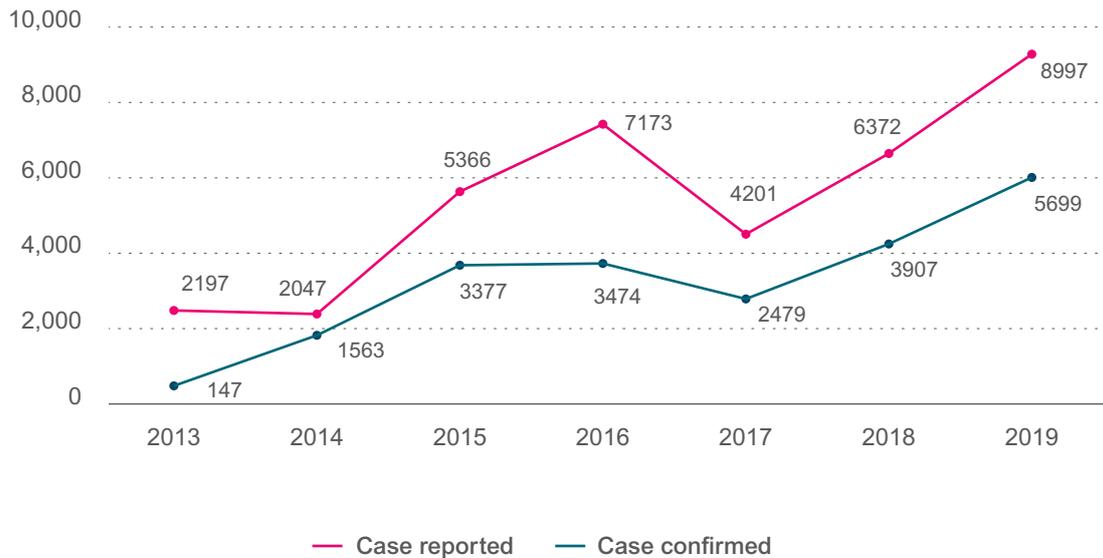


Figure 1.1: DOSH's statistics on cases of occupational noise-related hearing disorders from 2013 to 2019

One of the main difficulties faced by OHDs is diagnosing ONRHD. The new Regulations has taken a bold step by empowering the OHDs to diagnose ONRHD, specifically occupational noise-induced hearing loss (NIHL). These guidelines serve as an essential guide for the OHDs in diagnosing and managing ONRHD to reduce non-ONRHD being reported. This initiative further enhances OHDs' role in addressing issues related to occupational noise in the industries.

1.2 THE IMPORTANCE OF CONFIRMING THE DIAGNOSIS OF OCCUPATIONAL NOISE-RELATED HEARING DISORDERS.

Previously, the decisions made by OHDs in notifying ONRHD to DOSH are solely based on the results from screening pure tone audiometry, resulting in a significant number of unconfirmed cases brought to the attention of DOSH. Thus, DOSH had decided to encourage OHD to only notify confirmed ONRHD cases to DOSH based on diagnostic pure tone audiometry results. This move facilitates the following:

- Increasing reliability and accuracy of current ONRHD statistics;
- reducing Occupational Diseases Rate of the organization;
- easing compensation process; and
- avoiding inaccurate notification and unnecessary DOSH visits to the workplace.

1.3 THE PROCESS OF CONFIRMING THE DIAGNOSIS OF OCCUPATIONAL NOISE-RELATED HEARING DISORDERS.

Audiometric test prescribed in the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019 is limited to air conduction. In this situation, conductive hearing loss cannot be differentiated from sensorineural hearing loss. In diagnostic pure tone audiometry, both air and bone conduction tests are performed, with masking done when necessary, to distinguish between conductive and sensorineural hearing loss.

The prerequisite criteria for diagnosing Occupational Noise-Related Hearing Disorders is establishing sensorineural hearing loss achievable only by conducting diagnostic pure tone audiometry³.

1.4 OBJECTIVES

1.4.1



To guide Occupational Health Doctors (OHDs) in supervising workplace audiometric screening, diagnosing occupational noise-related hearing disorders (ONRHD), and notifying ONRHD to DOSH.

1.4.2



To provide OHDs with a guide to the principle criteria of SOCSO compensation.

1.4.3



To supplement the Occupational Safety and Health (Noise Exposure) Regulations 2019 and the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

1.5 SCOPE AND APPLICATION

These guidelines are only applicable to all activities conducted under the Occupational Safety and Health (Noise Exposure) Regulations 2019 and the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

1.6 READING GUIDANCE

To better understand the overall process of audiometric testing, OHDs are advised to read these guidelines as a whole, together with Occupational Safety and Health (Noise Exposure) Regulations 2019 and Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

CHAPTER 02

LEGAL PROVISIONS RELATED TO OCCUPATIONAL NOISE-RELATED HEARING DISORDERS

5



main legal provisions related to occupational noise are:

- Occupational Safety and Health Act 1994 (*Act 514*)
- Occupational Safety and Health (Noise Exposure) Regulations 2019
- Occupational Safety and Health (Notification of Accident, Dangerous Occurrence, Occupational Poisoning, and Occupational Disease) Regulations 2004
- Employees' Social Security Act 1969 (*Act 4*)
- Self-employment Social Security Act 2017 (*Act 789*)

.....

2.1 OCCUPATIONAL SAFETY AND HEALTH ACT 1994 (ACT 514).

OSHA 1994 aims to secure persons' safety, health and welfare at work and protect others in relations to the activities or persons at work. The objectives of this Act are:

- To secure the safety, health and welfare of persons at work.
- To protect persons at the place of work other than persons at work.
- To promote an occupational environment adaptable to the person's physiological and psychological needs.
- To provide the means towards a legislation system based on regulation and industry codes of practice in combination with the provisions of the Act.

“ it shall be the duty of every employer and every self-employed person to ensure, so far as is practicable, the safety, health and welfare at work of all his employees. ”

Section 15(1) OSHA 1994 stipulates that “it shall be the duty of every employer and every self-employed person to ensure, so far as is practicable, the safety, health and welfare at work of all his employees.” In addition, section 15(2)(e) indicates the provision and maintenance of a working environment for his employees that is, so far as is practicable, safe without health risks and adequate as regards to facilities for their welfare at work.

2.2 OCCUPATIONAL SAFETY AND HEALTH (NOISE EXPOSURE) REGULATIONS 2019

The regulations enacted were to emplace the following:

- To replace the Factories and Machinery (Noise Exposure) Regulations 1989
- To introduce the new noise exposure limit (NEL) and impose a more practical standard to control the exposure of excessive noise to the employees at the place of work
- To enforce the regulation to all sectors under Occupational Safety and Health Act 1994 [Act 514].
- Together with the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019 promulgated under Section 37 of Occupational Safety and Health Act 1994 [Act 514] as guidance to comply with the provisions of this regulation

2.3 OCCUPATIONAL SAFETY AND HEALTH (NOTIFICATION OF ACCIDENT, DANGEROUS OCCURRENCE, OCCUPATIONAL POISONING AND OCCUPATIONAL DISEASE) REGULATIONS 2004.

The regulations were enacted into achieving the following objectives.

- To comply with the act of reporting any accident, dangerous occurrence, occupational poisoning and occupational disease occurring at the workplace.
- To standardize the reporting of any accident, dangerous occurrence, occupational poisoning and occupational disease occurring at the workplace (where only hearing impairment listed in the 3rd Schedule).
- To establish valid and reliable data.

Regulation 7 stipulates those cases of occupational poisoning and disease as described below.

- Regulation 7(1); An employer shall send a report in an approved form to DOSH within seven days. A person at work suffers from occupational poisoning or occupational disease in the 3rd Schedule (where only hearing impairment listed in the 3rd Schedule).
- Regulation 7(2); A registered medical practitioner or medical officer attending to a patient suffering from any occupational poisoning or occupational diseases listed in the 3rd Schedule shall within seven days report to DG and notify the patient's employer (where only hearing impairment listed in the 3rd Schedule).

2.4 EMPLOYEES' SOCIAL SECURITY ACT 1969 (ACT 4)

The compensation of occupational diseases is specified in the Employees' Social Security Act 1969, specifically in Sections 28 and 32(A). Section 28 of the Act details the definition of occupational diseases. Section 32(A) describes the function and procedures of the Special Medical Board in determining occupational diseases and the subsequent impairment assessment related to the disease. The Fifth Schedule of the Act contains compensable occupational diseases, including Noise-Induced Hearing Loss and Acoustic Trauma.

2.5 SELF-EMPLOYMENT SOCIAL SECURITY ACT 2017 (ACT 789)

The compensation for occupational diseases is specified in the Self-Employment Social Security Act 2017, specifically in Sections 16 and 40. Section 16 of the Act details the definition of occupational diseases, while Section 40 describes the procedures in determining occupational diseases and the subsequent impairment assessment.

CHAPTER 03

ROLES OF OCCUPATIONAL HEALTH DOCTOR IN MANAGING OCCUPATIONAL NOISE-RELATED HEARING DISORDERS

3.1 ROLES OF OCCUPATIONAL HEALTH DOCTORS (OHD)

OHDs are registered medical practitioners under the Medical Act 1971 with valid Annual Practising Certificate, who are also registered with the Director-General and possess a valid Occupational Health Doctor certificate.

OHD's roles in managing occupational noise-related hearing disorders are clearly stated in the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019, which are.

- ensure the audiometric testing conducted by an audiometric technician is following the procedures and legal requirements.
- interpret audiograms and diagnose hearing disorders accordingly.
- notify occupational noise-related hearing disorders to the Director-General.
- revise baseline audiogram of an employee if necessary.
- refer an employee with a hearing disorder to establish a diagnosis or for further treatment if needed and follow them up.
- instruct the employer to repeat the audiometric testing of an employee with STS within three (3) months from the date of the previous audiometric test.
- perform a medical examination for an employee with an abnormal audiogram.
- instruct the employer to refit and retrain in the use of PHP for an employee with hearing impairment, hearing loss, or permanent STS; and
- inform an employee with an abnormal audiogram regarding his condition and educate him on best practices to conserve hearing.

Additional roles that OHDs might need to do are.

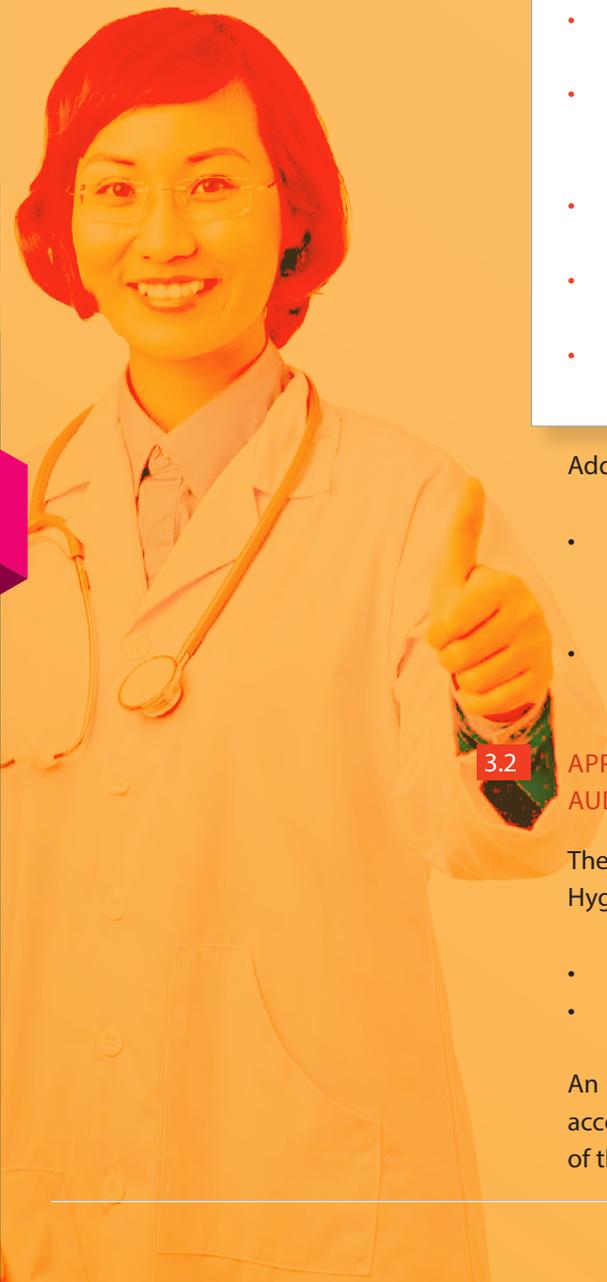
- assist workers and employers in the compensation process, including establishing the diagnosis and preparing the appropriate medical report; and
- assist the employer in implementing effective HCP at the workplace.

3.2 APPOINTMENT OF OCCUPATIONAL HEALTH DOCTOR BY AN AUDIOMETRIC TESTING CENTRE (ATC)

The ATC is required to send the following documents to the Industrial Hygiene and Ergonomics Division of DOSH Malaysia to appoint an OHD:

- OHD registration certificate; and
- OHD appointment letter.

An ATC may appoint more than one OHD. Each appointment must be accompanied by an official appointment letter and registration certificate of the respective OHD to be sent to DOSH.



CHAPTER 04

OVERVIEW OF THE AUDIOMETRIC TESTING



This audiometric testing is a legal requirement for companies to include all employees exposed to the Noise Exposure Limit (NEL)..

The audiometric testing flowchart found in Appendix 3 of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019 summarizes the process flow from the start of audiometric testing until its intended conclusion. This audiometric testing is a legal requirement for companies to include all employees exposed to the Noise Exposure Limit (NEL) as stipulated in the Occupational Safety and Health (Noise Exposure) Regulations 2019. For these employees, audiometric testing should be conducted annually.

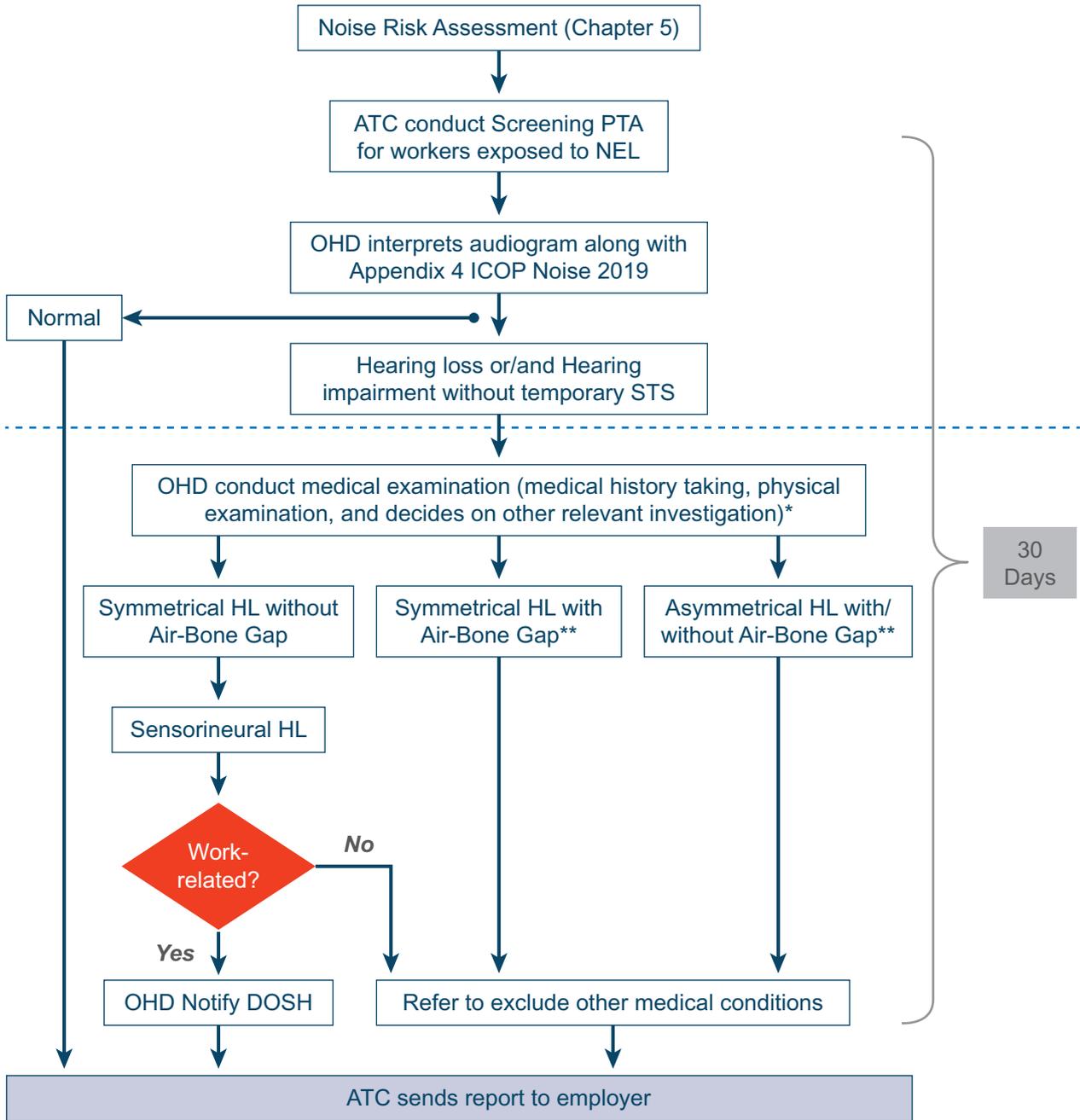
For these guidelines, the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019's flow chart was elaborated to understand the audiometric testing process further. Three (3) flow charts prepared explained the process of audiometric testing based on four (4) possible outcomes of screening audiometric testing.



The four (4) outcomes are:

- **Figure 4.1:** Normal Audiogram;
- **Figure 4.1:** Hearing Loss or/and Hearing Impairment without temporary STS.
- **Figure 4.2:** Hearing loss or/and Hearing Impairment with temporary STS.
- **Figure 4.3:** Temporary STS only.

The three flow charts also highlight the different requirements for report submission by ATC to the employer.

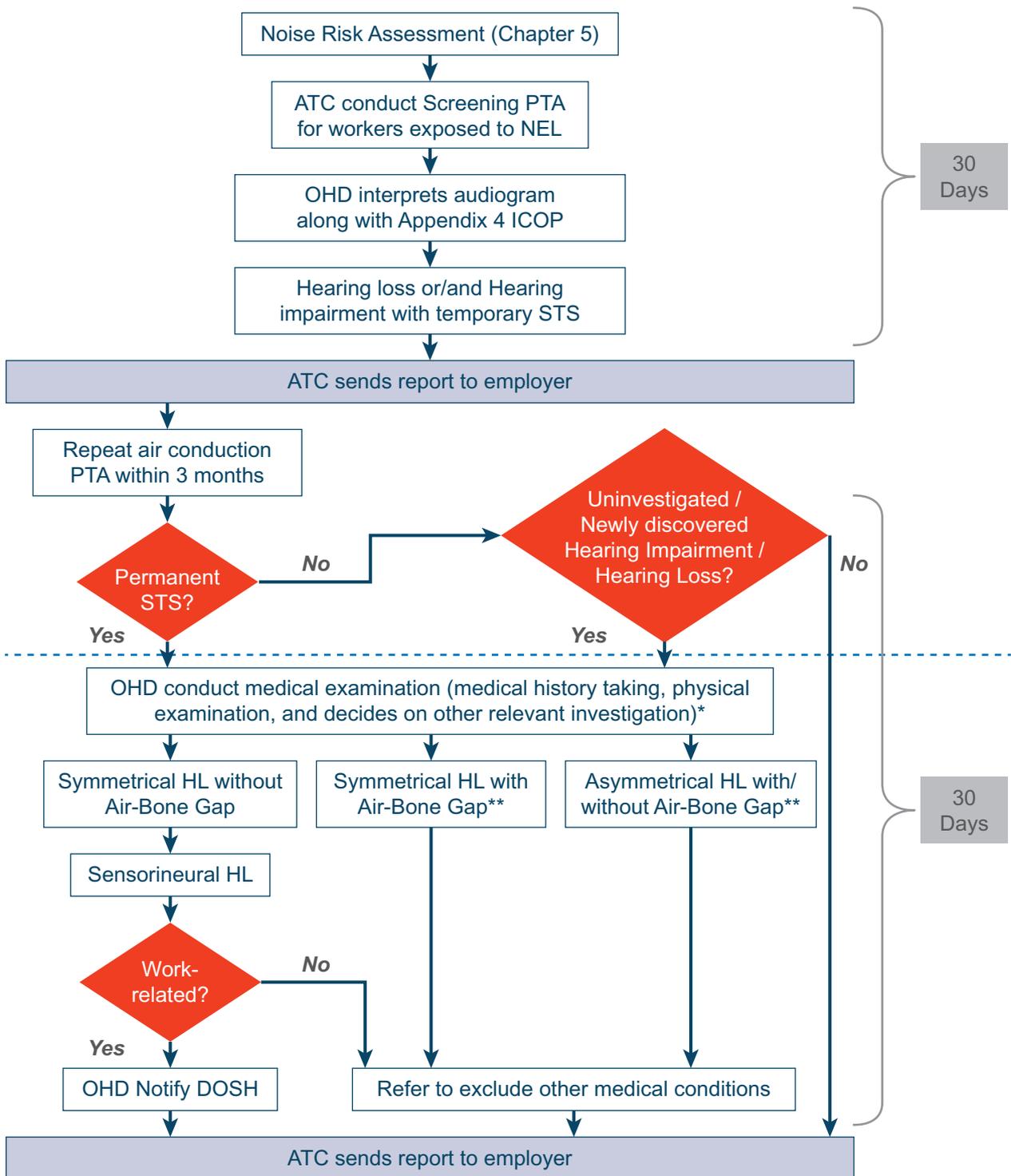


* Medical Examinations shall be repeated for a previously diagnosed NIHL or HI ONLY if there are changes in the hearing status. This is applicable for a case of “previously diagnosed NIHL with HI and/or permanent STS in current audiometry” and “a previously diagnosed HI with permanent STS in current audiometry”.

** For Symmetrical HL/Asymmetrical HL with or without Air-Bone Gap may still be work-related and require notification to DOSH

Note: The blue line indicates separation between the time when screening pure tone audiometry and diagnostic pure tone audiometric is needed

Figure 4.1: Audiometric Testing Flow Chart based on the outcome of screening audiometric testing (Normal Audiogram and Audiogram with Hearing Loss or/and Hearing Impairment without temporary STS)

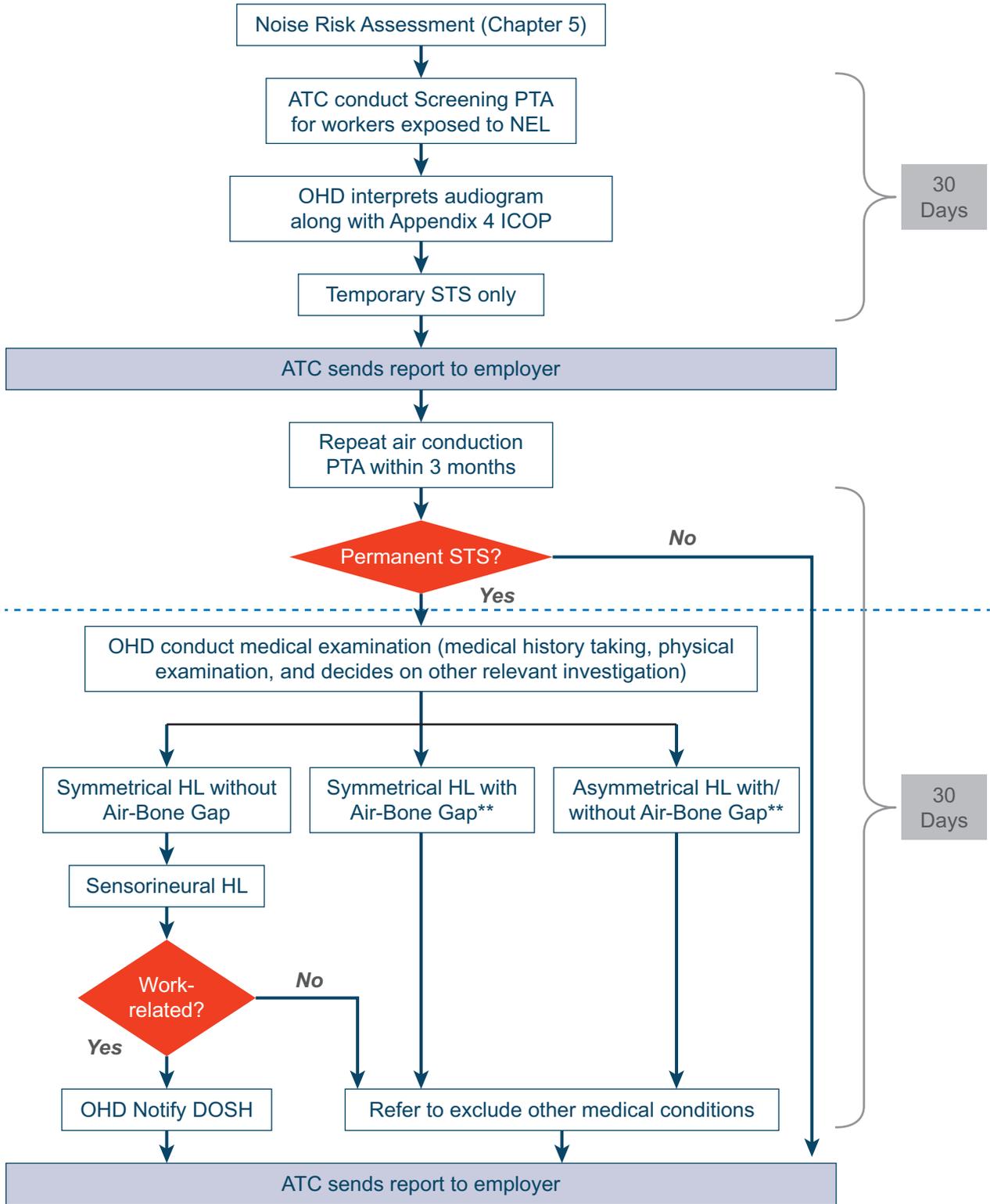


* Medical Examinations shall be repeated for a previously diagnosed NIHL or HI ONLY if there are changes in the hearing status. This is applicable for a case of “previously diagnosed NIHL with HI and/or permanent STS in current audiometry” and “a previously diagnosed HI with permanent STS in current audiometry”.

** For Symmetrical HL/Asymmetrical HL with or without Air-Bone Gap may still be work-related and require notification to DOSH

Note: The blue line indicates separation between the time when screening pure tone audiometry and diagnostic pure tone audiometric is needed

Figure 4.2: Audiometric Testing Flow Chart based on the outcome of screening audiometric testing (Audiogram with Hearing Loss or/and Hearing Impairment with temporary STS)



** For Symmetrical HL/Asymmetrical HL with or without Air-Bone Gap may still be work-related and require notification to DOSH

Note: The blue line indicates separation between the time when screening pure tone audiometry and diagnostic pure tone audiometric is needed

Figure 4.3: Audiometric Testing Flow Chart based on the outcome of screening audiometric testing (Audiogram with Temporary STS only)

4.1 WHO SHALL UNDERGO AUDIOMETRIC TESTING?

 <p>4.1.1</p> <p>Employers need to send workers exposed to excessive noise exceeding the Noise Exposure Limits (NEL) for annual audiometric testing.</p>	 <p>4.1.2</p> <p>Noise Exposure Limits comprises of;</p> <ul style="list-style-type: none"> • daily noise exposure > 85dB(A). • daily personal noise dose > 100%. • maximum SPL > 115dB(A) at any time; OR • peak SPL > 140dB(C). 	 <p>4.1.3</p> <p>Employers also need to establish a baseline audiogram for their workers within three months after they commence work at any area that exposed them to excessive noise exceeding the NEL.</p>	 <p>4.1.4</p> <p>Refer to Chapter 5 for more explanation on Noise Risk Assessment.</p>
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4.2 APPOINTING AUDIOMETRIC TESTING CENTRE

- 4.2.1** All audiometric testing must be conducted at an approved ATC.
- 4.2.2** ATC can be either static or mobile; however, the service provider must be registered with the DOSH.
- 4.2.3** Employers are advised to get quotations for screening pure tone audiometry and medical examination (including diagnostic pure tone audiometry) from ATCs before deciding which ATC to appoint.

4.3 ATC PERFORMING SCREENING PURE TONE AUDIOMETRY

- 4.3.1** Refer to Chapter 6 for the steps to conduct screening audiometric testing.

4.4 AUDIOGRAM INTERPRETATION AND MEDICAL EXAMINATION BY OCCUPATIONAL HEALTH DOCTOR

- 4.4.1** Once the screening pure tone audiometry has been conducted, all audiograms, along with the questionnaire form for audiometric testing (Appendix 4 of Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019), should be given to the OHD appointed by the ATC for interpretation. (Refer to Chapter 7).
- 4.4.2** For employees with temporary STS, the OHD shall instruct the employer to repeat the test within three months from the date of screening the pure tone audiometry test.
- 4.4.3** For an employee with an abnormal audiogram, if indicated, the OHD shall inform the ATC to advise the employer to proceed with diagnostic pure tone audiometry to confirm the sensorineural portion of hearing loss.
- 4.4.4** Refer to Chapter 6 for steps to conduct diagnostic pure tone audiometry.
- 4.4.5** Once diagnostic pure tone audiometry is conducted, the OHD reviews the audiogram, conducts medical examination as prescribed in Appendix 6 of Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019, and decides on the need for referral. (Refer Chapter 10)

4.4.6 The OHD concludes the case in the form as prescribed in Appendix 6 of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation and notify DOSH if required. (Refer Chapter 9 & 11)

4.4.7 For employees with Temporary STS only, medical examination (including diagnostic pure tone audiometry) should be implemented only after confirming Permanent STS.

4.4.8 After interpreting the pure tone audiometry audiogram and conducting medical examination (including diagnostic pure tone audiometry), the OHD must submit a summary report to the ATC using the recommended format as Appendix 1.

4.5 SUBMISSION OF AUDIOMETRIC REPORT BY AUDIOMETRIC TESTING CENTRE TO EMPLOYER

<p>4.5.1</p> <p>The ATC must submit the report to the employer within 30 days from screening pure tone audiometric testing.</p>	<p>4.5.2</p> <p>The report shall include;</p> <ul style="list-style-type: none"> • employee’s personal and employment particulars. • test date. • employee’s noise exposure level. • relevant medical histories and hobbies. • audiogram. • interpretation of audiogram. • the medical examination report, and • recommendation as necessary. 	<p>4.5.3</p> <p>A sample of an audiometric report to the employer can be found in Appendix 2.</p>	<p>4.5.4</p> <p>The employer shall inform the employee of his audiometric test result within 21 days after receiving the report from ATC.</p>
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4.6 REPEAT TEST AFTER TEMPORARY STANDARD THRESHOLD SHIFT

4.6.1 The steps to conducting repeat audiometric testing are the same as screening pure tone audiometry.

4.6.2 Once Permanent STS has been confirmed, the OHD shall conduct a medical examination (including diagnostic pure tone audiometry).

