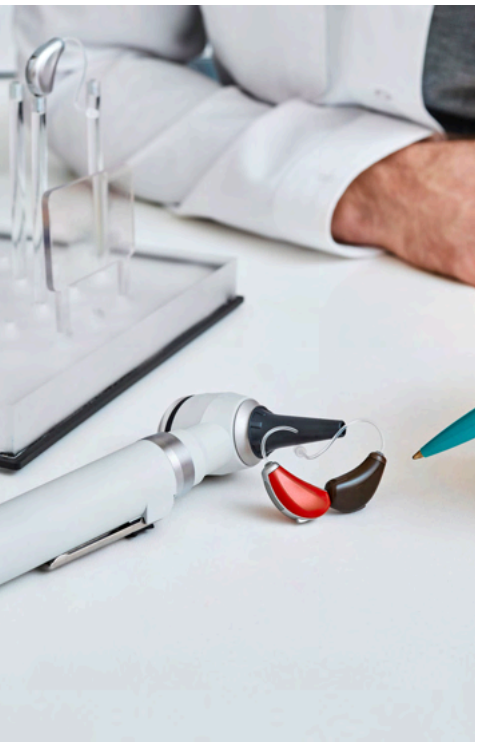
ACAud inc. HAASA

BEST PRACTICE HANDBOOK

FOR CLINICAL PRACTICE



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Best Practice Handbook for Clinical Practice

Australian College of AudiologyIncHAASA(ACAud)

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Acknowledgement

The Australian College of Audiology Inc HAASA (ACAud) acknowledges and sincerely thanks the organisations and professional bodies whose resources, guidance documents, and clinical expertise have contributed to the development of this Best Practice Handbook for Clinical Practice.

In particular, ACAud acknowledges the valuable contribution of materials and reference resources provided by:

- Sonova
- Specsavers
- Amplifon
- Interacoustics
- British Society of Audiology
- Anthony McGeough - Natus

ACAud also recognises the many clinicians, educators, supervisors, and professional stakeholders whose collective knowledge, experience, and commitment to high-quality hearing healthcare have informed the development of this handbook.

This handbook has been developed to support contemporary, evidence-informed clinical practice and to promote consistency, professionalism, and excellence in hearing healthcare delivery across Australia.

Foreword from ACAud

The Australian College of Audiology Inc HAASA is proud to present the ACAud Best Practice Handbook for Clinical Practice.

This handbook has been developed to support clinicians across the hearing healthcare profession by providing practical, evidence-informed guidance aligned with contemporary clinical standards and patient-centred care principles.
The handbook reflects the collective knowledge and experience of practising clinicians, educators, supervisors, and industry contributors who remain committed to maintaining high standards of clinical care across Australia.

Importantly, this handbook has been developed by the ACAud Education Committee as part of ACAud's ongoing commitment to workforce development, professional excellence, and accessible hearing healthcare.

The protocols and procedures contained within this handbook are intended to support consistency in clinical practice, encourage reflective and ethical decision-making, and assist clinicians in delivering safe and effective hearing healthcare services.

ACAud acknowledges that hearing healthcare continues to evolve and that best practice requires ongoing review, education, and adaptation to emerging evidence, technologies, and community needs.

We thank all contributors who have supported the development of this important resource

Australian College of Audiology Inc HAASA

About ACAud

The Australian College of Audiology Inc HAASA (ACAud) is a professional practitioner body representing Audiologists, Audiometrists, Hearing Rehabilitation Specialists, students, and hearing healthcare professionals across Australia.

ACAud is committed to supporting accessible, evidence-informed, and patient-centred hearing healthcare through education, professional standards, workforce development, advocacy, and continuing professional development.

The organisation supports clinicians working across metropolitan, regional, rural, and remote communities and recognises the important role of all members of the hearing healthcare workforce in improving hearing health outcomes for Australians.

Purpose of the Handbook

The purpose of this handbook is to provide clinicians with practical best practice guidance for core clinical procedures commonly undertaken within hearing healthcare settings.

The handbook is intended to:

- support safe and consistent clinical practice
- provide guidance aligned with current evidence and accepted professional standards
- support clinical supervision and workforce development
- assist clinicians in maintaining high-quality patient-centred care
- support professional education and ongoing competency development
- provide a reference framework for clinics, educators, and supervisors.