4.6.3 The ATC must submit the repeat audiometric report to the employer within 30 days from the day of repeat audiometric testing. The contents of the report are the same as item 4.5.2.

4.7 REFERRAL

4.7.1

“For cases requiring referral to relevant specialists, a maximum of six months from the initial testing date is allowed to conclude these cases.”

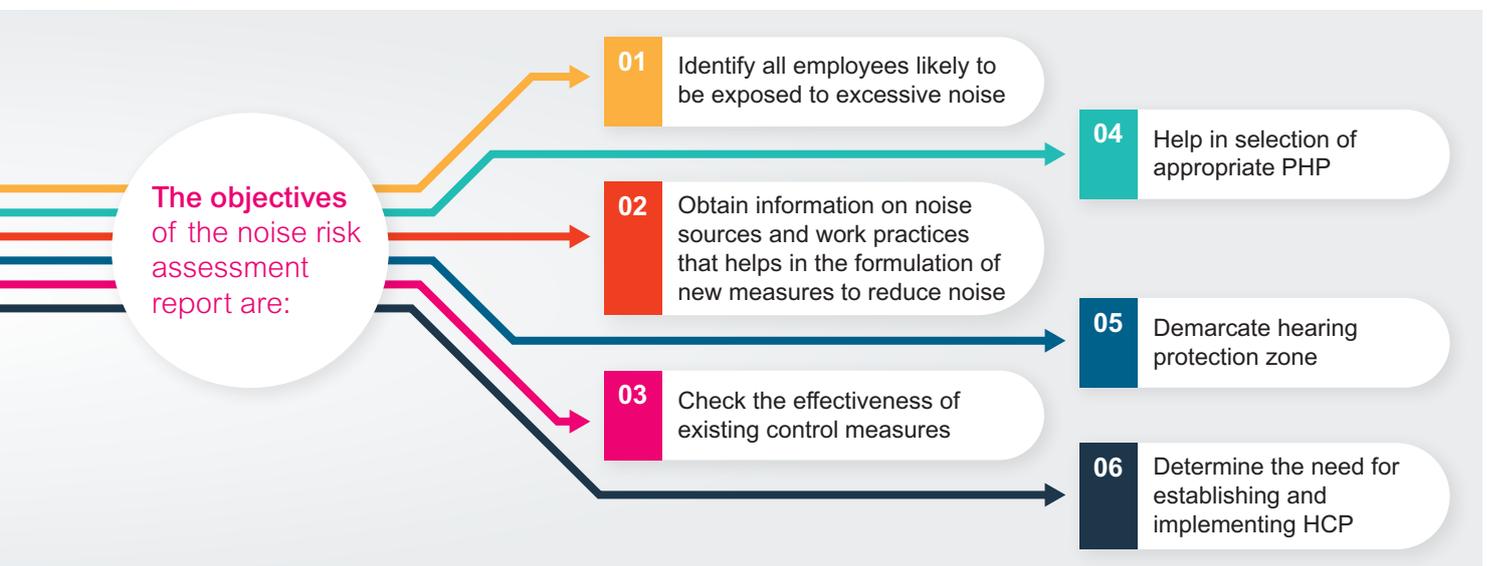
CHAPTER 05

UTILIZATION OF NOISE RISK ASSESSMENT REPORT

5.1 INTRODUCTION

Based on item 6.4 of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019, Noise Risk Assessment shall be conducted when excessive noise is identified at the workplace.

The Noise Risk Assessment report serves as an important document to enable the OHD to execute his/her role in determining the work-relatedness of the NRHD. The OHD is required to fill in the noise exposure level for the employee's SEG in the medical examination form (Appendix 6 of Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019).



The OHD could utilise the noise risk assessment report to:

- understand the noise exposure risk of the workplace.
- understand the SEG (the task and noise level exposed) that needs to participate in the annual audiometric program.
- know the PHP requirement
- see the requirement of training

The use of the information above is as below:

- Determine the work-relatedness of NHRD.
- Understand the reasons for the deterioration of the workers' hearing with abnormal audiogram after analyzing the noise risk assessment report and the information gathered during the medical examination. Some of the usual reasons for the deterioration are inappropriate fit and wear of PHP, improper selection of PHP, and poor understanding of the risk due to insufficient training.
- May provide recommendations to improve the HCP if requested by the company.

To fully utilize the noise risk assessment report, the OHD needs to understand the critical concepts listed below:



5.1.1 Noise Exposure Limit

Regulation 6 of the Occupational Safety and Health (Noise Exposure) Regulations 2019 defines the Noise Exposure Limit as:

- the daily noise exposure level exceeds 85dB(A) or daily personal dose exceeding a hundred percent (100%).
- the maximum SPL exceeding 115dB(A) at any time; or
- the peak SPL exceeding 140dB(C).

The Regulations also specify a maximum allowable daily noise dose, expressed in percentages. For example, a person continuously exposed to 85 dB(A) over an 8-hour work shift may reach 100% of their daily noise dose. This dose limit uses a 3-dB time-intensity trade-off commonly referred to as the exchange rate or equal-energy rule. For every 3-dB increase in noise level, the allowable exposure time is reduced by half.

Hence, a daily noise exposure level at more than 85dB(A) can also be expressed as a daily personal dose of 100 percent.

The Maximum SPL is regulated at more than 115 dB(A) at any time.

The Peak Exposure is set at more than 140 dB(C). Note that C-weighted is used here to imply that the damage can occur at any sound frequency, even those not apparent to the human ear. Hence any spike, even for a second, can damage human hearing.

“Daily personal dose” means the cumulative noise exposure of an employee corrected for a typical working day of eight hours. (Occupational Safety and Health (Noise Exposure) Regulations 2019).

The Daily Noise Dose is the total sound exposure normalized to an 8-hour working day.

Detailed calculation of the Daily Noise Dose is described in item 7.3.3(o) of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

The calculation must exclude the measurements taken during rest periods if the rest or meal area is protected from excessive noise. If the rest or meal area is within the extreme zone, the measurements should be included in calculating the daily dose.

For example, the work shift is 12 hours. The NRA must conduct personal monitoring for the whole period of 12 hours. He then recalculates using a formula (example in section 7.3.3(o) to get the total sound exposure normalized to an 8-hour working day.

5.1.2 Exchange Rate

The risk of contracting noise-related hearing disorders is dependent on two main factors: the noise intensity level and the duration of exposure. Noise-induced hearing loss has been found to occur with repeated 8-hour exposures of 85 dB(A), but shorter exposures to greater levels can be equally hazardous.

The exchange rate is the usual recommended method of evaluating risk.

Occupational Safety and Health (Noise Exposure) Regulations 2019 are based on the 3 dB exchange rate, which means that each time the sound level increases by 3dB, the dose doubles given the same exposure time. Similarly, if the sound level decreases by 3dB, the Dose halves for the same exposure time. For example, noise levels of 88 dB(A) have twice as much energy as levels at 85 dB(A). Since 85 dB(A) equals 100% noise dose, then 88 dB(A) is equal to 200% noise dose, and therefore the maximum exposure time is restricted to 4 hours per shift - ergo, twice the level means half the time

Doubling the exposure time doubles the dose, and halving the exposure time halves the dose given the same sound level.

5.1.3 Similar Exposure Group (SEG)

Determination of a Similar Exposure Group (SEG) is perhaps one of the most critical pieces of information in the Noise risk assessment report. A good determination of SEG certainly avoids much uncertainty on the employee at risk in the management of the HCP and the audiometric program. The NRA should ensure that no employee at risk is excluded from the HCP or the Audiometric program.

The NRA shall justify classifying each SEG and include the justifications as part of the noise risk assessment report.

The determination should be implemented through consultations and verifications with the Hearing Conservation Administrator (HCA), workers, and supervisors. The SEG is usually made according to the job title, function, work area, or profession. SEGs can also be defined according to production, process, or work activity criteria.

Most exposed employees are the employees or groups of employees believed to have the most significant exposure to be measured.

The NRA shall ensure the most exposed employees in each SEG is selected based on the following

criteria:

- Work directly with noise source (tools, machinery, etc.).
- work near or pass through areas with noise exposure; or
- work in a noisy area for an extended period.

An example of a possible issue regarding SEG selection is when an employee is referred to an OHD to determine the work-relatedness of a Hearing Loss or Hearing Impairment. Still, he was not included in an audiometric program. Thus, a proper selection of the SEG can avoid uncertainty in determining the work-relatedness.

5.2 STEPS IN DETERMINING THE RISK

5.2.1 Identification of Excessive Noise



“Excessive noise” means daily noise exposure level exceeding 82dB(A), daily personal noise dose exceeding fifty percent, maximum SPL..

“Excessive noise” means daily noise exposure level exceeding 82dB(A), daily personal noise dose exceeding fifty percent, maximum SPL exceeding 115dB(A) at any time, or peak sound pressure exceeding 140dB(C). (Occupational Safety and Health (Noise Exposure) Regulations 2019). Exposure to excessive noise is regulated in Regulation 3 of the Occupational Safety and Health (Noise Exposure) Regulations 2019.

Regulation 3 (1) requires the employer to conduct an assessment using the Noise Hazard Identification checklist. The Noise Hazard Identification checklist is the first step towards identifying the presence of excessive noise at work. Any ‘yes’ answer in the checklist indicates excessive noise and shall proceed with the Noise risk assessment.

Re-identification of the excessive noise is detailed in item 6.5 of the Industry Code of Practise for Management of Occupational Noise Exposure and Hearing Conservation 2019. The employer shall re-identify excessive noise if there is a change in the machinery, equipment, process, work, control measures, or operation. Any employee may be exposed to excessive noise.

Item 6.7 of the same document dictates that if re-identification of excessive noise shall be repeated not more than one year since the last identification of excessive noise.

A noise risk assessment must be carried out when an employee may be exposed to excessive noise. (Regulation 4 of Occupational Safety and Health (Noise Exposure) Regulations 2019).

5.2.2 Noise risk assessment

The methodology in conducting the Noise risk assessment is clearly explained in item 7 of the Industry Code of Practise for Management of Occupational Noise Exposure and Hearing Conservation 2019.

For the OHD to understand the methodology and the results, he needs to understand the basic principles of sound measurements.

5.2.2.1 Sound measurements

One way of measuring sound levels is to measure them according to the human ear's response.

Our ears are most sensitive to frequencies between 500Hz and 6kHz and are less sensitive to frequencies above and below. For a sound level meter or noise dosimeter to measure and report noise levels representing what we hear, frequency weightings are used, as shown in Figure 5.1. These are electronic filters within the instrument that adjust the way the instrument measures the noise. When measuring the noise intensity or SPL, they are typically measured as A-weighted or C weighted.

a. A-weighted

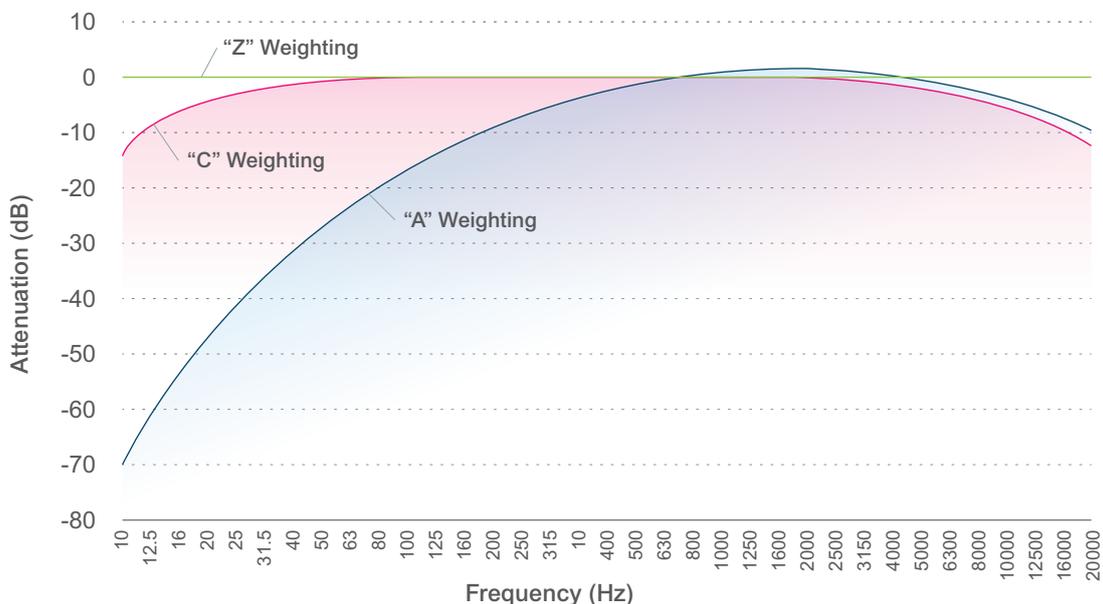
The most common weighting that is used in noise measurement is A-Weighting. This method effectively cuts off the lower and higher frequencies that the average person cannot hear, like the human ear. Therefore, the A-weighted is usually used for workplace sound measurements.

A-weighted measurements are expressed as dBA or dB(A).

b. C-weighted

At low frequencies, noise intensity is not well represented by the A-weighted scale. Thus, for peak level, the C-weighted is more appropriate because it represents the low frequencies well due to the flatter response at all frequencies. Although our ear does not respond well to low frequencies, the peak level at low frequencies may still damage our hearing.

C-weighted measurements are expressed as dBC or dB(C).



Note: All frequency weightings are defined in the standards to which a noise measurement instrument is designed. For example, the frequency weightings used on a sound level meter are defined in IEC 61672:2003 (BS EN 61672-1:2003).

Figure 5.1: Frequency Weightings of Sound

5.2.2.2 Area and Personal Monitoring

In principle, Noise risk assessment comprises area monitoring and personal exposure monitoring to noise.

The objective of the area monitoring is to determine the noise source, the noise level of the noise source, demarcate the noise area and determine the appropriate PHP when entering the excessive noise area. This determination is done using a sound level meter, which measures a sound level at a point in time.

Personal noise exposure monitoring or measurement is carried out by using a dosimeter. A noise dosimeter is a specialized sound level meter intended to precisely measure the noise exposure of a person over some time. The selection of PHP for a particular SEG shall be based on the Personal Monitoring results.

5.3 EXPLANATION OF THE NOISE RISK ASSESSMENT RESULT

The following section describes the summarization of monitoring data in tabulated form.

5.3.1 Area monitoring

Table A1: Result of area monitoring

WORKING AREA	JOB SPECIFICATION & TASK	NUMBER OF EMPLOYEES	NUMBER OF EMPLOYEES MONITORED	SOURCE OF NOISE	TYPE OF NOISE	NOISE LEVEL

The results of the area monitoring must contain the information as shown in the following diagram:

Result of area monitoring shall be illustrated by noise mapping in the form of the colour zone as shown below:

Noise mapping colour zone

SOUND PRESSURE LEVEL	COLOUR ZONE
> 140 dB (C)	Purple
> 115 dB (A)	
> 85 dB (A) to 115 dB (A)	Red
> 82 dB (A) to 85 dB (A)	Yellow
≤ 82 dB (A)	White

The area monitoring:

- Refers to noise exposure (using a sound level meter) of an area consisting of one or more workgroups and creates area noise mapping.
- It describes the noise source characteristic in that area and the sound levels detected. The option to reduce exposure shall depend on this information. The highest noise source needs to be controlled first for the engineering control to be effective. Without this information, it is quite challenging for effective engineering control to be carried out.
- Based on the noise mapping, the NRA determines the hearing protection zones.

The area monitoring results cannot be used to reference a daily noise dose for a worker. The daily noise dose is captured in the personal monitoring results.

There should be a consistency between the area monitoring results and the personal exposure monitoring results. Any peak level detected in the personal noise monitoring report but not recorded in the area monitoring report shall be considered as uncertainty that needs to be resolved by the NRA. The Industry Code of Practise for Management of Occupational Noise Exposure and Hearing Conservation 2019 is explained in detail in item 6 (l), (m), and (n).

5.3.2 Personal Monitoring

When reading the results of the personal noise monitoring of an SEG, the OHD shall compare the results with the Noise Exposure Limit.

The personal noise monitoring result is presented in the table form below:

Table A2: Result of personal monitoring

SEG	EMPLOY-EE NAME	WORKING AREA	SAMPLING DURATION	DOSE _{Te} %	L _{eqTe}	L _{ex, 8h}	MAX LEVEL	PEAK LEVEL

The noise level exceeds the NEL when:

- Daily personal dose (Dose_{Te} %) is more than 100%. (T_e is the effective duration of the working day.) The L_{ex, 8h} is more than 85dB(A).
- Max level exceeds 115dB(A); or
- Peak level exceeds 140dB(C).

The OHD needs to look for comments about the peak levels within this section. The reason for doing so is because the NRA is required to confirm the presence of the peak level noise source. A peak level can be due to noise artifacts such as accidental knocking on the microphone.

L_{eqTe} is the A-weighted equivalent continuous SPL for the effective duration of the working day. The L_{eqTe} value is derived from the dosimeter based on the sampling duration. For example, the reading for the sampling of 12-hour shifts is then calculated to get L_{ex, 8h}, and used for the calculation to get the daily personal dose (item 7.3.3 of ICOP for Management of Occupational Noise Exposure and Hearing Conservation 2019).

The OHD must fill in the noise level in the medical examination form (appendix 6) with the above information. This is the NEL level which is one of the criteria to determine work-relatedness.

5.4 EXPLANATION OF THE DISCUSSION SECTION OF THE NOISE RISK ASSESSMENT REPORT

Under this section, the NRA shall discuss the adequacy of the existing control measures, if any. Some of the improvements of the control measures can be executed by adequately maintaining or repairing the current engineering control measures.

Comment on the noise mapping is significant for the effort to reduce the noise exposure. A good and detailed noise map is appreciated because every noise and the noise level is determined correctly. Detailed noise risk of a worker is possible when determining the work-relatedness. It provides another source of information of the noise risk, other than the result of the Personal Monitoring.

The NRA is expected to comment on any results exceeding NEL (Maximum Level, Peak, and Daily Noise Exposure Level). It also needs to include the contributing factors for exceeding NEL (Maximum Level, Peak, and Daily Noise Exposure Level).

This information is useful for the management in the effort to reduce the noise levels. The OHD benefits from the information by having a better understanding of the risk. It assists the OHD in determining work-relatedness.

5.4.1 Explanation of the recommendations section of the Noise risk assessment report

In the Noise risk assessment report, the recommendation shall be presented in Table A3 as follows:

Table A3: Recommendations of control measure

SEG	L _{EX, 8H}	MAX LEVEL	PEAK LEVEL	NOISE SOURCE	TYPE OF CONTROL MEASURE	EXISTING CONTROL MEASURE	RECOMMENDED CONTROL MEASURE ¹
					Engineering		
					Administrative		
					PHP		
					Others		

Note: ¹ Please state the references

Recommendations listed in Table A3 shall be specified to the SEG’s area of work, for example:

- It describes specific methods of the engineering control based on the engineering control principle of absorption, insulation, damper, silencer, and vibration isolation.
- The selection of PHP. The noise reduction rating (NRR) required for personal hearing protectors (PHP) shall be listed here.
- Administrative control includes a daily exposure duration limit for an employee and the recommended job rotation for the particular SEG.

Besides that, recommendations shall also include other provisions of the regulations to be complied with, such as:

- employees to be placed on an audiometric testing program
- employees to be given information, instruction, and training on HCP
- areas to be posted with warning signs (HEARING PROTECTION ZONES)
- the requirement to wear PHP

The recommendations on the provision of PHP and the requirement of the audiometric program are relevant to the OHD to facilitate ONRHD management. The information is relevant during the determination of work-relatedness.

5.4.2 Provision of Personal Hearing Protector (PHP)

The Noise risk assessment report shall include the PHP requirement, especially the Noise Reduction Rating (NRR).

Examples of the need for the understanding of the provision of personal hearing protections are as below:

During the medical examination session by the OHD, the OHD may notice a physical constraint of the worker to put on a particular PHP. The OHD may inform the employer about the issue or provide a recommendation for an appropriate PHP.

A worker with chronic otitis media is unable to wear earplugs and should be given earmuffs instead. Workers with unique external ear anatomy may require a proper fitting to find an appropriate PHP. Improper PHP and its improper wear may contribute to the work-relatedness of the NHRD.

In determining the work-relatedness, the OHD may also decide to analyse the reasons for the deterioration due to problems related to PHP.

The PHP shall be determined based on the area monitoring results for persons not part of an SEG. For example, for non-routine tasks and visitors to the work area.

For a SEG, which PHP to choose shall be based on the Personal Noise Monitoring results. For SEGs exposed to noise above the NEL, the basis of NRR calculations is the $L_{ex, 8h}$. This information can be found in the personal noise exposure monitoring results.

The appropriate noise reduction of the PHP is currently based on NRR (Noise Reduction Rating) or SNR (Single Number Rating).

The use of NRR is described at length in ICOP for Management of Occupational Noise Exposure and Hearing Conservation 2019 under item 11.

The SNR is the EU's standard for showing the attenuation of hearing protection.

For example, there are other standards, SLC80 (sound level conversion), mainly used in Australia and New Zealand.

Do note that the best way to determine the actual protection is through quantitative fit testing.

5.4.3 Requirement of Audiometric Program

Regulation 9(1) of Occupational Safety and Health (Noise Exposure) Regulations 2019 requires an annual audiometric program for a similar exposure group (SEG) that exceeds the noise exposure limit (NEL).

The requirements of an audiometric program can also be found in the recommendations section of the Noise risk assessment report. Indication of the requirement of the audiometric program is based on the personal exposure monitoring results showing exposure above the NEL.

During an audiometric program, when determining the work-relatedness of the NRHD, the OHD may find inadequate information in the report.

For example, during the medical examination (triggered by an abnormal audiogram), an OHD found that the worker does not belong to any SEG monitored in the Noise risk assessment. The worker, however, insisted that he is exposed to significant noise at work. In this case, the OHD may inform the employer and note down the issue in the investigation report. For this type of case, the OHD may refer to the closest SEG and the area monitoring results and discuss with the employer to determine the work-relatedness of the NRHD.

5.5 REVISION OF NOISE RISK ASSESSMENT

The initial Noise risk assessment is the first Noise risk assessment for the company, and then NRA shall be reviewed as follows:

Not more than 5 years from the date of previous NRA

If directed by Director General

Changes after the result of re-identification of excessive noise after the assessment.



CHAPTER 06

AUDIOMETRIC TESTING PROCEDURE

6.1 INTRODUCTION

6.1.1

Based on Item 15.6.1 of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019, one of OHD's duties is to ensure the audiometric testing conducted by trained audiometric technicians complies with the procedures and legal requirements. Thus, it is imperative for an OHD to have an overview of the process of audiometric testing.

6.1.2

Screening & Diagnostic Pure Tone Audiometric

For these guidelines, screening pure tone audiometry refers to measuring the hearing threshold levels of a person through air conduction threshold tests, as stipulated by the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

Meanwhile, diagnostic pure tone audiometry refers to measuring the hearing threshold levels of a person through air and bone conduction threshold test with or without masking.

6.1.3

This document discusses audiometry procedures for trained audiometric technicians, based on the International Standard Organisation (ISO 8253-1:2010) and a Recommended Procedure by BSA on Pure-tone air-conduction and bone conduction threshold audiometry with and without masking (after this, the document is called BSA 2018). This document provides a reference standard for conducting an audiological intervention that represents, to the best knowledge, the evidence-based and consensus on good practice given the stated methodology and scope of the document in the ISO 8253-1:2010 and BSA 2018.

6.2 SCOPE

6.2.1 Subjects

This document describes pure tone audiometric (PTA) procedures suitable only for the use of adults concerning noise exposure at work, under the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

6.3 EQUIPMENT AND TEST ENVIRONMENT

6.3.1 Audiometric equipment

The audiometers, transducers, and response buttons must be cleaned. Audiometers shall meet the performance and calibration requirements under the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.



6.4 GENERAL ASPECTS OF AUDIOMETRIC MEASUREMENTS

6.4.1 General

Hearing threshold levels can be determined by air conduction and bone conduction audiometry. In air conduction audiometry, the test signal is presented to the test subject by earphones. In bone conduction audiometry, the test signal is presented by a bone vibrator placed on the mastoid or forehead of the test subject. It is recommended that the determination of threshold level begins with air conduction measurements followed by bone conduction measurements. Hearing threshold levels can be determined using test tones with fixed frequencies (fixed-frequency audiometry). Methods for fixed-frequency audiometry are given in item 6.6. In air and bone conduction measurements, the hearing threshold levels of both ears shall be determined separately. Under specified conditions masking noise shall be applied to the ear, not under test (contralateral ear). The masking noise is presented to that ear through a supra-auricular, circum-auricular, or insert-type earphone.

6.4.2 Requirements on audiometric equipment

Audiometers shall be constructed according to IEC 60645-1 and calibrated according to the requirements of the relevant part of ISO 389-7:2019 (Acoustics — Reference zero for the calibration of audiometric equipment). In occupational audiometry and testing schoolchildren, a type 4 audiometer (IEC 60645-1:2001) may be used with the frequency range sometimes limited to 500 Hz and upwards.

6.4.3 Test time

Care shall be taken not to fatigue the test subject unduly since reliable results may be progressively difficult to obtain if the test subject is not given a rest from testing after about 20 minutes.

6.4.4 Conditions for audiometric test environments

The test subject and the trained audiometric technician shall be comfortably seated during audiometric testing. They shall be neither disturbed nor distracted by unrelated events nor by people in the vicinity.

Air temperature in the audiometric test room should be in the range permitted for offices by local authorities.

The audiometric test room should allow for a sufficient exchange of air.

If the audiometer is operated manually, the test subject shall be visible to the trained audiometric technician, who shall not see the audiometer settings change or the test tone being switched on or interrupted. When using an automatic recording audiometer, the recording mechanism shall not be visible to the test subject.

When the test is carried out outside the audiometric test room, the test subject shall be visually monitored through a window or a closed-circuit TV system. Acoustic monitoring of the subject should be undertaken.

6.5 PREPARATION AND INSTRUCTION OF TEST SUBJECTS BEFORE AUDIOMETRIC TESTING AND POSITIONING OF TRANSDUCERS

6.5.1 Preparation of test subjects

Recent noise exposure may cause a temporary elevation of the hearing threshold levels. Therefore, significant noise exposure should be avoided before audiometric testing or taken note of. For errors due to excessive physical exertion to be avoided, test subjects should be present at least 5 minutes before testing.

An external ear examination precedes the audiometric test carried out by a trained audiometric technician (Refer to Appendix 4 of Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019). If obstructing wax is visualized at the outer ear, it shall be removed, and audiometry may be delayed for a suitable period.

The ear should also be checked for the possibility of collapsing ear canals and appropriate action taken, if necessary.

6.5.1.1 Procedure for collapsing ear canal check

Collapsing ear canal is an ear canal that closes over under the pressure of the headphones due to the loss of elasticity of the canal skin, particularly at the cartilaginous portion. The procedure to be followed in the case of a collapsing ear canal check is as follows:

- Mimic headphone pressure on the pinna by pushing the pinna towards the head
- Direct the otoscope light to the opening of the ear canal
- Inspect the ear canal opening to see whether the canal walls meet. If it is narrow, there is a large possibility that the ear canal collapses.

Note: Using headphones for collapsing ear canal creates an artificial conductive hearing loss. Use insert earphones instead of headphones.

Be careful if the subject has impacted earwax, don't use insert earphones as it might cause harm to the subject. Refer for earwax clearance as necessary.

6.5.2 Instruction of test subjects

To achieve reliable test results, it is essential that relevant instruction in the test procedure is given unambiguously and that the test subject fully understands it.

The instructions shall be phrased in language appropriate to the listener and shall usually indicate:

- the response task.
- the need to respond whenever the tone is heard in either ear, no matter how faint it may be.
- the need to respond as soon as the tone is heard and to stop responding immediately once the tone is no longer audible;
- the general pitch sequence of the tones.
- the ear to be tested first.

The response from the test subject indicating whether the tone is audible and when it is not shall be observable. Examples of commonly used responses are:

- pressing and releasing a signal switch.
- raising and lowering the finger or hand.

Test subjects shall also be instructed to avoid unnecessary movements to obviate extraneous noise.

After the instructions have been given, the test subject shall be asked if he or she have understood. The test subject shall be informed that he or she may interrupt the test in case of discomfort. If there is any doubt, the instructions should be repeated.

6.5.3 Placement of transducers

The following actions should be undertaken: spectacles and head ornaments, when necessary, and hearing aids shall be removed. If possible, hair shall be moved from between the head and the sound transducers, i.e., earphones and bone vibrators. The trained audiometric technician shall fit the transducers to ensure that they are correctly positioned, and thereafter subjects shall be instructed not to touch the transducers. The sound opening of an earphone shall face the ear canal entrance. The bone vibrator shall be positioned so that the largest possible area of the tip is in contact with the skull. If placed on the mastoid, the vibrator shall be positioned behind and as near as possible to the pinna without touching it.

6.6 MANUALLY CONTROLLED THRESHOLD DETERMINATION

6.6.1 Presentation and interruption of test tones

The test tone shall be continuous and presented for a duration of 1 to 2 seconds. When a response occurs, the interval between tone presentations shall be varied but shall not be shorter than the test tone duration. Unless otherwise stated, reference to tone presentation throughout this part of ISO 8253 refers to this method.

Automatic pulsed tones are sometimes used as an alternative stimulus. However, correlative data are not currently available. The use of such stimuli should be noted on the audiogram.

6.6.2 Initial familiarization

The test subject shall be familiarized with the task prior to threshold determination by presenting sufficient intensity to evoke a definite response. Using the familiarization step, the trained audiometric technician can ensure that the test subject understands and performs the response task.

The following method of familiarization can be used:

- present a tone of 1000 Hz at a hearing level that is audible, e.g., 40 dB for a normal hearing test subject;
- reduce the level of the tone in steps of 20 dB until no response occurs;
- increase the level of the tone in steps of 10 dB until a response occurs;
- present the tone again at the same level.

If the responses are consistent with the tone presentation, the familiarization is complete. If not, it should be repeated.

After a second failure, the instructions should be repeated.

In cases of profound deafness, these procedures may not be applicable.

6.6.3 Air Conduction Hearing threshold measurements with and without masking

6.6.3.1 General

In 6.6.3.2, test procedures are outlined for those tests in which masking noise is not applied to the non-test ear. In 6.6.3.3, procedures are outlined for tests with masking. The method for calculating the hearing threshold level is given in 6.6.4.

6.6.3.2 Procedures for testing without masking

Hearing threshold level measurements resulting in a hearing level of 40 dB or more in either ear at any frequency must be interpreted with caution due to the phenomenon of cross-hearing. Contralateral masking can then be necessary.

Step 1

Present the first test tone at a level 10 dB below the lowest level of the test subject's response during the familiarization session. After each failure to respond to a test tone, increase the test tone level in steps of 5 dB until a response occurs.

Step 2

Ascending method

After the response, decrease the level in steps of 10 dB until no response occurs. Then begin another ascent with 5 dB steps.

A shortened version of the ascending method has been shown. In this shortened version, continue the testing until at least two responses occur at the same level out of three ascents.

Step 3

As indicated by the previous responses, proceed to the subsequent test frequency at an estimated audible level and repeat step 2. Finish all test frequencies on one ear.

Note: For any frequency, the familiarization, or an abbreviated form, can be repeated.

Finally, repeat the measurement at 1000 Hz. If the results at 1000 Hz of the repeat measurement for that ear agree to 5 dB or less with those of the first measurements for the same ear, proceed to the other ear.

If 10 dB or more improvement or worsening in hearing threshold level is discernible, retest at additional frequencies in the same order until the agreement is 5 dB or less.

Step 4

Proceed until both ears have been tested.

6.6.3.3 Procedures for testing with masking

To avoid the test tone being heard in the non-test ear, it may be necessary to apply masking noise to that ear.

For the procedure described below, the masking noise signal is delivered through an earphone.

Although experience, to a large extent, dictates the procedures used and the choice of the masking noise level, the following procedure is recommended to determine the hearing threshold level with masking.

Step 1

Present a test tone to the ear being tested equal to the hearing threshold level without masking.

Next, present masking noise to the non-test ear with an effective masking level equal to the hearing threshold level of the non-test ear. Increase the noise level until the test tone is inaudible or until the noise level exceeds the test tone level.

Step 2

If the tone is still audible when the noise level equals the test tone level, assume this to be the hearing threshold level. If the tone is inaudible, increase its level until it becomes audible again.

Step 3

Increase the noise level by 5 dB. If the test tone is inaudible, increase the test tone level until the tone becomes audible again. Repeat this procedure until the test tone remains audible, although the masking noise level has been increased by more than 10 dB. This masking level, i.e., the level above which no further increase in the tone level is required for its audibility, is the correct masking level. This procedure should have produced the correct hearing threshold level for that test frequency. Note the correct masking level.

Note 1: This is the plateau-seeking method. In some cases where the plateau is short, the above procedure can give false results.

Note 2: The masking noise can also mask the test tone in the ear being tested. This phenomenon, called over masking, can be reduced by presenting the masking noise using an appropriate insert earphone.

6.6.4 Calculation of hearing threshold level**6.6.4.1 General**

The hearing threshold levels for each frequency and ear shall be determined following the following procedures, dependent upon the measurement method used.

6.6.4.2 Determination when the ascending method has been used

For each frequency and ear, determine the lowest level at which responses occur in more than half of the ascents. This level is defined as the hearing threshold level.

If the lowest response levels span more than 10 dB at a given frequency, the test should be considered doubtful reliability and repeated. This result should be noted on the audiogram.

6.7 BONE CONDUCTION HEARING THRESHOLD AUDIOMETRY**6.7.1 Method of audiometry**

The same procedures for air and bone conduction audiometry shall be used.

6.7.2 Occlusion

The ear being tested by bone conduction should be un-occluded. If the ear is occluded, it shall be noted on the audiogram.

6.7.3 Airborne sound radiation from the bone vibrator

Any airborne sound that the bone vibrator radiates when in contact with the head of a test person having unimpaired outer- and middle-ear function should be low enough. The value obtained provides a sufficient margin between the true bone conduction hearing threshold level and a false air conduction hearing threshold level evoked by the bone vibrator.

Should this condition not be met directly at frequencies above 2 000 Hz, the effect of unwanted sound radiation can be eliminated by inserting an earplug into the outer ear canal of the test subject. However, consideration should be given to the possibility of the occlusion effect occurring at frequencies above 2 000 Hz.

Note: A detailed test procedure is described in IEC 60645-1.

6.7.4 Vibrotactile sensation

For the mastoid location of the bone vibrator, the vibrotactile threshold coincides on average with a hearing level of approximately 40 dB at 250 Hz, 60 dB at 500 Hz, and 70 dB at 1 000 Hz. However, considerable individual variations may occur. Therefore, care shall be taken that vibrotactile sensations not be misinterpreted as hearing sensations.

Note: If the audiometer is calibrated for forehead placement of the vibrator, the values quoted above are approximately 10 dB lower.

6.7.5 Procedures for testing with masking in bone conduction audiometry

Although experience, to a large extent, dictates the procedure used and the choice of the masking level, the following procedure is recommended.

Step 1

After positioning the bone vibrator on the subject, place the masking earphone on the non-test ear. Care shall be taken that the headbands of the two transducers do not interfere with each other. Measure the hearing threshold level without masking noise following one of the shortened procedures described in 6.3.2.

Note: The result of this measurement may not represent an accurate estimate of the non-masked bone conduction threshold because of the possible occlusion effect in the non-test ear.

Step 2

Repeat the test tone at this level while presenting masking noise to the non-test ear with an effective masking level equal to the air conduction hearing threshold of the non-test ear. Increase the noise level until the test tone is inaudible or until the noise level exceeds the test tone level by 40 dB.

Step 3

If the tone is still audible when the noise level is 40 dB above the test tone level, assume this to be the hearing threshold level. If the tone is inaudible, increase its level until it becomes audible again.

Step 4

Increase the noise level by 5 dB. If the test tone is inaudible, increase the test tone level until the tone becomes audible again. Repeat this procedure until the test tone remains audible, although the masking noise level has been increased by more than 10 dB. This masking level, i.e., the level above which no further increase in the tone level is required for its audibility, is the correct masking level. This procedure should have produced the correct hearing threshold level for that test frequency. Note the correct masking level.

Note 1: This is the plateau-seeking method. In some cases where the plateau is short, the above procedure can give false results.

Note 2: The masking noise can also mask the test tone in the ear being tested. This phenomenon, called over-masking, can be reduced by presenting the masking noise using an appropriate insert earphone.

Note 3: The masking plateau can have a slope greater than zero due to central masking.

Note 4: In some instances, it is appropriate to increase the noise level in steps of 10 dB.

6.8 CROSS-HEARING AND ITS PREVENTION BY MASKING

Cross hearing is the transmission of sound that transducers at the test ear, which crosses through the head by bone conduction mechanism and reaches the non-test ear cochlea. Though earphones allow sound to be presented to one ear at a time, it is not always convincing that only the intended (test) ear is the one sensing the sound. When the hearing acuity of the ears is very different, it is likely that, when testing the worse ear, the better (non-test) ear senses the test signals more readily even though the signals reaching it are attenuated. If the sound presented to the worse ear (test ear) is loud enough, it can cause vibration to the cochlea of the non-test ear and can be heard by the non-test ear cochlea if it exceeds the non-test ear bone conduction (BC) threshold.

Interaural attenuation (IAA), also known as transcranial transmission loss, describes the energy reduction of acoustic signals from test ear transducers to the non-test ear cochlea. It differs considerably from person to person and varies by frequency. It is also earphone-dependent. It varies between 40-80 dB when using supra-aural or circum-aural earphones. The transcranial transmission loss is greater with insert earphones, with at least transcranial transmission loss of 55 dB. With BC testing, there can be slight or no transcranial transmission loss at all.

When the difference in the thresholds of the two ears is more than the transcranial transmission loss, cross-hearing could occur, and the apparent threshold of the worse ear is, in fact, a 'shadow' of the better ear. Reliance should NOT be placed on the SUBJECT to make an accurate report of the ear in which the sounds were heard since many people cannot make such judgments easily, and the sound may not be fully lateralized to one ear.

 Cross hearing when:

$$\text{Stimulus level}_{\text{TEST EAR}} - \text{IAA} \geq \text{BC}_{\text{NON-TEST EAR}}$$

Cross-hearing can usually be corrected by temporarily elevating the hearing threshold of the non-test ear by a calculated amount to enable a precise assessment of the test ear threshold. Presenting a masking noise into the non-test ear at the appropriate intensity prevents the non-test ear from sensing the test signals, and at the same time, measures the threshold of the test ear with the test signals. There is generally a 1:1 association between the increase in masking noise and the elevation of the masked threshold of the non-test ear.

The term 'not masked' indicates that tests were made without masking, rather than the term 'unmasked,' which refers to different psychophysical phenomena.

6.8.1 Effective masking level

Masking noise should be calibrated in terms of effective masking level (EML). In the presence of masking noise at a particular center frequency and effective masking level, the pure-tone threshold of hearing (dB HL) at that frequency is raised to that level. For example, a 1000 Hz noise at 50 dB EML presented to an ear typically raises its hearing threshold for a 1000 Hz pure tone to 50 dB HL.

6.8.2 Indicators of cross-hearing and the rules for masking

The indicators (or 'rules') given below are to be considered at each frequency individually. Words such as 'better' and 'worse' describe hearing as measured by air conduction. The test ear is always the ear whose hearing threshold is being sought (the worst); the ear is directly presented with the pure tone. Masking is done on the non-tested ear to prevent detection of the pure tone. Masking needed to be effected at all frequencies where a cross hearing occurred.

6.8.2.1 Rule 1

This rule is applicable for air conduction masking. Masking is needed at any frequency where the difference between the left and right not-masked AC thresholds is 40 dB or more when using supra- or circum-aural earphones or 55 dB when using insert earphones. The worse ear is the test ear where the tone is presented, and the better ear is where the masking noise is presented.

Rule 1 is applied when:

$$AC_{\text{TEST EAR}} - AC_{\text{NON-TEST EAR}} \geq IAA$$

6.8.2.2 Rule 2

Rule 2 is applicable for bone conduction only. Masking is needed at any frequency where the not-masked BC threshold is better than the air-conduction threshold of either ear by 10dB or more. The worse ear (by air-conduction) would then be the test ear, and the better ear would be the non-test ear to be masked.

Notes on Rule 2:

Rule 2 may frequently indicate the need for masking; there are occasions where this is not warranted, depending on the purpose of the investigation. For example, it may not benefit patient management to mask more than two BC frequencies on one ear or to mask small air-bone gaps.

If the BC threshold with masking is more than 10 dB worse than the not-masked BC threshold, then the not-masked BC threshold can be attributed to the other (non-test) ear. However, if the BC threshold with masking is not more than 10 dB worse than the not-masked BC threshold, a possibility is that the not-masked BC result was from the test ear, and it may be necessary to test the BC thresholds of the other ear with masking.

Rule 2 is applied when:

$$\text{Air-Bone Gap}_{\text{TEST EAR}} \geq 10 \text{ dB}$$

where

$$\text{Air-Bone Gap} = AC_{\text{TEST EAR}} - \text{Not Masked BC}$$

6.8.2.3 Rule 3

Rule 3 is applicable for air conduction masking. Masking is needed additionally if Rule 1 has not been applied. When the BC threshold of one ear is more acute by 40 dB or more (if supra- or circum-aural earphones have been used) or 55 dB (if insert earphones have been used), the not-masked AC threshold is attributed to the other ear.

Notes on Rule 3:

Rule 3 is necessary because an AC frequency that does not require masking under Rule 1 may be masked if the BC results show that the non-test ear has a conductive element. Note that the sensitivity of the non-test cochlea (as indicated by the BC threshold) is an important factor in cross-hearing. Rule 1 is merely a convenient way of anticipating the need to mask in many cases.

At frequencies where no BC thresholds have been measured, doubt may exist regarding the possible effect of Rule 3. If there is a possibility that AC thresholds at these frequencies (including 250 Hz and 8000 Hz) are not the true thresholds, they should be masked or marked accordingly on the audiogram form.

Rule 3 is applied when:

$$AC_{\text{TEST EAR}} - BC_{\text{NON-TEST EAR}} \geq IAA$$

Summary rule of masking and value of interaural attenuation:

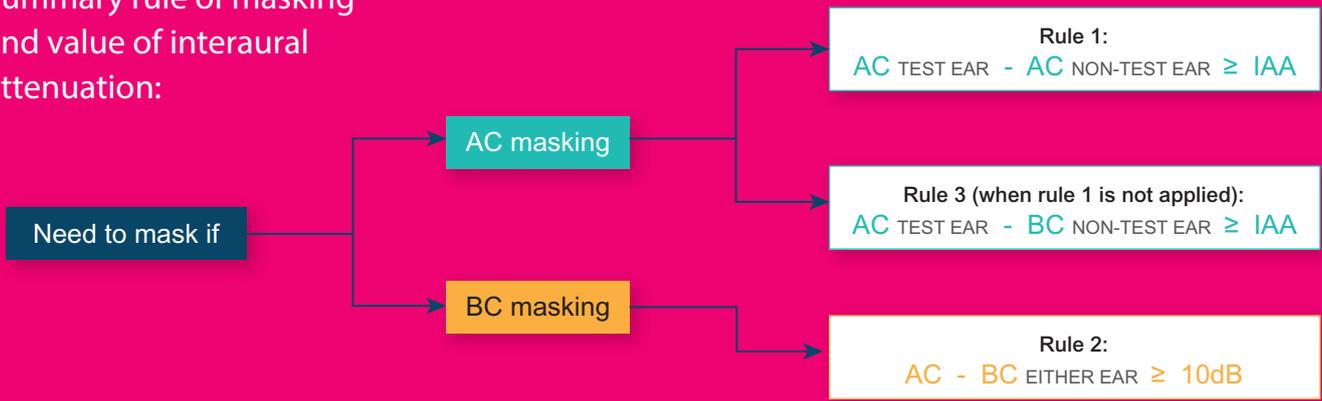


Table 6.1: Showing Inter-Aural Attenuation (IAA) value

STIMULUS	TRANSDUCER	FREQUENCIES (HZ)					
		250	500	1000	2000	4000	8000
Air conduction	Supra- / Circum-aural earphones	40					
	Insert earphones	55					
Bone conduction	Bone vibrator	0					

Recommended clinical masking

- Present initial masking level at AC non-test ear + 10 dB and re-established pure tone threshold at test ear.
- If there is no response, increase the tone by 5 dB until the response is obtained.
- If there is a response, increase the noise by 10 or 5 dB.
- A plateau is established when the noise level can be increased over 15 to 20 dB without shifting the threshold of the tone. This value corresponds to a response to the tone at the same hearing level when the masker is increased in three to four consecutive levels (if 5-dB steps of masking noise are used).
- If the 10-dB step size is used for increasing masking level, then the plateau corresponds to a range of 20 dB (i.e., a response to the tone at the same hearing level when the masker is increased in two consecutive levels)

Notes on masking method:

Proceed with caution when using masking noise greater than 80 dB EML or tones greater than 100 dB hearing level.

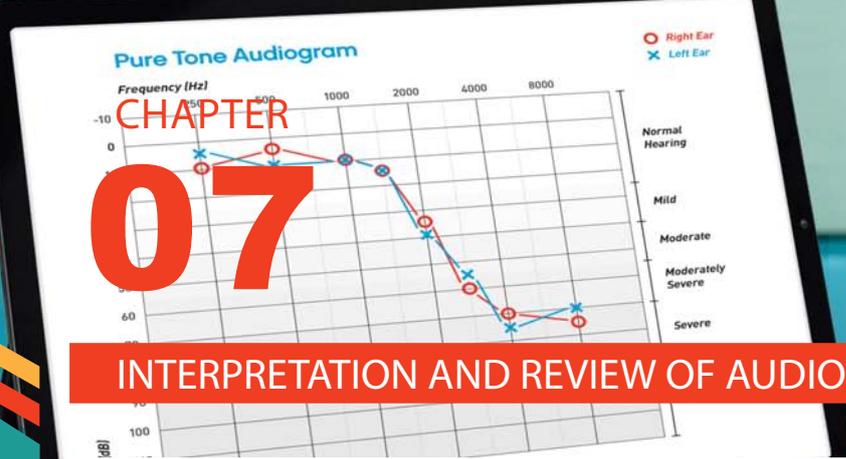
There is a possibility that cross masking can occur when the masking noise presented to the non-test ear crosses across the skull by bone conduction to the test ear cochlea and masks out the test tone in the test ear.

10-10 dB pattern (10 dB increase in tone over 10 dB increase in noise) is observed and unable to get plateau.

Cross masking when:

$$\text{Masking noise level} - \text{IAA}_{\text{NON-TEST EAR transducer}} > \text{TEST EAR BC threshold}$$

“There is less risk of cross masking with insert earphones.”



INTERPRETATION AND REVIEW OF AUDIOGRAMS

7.1 INTRODUCTION

This chapter is intended to give a systematic review of how a pure tone audiogram should be interpreted. Summary on topics that are prerequisites to understanding the principles behind the audiometric test is made.



The topics are:



- The hearing process
- Pure tone audiometry
- Classification of hearing loss
- The flow of audiometric test

Diagnosing ONRHD depends on clinical judgment, consisting of audiogram interpretation and other aspects such as history taking, physical examination, and other relevant investigations. Sound knowledge of audiogram interpretation greatly assists in this process. It is imperative that this chapter is read along with other chapters, especially those pertaining to the procedures for performing audiometric tests and requirements for masking in audiograms.

7.2 HEARING PROCESS

Hearing is the process of perceiving sound. Vibrating objects force the adjacent air molecules to oscillate back and forth in a horizontal plane in a cyclical manner – a phenomenon known as compression and rarefaction. The oscillation continues, and when it reaches the tympanic membrane (TM) (through the ear canal), it causes the TM to vibrate.

Since the TM is connected to the three ossicles of the middle ear (malleus, incus, and stapes), this causes the ossicles to move synchronously. The foot of stapes is attached to the membrane covering the oval window of the cochlear; hence, a movement causes the membrane to be pushed and pulled in a piston-like manner. This movement causes rippling of the fluid in the cochlear (endolymph) and subsequently excites the hair cells located in the basilar membrane. A series of electrochemical reactions then occur at the hair cells where neurotransmitter release causes the nerve cells to be depolarized. The electrical impulse is carried through the cochlear nerve to the brain.

The whole process involves transforming the sound energy from its source to kinetic energy through the vibration of air molecules and mechanical energy from the movement of the TM and the ossicles. Ultimately, hydraulic energy is produced by the movement of the endolymph that excites the hair cells, and the brain perceives sound.

The classical way of perceiving noise, as mentioned above, is through air conduction. However, if the cochlear is stimulated directly and causes the hair cells to be excited, noise can still be perceived. As the cochlea is encased in a solid skull, any skull vibration causes the cochlear to be stimulated and subsequently excites the hair cells. This response is known as bone conduction of noise. Strictly speaking, in bone conduction, hearing is made possible by bypassing the classical air conduction pathway. This principle is used to assess the cochlear function of the ear through a bone audiometric test.

The pathway of sound transmission is illustrated below, where a tuning fork is used to create vibration. When the vibrating prongs are placed next to the pinna, the brain perceives the sound as the sound wave travels through air conduction (AC). Likewise, the sound is also perceived when the base of the vibrating tuning fork is placed on the skull. The vibration is transferred directly to the cochlear via the skull bone (bone conduction, BC), exciting the hair cells located within the cochlear.

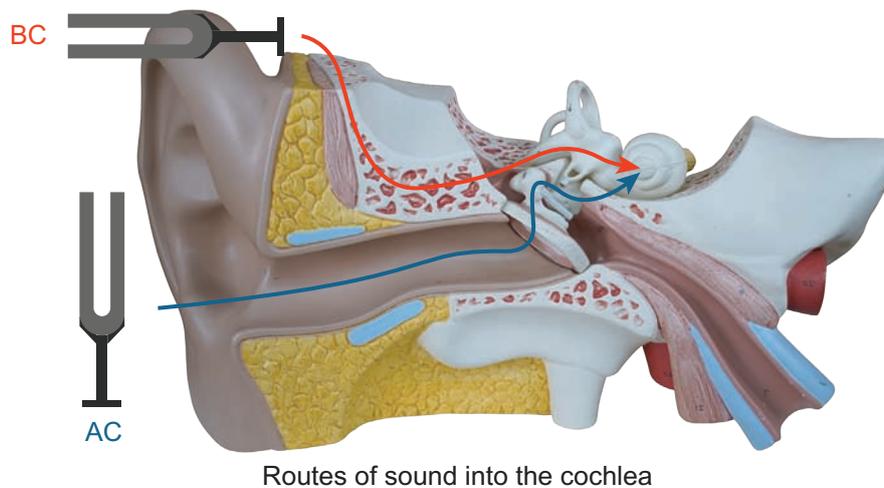


Figure 7.1: Routes of sound transmission (AC = Air Conduction, BC = Bone Conduction)

7.3 PURE TONE AUDIOMETRY

An audiometric test is performed to establish an individual's hearing state by determining the frequency and intensity at which sounds can be heard. Establishing a worker's hearing status is crucial for safety purposes as specific tasks require good hearing (e.g., crane drivers). Additionally, the workers' hearing must be monitored regularly to detect any deterioration caused by exposure to noise at the workplace (Occupational Noise-Related Hearing Disorders, ONRHD). Monitoring hearing of workers exposed to noise above noise exposure limit (NEL) is compulsory under the Occupational Safety and Health (Noise Exposure) Regulations 2019.

The audiometric test makes use of pure tone and hence is known as pure tone audiometry or PTA. Pure tone refers to the single-frequency tone emitted through the headphone (air conduction test) or the bone vibrator (bone conduction test). The hearing threshold is the lowest level of hearing (in dB) that the subject perceives when tested against a particular frequency.

7.3.1 Audiogram

An audiogram is essentially a graph showing the result hearing threshold plotted against the tested frequency. The hearing threshold is usually plotted on the vertical or y-axis, while the frequency is horizontal or x-axis. The frequency range that can be tested is from 125 to 8000 Hz. However, Occupational Safety and Health (Noise Exposure) Regulations 2019 require that the frequencies of 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz be tested. A sample of pure tone air conduction audiogram is depicted below.

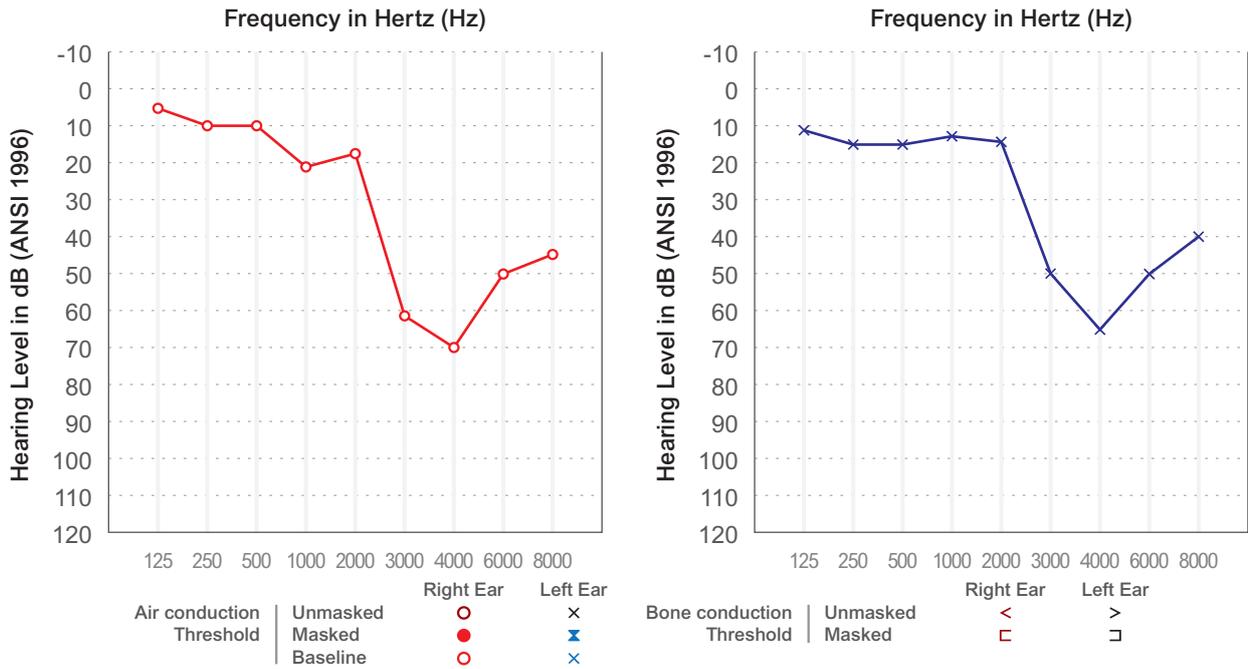


Figure 7.2: Sample of pure tone air conduction audiogram

7.4 SUMMARY OF PROCESS FLOW IN PERFORMING PTA

The process of conducting PTA was described in detail in Chapter 6. PTA starts with each ear being tested separately for their air conduction hearing threshold respectively. Subsequently, values obtained for each tested frequency are recorded. As a general rule, the air conduction hearing threshold obtained is independent on the site where the pure tone is presented. The exception to this rule is when the pure tone presented to the test ear is intense enough to cause it to be heard by the non-test ear. This phenomenon is discussed below. In this situation, a masking procedure is required to obtain the actual air conduction threshold of the tested ear. Once the air conduction has been completed, the headphone is removed, and the bone vibrator is placed on either right or left mastoid prominence.

The bone vibrator then sends vibration at the tested frequencies directly to the cochlear, and the bone conduction hearing threshold is recorded. It is imperative to note that the bone conduction hearing threshold obtained depends on where the bone vibrator is placed. This position means that a bone vibrator placed on the right mastoid does not necessarily send the signal to the right cochlear but rather to both the right and left cochlear. For that reason, the bone conduction threshold value has the same value when documented on left and right audiograms. Figure 7.3 summarizes the sequence of performing PTA.

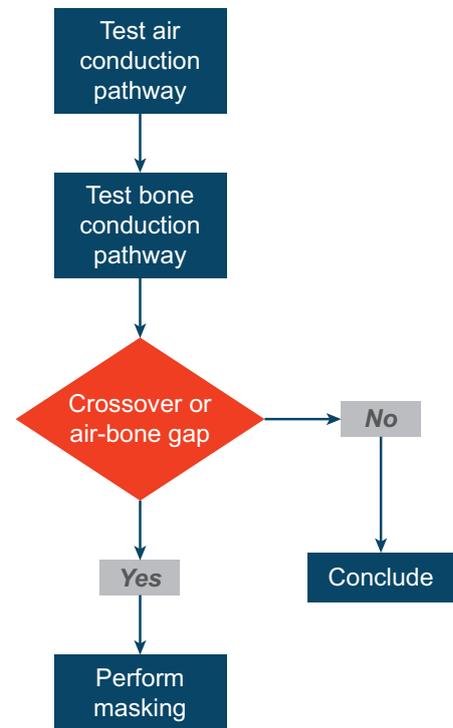


Figure 7.3: Flow chart on the sequence of performing PTA

7.4.1 Interaural Attenuation (IAA)

Knowledge of IAA is a necessary requisite to appreciate the rationale, indication, and rules of masking. When the tone is presented in the test ear through air conduction, a possibility is that the non-test ear could hear the tone if the signal is intense enough to cause the skull to vibrate⁴. This effect is known as crossover. The supra-aural earphone has a higher contact area with the skull as compared to the insert headphone. Thus, supra-aural headphones can cause the skull to vibrate more readily compared to insert earphones. It follows that when the same sound intensity is presented to the test ear, the supra-aural earphone transfers the sound readily to the non-test ear when compared to insert earphones. In other words, the supra-aural headphone has less IAA than the insert headphone.

In practice, supra-aural headphones can potentially result in more masking as the presented tone to the test ear can more easily cross to the non-test ear compared to insert headphones. It has been demonstrated that the IAA of supra-aural compared to insert headphone is 40 dB versus 55 dB, respectively. The value of IAA is demonstrated in the figure below.

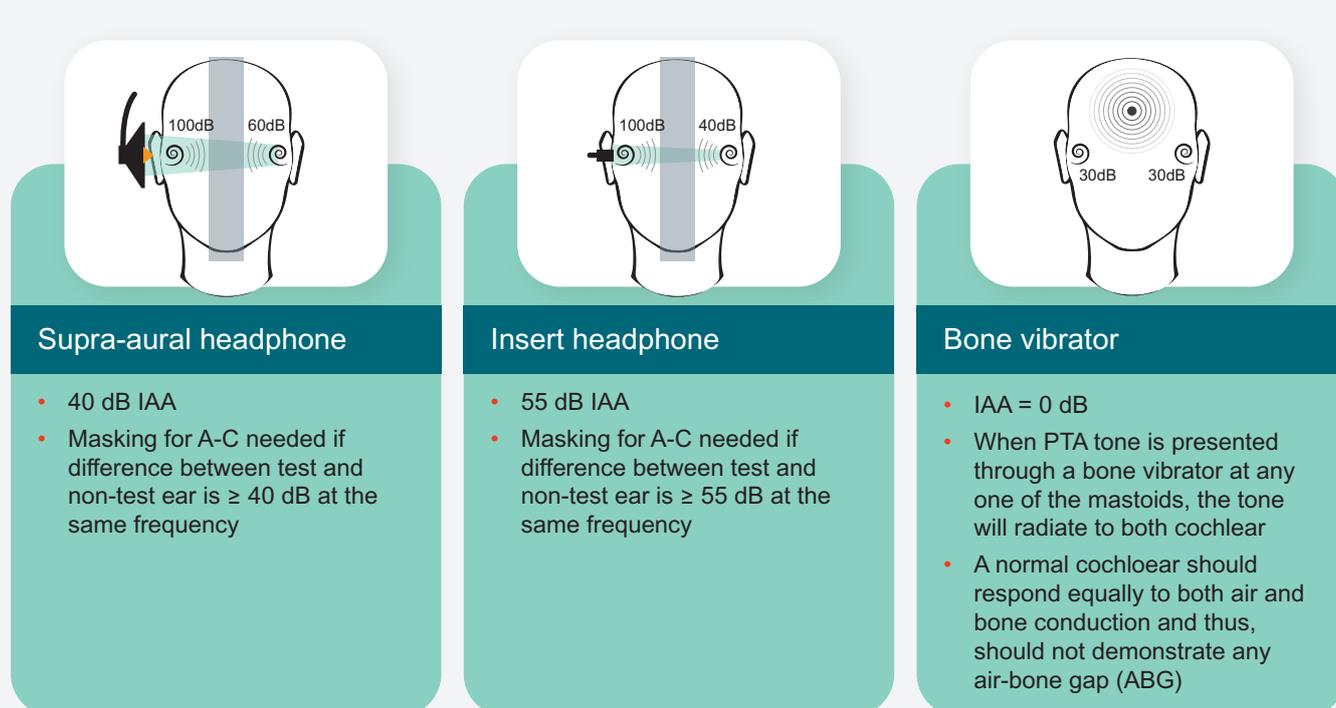


Figure 7.4: Value of IAA by types of earphone and bone vibrator

7.4.2 Masking PTA

The detailed procedure in performing both air and bone conduction is described in Chapter 6. Masking in audiology is playing noise into the non-test ear to prevent it from hearing the crossover tone from the test ear. This “distracts” the non-test ear from “helping” the test ear from hearing the presented tone. The masked hearing threshold is usually higher (worse) than the non-masked threshold of the tested ear. It is essential to realize that presenting the masking noise into the non-test ear allows the presented tone from crossing over to the non-test ear. The masking noise instead raises the hearing threshold of the non-test ear. Finally, the hearing threshold obtained after masking should be equal or worse (more) than the original threshold (not-masked). There are three (3) rules for masking⁵, and these rules are summarized in the table and figure below:

4 Munro KJ, Agnew N. A comparison of inter-aural attenuation with the Etymotic ER-3A insert earphone and the Telephonics TDH-39 supra-aural earphone. *Br J Audiol.* 1999;33(4):259-262. doi:10.3109/03005369909090106.