Scope and Intended Use

This handbook is designed for use by appropriately trained hearing healthcare professionals working within their individual qualifications, competencies, certification requirements, workplace policies, and applicable legislation.

The handbook does not replace clinical judgement, formal training requirements, employer policies, or legislative obligations.

Clinicians must continue to exercise professional judgement and work within their defined scope of practice at all times.

Development of the Handbook

This handbook was developed by the ACAud Education Committee in consultation with practising clinicians and industry stakeholders.

The handbook incorporates reference material, clinical procedures, and best practice guidance drawn from:

- contemporary clinical literature
- professional practice resources
- existing clinical protocols
- industry guidance documents
- contributions from hearing healthcare providers and professional organisations.

The handbook is intended to be a living document and will continue to evolve alongside developments in clinical evidence, technology, education, and professional practice.

Evidence Base and Reference Standards

Where appropriate, the handbook draws upon recognised national and international guidance documents, evidence-informed practice standards, and accepted clinical protocols.

Reference materials utilised during development included selected procedures and guidance from organisations including the British Society of Audiology and industry clinical resources.

Clinicians should also remain familiar with:

- relevant Australian legislation and standards
- infection control requirements
- workplace health and safety obligations
- manufacturer instructions for use
- local workplace policies and procedures.

Disclaimer

This handbook is intended as a professional guidance resource only.

While every effort has been made to ensure the accuracy and relevance of the information contained within this handbook at the time of publication, ACAud does not guarantee that all information is free from error or applicable in every clinical circumstance.

Clinicians remain individually responsible for exercising professional judgement and complying with all relevant legislation, regulatory requirements, workplace policies, and professional obligations.

Review and Revision Schedule

This handbook will undergo periodic review by ACAud to ensure alignment with contemporary evidence, professional practice developments, and evolving clinical standards.

Feedback and suggested amendments may be submitted to ACAud for consideration in future revisions.

ACAud Recommended Procedure for Case History Intake Prior to Pure-Tone Audiometry

This guideline outlines a structured approach for gathering case history, informed by established audiological standards and requirements. It assumes familiarity with ethical considerations and client communication.

1. Summary

This procedure establishes ACAud inc. HAASA framework for collecting essential client information before initiating pure-tone audiometry, ensuring comprehensive assessments that support accurate diagnosis and management. It draws from global best practices to identify potential influencing factors on hearing thresholds. Applicable to all audiologists and audiometrists, this applies across client groups such as private, workers' compensation, disability services, veterans, and government programs. The process emphasizes client-centred communication, risk factor evaluation, and preparation for testing. Updates in this revision incorporate regulations for AI-assisted notetaking to ensure compliance with Australian privacy and professional standards.

2. Scope and Purpose

2.1. Clients

Suitable for adults and older children; modifications may be needed for younger children, those with cognitive challenges, or non-verbal individuals, potentially affecting data reliability.

2.2. Objectives

- Identify hearing concerns, onset, and progression.
- Assess medical, environmental, and familial factors impacting hearing.
- Evaluate readiness for testing, including recent exposures.
- Facilitate informed consent and build rapport.

This precedes otoscopy and audiometric testing; it does not cover interpretation or post-test counselling.

3. Preparation for Case History Intake

- **Environment**: Conduct in a quiet, private space with clear visibility and minimal distractions. Ensure accessibility for communication aids if needed.

- **Tester Responsibilities**: Use effective strategies tailored to client's age, language, hearing status, or cognitive needs. Obtain informed consent for the assessment process.

- **Timing**: Allocate 10-15 minutes; integrate with overall appointment to avoid fatigue.

- **Tools**: Use a standardized form or digital template for consistency and for HSP compliance; include space for notes on communication barriers.

4. Case History Questionnaire

Employ open-ended questions to encourage detailed responses, followed by probes for clarification. Record answers verbatim where possible, noting any inconsistencies or non- responses.

Demographic and Referral Information

- Client's full name, age, gender, contact details, and preferred language/communication method.

- Referral source and reason (e.g., self-referred for hearing difficulties, medical referral for monitoring).

- Occupation or daily activities, including potential noise exposure risks.