5 A Recommended Procedure by the British Society of Audiology (BSA) on Pure-tone air-conduction and bone conduction threshold audiometry with and without masking. <https://www.thebsa.org.uk/wp-content/uploads/2018/11/OD104-32-Recommended-Procedure-Pure-Tone-Audiometry-August-2018-FINAL.pdf>

Table 7.1: Rules for performing masking

RULE	DESCRIPTION
1	Masking is needed at any frequency where the difference between left and right not-masked air conduction threshold is 40 dB or more when using supra-aural earphones or 55 dB when using insert earphones
2	Masking is needed at any frequency when the not-masked bone conduction threshold is more acute than the air conduction threshold of either ear by 10 dB or more
3	Masking is needed if Rule 1 has not been applied but where the bone conduction of one ear is 40 dB or more (if supra-aural earphones have been used) or 55 dB or more (for insert earphones)

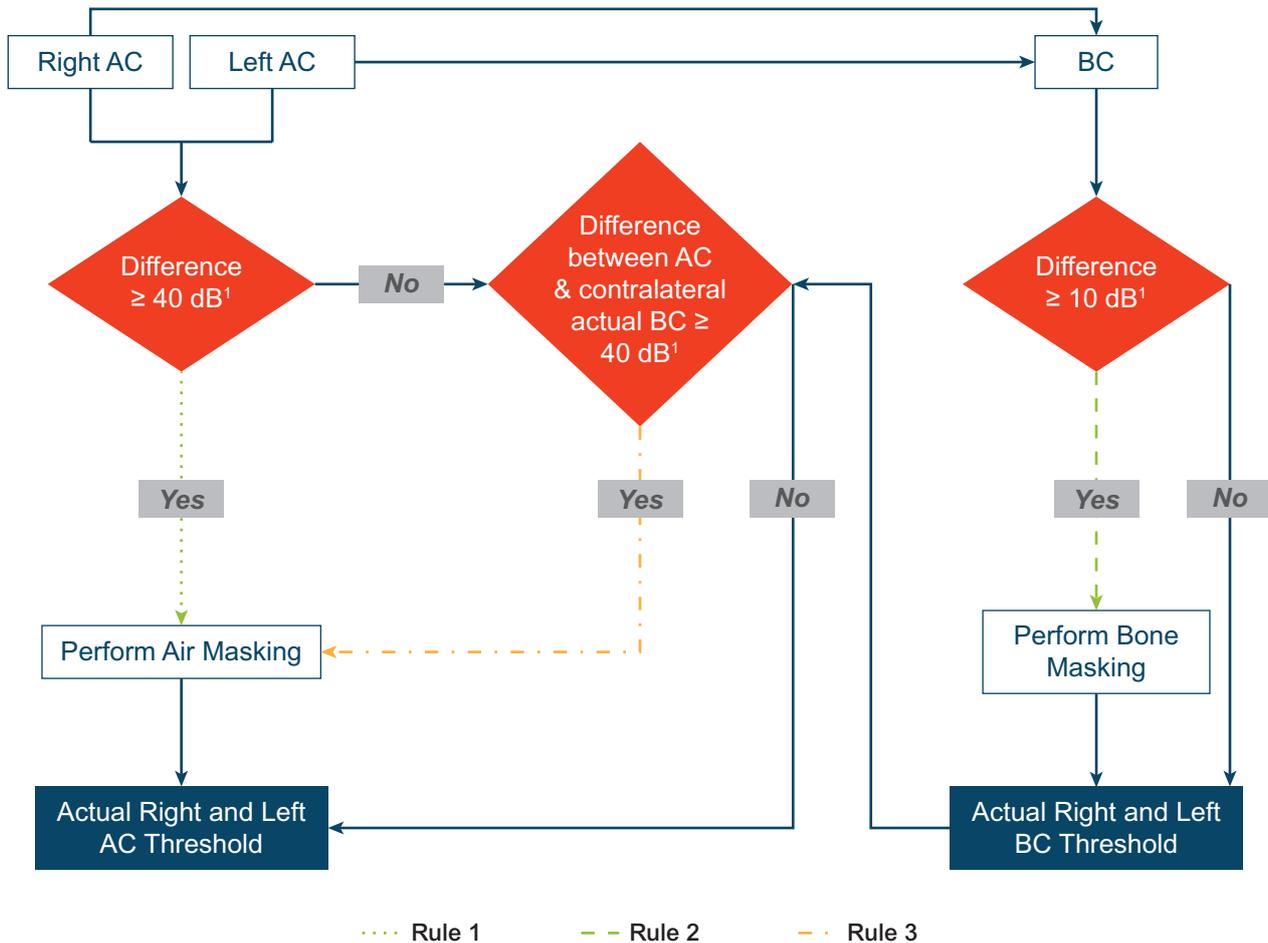
The matrix below simplifies the requirement for masking based on the comparison of air and bone conduction hearing threshold values obtained for the left and right ears.

				
		≥ 140 dB (Rule 1)	≥ 10 dB (Rule 2)	≥ 140 dB (Rule 3)
	≥ 140 dB (Rule 1)		≥ 140 dB (Rule 3)	≥ 10 dB (Rule 2)
	≥ 10 dB (Rule 2)	≥ 140 dB (Rule 3)		
	≥ 140 dB (Rule 3)	≥ 10 dB (Rule 2)		

Note: ¹ 40 dB is when supra-aural headphone is used and shall be replaced with 55 dB for insert earphone

Figure 7.5: Matrix showing the indication for masking

The flow chart below summarizes the masking process to obtain the actual air and bone conduction hearing thresholds.



Note: ¹ 40 dB supra-aural headphone is used and shall be replaced with 55 dB if using insert earphone

Figure 7.6: Flow chart showing the rules of masking in obtaining the actual air and bone conduction hearing thresholds

7.5 AUDIOGRAM INTERPRETATION

When interpreting an audiogram, the interpreter must realize that the final audiogram might be presented by any of these two (2) forms:

- The “evolving audiogram” in which the audiogram shows all the symbols used for air and bone unmasked, as well as masked. Usually, this is done manually. This type of audiogram has the advantage as the interpreter is able to look into the “history” of how the audiogram is generated – starting from the very second air conduction not-masked test was performed. The interpreter is able to examine the audiogram based on the steps in the flow chart (Figure 7.6) to ensure that the steps are not missed and appreciate any changes that have taken place due to the masking procedure. However, the audiogram might look a little “cluttered,” cramped with all the symbols in the audiogram tracing.
- The “complete audiogram.” Here, only the masking symbols are documented, and thus the audiogram looks neater with only the final (actual) air and bone conduction of each ear presented. This type of audiogram is usually software-generated and is becoming more common nowadays.

The audiogram interpretation starts with determining the validity of the audiometric booth, testing procedure, the trained audiometric technician, and the audiogram itself. Among the parameters to be observed are:

- Test equipment has been calibrated.
- The test is conducted in approved centres or mobile units.
- The trained audiometric technician has undergone the required, appropriate training
- The testing methodology was correct (questionnaire, frequencies tested)

It should be made clear that the items (i) and (ii) above are applicable for screening PTA only. The details can be referred to the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019 under Audiometric Testing. When interpreting a pure tone audiogram, it is important that the description is standardized and must contain the types of hearing loss and the specific hearing threshold at each frequency of both ears, or enumerating all these 4 (four) of the elements as such:

- The severity of hearing loss
- Frequency of hearing loss
- Type of hearing loss
- Side of hearing loss

7.5.1 Severity of hearing loss

The degree of hearing loss for each of the frequency tested must be determined based on the classification below:

Table 7.2: Classification of hearing loss⁶

HEARING LEVEL DB	CLASSIFICATION OF HEARING LOSS
26 – 40	Mild
41 – 70	Moderate
71 – 90	Severe
≥ 91	Profound

Any hearing level at 25 dB or less is considered normal.

7.5.2 Frequency of hearing loss

The interpreter must examine each frequency separately for hearing loss and describe the type of hearing loss (see below). Sometimes, the term “high-frequency loss” is used, especially when describing hearing loss related to noise. ‘High frequency’ refers to frequencies above 3000. “Low frequencies” refer to frequencies of 500 Hz or lower. 1000 and 2000 Hz are more often termed as the mid-frequencies. These terms have long been used for convenience and practicality and are somewhat arbitrary.

It is worth noting that while air conduction has a wide range of frequencies to be tested (125 – 8000 Hz), bone conduction is usually limited to 8000 Hz due to the nature of the bone transducers.

⁶ Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

7.5.3 Type of hearing loss

Finally, the interpretation must describe the types of hearing loss for each frequency tested. Table 7.3 describes the types of hearing loss that have to be addressed in the interpretation.

Table 7.3: Types of hearing loss

TYPE OF HEARING LOSS	DESCRIPTION	NOTE
Conductive	The hearing threshold for air conduction is more than 25 dB at any frequency with a normal bone conduction threshold	Conductive loss occurs when transferring sound waves anywhere along the pathway through the outer ear, TM, or middle ear (ossicles). "Screening pure tone audiometry" tests both air and sensorineural pathways without discriminating which pathway has been affected in hearing loss
Sensorineural (SNHL)	The hearing threshold for bone conduction is more than 25 dB at any frequency	Sensorineural hearing loss (SNHL) is a hearing loss with the root cause of the inner ear or sensory organ (cochlea and associated structures) or the vestibulocochlear nerve. This loss is seen as an absence of air-bone gap (i.e., the gap is < 10 dB) in the audiogram
Mixed hearing loss	The hearing threshold for both air and bone conduction is more than 25 dB at any frequency	Mixed hearing loss occurs due to problems when transferring sound from the outer, middle, and inner ear. This loss is seen as the presence of an air-bone gap (i.e., the gap is \geq 10 dB) in the audiogram, and both the air and conduction hearing loss are more than 25 dB

7.5.4 Side of an audiogram

The side of hearing loss or abnormality seen in the audiogram should be specifically indicated, i.e., the left or right ear. Bilateral hearing loss (instead of describing each ear separately) is usually used when the abnormality is symmetrical in both ears. The term unilateral is usually used to compare between a normal and its contralateral abnormal ear. The term asymmetrical is used when there is a difference between both abnormal ear thresholds.

7.5.5 Legal interpretation of audiogram

Specific legal definitions need to be addressed while interpreting audiograms. These definitions are replicated from the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

- "standard threshold shift (STS)" means an average shift of 10 dB or more at frequencies of 2000, 3000, and 4000 Hz than the baseline audiogram.
- "baseline audiogram" means the audiogram against which future audiograms are compared.
- "abnormal audiogram" means an audiogram that shows a hearing loss, hearing impairment, or permanent Standard Threshold Shift (STS).
- "hearing impairment" means the arithmetic average of an employee's permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz, which is shifted by 25 dB or more than the standard audiometric reference level.
- "hearing loss" means partial or total inability to hear marked by a hearing threshold worse than 25 dB at any audiometric test frequency. Hearing loss may be mild (26 to 40 dB), moderate (41 to 70 dB), severe (71 to 90 dB), or profound (equal or more than 91 dB).
- "abnormal audiogram" means an audiogram that shows a hearing loss, hearing impairment, or permanent Standard Threshold Shift (STS).

7.6 REVISED BASELINE

Item 13.3.7 of Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019 has stated that the baseline audiogram shall be replaced by the annual or retest audiogram whenever there is the presence of:

- permanent STS; or
- an improved hearing threshold to the baseline at two (2) or more test frequencies.

While replacing the baseline is straightforward when the hearing threshold has improved (b), this might not be the case when dealing with STS. Following temporary STS, the employee shall undergo a retest within three (3) months from the date of temporary STS. If the temporary STS is unilateral, it seems appropriate that only the ear with temporary STS is tested.

However, both ears (rather only the affected ear) should be retested simultaneously with reference to best practices. When the ear previously without temporary STS is found to have a significant threshold shift, the interpretation of the retest result can be tricky. Therefore, the OHD is advised to exercise his/her clinical judgment on a case-to-case basis to trigger an investigation and acknowledge the threshold shift.

7.7 AUDIOGRAM'S FEATURES OF NOISE-INDUCED HEARING LOSS (NIHL)

Audiogram with these features requires **special attention** because it usually indicates that the employee's hearing has been affected by noise:

Presence of progressively worsening / gradually worsening high-frequency sensorineural hearing loss (at either 3 or 4 or 6 kHz, usually with recovery at 8 kHz)

Presence of notch, usually at 4kHz⁷, even though this is not pathognomonic;

Usually symmetrical.

In addition, the hearing loss is symmetrical, where:

- The difference between air conduction hearing threshold between both ears is < 40 dB at any frequency (or 55 dB when using insert headphones)
- The difference between bone conduction and air conduction hearing threshold between either ear at any frequency is < 10 dB
- The difference between one ear's air conduction hearing threshold and bone conduction of its contralateral ear at any frequency ear is < 40 dB (or < 55 dB when using insert earphone).

7 McBride, D. I., & Williams, S. (2001). Audiometric notch as a sign of noise induced hearing loss. *Occupational and environmental medicine*, 58(1), 46–51. <https://doi.org/10.1136/oem.58.1.46>

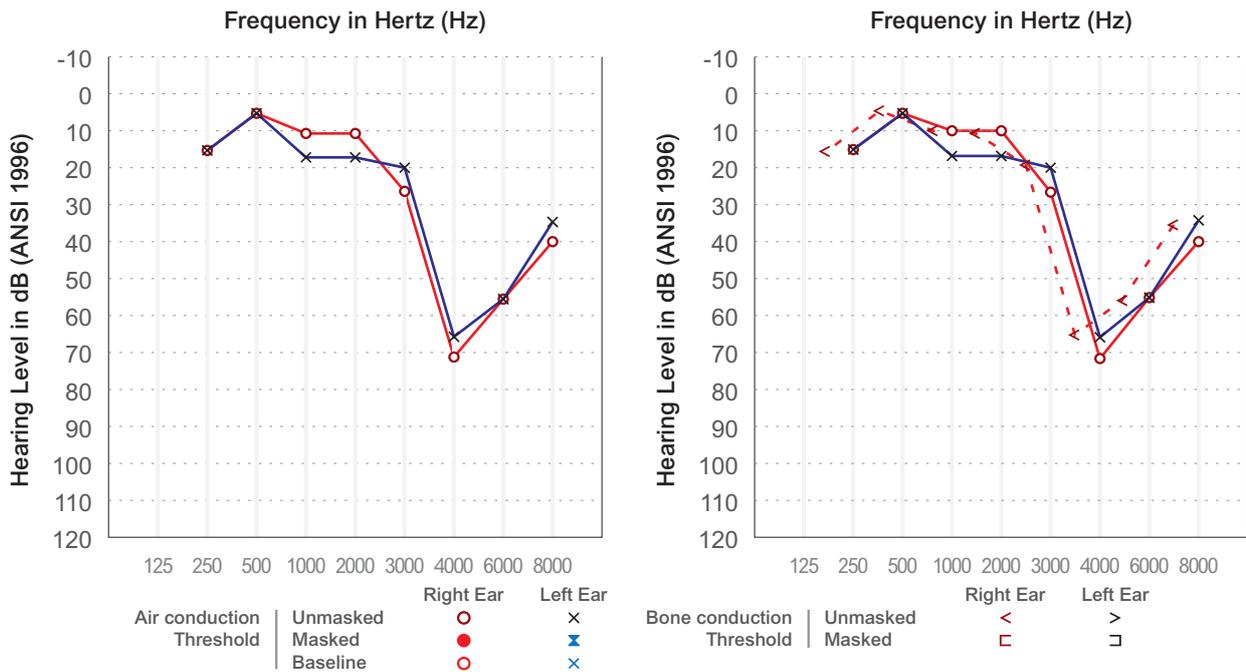


Figure 7.7: Example of audiogram with features of NIHL seen in air conduction or “screening” audiogram (left) and after bone conduction or “diagnostic” has been performed (right)

Figure 7.7 above shows what a classical NIHL audiogram looks like. In the air conduction audiogram (left), both ears show high-frequency hearing loss with “notch” at 3000 Hz and recovery at higher frequencies. The audiogram on the right shows no air-bone gap in both ears, indicating a sensorineural type of hearing loss. Note that the right and left ear bone conduction test was performed separately in this audiogram, which is sometimes seen in practice. Also, note that the bone conduction was performed only until 4000 Hz, whereas air conduction was until 8000 Hz. The amount of sensorineural hearing loss of the left and right ear is the same until 2000 Hz. However, left ear hearing loss is more severe at 3000 and 4000 Hz.

CONCLUSION

Audiogram interpretation requires understanding on how sound is conducted through two different media – air and solid (skull) and the corresponding air and bone air conduction PTA. Masking needs to be performed to obtain the actual air and bone conduction hearing threshold if the hearing loss is asymmetrical. Additionally, the high-frequency sensorineural hearing loss must be established to diagnose NIHL. Finally, upon interpreting the audiogram to be NIHL, the 4 (four) elements (type, severity, frequency, and side of hearing loss) must be enumerated.

CHAPTER 08

MEDICAL EXAMINATION AND ESTABLISHING DIAGNOSIS

8.1 APPROACH TO WORKERS WITH ABNORMAL AUDIOGRAM

As stated in the Occupational Safety and Health (Noise Exposure) Regulations 2019, if the OHD determines that any worker has an abnormal audiogram, the OHD shall carry out a medical examination on such worker. The medical examination shall include medical history taking, physical examination, and relevant investigations.

These can give valuable clues for the causes of the hearing loss or abnormalities and assist in establishing the diagnoses of occupational noise-related hearing disorders.

The medical examination shall be conducted on all newly discovered abnormal audiograms and repeated in the subsequent year only if there is a significant change in the hearing threshold.

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8.1.1 Clinical History

A complete history should consist of:

- The onset of hearing loss – sudden or gradual.
- Associated symptoms: tinnitus, aural fullness, vertigo, imbalance, otalgia, otorrhea.
- Smoking habit
- A history of previous infections: systemic or ear only.
- A history of ear surgery or procedure or previous intracranial surgery.
- A history of trauma to the ear or head, or barotrauma.
- A family history of hearing loss or ear-related tumour.
- Use of medications: Aminoglycosides, NSAIDs, Loop diuretics, Quinine, Antineoplastic (Cisplatin).
- Occupational history (discussed in detail in Chapter 9).
- Other medical diseases: metabolic or autoimmune disorders.
- Hobbies: motorsports, hearing loud music or using earphones, weapon firing.
- Assessing the usage, training on HCP, and proper wearing and fit test of PHP.
- Ascertaining the Noise Exposure Limit from the NRA report

8.1.2 Physical Examination

The physical examination includes:

8.1.2.1 General external ear examination

- Any syndromic facies, white patch of hair, goitre
- Auricles: Skin lesions, erythema, tenderness.
- External auditory canals: tragal tenderness, lesion, ear discharge.
- Mastoid tenderness/swelling

8.1.2.2 Other systems examination if indicated from the clinical history.

- Cranial nerves examination
 - » Examination of the related cranial nerves (e.g., vestibulocochlear nerve)
- Cerebellar examinations

8.1.2.3 Head and neck examination

- Nose
- Oral cavity and throat
- Anterior rhinoscopy
- Neck
- Lymph nodes

8.1.2.4 Otoscopy

- Assess the external auditory canal, tympanic membrane (TM), and middle ear.
- Inspect the external auditory canal for cerumen impaction, foreign objects, canal edema, erythema, and otorrhea.
- Inspect the TM for colour, shape, light reflex, bulging, perforation, scarring, and the presence or absence of typical landmarks:

a. Colour

- A healthy TM should appear pearly grey and translucent.
- Erythema suggests inflammation of the TM, which can occur in conditions such as acute otitis media.

b. Shape

- Bulging of the TM suggests increased middle ear pressure, which is commonly caused by acute otitis media with effusion (there is often an associated visible fluid level).
- Retraction of the TM suggests reduced middle ear pressure, which is commonly caused by pharyngotympanic tube dysfunction secondary to upper respiratory tract infections and allergies.

c. Light reflex

- The light reflex (also known as the “cone of light”) is visible when a light is shone onto the TM.
- If a TM is healthy, the cone-shaped reflection of light should appear in the inferior anterior quadrant.
- Absence or distortion of the light reflex is often associated with otitis media (due to bulging of the TM).

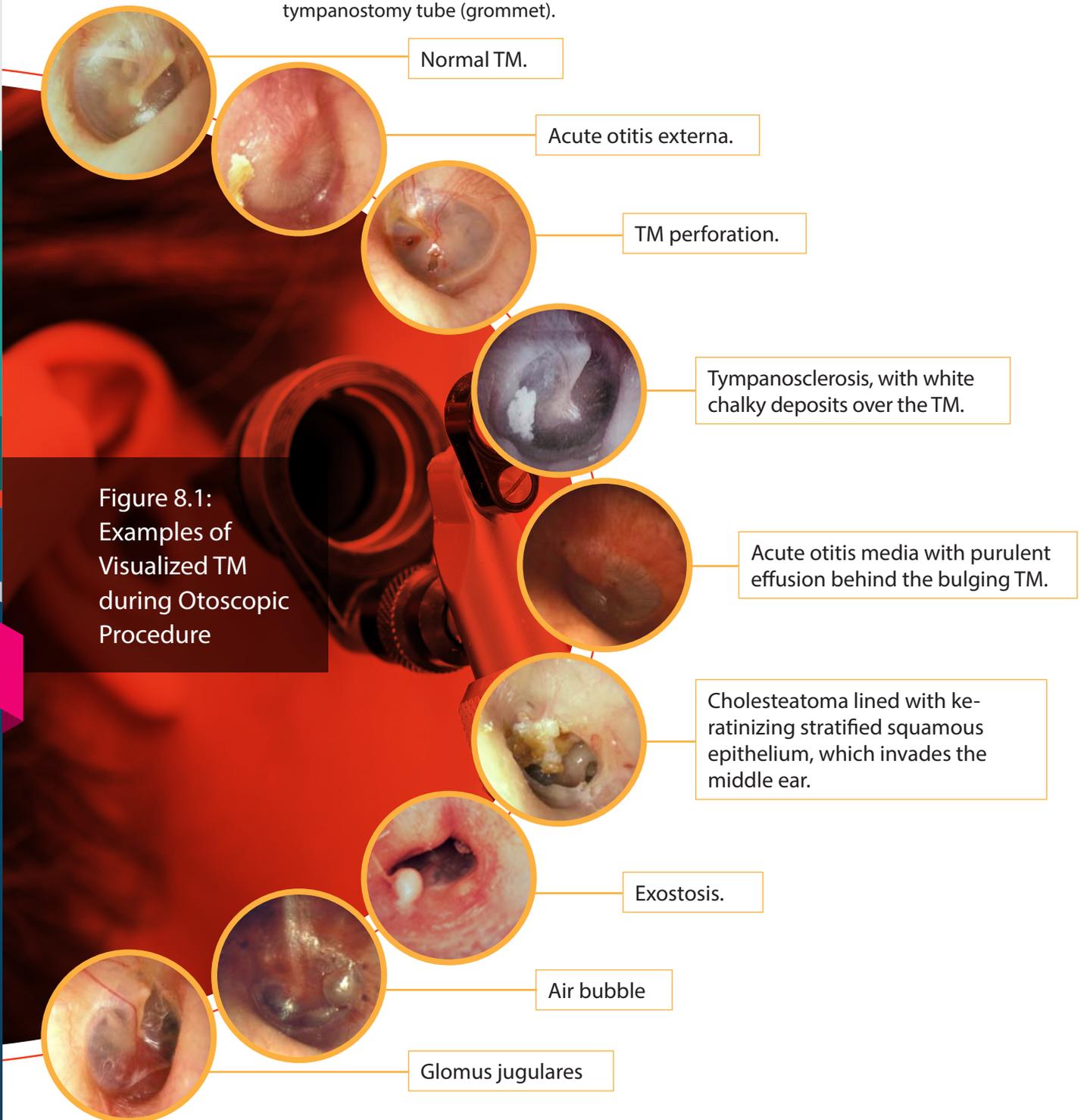


d. Perforation

- Note the size (and shape) and the position of any perforation of the TM.
- Causes of TM perforation include infection (e.g., otitis media with effusion), trauma (e.g., diving-related), cholesteatoma, and insertion of tympanostomy tubes (also known as grommets).

e. Scarring

- Scarring of the TM is known as tympanosclerosis and can result in significant conductive hearing loss if it is extensive.
- Tympanosclerosis often develops secondary to otitis media or after the insertion of a tympanostomy tube (grommet).



8.1.2.5 Tuning Fork Test⁸

A tuning fork test is a brief and straightforward test to establish the probable presence or absence of a significant conductive element to hearing loss and provide early diagnostic information if audiometry is unavailable. It should not be the sole indicator on which a decision for further audiological assessment is based.

The preferred tuning fork is a 512 Hz tuning fork, as the tone does not fade too quickly, producing limited overtones and is not vibrotactile. The test should be done in a quiet room. Prior to the test, the practitioner should explain and instruct the worker on each of the tests.

8.1.2.6 The Weber Test

The Weber Test is a lateralization test to establish where a sound is perceived. The test is done by placing the stricken tuning fork on the midline of the worker's forehead, vertex, bridge of the nose, or chin. To ensure enough counter-pressure is applied, place your other hand on the back of the head. Then, ask the worker where the tone is heard: in both ears; centrally; towards the left or right.



Figure 8.3: Appropriate technique to perform Weber test

Interpretation:

- With symmetrical hearing or a symmetrical hearing loss, the sound heard should be central
- With an asymmetrical sensorineural loss, the sound heard should be in the better ear
- With an asymmetrical conductive hearing loss, the sound heard should be in the poorer ear

8.1.2.7 The Rinne Test

The test compares the loudness of perceived air conduction to bone conduction in one ear at a time. First, strike the tuning fork and hold the tuning fork's tines at approximately 2.5 cm from the ear canal entrance. Hold the tuning fork for 2 seconds. Press the footplate firmly against the worker's mastoid process for another 2 seconds without any interruption to the tuning fork. Ask the worker whether the sound is louder next to the ear or behind it.

**The vibrating tuning fork must be placed with the tines oriented perpendicular to the ear canal to ensure the acoustic axis is pointing towards the ear canal.*

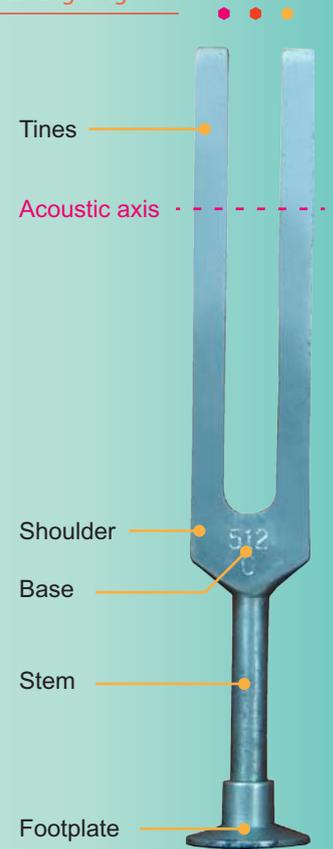


Figure 8.2: The tuning fork



Figure 8.4: Left: Appropriate technique for air conduction test, Right: Appropriate technique for bone conduction test

Interpretation:

- If sound via air conduction (next to the ear canal) is louder, this is a Rinne positive result, indicating either normal hearing or a sensorineural hearing loss
- If sound via bone conduction (held on mastoid) is louder, this is a Rinne negative result, indicating a significant conductive element to the hearing loss

Rinne test can result in a false Rinne negative, where the subject can detect sound at the opposite ear. The sound can be detected as the bone conduction transmits through the skull to the opposite ear. It is detected through cross hearing by the better cochlear in the non-test ear. This condition can occur in a severe sensorineural hearing loss, predominantly on the test side. Masking of the non-test ear by tragal rubbing can prevent cross hearing.

8.1.2.8 Limitation of Weber and Rinne

- Rinne test is not sensitive in differentiating conductive and sensorineural loss.
- False negative Rinne may happen in a worker with profound sensorineural hearing loss, as the sound transmits through the skull to the contralateral ear. The worker may be unable to identify which ear he heard the sound.
- The techniques of performing the test vary among individuals.
- There is a poor correlation between the air-bone gap and the tuning fork test result.
- The tests cannot confirm normal hearing as they do not measure sound sensitivity quantitatively.

8.1.3 Specific test

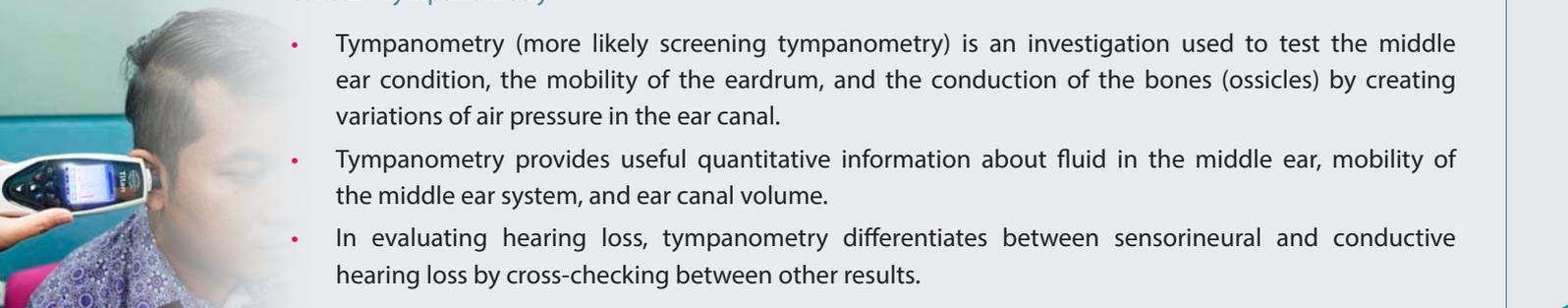
8.1.3.1 Diagnostic pure tone audiometry

- In diagnostic pure tone audiometry, air conduction and bone conduction test is performed, with masking done when necessary to differentiate between conductive and sensorineural hearing loss.
- As prescribed in the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019, audiometry test is limited to air conduction only. Conductive hearing loss cannot be differentiated from sensorineural hearing loss. The reliability and validity of the test also depend on the technician’s (trained audiometric technician) skills, worker’s cooperation, test environment, and equipment calibration.

- OHD needs to obtain the following information from a diagnostic PTA:
 - » The severity of hearing loss (mild, moderate, severe, profound)
 - » Frequencies affected
 - » Hearing loss (conductive, sensorineural, or mixed)
 - » Side of hearing loss (right, left, or bilateral)

8.1.3.2 Tympanometry

- Tympanometry (more likely screening tympanometry) is an investigation used to test the middle ear condition, the mobility of the eardrum, and the conduction of the bones (ossicles) by creating variations of air pressure in the ear canal.
- Tympanometry provides useful quantitative information about fluid in the middle ear, mobility of the middle ear system, and ear canal volume.
- In evaluating hearing loss, tympanometry differentiates between sensorineural and conductive hearing loss by cross-checking between other results.



- It is performed if there is any indication of middle ear problem from the clinical assessment, such as:
 - » Suspected middle ear effusion
 - » Perforation or impaired mobility of eardrums
 - » Mobility of the ossicular chains
- Limitation of tympanometry
 - » A test cannot be completed if a worker has a surgically altered, congenital ear canal problem or ear discharge.
 - » Affected by movement - need cooperative patient and skills to handle it
 - » Old age may affect the result as they may have collapsed ear canal
 - » It is operator dependent

8.1.3.3 Diagnostic imaging

- In general, the external auditory canal, middle ear space, mastoid, petrous apex, and otic capsule are best visualized with CT scan, whereas suspicion of retro-cochlear pathology warrants MRI.
- If suspected bony lesion pathology, HRCT is the preferred diagnostic imaging.
- MRI of the internal auditory meatus may be indicated in adults with hearing loss and localizing symptoms or signs (such as facial nerve weakness), which may indicate a possible vestibular schwannoma or CPA (cerebellopontine angle) lesion (NICE Guidelines).
- Consider MRI of the internal auditory meatus for adults with sensorineural hearing loss and no localizing signs if there is an asymmetry on pure tone audiometry of 15 dB or more at any 2 adjacent test frequencies, using test frequencies of 0.5, 1, 2, 4, and 8 kHz (NICE Guidelines).

8.1.3.4 Serology, Haematology or Biochemistry test

- a. The test may be useful to investigate the causes of hearing loss, and the choice of investigations is determined by the finding from clinical history and physical examination. Examples are:
 - ESR, ANA, RF (suspected Autoimmune Disorders)
 - Fasting blood sugar, HbA1c, 2-hour postprandial (Diabetes mellitus)
 - Fluorescent Treponemal antibody (Syphilis)
 - Thyroid Function Test (Hyper or Hypothyroidism)

8.1.3.5 Electrophysiologic test

a. Auditory Steady-State Response (ASSR)

It is an electrophysiological response that is evoked by a periodically repeated (rapid) auditory stimulus. It typically uses frequency-specific stimuli (0.5, 1, 1, 3 kHz) to create an estimated audiogram. ASSR looks at amplitudes and phases in the frequency domain. The response is detected using a statistic-based mathematical detection algorithm.

b. Auditory Brainstem Evoked Response (ABER)

It is a neurologic test or auditory brainstem function in response to auditory stimuli. ABER is only valuable for estimating hearing thresholds from 2kHz to 4 kHz. ABER looks at amplitude and latency or the response in the time domain. ABER can be used to identify retro-cochlear pathology or to investigate for signs and symptoms of 8th cranial nerve abnormalities.



8.2 DIFFERENTIAL DIAGNOSIS FOR NOISE-RELATED HEARING DISORDERS

8.2.1 Hearing loss can be classified into three types;

- Conductive hearing loss
- Sensorineural hearing loss
- Mixed hearing loss (combination of conductive and sensorineural hearing loss)

Several abnormalities can lead to hearing loss for each type. Conductive hearing loss is usually related to abnormalities in the outer ear or middle ear, while sensorineural hearing loss is related to inner ear abnormalities. Table 8.1 listed the differential diagnosis for hearing loss.

Table 8.1: Differential Diagnosis of Hearing Loss

HEARING LOSS	
CONDUCTIVE	SENSORINEURAL
Earwax	Noise Exposure
Ruptured eardrum	Meniere’s Disease
Otitis Externa	Trauma (Temporal Bone Fracture, Head Injury), Idiopathic
Chronic Suppurative Otitis Media	Infections (Herpes, Meningitis, Mumps, Syphilis, Tuberculosis)
Middle Ear Effusion	Ototoxic substance (chemical, drugs)
Foreign Body in the ear canal	Neoplastic (Vestibular Schwannoma, Cerebellopontine Angle tumor)
Otosclerosis	Systemic/ Autoimmune (Vasculitis, Scleroderma, SLE), Endocrine (Paget’s Disease, Diabetes mellitus, Thyrotoxicosis) Presbycusis
MIXED HEARING LOSS	
Otosclerosis	

8.3 DISEASE EXPLANATION

8.3.1 Conductive Hearing Loss

8.3.1.1 Earwax (Impacted Cerumen)

Cerumen (or earwax) is usually expelled from the ear canal through a self-cleaning mechanism. This mechanism may fail occasionally and leads to the accumulation of cerumen. It is one of the most common reasons workers seeking treatment for ear problems.

a. Signs and Symptoms

Typically, it is asymptomatic, but a worker may present with hearing loss, ear pain, itching, tinnitus, or, rarely, a sensation of imbalance. Physical examination may show impacted cerumen on otoscopy.

b. Relevant investigations

- Audiometry – shows conductive loss
- Tympanometry – may be abnormal in cases of severely impacted wax

c. Treatment

- Observation
- Cerumenolytic agents
- Ear canal irrigation
- Manual removal other than irrigation (curette, probe, forceps, suction, hook) under direct visualization

8.3.1.2 Middle Ear Effusion^{9,10,11}

Middle ear effusion is the accumulation of fluid behind the eardrum without signs of acute infection. The middle ear is a small cavity filled with air, and it contains several vital structures such as ossicles and facial nerve (cranial nerve VII). It is connected to the nasopharynx via the Eustachian tube, which allows ventilation of the middle ear. The eardrum, also known as TM, separates the middle ear from the outer ear. Effusion in the middle ear disturbs the transmission of sound, causing conductive hearing loss. This condition is known as otitis media with effusion (OME)

a. Pathophysiology

Middle ear effusion can be caused by:

- Eustachian tube dysfunction
The eustachian tube provides equilibration of pressure between the middle and external ears, assists in clearing secretions, and protects the middle ear. Anatomic blockage secondary to inflammation/tumor, upper respiratory infections, or trauma can cause its dysfunction. If it is persistently dysfunctional, a negative pressure develops within the middle ear from the absorption or diffusion of nitrogen and oxygen into the middle ear mucosa. This may lead to the accumulation of effusion and bacteria proliferation.
- Inflammation of the middle ear mucosa.
This inflammation might be caused by a reaction to bacteria that is already present in the middle ear.

9 Sallahuddin Z. Middle ear effusion. July 2017. Ministry of Health Malaysia. <http://www.myhealth.gov.my/en/middle-ear-efusion/>

10 Thomas S Higgins. Otitis Media with Effusion. April 2020. Medscape. <https://emedicine.medscape.com/article/858990-overview#a3>

11 Searight FT, Singh R, Peterson DC. Otitis Media With Effusion. [Updated 2020 Aug 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK538293/>

b. Signs and Symptoms

In adults, most ear problem presentations are unilateral ear problems. These commonly occur with upper respiratory tract infections. The other common clinical presentations are:

- Hearing loss
- Otagia
- Tinnitus
- The sensation of a foreign body in the external auditory canal
- Otoscopy: Opacification, loss of light reflex, retraction, and decreased mobility of the TM

c. Relevant investigations

- Audiometry
- Tympanometry: An array of abnormal results, including but not limited to type A, B or C.
- Nasoendoscope, CT scan, or MRI may be performed if a tumor is suspected

d. Treatment

- Treat the underlying pathology
- Middle ear effusion may resolve spontaneously with observation
- If it is persistent, myringotomy with tympanostomy tube insertion shall be considered.

8.3.1.3 Ruptured TM^{12,13,14,15}

A ruptured TM is when the TM has a tear or hole between the external and middle ear. The TM aids in hearing by creating vibrations from sound waves and transmitting the vibrations to the inner ear. The TM separates the outer ear from the middle ear and ossicles. A tear or hole in the TM exposes the middle and inner ear organs to potential damage or injury. When it perforates, it may no longer create vibrational patterns, leading to hearing loss.

a. Pathophysiology

The pathophysiology of TM rupture depends on the etiology that caused the rupture. Common etiologies include complication of infection, barotrauma, insertion of objects into ear, head trauma, acoustic trauma, slaps or punches to the face/ear, and iatrogenic from attempting to remove foreign body or earwax.

In barotrauma, there could be significant and rapid changes in pressure gradients between the middle and external ear. This explosively rapid difference in pressure gradients can lead to TM rupture.

Acoustic trauma also works on the same principle: sudden exposure to an intense sound (e.g., gunshot, fireworks) causing rupture to the TM from the high-pressure wave. It could also cause damage to the inner ear structure from the intense sound wave.

12 Dr. Dipaka/IBanarsi Dass. Ruptured Tympanic Membrane. April 2012. Ministry of Health Malaysia. <http://www.myhealth.gov.my/en/ruptured-tympanic-membrane/>

13 Matthew L Howard. Middle Ear, Tympanic Membrane, Perforations. May 2020. Medscape. <https://emedicine.medscape.com/article/858684-overview>

14 Dolhi N, Weimer AD. Tympanic Membrane Perforations. [Updated 2020 Nov 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK557887/>

15 Acute acoustic trauma. 2020. Duodecim Medical Publications Limited. https://evidence.unboundmedicine.com/evidence/view/EBMG/457351/all/Acute_acoustic_trauma

b. Signs and Symptoms

- Sudden onset of ear pain and hearing loss
- Ear discharge
- Vertigo
- Tinnitus
- Otoscopy: Perforated TM, visualized bones in the middle ear

c. Relevant investigations

- Audiometry
- Tympanometry – Type B, very helpful in detecting even small pinpoint perforation.

d. Treatment

- Ruptured TM may heal spontaneously.
- Symptomatic treatment: to relieve pain, to prevent infection
- Surgical repair: If ruptured TM does not heal on its own (in 2 months)



Figure 8.5:
Otoscope view
showing ruptured
TM

8.3.1.4 Chronic Suppurative Otitis Media (CSOM)^{16,17,18,19}

Chronic suppurative otitis media is a persistent inflammation of the middle ear, including the mastoid air cells. CSOM can occur with or without cholesteatoma. CSOM is different from chronic otitis media with effusion. As for the latter, there is usually an intact TM with fluid in the middle ear but no active infection.

The most common organism associated with CSOM is *Pseudomonas aeruginosa* and *Staphylococcus aureus*.

a. Pathophysiology

CSOM occurs when bacterial pathogens invade the middle ear mucosa leading to an inflammatory reaction in the middle ear. This invasion is often accompanied by edema, fibrosis, granulation tissue formation, perforation of the TM, and ongoing infection. It can occur as a complication of tympanostomy tube insertion.

b. Signs and Symptoms

- Recurrent otorrhea over 2-6 weeks with the previous history of recurrent acute otitis media, perforation, or tympanostomy tube insertion.
- Hearing loss at the affected ear
- Fever, ear pain, vertigo may indicate intratemporal or intracranial complications:
- Mastoiditis: if having fever, ear pain, or tenderness behind the ear
- Brain abscess/meningitis: if having neck stiffness, focal neurological signs, or impaired consciousness
- The external auditory canal may be oedematous but not tender
- Thickened granular middle ear mucosa and mucosal polyps
- Cholesteatoma

16 Denny Varughese. Chronic Suppurative Otitis Media Clinical Presentation. Oct 2019. Medscape. <https://emedicine.medscape.com/article/859501-clinical>

17 Oliver Starr. Chronic Suppurative Otitis Media. Jan 2018. Patient Platform Limited. <https://patient.info/doctor/chronic-suppurative-otitis-media>

18 Rosario DC, Mendez MD. Chronic Suppurative Otitis. [Updated 2021 Jan 9]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK554592/>

19 Chronic suppurative otitis media (CSOM). Médecins Sans Frontières (MSF). <https://medicalguidelines.msf.org/viewport/CG/english/chronic-suppurative-otitis-media-csom-16689236.html>

c. Relevant investigations

- Audiometry
- Tympanometry
- Imaging studies:
 - CT scan
 - MRI – if intratemporal or intracranial complications are suspected

d. Treatment

- Antibiotic, topical steroids
- Regular intensive aural toilet
- Granulation tissue control
- Surgery:
 - » Myringoplasty
 - » Tympanoplasty
 - » Mastoidectomy

8.3.1.5 Otitis Externa

Otitis externa (OE) is an inflammation (infectious or non-infectious) of the external auditory canal and can extend to the outer ear. It is also known as the swimmer's ear as it is often occurring during summer and in tropical climates. It is mainly caused by bacterial infection. It may be associated with allergies, eczema, and psoriasis. Risk factors of developing otitis externa include:

- Humidity
- Trauma
- A narrow external ear canal
- Ear canal obstruction
- Dermatologic condition (eczema/psoriasis)
- Radiotherapy or chemotherapy
- Stress

a. Pathophysiology

The external auditory canal is covered by hair follicles and cerumen-producing glands. Cerumen provides a protective barrier and an acidic environment that inhibits bacterial and fungal growth. The inflammatory response in otitis externa is caused by disrupting the normal pH and protective factors within the auditory canal. This disruption includes a sequential process of damage to the epithelium, loss of protective wax, and moisture accumulation, leading to a higher pH and bacterial growth.

b. Signs and Symptoms

A worker may present with the following:

- Otagia, typically tragal tenderness
- Hearing loss
- Ear fullness
- Tinnitus
- Fever
- Itchiness



- Ear discharge
- Otoscopy shows an erythematous and oedematous ear canal. A purulent or serous ear discharge may be present

Physical examination should include an assessment of the external ear, surrounding skin, and lymph nodes.

c. Relevant investigations

- Ear canal cultures are recommended for recurrent or resistant cases, especially in an immunocompromised patient.
- Audiometry

8.3.1.6 Foreign body^{20,21,22}

Foreign bodies in the external auditory canal are common problems encountered in primary care clinics. During daily activities at the workplace, foreign objects may accidentally enter the ear canal and get stuck there

a. Pathophysiology

The external auditory canal narrows at the bony cartilaginous junction and is just lateral to the TM. The foreign body entered can be impacted at this point, thus difficult to be removed.

b. Signs and Symptoms

- The worker may be asymptomatic
- Ear pain
- Hearing loss
- Sense of ear fullness
- Ear discharge
- Tinnitus
- Otoscope: may visualize the foreign body

c. Relevant investigations

- Audiometry – shows a conductive loss, with low-frequency preponderance
- Tympanometry

d. Treatment

- Removal of foreign body (manual removal, micro-suction, irrigation)

20 Lotterman S, Sohal M. Ear Foreign Body Removal. [Updated 2021 Jan 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK459136/>

21 Steven W. Heim. Foreign Bodies in the Ear, Nose, and Throat. Oct 2017. American Academy of Family Physicians. <https://www.aafp.org/afp/2007/1015/p1185.html>

22 Glenn C Isaacson et. al. Diagnosis and management of foreign bodies of the outer ear. Oct 2020. UpToDate. https://www.uptodate.com/contents/diagnosis-and-management-of-foreign-bodies-of-the-outer-ear?search=foreign%20body%20ear&source=search_result&selectedTitle=2~20&usage_type=default&display_rank=2

8.3.2 Sensorineural Hearing Loss

8.3.2.1 Noise-Induced Hearing Loss (NIHL)^{23,24,25}

Noise-induced hearing loss (NIHL) is a gradual hearing loss as the result of exposure to intermittent or continuous noise. The source of noise can be from the workplace or the external environment. It is irreversible, but usually, the loss is not progressive anymore once noise exposure ceased. Relevant history of noise exposure at the workplace is essential in diagnosing occupational NIHL.

a. Pathophysiology

Excessive noise exposure may lead to fatigue and eventually death of the hair cells, which are the auditory receptors within the organ of Corti, thus unable to produce action potentials that transmit information about the sound to the brain. With more severe exposure, injury can proceed from a loss of adjacent supporting cells to complete disruption of the organ of Corti.

b. Signs and Symptoms

- Gradual onset of bilateral hearing loss
- Tinnitus – many may have adapted to it
- Otoscopy – an examination of the ear canal and middle ear to rule out symptoms such as earache, the ear feeling full, or hearing loss

c. Relevant investigations

- Audiometry
 - » Presence of high-frequency sensorineural hearing loss (at 3 or 4 or 6 kHz, usually with recovery at 8 kHz)
 - » Presence of notch, usually at 4 kHz²⁶, even though this is not pathognomonic
 - » The presence of Permanent STS indicates deterioration in hearing due to continuous exposure to excessive noise
- Electrophysiological test (Auditory Steady-State Response/ Frequency Specific Auditory Brainstem Response):
 - » It can be performed to confirm NIHL in ambiguous cases.

d. Treatment

- No scientifically validated treatments have been empirically accepted for noise-induced hearing loss (NIHL).
- The appropriate management of tinnitus (if present) may be considered as treatment.
- Amplification should be considered in symptomatic workers.

e. Prevention

- Advice employer to implement HCP at the workplace.

23 Guidelines on the Diagnosis of Occupational Disease, SOCSO, 2019

24 ACOEM guidance statement, Occupational Noise-Induced Hearing Loss, 2018

25 Trung N. Le et al. Current insights in noise-induced hearing loss: a literature review of the underlying mechanism, pathophysiology, asymmetry, and management options. 2017. Journal of Otolaryngology - Head and Neck Surgery.

26 McBride, D. I., & Williams, S. (2001). Audiometric notch as a sign of noise induced hearing loss. Occupational and environmental medicine, 58(1), 46–51. <https://doi.org/10.1136/oem.58.1.46>

8.3.2.2 Ototoxic exposure^{27,28,29}

Ototoxicity is the property of being toxic to the ear, specifically the cochlea or auditory nerve and sometimes the vestibular system. Exposure to ototoxic agents can lead to hearing loss.

a. Pathophysiology

Ototoxic agents can be classified as neurotoxicants, cochleotoxicants, or vestibulotoxicants based on the part of the ear they damage. They can affect humans from the three routes of entry: inhalation, skin penetration, and ingestion. They can reach the inner ear through the bloodstream and cause injury to inner parts of the ear and connected neural pathways. Exposure to both ototoxic chemicals and noise can do more damage than a higher exposure to one of them alone.

Table 8.2: Examples of substances that may cause ototoxicity

SUBSTANCE CLASS	CHEMICALS
Pharmaceuticals *Ototoxicity at therapeutic doses is limited	Aminoglycoside antibiotics (e.g., streptomycin, gentamycin) and some other antibiotics (e.g., tetracyclines), Loop diuretics* (e.g. furosemide, ethacrynic acid) Certain analgesics* and antipyretics* (salicylates, quinine, chloroquine) Specific antineoplastic agents (e.g., cisplatin, carboplatin, bleomycin).
Organic Solvents	Carbon disulfide, n-hexane, toluene, p-xylene, ethylbenzene, n-propylbenzene, styrene and methyl styrene, trichloroethylene.
Asphyxiants	Carbon monoxide, hydrogen cyanide, and its salts, tobacco smoke
Nitriles	3-Butenenitrile, cis-2-pentenenitrile, acrylonitrile, cis-crotonitrile, 3,3'-imidipropionitrile.
Metals and Compounds	Mercury compounds, germanium dioxide, organic tin compounds, lead.

b. Signs and Symptoms

- Mild to severe hearing loss
- Fullness of ear
- Tinnitus
- Body imbalance
- Headache or light-headedness
- Dizziness
- Blurry vision

c. Relevant investigations

- Audiometry: to establish the sensori-neural hearing loss
- Central Auditory Processing Tests

d. Prevention

Advise employer to comply with Occupational Safety and Health (Use and Standard of Exposure to Chemicals Hazardous to Health) Regulations 2000 and Chemical Health Risk Assessment (CHRA) report's recommendations.

- Identify the presence of ototoxic chemicals at the workplace. (e.g., reviewing Safety Data Sheet (SDS), CHRA report, Chemical Exposure Monitoring report)
- Limit the exposure by implementing appropriate control measures.
- Provide appropriate PPE to the workers
- Provide training and education on the health and safety of chemicals to the exposed workers.
- Periodic medical surveillance (including audiometric testing).

27 Alberto Behar. Ototoxicity and Noise. Oct 2018. Journal of Otorhinolaryngology, Hearing and Balance Medicine. <https://www.mdpi.com/2504-463X/1/2/10/pdf>

28 Audiology Information Series: Chemical exposure on hearing and balance. 2015. American Speech-Language-Hearing Association. <https://www.asha.org/siteassets/uploadedFiles/AIS-Chemical-Exposure-Effects-Hearing-Balance.pdf>

29 Safety and Health Information Bulletin: Preventing Hearing Loss Caused by Chemical (Ototoxicity) and Noise Exposure. Aug 2018. Occupational Safety and Health Administration, United States Department of Labour. <https://www.osha.gov/dts/shib/shib030818.html#ftn7>

8.3.2.3 Sensorineural hearing loss due to trauma³⁰

Sensorineural hearing loss due to trauma is commonly caused by head injury. Head injury may cause a temporal bone fracture that can cause damage to the middle or inner structures of the ear.

a. Pathophysiology

The following mechanism can cause sensorineural hearing loss due to trauma:

- Disruption of the membranous labyrinth
- Avulsion or trauma to the cochlear nerve
- Interruption of the cochlear blood supply
- Hemorrhage into cochlea
- Perilymph fistula

Temporal bone fractures are mainly attributed to the mechanical forces that disrupt the middle and inner ear structures.

b. Investigations

- Audiometry: to establish the sensorineural hearing loss
- Imaging: CT or MRI to determine the extent of the head injury

c. Treatment

- Corticosteroids (oral/injection)
- Cochlear Implant

8.3.2.4 Idiopathic^{31,32,33}

Idiopathic sensorineural hearing loss is defined as a sensorineural hearing loss of 30 dB or more over at least three contiguous audiometric frequencies with an onset of fewer than 3 days. Clinical history and physical examination are crucial to evaluate any risk factors that may cause hearing loss.

a. Pathophysiology

The pathogenesis of hearing loss has remained unclear. Some of the proposed theories explaining the mechanism include vascular compromise, labyrinthine membranes ruptures, a viral infection of the cochlea, metabolic disease, autoimmunity, trauma, and combinations of multiple factors.

b. Signs & Symptoms

- Sudden hearing loss
- Mainly affecting unilateral hearing, but some can be bilateral
- Blocked ear

c. Investigations

- Audiometry – to establish the diagnosis of sensorineural hearing loss
- Imaging: MRI – to evaluate for retro-cochlear pathology
- Laboratory evaluation: if any clinical suspicion for a particular etiology (e.g., hypothyroidism)

30 Cassano, Michele & Valeria, Tarantini & Trecca, Eleonora & Moffa, Antonio & Grilli, Gianluigi. (2019). Traumatic Sensorineural Hearing Loss.

31 Sudden sensorineural hearing loss in adults: evaluation and management <https://www.uptodate.com/contents/sudden-sensorineural-hearing-loss-in-adults-evaluation-and-management#H3546853046>

32 Anyah A, Mistry D, Kevern E, Markiewicz K. Idiopathic Sudden Sensorineural Hearing Loss: Average Time Elapsed Before Presentation to the Otolaryngologist and Effectiveness of Oral and/or Intratympanic Steroids in Late Presentations. *Cureus*. 2017;9(12):e1945. Published 2017 Dec 14. doi:10.7759/cureus.1945

33 Xie, W., Dai, Q., Liu, J. et al. Analysis of Clinical and Laboratory Findings of Idiopathic Sudden Sensorineural Hearing Loss. *Sci Rep* 10, 6057 (2020).

d. Treatment

- Corticosteroid therapy
- Assistive hearing device (e.g., hearing aid, cochlear implant)

8.3.2.5 Infectious disease³⁴

Many infectious diseases caused by bacteria or viruses can cause sensorineural hearing loss. They may cause unilateral or bilateral hearing loss. Some diseases include herpes, mumps, measles, meningitis, syphilis, tuberculosis, chickenpox, shingles, influenza, and toxoplasmosis.

a. Pathophysiology

Hearing loss in viral infection can damage the inner ear at different stages of life, such as during intrauterine life, childhood, adolescence, or adulthood. There are pathological changes that predominate in the basal cochlea with the utricle and semi-circular canals preserved.

In toxoplasmosis, there is an accumulation of calcium deposits in the spiral ligament and the cochlea.

b. Signs and Symptoms

- Progressive sensorineural hearing loss
- Vertigo

c. Relevant investigations

- Audiometry: to establish the sensorineural hearing loss
- Relevant tests such as VDRL, TPHA

d. Treatment

- Treat underlying infections as necessary

8.3.2.6 Systemic disease³⁵

Hearing loss caused by systemic diseases may be rapidly progressive, bilateral and asymmetrical hearing loss, associated with vertigo, and tinnitus. Examples of systemic diseases that are associated with sensorineural hearing loss:

- Vasculitis
- Cogan syndrome
- Systemic Lupus Erythematosus (SLE)
- Antiphospholipid syndrome
- Sjogren's syndrome
- Sarcoidosis
- Autoimmune deafness (associated with systemic disease, for example, rheumatoid arthritis, Sjogren's syndrome, systemic sclerosis, and SLE)

³⁴ Luiz Alberto Alves Mota et al. Chapter 5: Hearing Loss in Infectious and Contagious Diseases. Update on Hearing Loss. 2015. INTECH. https://www.researchgate.net/publication/285577526_Hearing_Loss_in_Infectious_and_Contagious_Diseases

³⁵ Halwani, Chiraz. (2018). Otolaryngological Manifestations of Systemic Diseases. Scholarly Journal of Otolaryngology. 1. 10.32474/SJO.2018.01.000113.

8.3.2.7 Endocrine diseases³⁶

Several endocrine and metabolic abnormalities are associated with varying degrees of hearing loss. The physiology and anatomical structure of the auditory system may be influenced by changes in hormonal and metabolic changes. Examples of the endocrine disorders that may cause hearing loss are:

- Diabetes Mellitus
- Hypothyroidism
- Hypoparathyroidism
- Hypogonadism
- Paget's disease of bone
- Acromegaly

8.3.2.8 Tumour^{37,38,39}

Vestibular schwannoma (often known as the misnomer acoustic neuroma) is the most common tumor that can cause sensorineural hearing loss. It is a benign, slow-growing tumor that develops from the 8th cranial nerve (vestibulocochlear nerve) supplying the inner ear.

Tumor at Cerebellopontine angle (CP angle) may also cause sensorineural hearing loss. Most CP angle tumors are benign, with approximately 85% vestibular schwannoma, lipomas, vascular malformations, and hemangiomas.

a. Pathophysiology

Vestibular schwannoma occurs from the overproduction of Schwann cells and usually occurs adjacent to the cochlear and vestibular nerves. From previous studies, radiation exposure has shown to be a risk factor for developing the condition. In Neurofibromatosis type 2, bilateral vestibular schwannoma can be found.

b. Signs and Symptoms

- Unilateral or asymptomatic hearing loss
- Tinnitus
- Loss of balance
- Dizziness
- Facial numbness, facial weakness, facial paralysis (interference with trigeminal and facial nerve)
- Normal outer and middle ear

c. Relevant investigations

- Audiometry: to establish the sensorineural hearing loss
- Balance test: to determine and evaluate the vestibular nerve involvement
- MRI / HRCT

d. Treatment

- Surgical removal
- Radiotherapy
- Observation

36 Cherian KE, Kapoor N, Mathews SS, Paul TV. Endocrine Glands and Hearing: Auditory Manifestations of Various Endocrine and Metabolic Conditions. *Indian J Endocrinol Metab.* 2017;21(3):464-469. doi:10.4103/ijem.IJEM_10_17

37 Vestibular Schwannoma (Acoustic Neuroma) and Neurofibromatosis. March 2017. National Institutes of Deafness and Other Communication Disorders, U.S. Department of Health and Human Services. <https://www.nidcd.nih.gov/health/vestibular-schwannoma-acoustic-neuroma-and-neurofibromatosis>

38 Greene J, Al-Dahhir MA. Acoustic Neuroma. [Updated 2020 Aug 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK470177/>

39 Jack A Shohet. Skull Base Tumor and Other CPA Tumors. June 2020. Medscape. [https://emedicine.medscape.com/article/883090-overview#:~:text=Cerebellopontine%20angle%20\(CPA\)%20tumors%20are,%2C%20vascular%20malformations%2C%20and%20hemangiomas.](https://emedicine.medscape.com/article/883090-overview#:~:text=Cerebellopontine%20angle%20(CPA)%20tumors%20are,%2C%20vascular%20malformations%2C%20and%20hemangiomas.)