Chief Complaint and Hearing Concerns

- Describe your main hearing issues (e.g., difficulty in conversations, TV volume needs).
- When did you first notice problems? Has it worsened, fluctuated, or stayed constant?
- Is the issue in one ear, both, or varying?
- Do you perceive one ear as better?
- Any associated symptoms like ringing/buzzing (tinnitus), dizziness/balance issues, ear pain/pressure, or discharge?

Medical and Health History

- List current medications, including over the counter (note ototoxic drugs like certain antibiotics or chemotherapy).
- Past illnesses, surgeries (especially ear-related), or injuries (e.g., head trauma).
- Chronic conditions (e.g., diabetes, cardiovascular disease, autoimmune disorders).
- Recent illnesses or exposures (e.g., infections, COVID-19 effects on hearing).

Family and Genetic Factors

- Any family history of hearing loss (e.g., congenital, age-related)?
- Known genetic conditions or syndromes affecting hearing?

Environmental and Lifestyle Exposures

- Recent exposure to loud. If yes, details on duration/intensity; consider rescheduling if temporary threshold shift suspected.
- Occupational noise history (e.g., machinery, music industry; use of protection)?
- Recreational exposures (e.g., concerts, firearms, power tools)?
- Smoking, alcohol, or substance use history.

Previous Auditory Experiences

- Prior hearing tests or results? Any changes since last assessment?
- Current or past use of hearing devices (aids, implants)? Satisfaction and compliance?
- For children/guardians: Developmental milestones (e.g., response to sounds, speech development); prenatal/postnatal complications.

Additional Preparatory Questions

- Any tinnitus present today that might interfere with tone detection?
- Comfort with the testing process; any anxieties or needs (e.g., breaks)?
- Confirmation of no recent ear procedures or contraindications to testing.

If responses indicate urgent medical issues (e.g. infection signs), refer to a physician before proceeding. For sudden onset hearing loss, do the hearing test immediately and refer as medical emergency for appropriate treatment.

5. Documentation and Follow-Up

- Record all information in the client's file, flagging key risks (e.g., noise exposure) for test interpretation.
- Summarize findings to the client, explaining the audiogram.
- If needed, provide educational materials on hearing protection or next steps.
- Ensure compliance with privacy regulations; obtain signatures for consent forms.

6. Use of AI in Notetaking

When employing AI tools for transcribing, summarizing, or assisting with note-taking during case history intake, adhere to Australian regulations to protect client privacy and maintain professional standards. AI use must align with the Privacy Act 1988, Australian Privacy Principles (APPs), and AHPRA guidelines on AI in healthcare.

- **Informed Consent**: Explicitly inform clients about AI use, including the tool's function, data handling, and potential risks (e.g., data storage by providers). Obtain and document verbal or written consent before proceeding. If consent is withheld, revert to manual notetaking.

- **Privacy and Data Protection**: Ensure AI tools comply with APPs, particularly APP 3 (collection of personal information) and APP 6 (use/disclosure). Verify that health information is not used for AI training without explicit permission. Use tools with data sovereignty in Australia to prevent unauthorized offshore storage or access. Avoid tools that may generate inaccurate inferences or "hallucinations" about client data.

- **Professional Obligations**: Follow AHPRA's Shared Code of Conduct and AI-specific resources. ***Review AI-generated notes for accuracy before finalizing records.*** Do not rely solely on AI for sensitive decisions.

- **Security Measures**: Select AI products that meet cybersecurity standards; regularly update clinic privacy policies to include AI procedures. If recording audio for AI transcription, confirm compliance with state/territory surveillance laws to avoid criminal implications.

- **Documentation**: Note AI tool usage in the client file, including consent details and any edits made to AI outputs. Report any privacy incidents to the Office of the Australian Information Commissioner (OAIC) as required.

ACAud Inc. and HAASA

Hand Hygiene and Infection Control Protocol

Date of publication: October 2025
Date for review: October 2028

Purpose and Scope

This protocol provides clear guidelines for maintaining optimal hygiene standards and preventing infection transmission in audiology clinical practice. The aim is to ensure the safety of clients, clinicians, and administrative staff by promoting consistent infection control practices across all ACAud Inc. and HAASA- affiliated workplaces.

Infection prevention is a shared responsibility. All staff members are expected to understand both the practical procedures and the theoretical principles underpinning infection control. By adhering to these guidelines, clinicians demonstrate commitment to patient safety, professional standards, and the integrity of clinical environments.