8.3.2.9 Meniere's disease^{40,41}

Meniere's disease is a disorder of the inner ear that causes vertigo, tinnitus, hearing loss, and feeling of fullness or congestion in the ears. It usually affects only one ear initially. It is often diagnosed in adults between 40 to 60 years of age, although it usually first presents at a younger age, typically in the mid-20s.

a. Pathophysiology

In the inner ear, there are compartments called the labyrinth, which consists of the semi-circular canals, the otolithic organs, and the cochlea. It has two sections: the bony and the membranous labyrinth. The membranous labyrinth is filled with a fluid called the endolymph. In Meniere's disease, the endolymph build-up in the labyrinth interferes with normal balance and hearing signals between the inner ear and the brain. These may cause vertigo and other related symptoms.

b. Signs and Symptoms

Diagnosis of Meniere's disease is based upon clinical history and the following symptoms:

- Two or more episodes of vertigo lasting at least 20 minutes each
- Tinnitus
- Temporary hearing loss
- A feeling of fullness in the ear

c. Relevant investigations

- Audiometry test: Low to mid-frequency hearing loss at the affected ear
- Electronystagmogram: The test evaluates how the eyes and ears coordinate with the brain
- MRI brain (to rule out other causes)

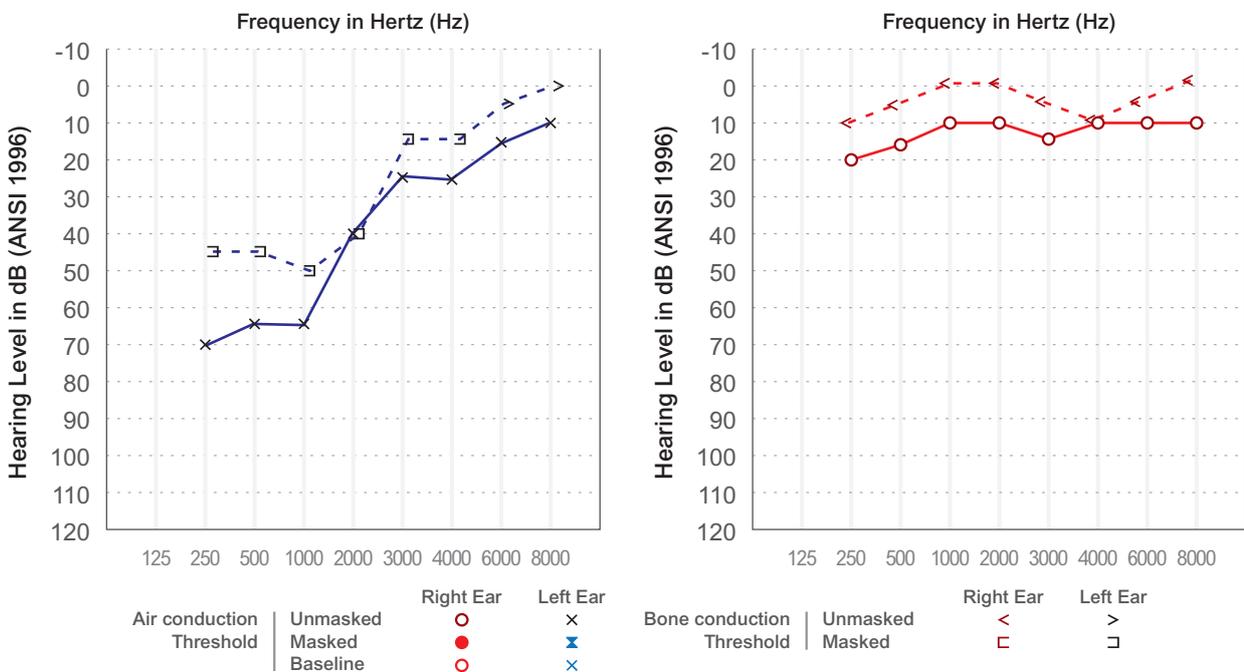


Figure 8.6: Audiogram example for Meniere's disease

40 Clinal Practice Guidelines: Meniere's Disease, American Academy of Otolaryngology–Head and Neck Surgery Foundation 2020

41 Ménière's Disease. Jul 2010. National Institutes of Deafness and Other Communication Disorders, U.S. Department of Health and Human Services. <https://www.nidcd.nih.gov/health/menieres-disease>

d. Treatment

- Diet restrictions (low-salt diet, limit alcohol and caffeine intake)
- Medications for symptomatic relief (diuretics, antivertigo, antihistamines, betahistine)
- Non-invasive therapies (vestibular rehabilitation, hearing aids)
- Ablative therapy via intra-tympanic injection (using corticosteroids or gentamicin)
- Surgery (Endolymphatic sac decompression, vestibular nerve section, labyrinthectomy)

8.3.2.10 Presbycusis^{42,43,44}

Presbycusis or age-related hearing loss gradually occurs as we grow older. It is one of the most common diagnoses made in older and elderly adults. Presbycusis may overlap with noise-induced hearing loss, especially if there is evidence of chronic work exposure to noise above the noise exposure limit.

a. Pathophysiology

It is a complex and multifactorial disorder. Commonly, it arises from changes in the inner ear as we age but can also result from changes in the middle ear or complex changes along the nerve pathways from the ear to the brain. Most often, both ears are affected equally and gradually. Hearing loss with presbycusis is usually affecting the high-pitched sound.

b. Signs and Symptoms

- Slow and progressive hearing loss (incredibly high-pitched sound)
- Difficulty in hearing and understanding speech (especially with background noise)
- Tinnitus
- Annoyance when hearing loud sounds

c. Relevant investigations

- Audiometry
- Blood investigations and diagnostic imaging (if another medical cause is suspected).

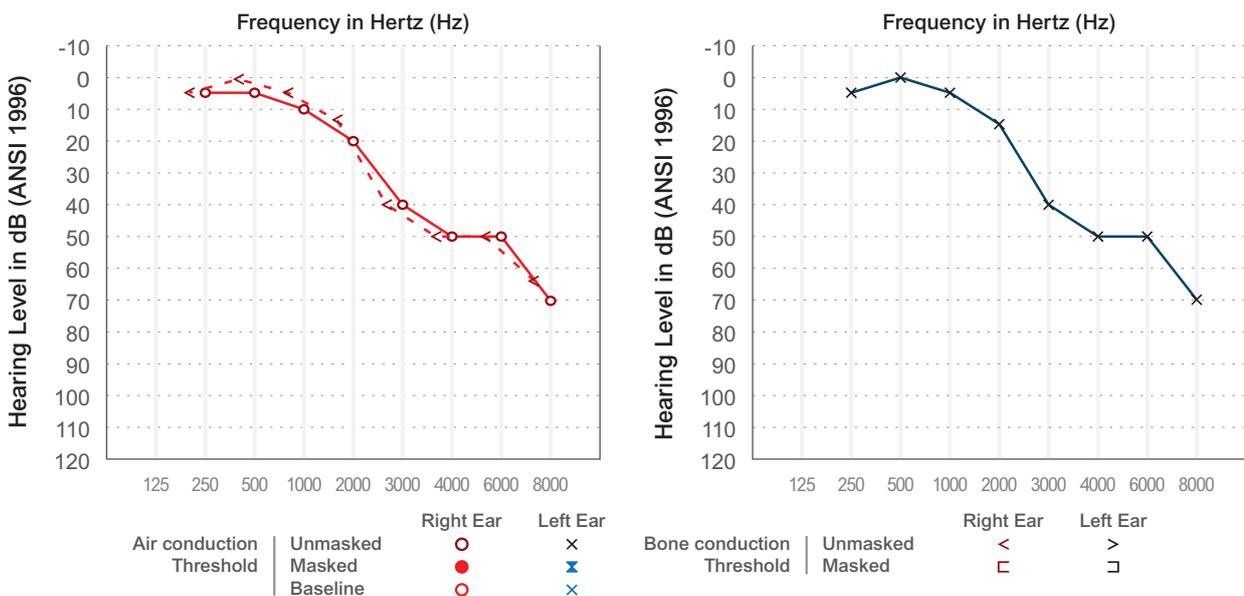


Figure 8.7: Audiogram of a worker with presbycusis

42 Presbycusis. Oct 1997. National Institute of Health U.S. <https://www.nidcd.nih.gov/sites/default/files/Content%20Images/presbycusis.pdf>
 43 Age-Related Hearing Loss. Jul 2018. National Institutes of Deafness and Other Communication Disorders, U.S. Department of Health and Human Services. <https://www.nidcd.nih.gov/health/age-related-hearing-loss>
 44 Presbycusis: An Update on Cochlear Mechanisms and Therapies J. Clin. Med. 2020, 9, 218; doi:10.3390/jcm9010218

d. Treatment

Presbycusis is not curable, but it may interrupt the worker's quality of life. Some of these strategies may help the worker, such as:

- Amplification devices
- Lip-reading
- Assistive listening devices (including hearing aids/ cochlear implants)

8.3.3 Mixed Hearing Loss

8.3.3.1 Otosclerosis^{45,46,47}

Otosclerosis is a condition where there is abnormal bone remodeling in the middle ear. The abnormal remodeling disrupts the sound waves to travel from the middle to the inner ear. Most of the cases are thought to be inherited.

a. Pathophysiology

Bone remodeling occurs typically throughout the skeleton regions. A typical otic capsule has minimal bone remodeling. However, in otosclerosis, there is an increase in the bone remodeling within the otic capsule that leads to the accumulation of bone deposits that damage the surrounding structure. The lesion can occur in the following areas: oval window and stapes, round window, pericochlear region, and anterior segment of the internal auditory canal.

The risk factor for otosclerosis is said to be influenced chiefly by genetics. Other risk factors for developing the disease are changes in hormones (puberty, pregnancy, menopause), measles exposure, and inflammation secondary to inflammatory and regulatory cytokines.

b. Signs and Symptoms

- Initially, the unilateral ear is involved and later, it progresses to bilateral
- Progressive hearing loss (worst in lower frequencies)
- Difficulty in hearing a low-pitched sound
- Tinnitus
- Vertigo
- Otoscopy: redness along the promontory of the TM (Schwartz sign). This presentation may be present in 10% of the cases.

c. Relevant investigations

- Audiometry:
 - » Carhart notch: loss of hearing threshold at 2 kHz
 - » Low-frequency conductive hearing loss (early stage of disease)
 - » High-frequency loss with cochlear involvement shows a mixed hearing loss

45 Otosclerosis. Jul 2018. National Institutes of Deafness and Other Communication Disorders, U.S. Department of Health and Human Services. <https://www.nidcd.nih.gov/health/otosclerosis>

46 Jack A Shohet. Otosclerosis. May 2019. Medscape. <https://emedicine.medscape.com/article/859760-overview>

47 Batson, Lora MPAS, PA-C; Rizzolo, Denise PA-C, PhD Otosclerosis, Journal of the American Academy of Physician Assistants: February 2017 - Volume 30 - Issue 2 - p 17-22 doi: 10.1097/01.JAA.0000511784.21936.1b

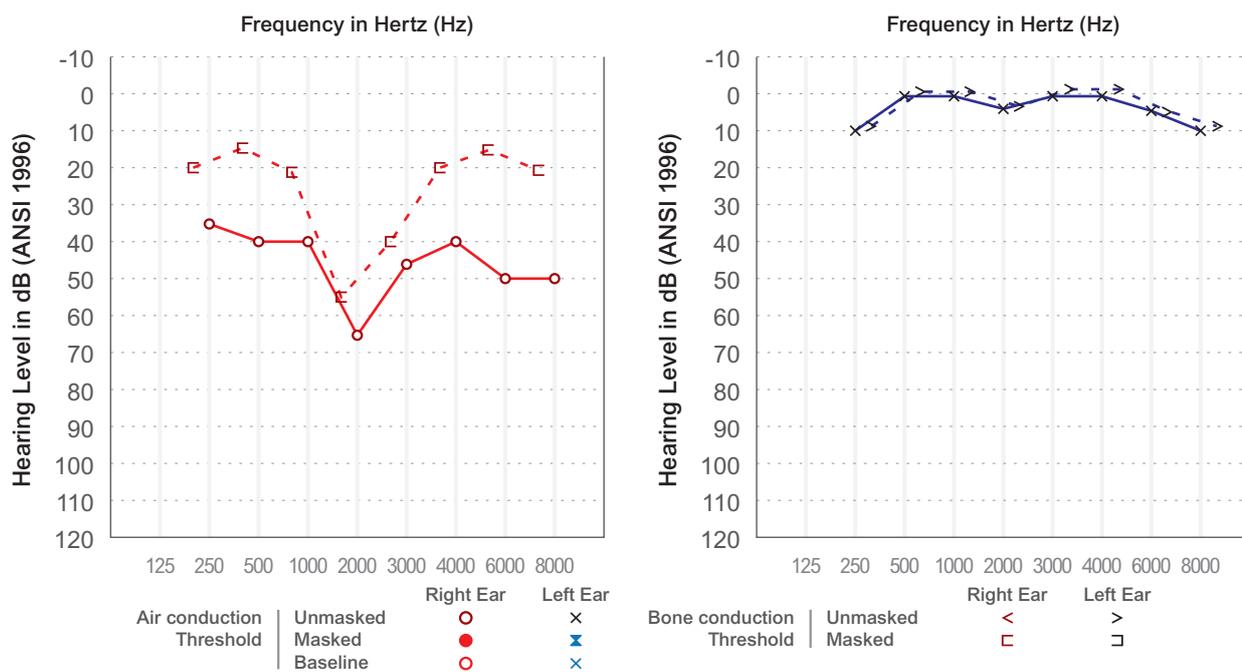


Figure 8.8: Audiogram pattern for Otosclerosis with Carhart notch

- Tympanometry: Normal (Flat wave if extensive disease occurred)
- High-resolution CT scan: if an extensive disease is suspected

d. Treatment

- Hearing aids
- Surgery (stapedectomy/stapedotomy)

CHAPTER 09

ESTABLISHING WORK - RELATEDNESS OF NRHD

9.1 INTRODUCTION

The determination of the work-relatedness of NRHD plays a vital role in addressing exposures at work and the health and welfare of the employees.

The determination of work-related NRHD plays an essential role in:

• • •



The need for workplace prevention measures.



Work placement of the affected employees.



Replacement of employees.



Compensation of the employees.

Work relatedness needs to be determined by the Occupational Health Doctor (OHD), considering all the possible factors contributing to the hearing loss at work while ruling out all possible non-occupational exposures. The OHD should also consider the possibility of occupational and non-occupational factors playing a joint role in the affected employee.

The OHD should determine the presence of these factors to diagnose work-related NRHD:

- Exposure to noise above NEL at the workplace, taking into consideration of non-work noise exposure, use of PHP and exposure to other hazards (chemical).
- Sensorineural hearing loss. In the early phase, the sensorineural hearing loss starts at high frequencies (3, 4, and 6 kHz, usually with recovery at 8 kHz), but the low frequencies can be affected.
- Exclusion of other medical conditions because ONRHD is a diagnosis of exclusion. Despite that, the presence of medical conditions does not rule out the diagnosis of ONRHD since both ONRHD and medical conditions can coexist.

9.2 NECESSITY TO DETERMINE WORK-RELATEDNESS OF NOISE-RELATED HEARING DISORDERS

The OHD must determine the work-relatedness of the noise-related hearing disorders as this holds implications for the employers and the employees. The determination should be carried out as follows:

- When an audiogram shows abnormality (hearing impairment/ hearing loss/ permanent STS)
- When there is a compensation claim

The findings of the work-relatedness are used in the management of environmental controls at the workplace, administrative measures for the employees, and the use of PHP.

9.3 STEPS TO DETERMINE WORK-RELATEDNESS OF NRHD

The steps to determine the work-relatedness of NRHD in the employee are as follows:

- Review the audiometric results
- Review the medical history and perform evaluations
- Review the history of exposures to occupational and non-occupational noise
- Decide on work-relatedness

9.3.1 Review the audiometric results

Audiometric results of the employee should be reviewed from carrying out the audiometry to the readings obtained from the procedure.

a. Determine if audiometric results are valid

- All pre-audiometry criteria had been followed
- Testing equipment is calibrated
- The testing booth was approved
- Audiometric technician was suitably trained
- The testing methodology was correct

b. Interpret Audiogram;

- Determine the existence of Hearing Loss
- Determine the hearing impairment observed

c. Review Baseline Testing Results

Consider the baseline testing results be it the original baseline or revised baseline

d. Confirm if there is an STS

A difference of 10 dB or more in the calculation of the standard threshold indicates the occurrence of the STS (refer to Appendix 5 of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019)

e. Review previous audiometric findings of the employee

9.3.2 Review the medical history and perform evaluations

a. Review of other medical histories

- History of intake of medication: salicylates, aminoglycosides, antineoplastic agents, etc.
- History of exposure to chemicals outside of the workplace: n-Hexane, Toluene, etc.
- History of head injuries and accidents
- History of other relevant diseases.

b. Refer for further assessment if necessary

If the OHD suspects an underlying medical problem, the employee should be referred for a further detailed evaluation to rule out the possible medical causes of NRHD in the employee.

c. Review all results to rule out any medical causes

The OHD should review all results obtained and decide on the contribution of medical causes to the NRHD.

9.3.3 Review the history of exposures to occupational and non-occupational noise and other occupational hazards

a. Review workplace noise exposure report

The OHD should review all Noise Risk Assessment report obtained from the management, including

- Area Monitoring
- Personal monitoring

The OHD should determine if the results are consistent with each other and determine if noise exposure at work is the cause of the NRHD.

Consider if other workers are similarly affected

b. Obtain a history of occupational exposure to chemicals

The OHD should also obtain the history of possible chemical exposures at work that may cause ototoxicity

c. Review history of noise other than at work

The OHD should obtain the history of exposure to noise in non-occupational situations. These include

- Home
- Second or other jobs
- Hobbies
- Daily travel
- Chemical exposures

d. Review Controls at Work and Out of Work

- Review HCP

The OHD should obtain information on an HCP at the workplace of the employee looking into:

- » The presence of an HCP
- » The compliance of the employee to the HCP
- » Enforcement of the HCP by the management

- Review the use of PHP at the workplace

The OHD should review the usage of PHP by the employee at the workplace looking at;

- » The provision of PHP (whether PHP is provided or not)
- » Training on the usage of PHP was given
- » The adequacy of PHP provided (sufficient, replaced when damaged)
- » Noise Reduction Rating (NRR)
- » Compliance of the employee to using the PHP as well as the correct usage of the PHP

- Review the use of PHP if in noisy environment out of work

If there is a history of non-occupational exposure noise in the employee, the OHD should determine if any PHP was used and the type of PHP used.

9.3.4 Decision on work-relatedness

The OHD must consider all findings of the above and decide whether the NRHD are work-related. If work-relatedness is established, the case must be notified to DOSH as an Occupational Noise-Related Hearing Disorders.

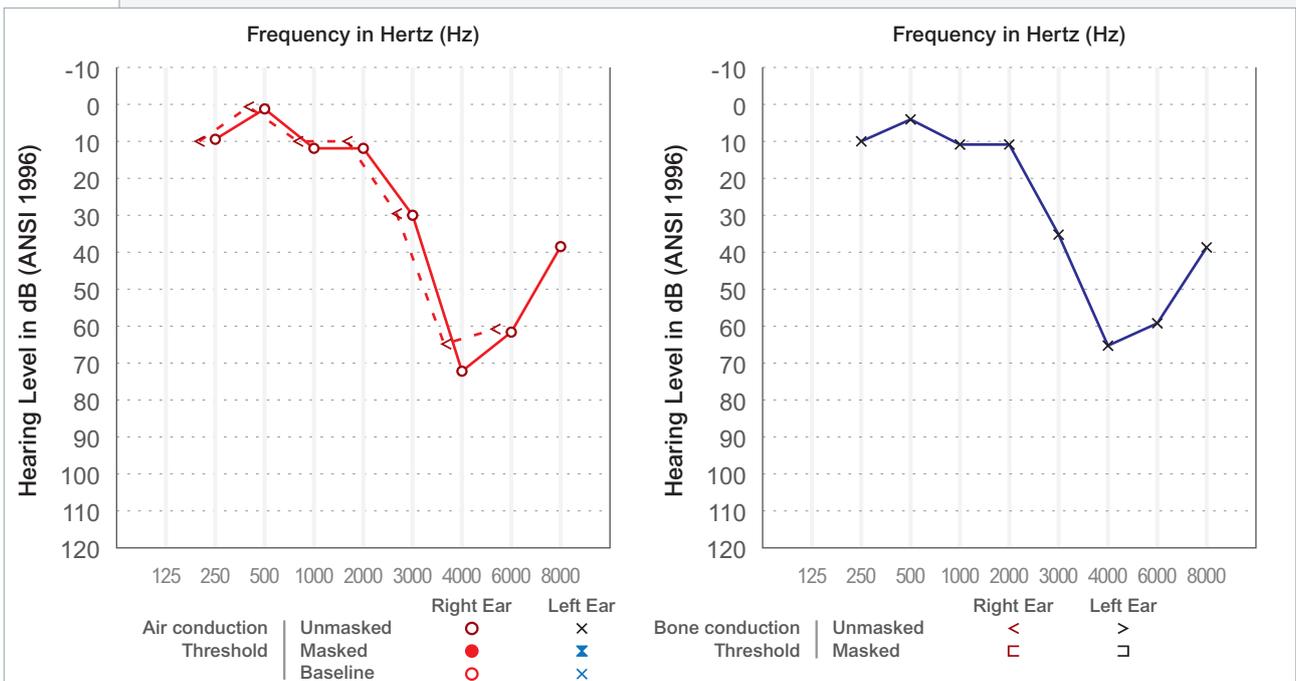
OHD to ensure documentation of assessment findings in the form prescribed in Appendix 6 of Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019 and notify DOSH if required.

Case Study



A 40 years old man with screening PTA showing high-frequency loss was referred by OHD for diagnostic pure tone audiometry. He has been working as a boilerman at a palm oil factory for almost 10 years. PHP was provided, but he reported on and off use due to the discomfort. Otoscopy showed normal findings on both ears. He had no history of head injury or any other otological problems and no non-occupational noise exposure.

The diagnostic PTA test revealed as below:



Note: Bone conduction was not performed for the left ear because there was no air-bone gap in the right ear, and the pattern is symmetrical in both ears.

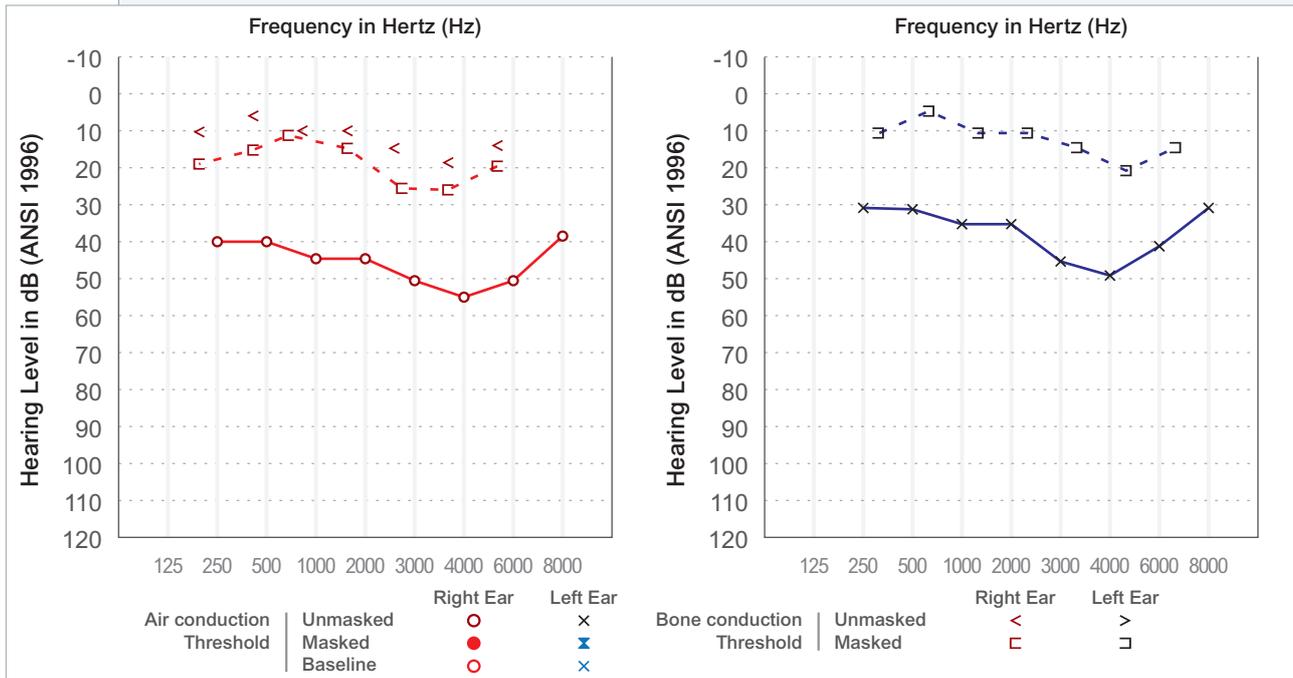
The OHD concluded that:

- The worker has a symmetrical sensorineural hearing loss on both ears.
- There is NIHL in both ears with no hearing impairment.
- It is a work-related case.
- The OHD had notified DOSH and the employer within 7 days of the diagnosis.
- The worker was also counselled on the importance of the proper use of PHP.

Case Study

A 30 years old man complained of hearing difficulty during HCP. He works as a welder for about 4 years. The employee is committed to using the PHP and had training once every 2 years on hearing conservation. He has had a history of intermittent ear discharge followed by ear pain since childhood. The last occurrence was a month ago. No history of head trauma and non-occupational noise exposure. The otoscopic examination revealed a dull TM in both ears. The diagnostic PTA was done to confirm the hearing loss.

The PTA results showed as below:



The OHD concluded that:

- The worker has conductive hearing loss bilaterally.
- There is mild hearing impairment in both ears but no NIHL.
- The worker was also referred to an ENT specialist to diagnose and manage the conductive hearing loss.
- The worker was advised to use PHP consistently when exposed to noise at the workplace.
- This case is not work-related

Case Study

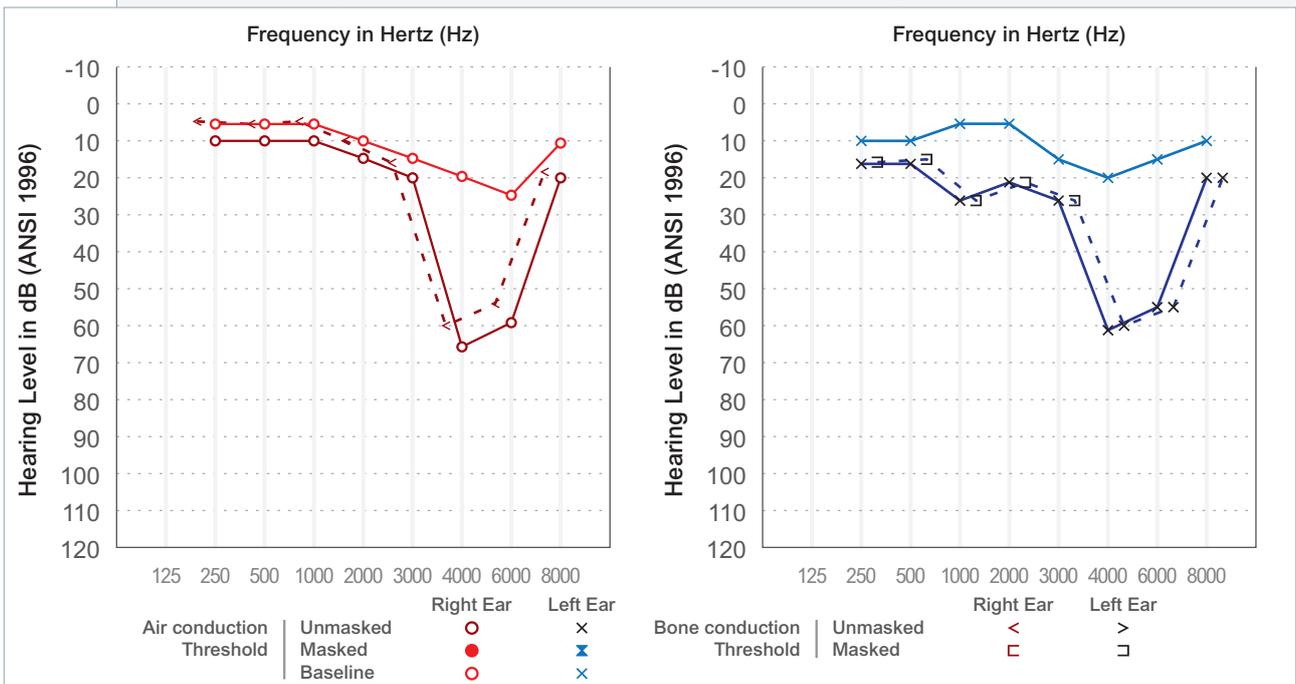
The screening PTA of a 39 years old man showed a high-frequency hearing loss, Temporary STS, and hearing impairment in the left ear. The OHD proceeded with a medical examination. He works as an air-cond technician at a production plant for the past 10 years. He had no history of head or ear injury and no non-occupational noise exposure. Otoscopy showed normal findings in both ears.

The OHD queried the employer about the baseline conducted in 2016 despite the worker being already employed for more than 10 years. According to the company’s representative, the noise exposure for his job was only realized based on the Noise Monitoring conducted in 2014. The noise monitoring was conducted because the company felt that the previous Noise Monitoring was not representative enough.

The employee is committed to wearing the PHP and had training once every 2 years on hearing conservation.

The OHD ordered a repeat screening PTA after 3 months, and a diagnostic PTA was conducted.

Below was the repeat PTA result and bone conduction with masking.