1. Hand Hygiene

Hand hygiene is the single most effective method to reduce the spread of infectious agents. Hands must be cleaned:

- Before and after any contact with clients or their devices.
- Between procedures on the same client where contamination risk exists.
- After contact with potentially contaminated equipment or surfaces.
- Before eating or handling food, and after coughing, sneezing, or using tissues.

Preparation

Before performing hand hygiene:

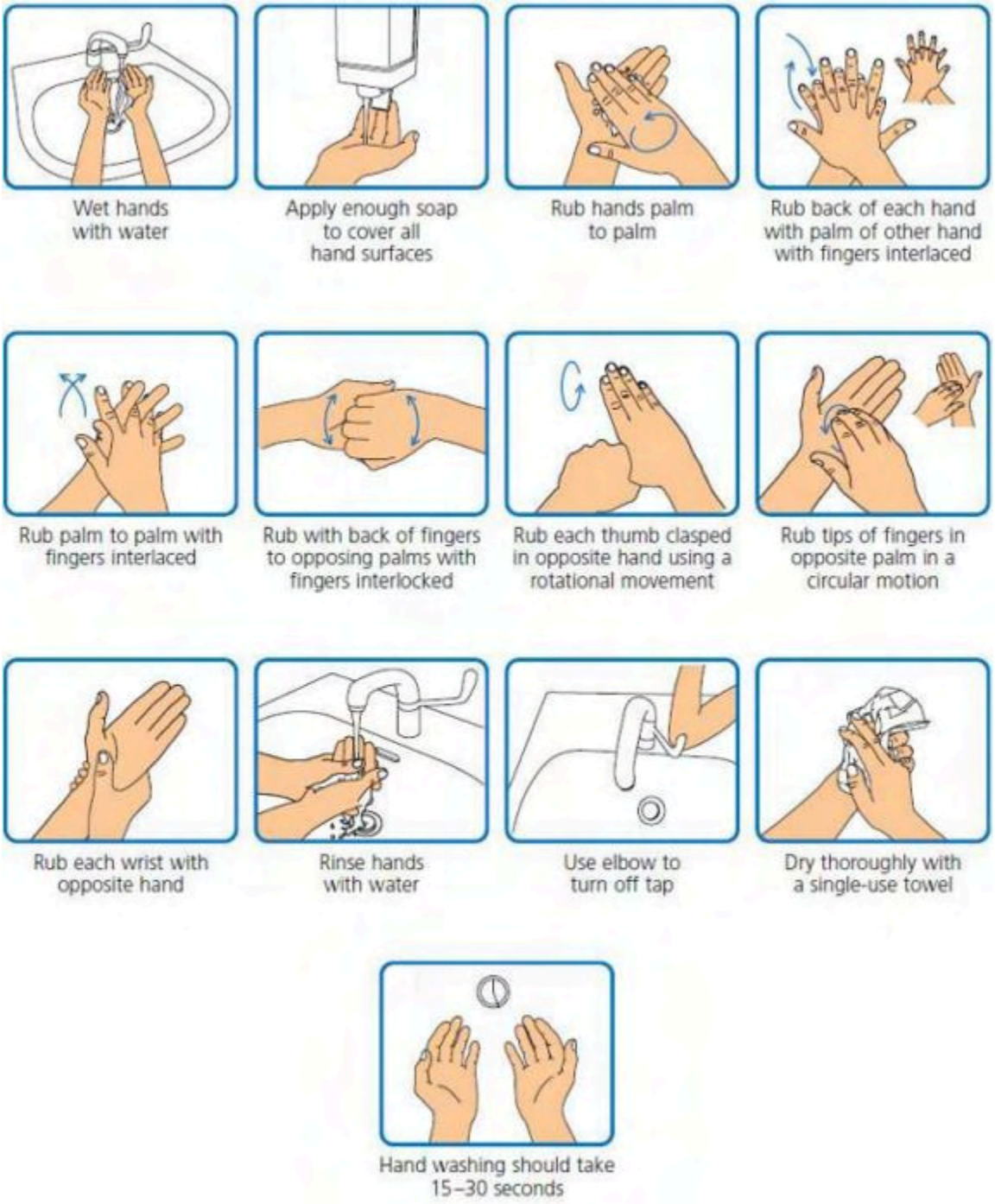
- Remove watches, bracelets, and rings (except plain wedding bands).
- Ensure nails are short, clean, and free from artificial coatings.
- Expose wrists and forearms by removing long sleeves or lab coats.
- Confirm the handwashing area is free of clutter and stocked with liquid soap, disposable towels, and alcohol-based hand rub.