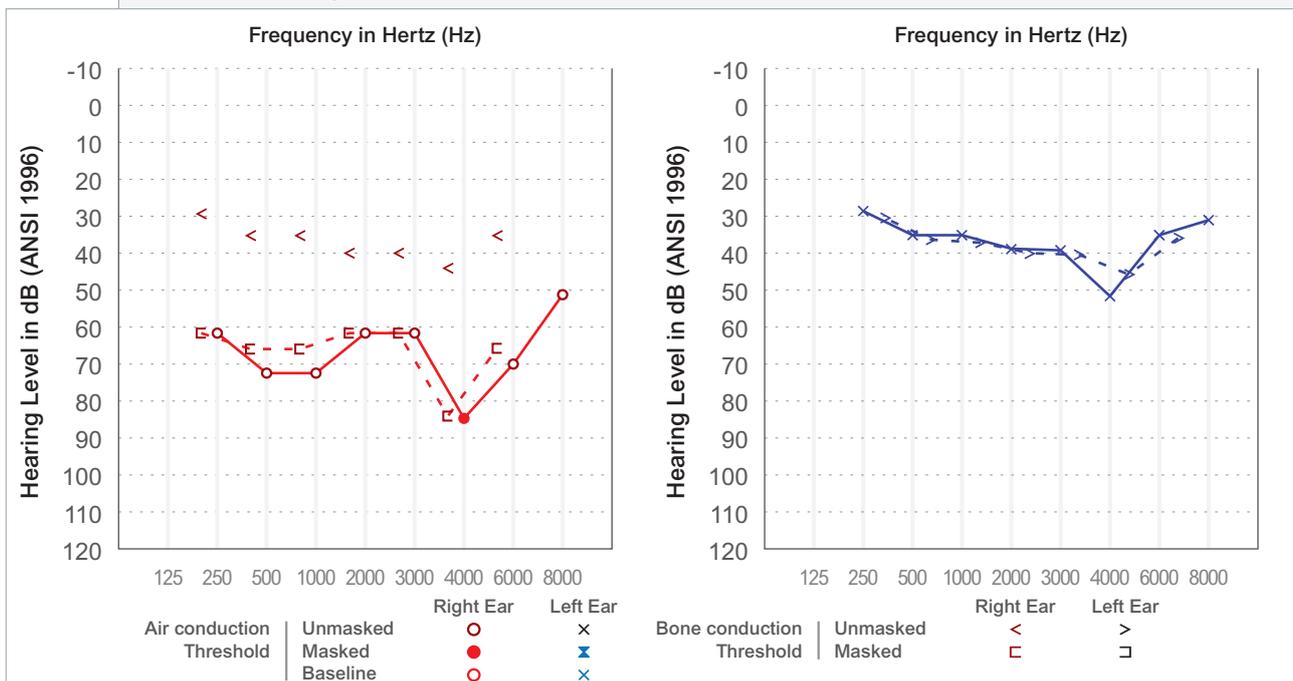
The OHD concluded that:

- The worker has mixed hearing loss in both ears.
- Right ear NIHL only.
- Left ear NIHL with Permanent STS and Mild hearing impairment.
- This is a work-related NRHD.
- The OHD had notified DOSH and the employer within 7 days of the diagnosis.
- The worker was also counseled on the importance of the proper use of PHP. The worker was also referred to an ORL specialist to diagnose and manage the conductive portion of the hearing loss.

Case Study

A 38 years old woman complained of worsening hearing difficulty on the right side. She works as a ground handler at an airport for almost 7 years. The employee is committed to using the PHP and had training once every 2 years on hearing conservation. She reported a ringing sound on the right side 5 months ago and sometimes feels unstable and dizzy. The last attack was 2 weeks ago. She lost her balance and almost fell to the ground during working. There was no history of head trauma and otological problems, and non-occupational noise exposure. The otoscopy examination revealed normal findings in both ears. The OHD requested a diagnostic PTA.

The result of diagnostic PTA is as below:



The OHD concluded that:

Both ears have hearing impairment with NIHL configuration, which sensorineural hearing loss; however, the audiogram showed an asymmetrical hearing loss, which required further evaluation to rule out other causes.

With the worker having significant noise exposure and his audiogram showing NIHL pattern on both ears, this case is diagnosed as occupational noise-induced hearing loss.

The worker was advised to continue with the usage of PHP when exposed to loud noise at the workplace, and the case was notified to DOSH within 7 days of the diagnosis

2 months following referral to ORL for her symptoms and PTA findings (asymmetry), the worker was confirmed to have vestibular schwannoma on the right side.

CHAPTER 10

REFERRAL CRITERIA

Some conditions can be appropriately treated in a primary care setting (e.g., earwax, otitis externa, otitis media)

10.1 REFERRAL CRITERIA

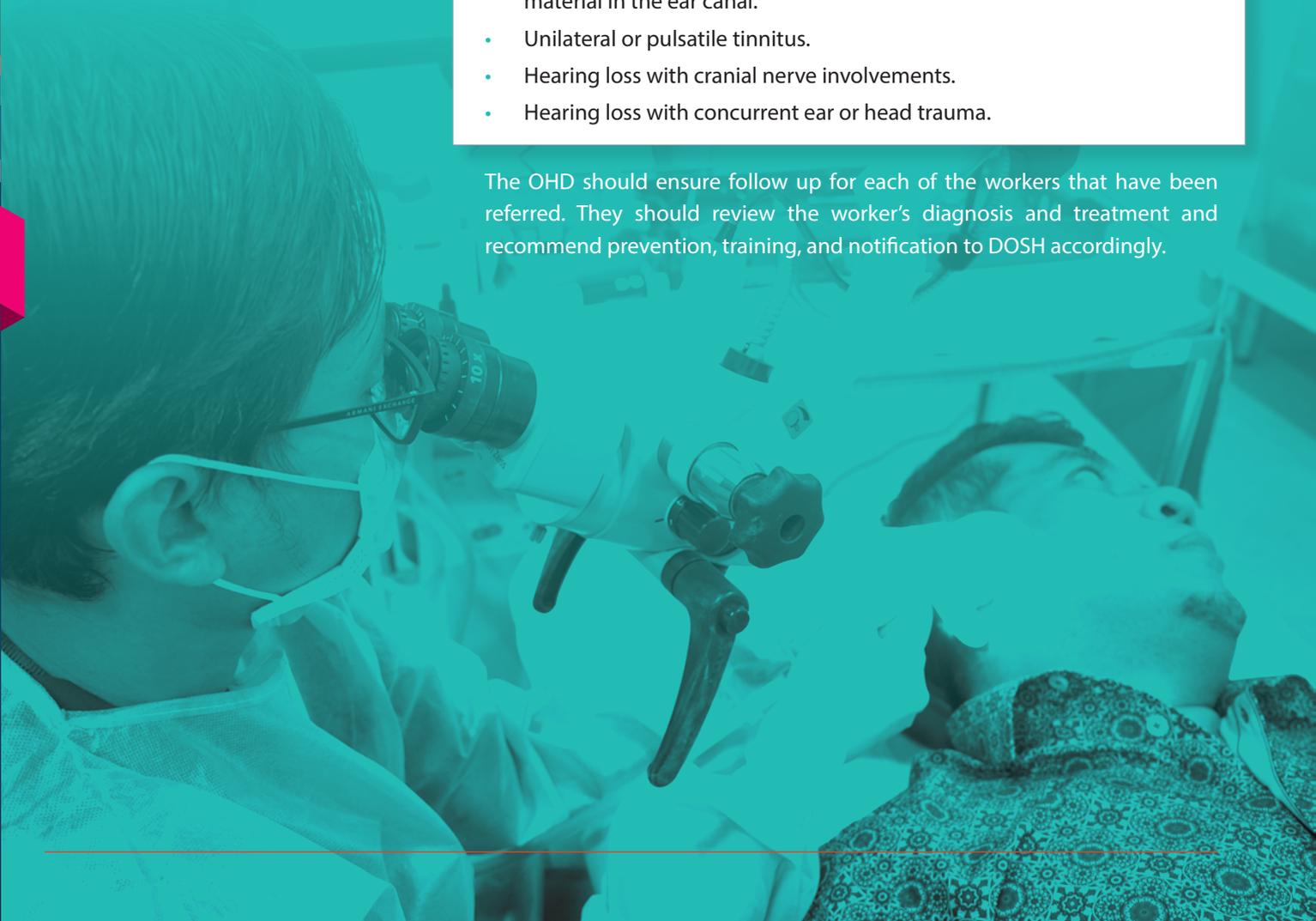
As stated in the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019, after examining the employee with an abnormal audiogram, the OHD shall decide whether referral for further management is needed.

Some conditions can be appropriately treated in a primary care setting (e.g., earwax, otitis externa, otitis media). In contrast, other conditions such as tumour or hearing loss due to autoimmune or systemic disease require specialist management. The referral should be made to the relevant specialties accordingly.

Some of the red flags that would prompt the OHD for immediate referral to the ORL specialists are:

- History of pain, active ear discharge, or bleeding from an ear.
- Sudden, fluctuating, or rapidly progressive hearing loss.
- Acute, chronic, or recurrent episodes of dizziness.
- Evidence of congenital or traumatic deformity of the ear.
- Visualization of blood, pus, cerumen plug, foreign body, or other material in the ear canal.
- Unilateral or pulsatile tinnitus.
- Hearing loss with cranial nerve involvements.
- Hearing loss with concurrent ear or head trauma.

The OHD should ensure follow up for each of the workers that have been referred. They should review the worker's diagnosis and treatment and recommend prevention, training, and notification to DOSH accordingly.



CHAPTER

11

NOTIFICATION

11.1 INTRODUCTION

According to Occupational Safety and Health (Noise Exposure) Regulation 2019, 9 (6): “Where the occupational health doctor has examined the employee under sub-regulation (4) and is of the opinion that the employee has an occupational noise-induced hearing loss, hearing impairment or permanent STS, the occupational health doctor shall notify the Director-General within seven days after medical examination.”

If the OHD, in his opinion, after diagnosing that an occupational-related permanent STS, Hearing Impairment, or NIHL has occurred (following the diagnostic procedure as discussed in these guidelines), he shall notify the Director-General within seven (7) days using an approved form. He must, at the same time, inform the employer.

After receiving the audiometric report, an employer shall notify any occupational-related permanent STS, hearing impairment, or NIHL by using an approved form to the nearest DOSH office within seven (7) days. Once Permanent STS is confirmed, notification is also required even if the worker’s hearing thresholds are within the normal limits (<25dB).

For cases that had been notified in the previous year, notification of ONRHD to DOSH is only required if there is a significant change in the worker’s hearing thresholds. Significant change is marked by the presence of a permanent STS in the worker’s audiograms.

Notification of disease can be made by using the JKKP7 form (Appendix 3). The notification to the nearest DOSH office shall include relevant information as shown in **Appendix 6 of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019** and a copy of the latest audiometric report.

For any occupational hearing disorder related to the accident, such as Acoustic trauma, notification of disease can be made under JKKP6.

Scenario 1, 2 and 3 are prepared for better understandings of the above statements. The primary focus of the given scenarios is to highlight the requirement for notification of ONHRD at baseline audiometry and repeated cases in annual audiometry. Thus, the medical examination is not mentioned in the discussion of each scenario to avoid confusion. However, it is understood that whenever a disorder (NIHL, Hearing Impairment or Permanent STS, or any possible combination of these disorders) is mentioned in this chapter, the condition was diagnosed after performing medical examination as per the flow given in Chapter 4. A similar assumption is to be made for the work-relatedness of the disorder.

As per the regulations and ICOP requirements, all baseline audiograms shall be carried out within 3 months of an employee commencing work, which would expose him to NEL. Although the audiometric testing will not be considered as baseline audiometric testing, but the audiogram will still be referred to as baseline audiogram in the future. [Note: performing baseline beyond the stipulated period contravenes the subregulation under the Occupational Safety & Health (Noise Exposure) Regulations 2019. It shall, on conviction, be liable to a fine or imprisonment or both].



11.2 SCENARIO 1

This scenario was taken from item 7.1 of Appendix 7 of Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

Table 11.1: Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry

YEAR	2014	2015		2016			
Frequency	Baseline Audiogram Threshold (dB) (within 3 months commencing of work)	2015 Annual audiogram threshold (dB)	Changes of the threshold between annual and baseline (2014)	2016 Annual audiogram threshold (dB)	Changes of the threshold between annual and baseline (2014)	2016 Retest audiogram threshold (dB) (within 3 months of 2016 annual audiogram)	Changes of the threshold between retest and baseline (2014)
500	20	20	0	30	+10	35	+15
1000	25	25	0	35	+10	45	+20
2000	30	35	+5	45	+15	50	+20
3000	30	35	+5	50	+20	55	+25
4000	40	45	+5	55	+15	60	+20
6000	35	40	+5	50	+15	55	+20
8000	25	35	+10	40	+15	45	+20
HI (Arit. Average)	Yes (26.3)	Yes (28.8)		Yes (40.0)		Yes (46.3)	
STS(Ave. Shift)	-	No (5.0)		Yes (16.7)		-	-
PSTS(Ave. Shift)	-	-	-	-	-	Yes (21.7)	
NIHL (Pattern)	Yes (Notching at 4kHz with recovery)	Yes (Notching at 4kHz with recovery)	-	Yes (Notching at 4kHz with recovery)	-	Yes (Notching at 4kHz with recovery)	-
Revision of Base-line	-	No	-	-	-	Yes (Baseline thresholds revised to 2016 annual audiogram as PSTS occurred)	
Notification to DOSH	Not required (unable to establish current work relationship)	Not required (no significant change in the hearing threshold)		Not required (need to confirm PSTS first)		Required (NIHL + Hearing Impairment + PSTS)	

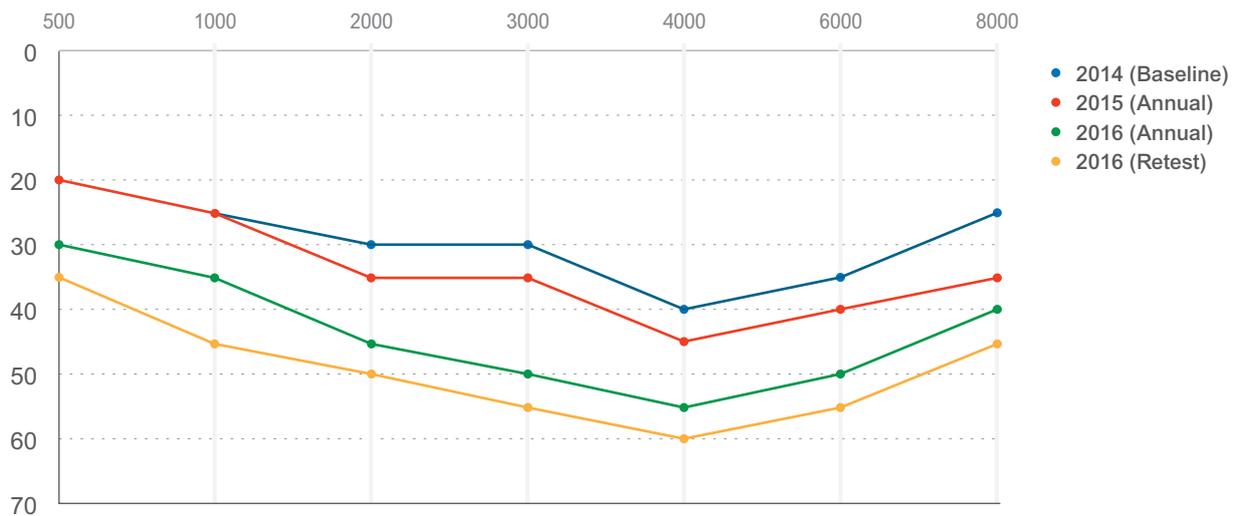


Figure 11.1: Audiogram describing the Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry from Table 11.1

Worker A commenced work in Factory X in 2014. He did a baseline audiogram within 3 months of working. His result is shown in Figure 11.2.

YEAR	2014	2015		2016			
Frequency	Baseline audiogram threshold (dB) (within 3 months commencing of work)	2015 Annual audiogram threshold (dB)	Changes of threshold between annual and baseline (2014)	2016 Annual audiogram threshold (dB)	Changes of threshold between annual and baseline (2014)	2016 Retest audiogram threshold (dB) (within 3 months of 2016 annual audiogram)	Changes of threshold between retest and baseline (2014)
500	20	20	0	30	+10	35	+15
1000	25	25	0	35	+10	45	+20
2000	30	35	+5	45	+15	50	+20
3000	30	35	+5	50	+20	55	+25
4000	40	45	+5	55	+15	60	+20
6000	35	40	+5	50	+15	55	+20
8000	25	35	+10	40	+15	45	+20

Figure 11.2: Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry from Table 11.1 – Highlighting on the baseline audiometry result done on 2014

Below is the calculation of the arithmetic average of the permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[20+25+30+30]}{4} = 26.3 \text{ dB (there is Hearing Impairment)}$$

The blue line in Figure 11.1 corresponding to the 2014 baseline audiogram shows an NIHL pattern. For this result, notification to DOSH is not required as it is unable to establish the Hearing Impairment and NIHL in the baseline to his current job.

Worker A underwent an annual audiogram in 2015, and the result is shown in Figure 11.3.

YEAR	2015		2016				
	2014	2015	2016	2016	2016	2016	
Frequency	Baseline audiogram threshold (dB) (within 3 months commencing of work)	2015 Annual audiogram threshold (dB)	Changes of threshold between annual and baseline (2014)	2016 Annual audiogram threshold (dB)	Changes of threshold between annual and baseline (2014)	2016 Retest audiogram threshold (dB) (within 3 months of 2016 annual audiogram)	Changes of threshold between retest and baseline (2014)
500	20	20	0	30	+10	35	+15
1000	25	25	0	35	+10	45	+20
2000	30	35	+5	45	+15	50	+20
3000	30	35	+5	50	+20	55	+25
4000	40	45	+5	55	+15	60	+20
6000	35	40	+5	50	+15	55	+20
8000	25	35	+10	40	+15	45	+20

Figure 11.3: Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry from Table 11.1 – Highlighting the annual audiometry result done on 2015

Below is the calculation of the arithmetic average of the permanent hearing threshold:

$$\text{Arithmetic average} = \frac{[20+25+35+35]}{4} = 28.8 \text{ dB (there is Hearing Impairment)}$$

Meanwhile, the calculation for changes in the threshold at 2000, 3000, and 4000 Hz frequencies is as follow:

$$\text{Arithmetic shift} = \frac{[5+5+5]}{3} = 5 \text{ dB (there is no STS)}$$

Although Hearing Impairment and NIHL configuration was noted in the 2015 annual audiogram (orange line in Figure 11.1), there is no significant change in his hearing thresholds marked by the absence of an STS. The abnormalities identified in the 2015 annual audiogram were present even in his 2014 baseline audiogram without any significant change in his hearing threshold, which may be attributable to his current workplace noise exposure. Thus, notification to DOSH is not required, and the worker’s baseline need not be revised to the 2016 annual audiogram.

In 2016, Worker A did an annual audiogram with the result shown in Figure 11.4.

YEAR	2014			2015		2016	
	Frequency	Baseline audiogram treshold (dB) (within 3 months commencing of work)	2015 Annual audiogram treshold (dB)	Changes of treshold between annual and baseline (2014)	2016 Annual audiogram treshold (dB)	Changes of treshold between annual and baseline (2014)	2016 Retest audiogram treshold (dB) (within 3 months of 2016 annual audiogram)
500	20	20	0	30	+10	35	+15
1000	25	25	0	35	+10	45	+20
2000	30	35	+5	45	+15	50	+20
3000	30	35	+5	50	+20	55	+25
4000	40	45	+5	55	+15	60	+20
6000	35	40	+5	50	+15	55	+20
8000	25	35	+10	40	+15	45	+20

Figure 11.4: Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry from Table 11.1 – Highlighting the annual and retest audiometry result done on 2016

Below is the calculation of the arithmetic average of the permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[30+35+45+50]}{4} = 40.0 \text{ dB (there is Hearing Impairment)}$$

Meanwhile, the calculation changes in the threshold at 2000, 3000, and 4000 Hz frequencies as below:

$$\text{Arithmetic shift} = \frac{[15+20+15]}{3} = 16.7 \text{ dB (there is STS)}$$

The green line in Figure 11.1 corresponding to the 2016 annual audiogram shows an NIHL pattern with Hearing Impairment. This worker needs to retest audiometry within 3 months as his average shift shows that STS has occurred. Notification is not required yet at this point since the STS needs to be confirmed as Permanent STS.

Retest audiogram within 3 months is shown in Figure 11.4.

Below is the calculation of the arithmetic average of the permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[35+45+50+55]}{4} = 46.3 \text{ dB (there is Hearing Impairment)}$$

Meanwhile, the calculation changes in threshold at 2000, 3000, and 4000 Hz frequencies as follow:

$$\text{Arithmetic shift} = \frac{[20+25+20]}{3} = 21.7 \text{ dB (permanent STS is confirmed)}$$

The yellow line in Figure 11.1 corresponding to the 2016 retest audiogram shows an NIHL pattern with Hearing Impairment and Permanent STS. Hence, notification to DOSH is required for the Hearing Impairment, NIHL, and Permanent STS.

The baseline audiogram needs to be revised to the 2016 retest audiogram as Permanent STS has occurred.



11.3 SCENARIO 2

This scenario was taken from item 7.2 of Appendix 7 of Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

Table 11.2: Illustrative Example of Repeated Cases of Occupational Noise-Related Hearing Disorder.

YEAR	2014	2015				2016	
Frequency	Baseline Audiogram Threshold (dB) (within 3 months commencing of work)	2015 Annual audiogram threshold (dB)	Changes of the threshold between annual and baseline (2014)	2015 Retest audiogram threshold (dB) (within 3 months of 2015 annual audiogram)	Changes of the threshold between annual and baseline (2014)	2016 Annual audiogram threshold (dB)	Changes of the threshold between retest and baseline (2015)
500	5	20	+15	20	+15	20	0
1000	5	25	+20	25	+20	25	0
2000	10	30	+20	30	+20	35	+5
3000	15	30	+15	30	+15	35	+5
4000	15	40	+25	40	+25	45	+5
6000	15	35	+20	35	+20	40	+5
8000	10	25	+15	25	+15	35	+10
HI (Arit. Average)	No (8.8)	Yes (26.3)	-	Yes (26.3)	-	Yes (28.8)	-
STS (Ave. Shift)	-	Yes (20.0)		-		No (5.0)	
PSTS (Ave. Shift)	-	-	-	Yes (20.0)	-	-	-
NIHL (Pattern)	-	Yes (Notching at 4kHz with recovery)	-	Yes (Notching at 4kHz with recovery)	-	Yes (Notching at 4kHz with recovery)	-
Revision of Baseline	-	-	-	Yes (Baseline thresholds revised to 2015 audiogram as PSTS occurred)		-	
Notification to DOSH	-	Deferred (to confirm PSTS first)		Required (NIHL + Hearing Impairment + PSTS)		Not required (no significant change in the hearing threshold)	

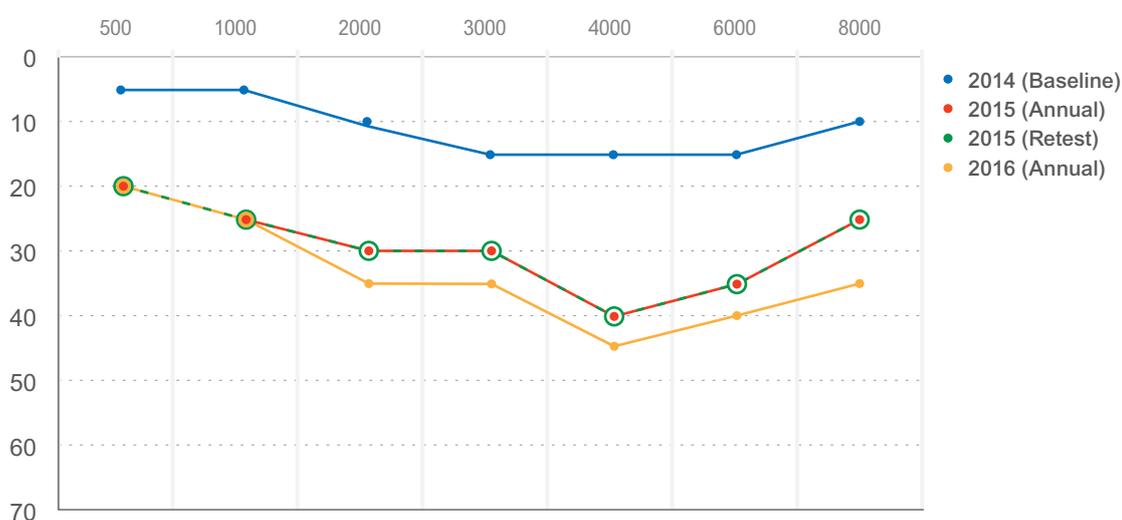


Figure 11.5: Audiogram describing the Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry from Table 11.2

Worker B started working at Factory Y in 2014, and an audiogram test was done within 3 months of work commencement. In 2014, the audiogram report result was typical (as shown in Figure 11.6).

YEAR	2014	2015				2016	
Frequency	Baseline audiogram treshold (dB) (within 3 months commencing of work)	2015 Annual audiogram treshold (dB)	Changes of treshold between annual and baseline (2014)	2015 Retest audiogram treshold (dB) (within 3 months of 2015 annual audiogram)	Changes of treshold between annual and baseline (2014)	2016 Annual audiogram treshold (dB)	Changes of treshold between retest and baseline (2015)
500	5	20	+15	20	+15	20	0
1000	5	25	+20	25	+20	25	0
2000	10	30	+20	30	+20	35	+5
3000	15	30	+15	30	+15	35	+5
4000	15	40	+25	40	+25	45	+5
6000	15	35	+20	35	+20	40	+5
8000	10	25	+15	25	+15	35	+10

Figure 11.6: Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry from Table 11.2 – Highlighting on the baseline audiometry result done on 2014

YEAR	2014	2015				2016	
Frequency	Baseline audiogram treshold (dB) (within 3 months commencing of work)	2015 Annual audiogram treshold (dB)	Changes of treshold between annual and baseline (2014)	2015 Annual audiogram treshold (dB)	Changes of treshold between annual and baseline (2014)	2016 Retest audiogram treshold (dB) (within 3 months of 2016 annual audiogram)	Changes of treshold between retest and baseline (2015)
500	5	20	+15	20	+15	20	0
1000	5	25	+20	25	+20	25	0
2000	10	30	+20	30	+20	35	+5
3000	15	30	+15	30	+15	35	+5
4000	15	40	+25	40	+25	45	+5
6000	15	35	+20	35	+20	40	+5
8000	10	25	+15	25	+15	35	+10

Figure 11.7: Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry from Table 11.2 – Highlighting the annual and retest audiometry result done on 2015

In 2015, the worker did an annual audiogram with the result shown in Figure 11.7. Below is the calculation of the arithmetic average of the permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[20+25+30+30]}{4} = 26.3 \text{ dB (there is Hearing Impairment)}$$

Meanwhile, the calculation changes in threshold at 2000, 3000, and 4000 Hz frequencies as follow:

$$\text{Arithmetic shift} = \frac{[20+15+25]}{3} = 25 \text{ dB (there is STS)}$$

The orange line in Figure 11.5 corresponding to the 2015 annual audiogram shows an NIHL pattern with Hearing Impairment. This worker needs to undergo an audiometry retest within 3 months as his average shift shows that STS has occurred. Although in the 2015 annual audiogram, new abnormalities were noted (Hearing Impairment and NIHL), notification is to be deferred at this point of time since the STS needs to be confirmed as Permanent STS.

Retest audiogram within 3 months is shown in Figure 11.7. Below is the calculation of the arithmetic average of the permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[20+25+30+30]}{4} = 26.3 \text{ dB (there is Hearing Impairment)}$$

Meanwhile, the calculation changes in threshold at 2000, 3000, and 4000 Hz frequencies as follow:

$$\text{Arithmetic shift} = \frac{[20+15+25]}{3} = 25 \text{ dB (permanent STS is confirmed)}$$

The green line in Figure 11.5 corresponding to the 2015 retest audiogram shows an NIHL pattern with Hearing Impairment and Permanent STS. Hence, notification to DOSH is required for the Hearing Impairment, NIHL, and Permanent STS. The worker’s baseline threshold needs to be revised to the 2015 audiogram as Permanent STS is confirmed.

YEAR	2014		2015			2016		
	Frequency	Baseline audiogram treshold (dB) (within 3 months commencing of work)	2015 Annual audiogram treshold (dB)	Changes of treshold between annual and baseline (2014)	2015 Annual audiogram treshold (dB)	Changes of treshold between annual and baseline (2014)	2016 Retest audiogram treshold (dB) (within 3 months of 2016 annual audiogram)	Changes of treshold between retest and baseline (2014)
	500	5	20	+15	20	+15	20	0
	1000	5	25	+20	25	+20	25	0
	2000	10	30	+20	30	+20	35	+5
	3000	15	30	+15	30	+15	35	+5
	4000	15	40	+25	40	+25	45	+5
	6000	15	35	+20	35	+20	40	+5
	8000	10	25	+15	25	+15	35	+10

Figure 11.8: Illustrative example of Occupational Noise-Related Hearing Disorder at Baseline Audiometry from Table 11.2 – Highlighting the annual audiometry result done on 2016

In 2016, Worker B did an annual audiogram with the result shown in Table 11.8. Below is the calculation of the arithmetic average of the permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[20+25+30+30]}{4} = 28.8 \text{ dB (there is Hearing Impairment)}$$

Meanwhile, the calculation changes in the threshold at 2000, 3000, and 4000 Hz frequencies is as follow:

$$\text{Arithmetic shift} = \frac{[5+5+5]}{3} = 5 \text{ dB (there is no STS)}$$

The yellow line in Figure 11.5 corresponding to the 2016 annual audiogram shows an NIHL pattern with Hearing Impairment. Still, notification to DOSH is not required as the NIHL and Hearing Impairment was already present in 2015 and was notified then. Furthermore, there is no significant change of his hearing threshold in the current audiometry marked by the absence of an STS.



11.4 SCENARIO 3

Table 11.3: Illustrative Example of Permanent Standard Threshold Shift within Normal Limits of Hearing Thresholds (< 25dB)

YEAR	2014	2015				2016	
Frequency	Baseline Audiogram Threshold (dB) (within 3 months commencing of work)	2015 Annual audiogram threshold (dB)	Changes of the threshold between annual and baseline (2014)	2015 Retest audiogram threshold (dB) (within 3 months of 2015 annual audiogram)	Changes of the threshold between annual and baseline (2014)	2016 Annual audiogram threshold (dB)	Changes of the threshold between retest and baseline (2015)
500	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0
2000	0	15	+15	15	+15	15	0
3000	5	20	+15	20	+15	20	0
4000	5	15	+10	15	+10	15	0
6000	0	0	0	0	0	0	0
8000	0	0	0	0	0	0	0
HI (Arit. Average)	No (1.2)	No (8.7)	-	No (8.7)	-	No (8.7)	-
STS (Ave. Shift)	-	Yes (13.3)		-	No (0)		
PSTS (Ave. Shift)	-	-	-	Yes (13.3)	-	-	-
NIHL (Pattern)	-	No	-	No	-	No	-
Revision of Base-line	-	-	-	Yes (Baseline thresholds revised to 2015 audiogram as PSTS occurred)		-	
Notification to DOSH	-	Deferred (to confirm PSTS first)		Required (PSTS)		Not required (no significant change in the hearing threshold)	

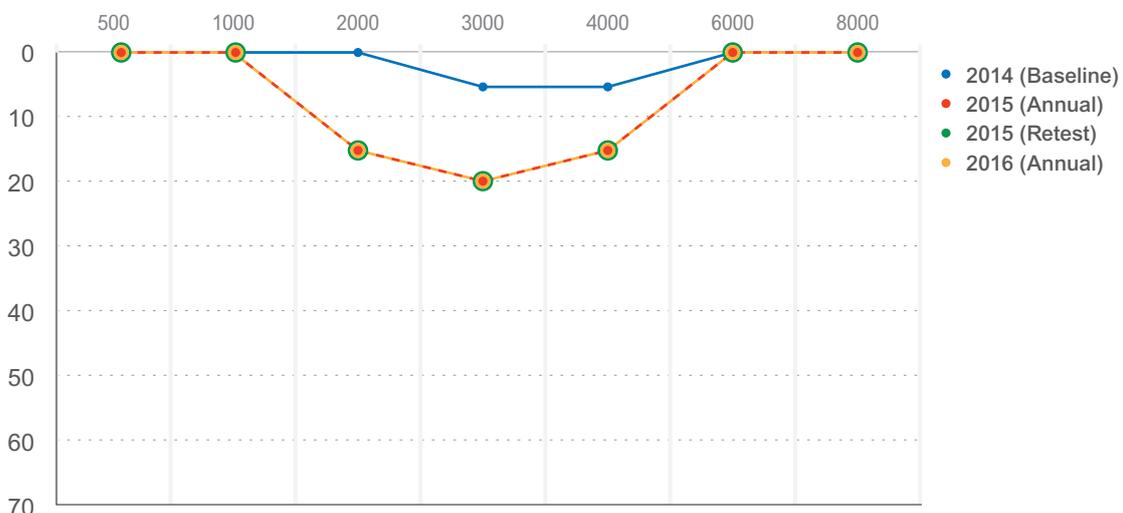


Figure 11.9: Audiogram describing the Illustrative Example of Permanent Standard Threshold Shift within Normal Limits of Hearing Thresholds (< 25dB) from Table 11.3

YEAR	2014	2015				2016	
Frequency	Baseline Audiogram Threshold (dB) (within 3 months commencing of work)	2015 Annual audiogram threshold (dB)	Changes of the threshold between annual and baseline (2014)	2015 Retest audiogram threshold (dB) (within 3 months of 2015 annual audiogram)	Changes of the threshold between annual and baseline (2014)	2016 Annual audiogram threshold (dB)	Changes of the threshold between retest and baseline (2015)
500	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0
2000	0	15	+15	15	+15	15	0
3000	5	20	+15	20	+15	20	0
4000	5	15	+10	15	+10	15	0
6000	0	0	0	0	0	0	0
8000	0	0	0	0	0	0	0

Figure 11.10: Illustrative Example of Permanent Standard Threshold Shift within Normal Limits of Hearing Thresholds (< 25dB) from Table 11.3 – Highlighting on the baseline audiometry result done on 2014

Worker C started working at Factory Z in 2014, and an audiogram test was done within 3 months of work commencement. In 2014, the audiogram report result was expected.

YEAR	2014	2015				2016	
Frequency	Baseline Audiogram Threshold (dB) (within 3 months commencing of work)	2015 Annual audiogram threshold (dB)	Changes of the threshold between annual and baseline (2014)	2015 Retest audiogram threshold (dB) (within 3 months of 2015 annual audiogram)	Changes of the threshold between annual and baseline (2014)	2016 Annual audiogram threshold (dB)	Changes of the threshold between retest and baseline (2015)
500	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0
2000	0	15	+15	15	+15	15	0
3000	5	20	+15	20	+15	20	0
4000	5	15	+10	15	+10	15	0
6000	0	0	0	0	0	0	0
8000	0	0	0	0	0	0	0

Figure 11.11: Illustrative Example of Permanent Standard Threshold Shift within Normal Limits of Hearing Thresholds (< 25dB) from Table 11.3 – Highlighting on the annual and retest audiometry result done in 2015

In 2015, Worker C did an annual audiogram with the result shown in Figure 11.11. Below is the calculation of the arithmetic average of the hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[0+0+15+20]}{4} = 8.7 \text{ dB (there is no Hearing Impairment)}$$

Meanwhile, the calculation changes in threshold at 2000, 3000, and 4000 Hz frequencies is as follow:

$$\text{Arithmetic shift} = \frac{[15+15+10]}{3} = 13.3 \text{ dB (there is STS)}$$

This worker needs to retest within 3 months as the average shift showed that STS has occurred. Notification is not required as Permanent STS needs to be confirmed.

Retest audiogram within 3 months is shown in Figure 11.9. Below is the calculation of the arithmetic average of the permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[0+0+15+20]}{4} = 8.7 \text{ dB}$$

Meanwhile, the calculation changes in threshold at 2000, 3000, and 4000 Hz frequencies as follow:

$$\text{Arithmetic shift} = \frac{[15+15+10]}{3} = 13.3 \text{ dB (PSTS is confirmed)}$$

The green line in Figure 11.9 corresponding to the 2015 retest audiogram shows no NIHL pattern or Hearing Impairment. However, Permanent STS is confirmed. Notification to DOSH is required for Permanent STS, and his baseline needs to be revised to the 2015 audiogram.

YEAR	2014	2015				2016	
Frequency	Baseline Audiogram Threshold (dB) (within 3 months commencing of work)	2015 Annual audiogram threshold (dB)	Changes of the threshold between annual and baseline (2014)	2015 Retest audiogram threshold (dB) (within 3 months of 2015 annual audiogram)	Changes of the threshold between annual and baseline (2014)	2016 Annual audiogram threshold (dB)	Changes of the threshold between retest and baseline (2015)
500	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0
2000	0	15	+15	15	+15	15	0
3000	5	20	+15	20	+15	20	0
4000	5	15	+10	15	+10	15	0
6000	0	0	0	0	0	0	0
8000	0	0	0	0	0	0	0

Figure 11.12: Illustrative Example of Permanent Standard Threshold Shift within Normal Limits of Hearing Thresholds (< 25dB) from Table 11.3 – Highlighting on the annual audiometry result done in 2016

In 2016, Worker C did an annual audiogram with the result shown in Figure 11.12. Below is the calculation of the arithmetic average of the permanent hearing threshold level at 500, 1000, 2000, and 3000 Hz frequencies:

$$\text{Arithmetic average} = \frac{[0+0+15+20]}{4} = 8.7 \text{ dB (there is no Hearing Impairment)}$$

Meanwhile, the calculation changes in threshold at 2000, 3000, and 4000 Hz frequencies is as follow:

$$\text{Arithmetic shift} = \frac{[0+0+0]}{3} = 0 \text{ dB (there is no STS)}$$

Notification to DOSH is not required as the results show the hearing thresholds are within the normal limits (below 25dB), and there is no Permanent STS.

In all the scenarios above, it is not appropriate to assume that permanent STS is the sole indicator for notification. In conclusion, the principle behind notification is whether the abnormality found in the current audiometry is a new discovery or if there has been a significant change in hearing thresholds of the worker (marked by the presence of Permanent STS), in comparison with the abnormalities detected in a worker's baseline audiogram.

CHAPTER 12

ONRHD COMPENSATION



12.1 INTRODUCTION

Social Security Organisation (SOCSO) was established in 1971 to administer, implement and enforce the Employees' Social Security Act 1969. The primary function of SOCSO is to provide social security protection to employees and their dependents through the Employment Injury Scheme and the Invalidity Scheme. The Employment Injury Scheme protects employees against occupational injuries, occupational diseases, and commuting accidents.

..compensation
for occupational
diseases must be
based on evidence.



SOCSO is responsible for managing the fund contributed by employers and employees with due diligence and upheld social justice for all contributors. Hence, compensation for occupational diseases must be based on evidence. Pertinent to the focus on evidence-based decision-making is determining work-relatedness and the evaluation of impairment related to the disease. The purpose of this section is to increase the knowledge of OHD on SOCSO compensation requirements for ONRHD.

12.2 LEGISLATION

The Employees' Social Security Act 1969 (Act 4), specifically in Section 28 and 32(A), specifies compensation for occupational diseases. Section 28 of the Act details the definition of occupational diseases. In contrast, Section 32(A) describes the function and procedures of the Special Medical Board in determining occupational diseases and the subsequent impairment assessment related to the disease. The Fifth Schedule of the Act contains compensable occupational diseases, including Noise-Induced Hearing Loss and Acoustic Trauma.

Since 2017, SOCSO introduced the Self-Employment Social Security Act 2017 (Act 789), which protects against employment injuries, including occupational diseases, to self-employed persons. Section 16 of Act 789 allows compensations of occupational diseases listed in the Fifth Schedule of Act 4.

12.3 OCCUPATIONAL NOISE-INDUCE HEARING LOSS

Diagnosis of ONIHL due to prolonged exposure to excessive noise must fulfill the requirements outlined below to ensure the process of compensation is objective and evidence-based. It is consistent with Chapters 8 and 9 to establish a diagnosis and work-relatedness of the disease. The OHD shall identify occupational noise exposure according to these guidelines. The history and relevant investigation must be mentioned and documented in the medical report for compensation purposes.



ONRHD criteria for compensation purposes:

- Sensorineural hearing loss and usually bilateral.
- Gradual onset of signs and symptoms.
- Permanent hearing loss.
- Evidence of prolonged exposure to noise above the noise exposure limit (NEL).

Additional Investigations like Auditory Steady-State Response (ASSR) and Auditory Brainstem Evoked Response (ABER) are requested by SOCSO Special Medical Board if necessary.

It is vital to note that Screening Audiometry Test alone is not adequate to establish a diagnosis of NRHD for reasons explained earlier in these Guidelines. For compensation under SOCSO Employment Injury Scheme, the affected insured person (worker) must undergo Diagnostic Pure Tone Audiometry. The audiogram provided must fulfill the features mentioned in Chapters 6 and 7 in keeping with the consideration mentioned in Chapters 8 and 9. The comparison between the latest audiogram and its original or reviewed baseline should be included.

12.4 ACOUSTIC TRAUMA

Acoustic trauma can be considered as occupational injury or occupational disease. Both classifications for acoustic trauma are compensable under the SOCSO Employment Injury Scheme.

Acoustic trauma is a hearing loss that occurs following exposure to a single event involving an extremely intense noise, such as an explosion. The immediate effects of exposure to high-intensity sound stimulus include elevation of the hearing threshold, rupture of the eardrum, and traumatic damage to the middle and inner ears (dislocation of ossicles, cochlear injury, or fistulas). Even brief exposure to a very intense sound can result in permanent cochlear damage. In most cases, the hearing loss is temporary, lasting only a few hours or days, and the hearing returns to normal. When the hearing loss has persisted for many weeks, it can be considered permanent.

Characteristic features:

- An intense impulsive noise is usually associated with explosions. Explosive noise emission can occur in situations such as in quarry or accidental explosion. The history can reveal associated pain, bleeding from the ear, tinnitus, and sudden-onset hearing loss.
- An otoscopic examination may show perforated TM or haemotympanum. However, the examination can also be normal.
- Diagnostic pure tone audiometry may show a sensorineural hearing loss or conductive hearing loss. The conductive hearing loss is reversible; however, sensorineural hearing loss could be irreversible. Tympanometry may show type AD suggesting ossicular chain discontinuity.
- The minimum intensity of hazard exposure is around 130-140 dB in brief duration.

12.5 DETERMINATION OF WORK-RELATEDNESS AND IMPAIRMENT ASSESSMENT OF HEARING LOSS

Impairment assessment for ONRHD compensable under the Employees' Social Security Act 1969 is performed by the Special Medical Board. The Special Medical Board for ONRHD consists of at least three doctors, including the chairperson (usually the Hospital Director), an ORL specialist, and a doctor trained in Occupational Health or Occupational Medicine. Hence the attending OHD must adhere to Chapter 9 and present the findings sufficiently in the medical report. This information aids the Special Medical Board in making their decision objectively.

According to Section 40, Self-Employment Social Security Act (Act 789), the determination of Occupational Disease is performed by Medical Assessor appointed under the regulation made under this Act. A similar ground of documentation and information, as mentioned earlier, is required to make a decision.

Compensation for NRHD as an occupational disease in the Special Medical Board / Medical Assessor can be summarised by these steps:

a. Confirmation of the diagnosis

- Satisfy the criteria for NRHD
- Exclusion of other causes of sensorineural hearing loss

b. Determination of work-relatedness

- Evidence of exposure to noise in the workplace exceeding the NEL
- Exposure to work activities or processes associated with excessive noise exposure, e.g., quarrying (rock crushing)

c. Impairment assessment

- The assessment is as specified under the Second Schedule of the Employees' Social Security Act 1969 or when not available in the schedule, using methods of assessment outlined in the *Guidelines on Impairment and Disability Assessment of Traumatic Injuries, Occupational Diseases, and Invalidity* published by SOCSO.
- The assessment is based on diagnostic audiometry. The hearing loss at the frequencies of 0.5, 1, 2, and 3 kHz must amount to hearing impairment for any insured person to be eligible for compensation.

Insured persons may appeal the decision of the Special Medical Board or Medical Assessor if they are not satisfied with the decision within 90 days. Appeal cases are heard by the Appellate Medical Board consisting of a chairperson (State Health Director), an ORL specialist, and a doctor trained in Occupational Health or Occupational Medicine. The decision of the Appellate Medical Board is final.

12.6 MEDICAL REPORT WRITING FOR OCCUPATIONAL DISEASES COMPENSATION

Medical reports are documents prepared by a medical practitioner on a worker based on his medical records. Practitioners must provide comprehensive medical reports when requested by the worker or by the employer - with the worker's consent. Ethically, only the attending OHD of the worker has the right to prepare the medical report for compensation purposes. Refusal to provide or undue delay in preparing medical reports is considered an unethical practice.

Medical reports for compensation purposes must mention and justify NRHD's work-relatedness as described in Chapter 9. All relevant negative findings and non-occupational factors should be documented and included in the report. Any opinion or recommendation by the OHD shall be clearly labelled and explained for reference and consideration by the medical board.



The occupational disease medical report is as shown in Appendix 3. Medical Report for compensation shall include, but not limited to the following:

- Information about the practitioner (Name, Address, Contact details)
- The authority to write the report (Treating OHD or not)
- State the medical records that were referred to when writing the report
- Any exceptional circumstances in preparing the report.
- Worker's biodemographic details
- Dates and time of consultation, admission, or treatment
- History of signs and symptoms
- Detail occupational history and relate to the potential hazard associated with the diagnosis
- Medical history relevant to the diagnosis (e.g., diabetes, previous ear infections)
- Current job description
- History of exposure to hazards at the workplace relevant to diagnosis
- Significant examination findings
- Results of relevant clinical investigations (e.g., diagnostic pure tone audiometry, tympanometry, ASSR, ABER)
- Results of workplace monitoring if available (e.g., noise monitoring report)
- Diagnosis
- Treatment
- Management plan

CHAPTER 13

FAQ

POSSIBLE SCENARIOS DURING IMPLEMENTATION

Based on feedback from Occupational Health Doctors (OHD) and Audiometric Test Centres (ATC), several scenarios are not clearly described in the Industrial Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019, which are often encountered during audiometric testing. Thus, we have listed the scenarios and the possible approaches that can be used in those circumstances as follows;

SCENARIO 1

For offshore oil and gas workers, some companies allow their workers to undergo audiometric testing for a certain period (e.g., workers are given the option to come between January till June in a particular year). Can such practices be allowed?

Answer: Yes, such practice is allowed as long as;

- a) It does not affect the annual audiometric testing requirement for any worker; and
- b) It fulfills the requirement for ATC to submit a report to the employer within 30 days from the date of testing.

SCENARIO 2

Does an employee with Permanent STS occurring within his normal hearing threshold (i.e., thresholds ≤ 25 dB) required to be notified to DOSH?

Answer: Yes, an employee with Permanent STS that occurs within his normal hearing threshold shall be notified to DOSH. Permanent STS reflects worsening or improvement in the hearing threshold and may happen within the standard hearing threshold of an employee. Permanent STS is also a valuable indicator for monitoring the effectiveness of noise control at the workplace.

SCENARIO 3

An ATC appoints more than one OHD to interpret audiograms and conduct medical examinations for employees with abnormal audiograms from a company. Is the audiometric report required to be separated according to the attending OHD?

Answer: No, the ATC is not required to separate the audiometric report according to the attending OHD. The audiometric report is based on the date of testing conducted for a particular company. Although an ATC may appoint more than one OHD, the audiogram interpretation and medical examination of an employee shall be carried out by the same OHD

SCENARIO 4

If the OHD, during his medical examination, found that a worker has ONRHD but does not belong to any SEG with noise exposure more than NEL;

- a. Can the OHD recommend the employer re-assess the workplace?
- b. Should ATC include the worker result in the audiometric report?
- c. Shall OHD notify the case to DOSH?

Answer:

- a) Yes, OHD may recommend that the employer re-assesses the workplace.
- b) Audiometric report prepared under the Occupational Safety and Health (Noise Exposure) Regulations 2019 is only for workers exposed to noise more than NEL. Thus, if the employer sent workers who are not exposed to noise more than NEL for audiometric testing, ATC is advised to prepare a separate report.
- c) Yes, as per NADOPOD. However, the OHD shall exercise due diligence to determine the diagnosis of NRHD, including the work-relatedness of the case as per this document. Whenever determination of diagnosis is not possible, OHD to proceed with the notification as per NADOPOD requirement accordingly.

SCENARIO 5

Regarding fitness to work for workers who are already hearing-impaired, can they work in the area that exposes them to noise more than NEL?

Answer: Whether to allow hearing-impaired workers to work in specific areas with excessive noise or noise more than NEL is based on the company's policy or any standard set by specific industries.

SCENARIO 6

Are hearing-impaired workers exempted from the requirements of the Occupational Safety and Health (Noise Exposure) Regulations 2019?

Answer: No workers are exempted from complying with the Occupational Safety and Health (Noise Exposure) Regulations 2019.

SCENARIO 7

An employer sent his workers for annual audiometric testing for the year 2020. Employee A was identified to have temporary STS during testing, which warrants repeat audiometric testing within 3 months from the annual audiometric testing. However, the employer refused to send the worker for repeat audiometric testing, although advised by the Occupational Health Doctor (OHD).

In 2021, the employer sends Employee A for another annual audiometric. During testing, he once again was identified to have STS.

- a. Could the '2021 OHD' conclude the case as Permanent STS directly without repeating audiometric testing?
- b. Does the '2021 OHD' need to notify DOSH of the non-compliance?

Answer:

- a) No, Permanent STS should be established within 3 months from the date of initial testing based on the Occupational Safety and Health (Noise Exposure) Regulations 2019 & the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019
- b) OHD is encouraged to report any non-compliance to DOSH. OHD can send an email to [projkkp\[at\]mohr.gov.my](mailto:projkkp[at]mohr.gov.my) or contact the nearest DOSH office.

A SAMPLE OF AUDIOMETRIC REPORT

AUDIOMETRY ASSESSMENT
COMPANY XYZ

Nature of Industry: *e.g. Manufacturing / Oil & Gas / Mining*

Facilities and Location(s):

- (1)
- (2)
- (3)

Assessment Period: *DD MM to DD MM YYYY*

Prepared by / author(s):

AUDIOMETRIC TEST CENTRE

ATC Registration No:

Name of Trained Audiometric Technician(s):

-
-

Name of Occupational Health Doctor(s):

- Dr OHD Registration No:
- Dr OHD Registration No:

Note to author(s):

- This sample report serves as a guide but author(s) of this report is (are) required to adopt, adapt, add content and recommendation specific to the particular assessment for the company. Author(s) to complete relevant information in the proposed empty space
- ATC to comply with timeline of submission of the result of audiometric testing to the employer within 30 days from the date of testing as per requirement in the Occupational Safety and Health (Noise Exposure) Regulations 2019 and Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019. Subsequent follow-up report submission shall be made for cases that have completed the re-test to confirm threshold shift and cases subjected to further referral for confirmatory diagnosis.
- Report shall be submitted by ATC to employer as stated in Chapter 4 (refer flow chart: Figure 4.1, 4.2 and 4.3)
- For cases referred to a relevant specialist, follow-up submission of audiometric testing result to the employer should be made within 6 months from the testing date.
- Refer to Chapter 4 of this document for further details on the report submission timeline.

EXECUTIVE SUMMARY

OH, Services Provider ABC provided an audiometric assessment to Company XYZ on DD MM to DD MM YYYY. Repeat audiograms were conducted for employees presented with temporary Standard Threshold Shift (STS) within 3 months from the screening date. Employees with abnormal audiograms were required to undergo a medical examination by OHD, and selected cases were referred to a relevant specialist for further evaluation.

Testing was conducted by Trained Audiometric Technicians Name(s) under supervision of Occupational Health Doctor (OHD) Dr. Name(s). Testing was done in a static/mobile silent booth and audiometer with a valid calibration certificate. The facility has been registered as Audiometric Testing Centre (ATC).

The audiometric testing program was conducted according to the Occupational Safety and Health (Noise Exposure) Regulations 2019 and the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

A number of employees were subjected to further proceeding to confirm the diagnosis;

- Numbers of employees subjected to medical examination
- Numbers of employees referred to audiologist / Ear Nose and Throat (ENT) specialist for further evaluation.

Over the scheduled period of testing, number of workers had their hearing thresholds assessed.

Findings revealed;

- ___% (numbers) normal
- ___% (numbers) newly diagnosed Occupational Noise-Related Hearing Disorders (ONRHD)
- ___% (numbers) newly identified non-work-related hearing abnormalities / disorders

OBJECTIVE

The main objective of the audiometric assessment is to provide a surveillance report on the impact of noise at the workplace to the employee in compliance with Occupational Safety and Health (Noise Exposure) Regulation 2019.

The specific objectives of the testing are:

- To determine cases with ONRHD;
- To recommend appropriate actions to be taken based on the result of the audiometric test and analysis in line with the regulations as well as good practices

METHODOLOGY

General Audiometry Testing Process Flow

- Employees have been advised by their management to avoid exposure to high noise for at least 14 hours prior to the audiometry test.
- Employees with upper respiratory tract infections were told to re-arrange testing at another time after they have fully recovered.
- Before the test, workers were required to complete a questionnaire to document personal information, medical history, current health status, medication, and activities or hobbies that can affect their hearing.
- The audiometric test was conducted by a Trained Audiometric Technician under the supervision of an OHD in an audiometric test room.
- The hearing frequency test ranges were 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz.

- The employer has provided his employee’s baseline audiogram on every annual audiometry for reference to the attending OHD.
- Personal audiogram results and analyses were kept by the OHD.

Abnormal audiogram management

- All employees with abnormal audiograms were medically examined by the OHD. The medical examination consists of medical history taking, physical examination, and other relevant investigations to diagnose or rule out any occupational or non-occupational hearing disorder.
- All STS cases were re-tested within three months to confirm the occurrence of Permanent Standard Threshold Shift (STS).
- Based on the medical examination AND interpretation of the audiogram, the OHD had referred selected cases to a relevant specialist for further evaluation and need to conclude the case within 6 months from the date of screening audiometry.
- Based on information gathered, the OHD then proceeds with the diagnosis of hearing disorder and the potential correlation with occupation, i.e., determination of work-relatedness.
- All confirmed Occupational Noise-Related Hearing Disorders (ONRHD) shall be notified the Department of Occupational Safety and Health (DOSH).

RESULT

Table 1: Summary of audiometry assessment result and conclusion

RESULT AND CONCLUSION	NUMBER OF EMPLOYEES	
Normal		
Temporary Standard Threshold Shift #Note for author(s): For cases pending retest at time of this report being submitted.		
Hearing Disorders	Work Related (Occupational Noise-Related Hearing Disorder)	Non-Work Related (Non-occupational Noise-Related Hearing Disorder)
i. Permanent STS		
ii. NIHL		
iii. Hearing Impairment		
Others: e.g., non-NIHL pattern Age-related hearing disorder (presbycusis)		
Total		
Revision of baseline		
Notification to DOSH by OHD		
Abbreviation:		
<ul style="list-style-type: none"> • Standard Threshold Shift (STS) • Hearing Impairment (HI) • Noise-Induced Hearing Loss (NIHL) 		

Refer to appendices for further detail.

DISCUSSION

Note to author(s):

- Explain to the employer on result and analysis of table 1, namely the occurrence of temporary STS, ONHRD, and the non-work-related cases. Best to provide insight on the root cause(s) based on the overall assessment, namely history taking, occupational noise exposure data, audiometry analysis, medical examination, and specialist referral.
- Provide insight to the employer on the pattern of ONHRD in relation to the specific area of noise exposure or workgroup based on the availability of noise exposure monitoring report.
- Comment on the challenges during audiometry assessment, such as inadequacy of essential data from employer, timeliness of retest schedule, and cooperation from employees.
- May provide comments on training and hearing protection matters based on the interview with employees.

RECOMMENDATION

The hearing of employees exposed to excessive noise at the workplace shall be monitored through regular audiometric examinations as a comprehensive Hearing Conservation Program component. Recommendations for the employers listed below were made based on the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019. Kindly continue practices that are already in place and improve areas of concern to prevent legal implications.

Testing

- The employer shall ensure that the audiometric testing shall be preceded by a quiet period, the absence of exposure to sound level exceeding 80 dB(A) of at least 14 hours without wearing any PHP.
- The baseline audiogram shall be carried out within three (3) months of the employee commencing work, exposing him to Noise Exposure limit (NEL).
- The employer shall provide his employee's baseline audiogram on every annual audiometry for reference to the attending OHD.
- The employer shall provide his employee's workplace personal noise exposure monitoring information to the Audiometric Test Centre (ATC) for establishing work-relatedness of hearing disorders.
- Any changes in hearing levels over time revealed by audiometry shall be thoroughly investigated as to their cause(s) and the need for corrective action.

Audiometric Report

- The employer is expected to receive the audiometric report from the Audiometric Test Center within 30 days of testing.
- The employer, upon receiving notification of temporary STS, shall:
 - » make appropriate arrangements to protect the hearing of an employee from further deterioration by ensuring the employee fulfills at least 14 hours of quiet state without personal hearing protectors (PHP) prior to the retest audiometry, and
 - » conduct a retest within three (3) months after the previous audiometric testing was carried out.
- If an employee has a normal audiogram, the employer shall:
 - » inform the employee of his condition within 21 days after receiving the results; and
 - » continue the annual audiometric testing program.
- If an employee has a hearing impairment, hearing loss, or permanent STS, the employer shall:
 - » inform the employee of his condition within 21 days after receiving the results;
 - » provide the employee, if he has not been so provided, with a PHP; and
 - » refit and retrain the employee in the use of a PHP;

- The baseline audiogram shall be replaced with the retest audiogram if the retest audiogram reveals:
 - » a permanent STS; or
 - » improved hearing threshold with respect to the baseline at two (2) or more test frequencies.

Medical examination and referral

- The employer shall ensure his employees with abnormal audiograms undergo medical examination promptly after receiving audiogram interpretation from the OHD.

Notification

- Upon receiving the audiometric report, the employer shall notify any permanent occupational STS, HI, or NIHL using an approved form to the nearest DOSH office within seven (7) days. The notification to the nearest DOSH office shall include:
 - » Report for Occupational Diseases/Poisoning - Appendix 6 (Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019)
 - » Notification form - JKPP 7
 - » A copy of the latest audiometric report

Information, Instruction, and Training

- Employees exposed to excessive noise shall be provided with information, instruction, and training to understand their responsibilities and the risks of noise exposure. Information, instruction, and annual training programs shall be updated to be consistent with control measures and work processes changes.

CONCLUSION

Note to author(s):

- Comment on company status of compliance to legal requirement stipulated in Occupational Safety and Health (Noise Exposure) Regulations 2019 and Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.
- General comment on company effort in proactively or reactively managing noise hazards at the workplace.

REFERENCES

- Occupational Safety and Health (Noise Exposure) Regulations 2019 and
- Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

APPENDIX

Appendix 1: Example of Reporting Format for Occupational Health Doctor to Audiometric Test Centre After Completed Medical Examination.

Attached with:

Compilation of individual audiometry report –

- Questionnaire Form for Audiometric Testing (as in Appendix 4 of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019);
 - Audiogram of screening pure tone audiometry; and
 - Medical Examination form (as in Appendix 6 of the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019), along with audiograms of diagnostic pure tone audiometry.
-



JKKP 7 Form – Report for Occupational Poisoning/ Occupational Disease

JKKP 7

**REPORT FOR OCCUPATIONAL POISONING / OCCUPATIONAL DISEASE OCCUPATIONAL SAFETY AND HEALTH-
(NOTIFICATION OF ACCIDENT, DANGEROUS OCCURANCE, OCCUPATIONAL POISONING AND OCCUPATIONAL DISEASE) REGULATION 2004**
Part A1
 Notifier - Regulation 7(1) Employer
 (If more than one person please use separate form)

Name

Designation

Name & Address of Organisation

Contact Number

R.O.C. No

JKKP Reg. No

Industrial Classification Code (Table 3)

Contact person (if different from above)

Part A2

Notifier - Regulation 7(2) Registered Medical Practitioner

Name

Designation

Address of Clinic / Hospital

Contact Number

Part B - Affected Person

Name

Date of Birth

NIRC/Passport No

Nationality

Gender

L / P

Occupation

Name & Address of Organisation

Location of incident

Part C - Occupational Poisoning / Disease

Diagnosis / Provisional Diagnosis

Date of Diagnosis

Name and Address of Attending Doctor

Part D

Description of work that led to occupational poisoning/disease (Please describe any work done by the affected person which might have led to them getting the disease is thought to have been caused by exposure to an agent at work, e.g.a specific chemical - please state what that agent is)

Signature of Notifier

Date

Disclaimer

Completing this form does not constitute to an admission of liability of any kind by the person making the report or by any other person(s)


Clinical Examination: General and Specific examination of target organs.**Review of other systems examination.(Respiratory, skin, Cardiovascular, GIT(liver,spleen), Kidney, mental status, central / peripheral nervous system, others(specify)****INVESTIGATION Workplace monitoring results.**

Mention the specific hazards that are present in the workplace and the amount of personal & workplace exposure levels. For chemicals attach summary of Chemical Health Risk Assessment Report (CHRA). For noise attach noise report/map by competent person.

General Laboratory Tests

Blood & Urine examination.

Specify/confirmatory tests

(e.g Chest X-Ray, Spirometry, Serial Audiogram, ABER, Tympanogram, Skin Patch test etc.

FINAL DIAGNOSIS OF OCCUPATIONAL DISEASE (According to International Classification of Diseases ICD 10)

Date of diagnosis:

I certify that the above statements & findings are true.

Has the case been notified to Dept. of Occup. Safety & Health

Date :

No Yes When

Full Name and Qualification

Signature of Doctor / Specialist

Official Stamp of Hospital / Medical Centre

This form shall be filled in by the Occupational Health Doctor



Department of Occupational Safety and Health
Ministry of Human Resources

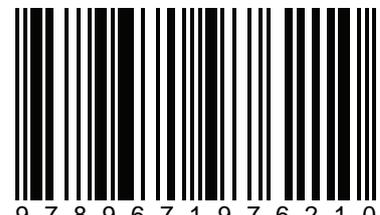
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