2. Handwashing Procedure

The physical process of washing hands removes transient microorganisms and soil.

1. Turn on warm running water.
2. Wet hands thoroughly before applying soap or antimicrobial solution.
3. Apply approximately 3 mL of product or as recommended by the manufacturer. 4. Rub palms together to create lather and cover all areas of hands, including:
    - Palms, backs of hands, thumbs
    - Between fingers, fingertips, and under nails
    - Wrists and forearms (if exposed)
5. Continue for 20–30 seconds.
6. Rinse thoroughly under running water, keeping hands pointed downward.
7. Turn off taps using elbows, paper towel, or other hands-free methods.
8. Dry hands completely using disposable paper towels. Dispose of them in a foot-operated bin.

Note: Prolonged washing beyond 30 seconds can damage skin integrity and is not recommended.



3. Alcohol-Based Hand Rub Procedure

Where sinks are unavailable, or between low-risk tasks, use alcohol-based hand rubs:

- Dispense a palmful of rub (approx. 3–5 ml).
- Rub all hand surfaces until dry (minimum 20 seconds).
- Do not wipe or rinse hands before the rub has dried completely.

4. Infection Control Principles in Clinical Practice

General Principles

Infection control relies on consistent cleaning, disinfection, and personal protective measures.

- Treat all bodily fluids and ear secretions as potentially infectious.
- Always use disposable specula and single-use probe tubes.
- Thoroughly clean and disinfect reusable equipment between clients.
- Maintain a visibly clean and organised workspace at all times.

5. Clinical Environment and Equipment

Hygiene Before Each Appointment

- Prepare the clinical area with all necessary materials.
- Ensure all tools are clean and ready for use.
- Place tissues, gloves, and alcohol wipes within easy reach.

After Each Client

- Wipe all surfaces, otoscopes, headphones, and equipment with an alcohol or antibacterial wipe.
- Dispose of used consumables (specula, probe tubes, domes).
- Clean reusable tools with detergent and water before disinfection.
- Wash hands or use alcohol rub after every client contact.

Weekly and Routine Cleaning

- Disinfect benches, grinding tools, and impression stations regularly.
- Replace alcohol in disinfection jars daily or when visibly soiled.
- Label containers clearly as “Clean” and “Used” to prevent cross-contamination.

6. Use of Personal Protective Equipment (PPE)

PPE acts as a barrier between staff and potential contaminants.

- Gloves must be worn when handling hearing aids from discharging ears or performing wax removal.
- Protective eyewear and masks are required when grinding ear moulds or when aerosol generation is possible.
- Dispose of gloves immediately after use and perform hand hygiene.

7. Cleaning and Disinfection of Equipment

Cleaning:
The first and most critical step in infection prevention. Cleaning removes debris and organic material that can reduce the effectiveness of disinfectants.

- Rinse soiled items with cold water first.
- Wash with warm water and detergent.
- Rinse again in hot water and dry with disposable paper towels.

Disinfection:

Used fornon-critical instruments that come in contact with intact skin only.

- After cleaning, soak items in 70% ethanol or equivalent for at least 10 minutes.
- Do not overload containers; ensure full coverage.
- Replace disinfectant daily or when visibly contaminated.
- Allow items to air dry before re-use.

8. Cough and Respiratory Etiquette

- Cover nose and mouth with a tissue when coughing or sneezing.
- Dispose of tissues immediately and perform hand hygiene.
- If tissues are not available, cough or sneeze into the elbow.
- Maintain distance from others when symptomatic and seek medical review as necessary.

9. Clinical Waste Disposal

- Dispose of single-use items (e.g., specula, domes, wipes) in appropriate bins.
- Do not overfill bins; seal and replace liners as required.
- Sharps, if used, must be placed directly into a designated sharps container.

10. Infection Prevention in Specific Audiology Procedures

Procedure	Infection Control Requirements
Ear Examination	Use new speculum for each client; disinfect reusable types thoroughly.*
Ear Impressions	Wipe syringes and light tips with alcohol; clean tiles after each use.
Wax Removal	Clean and disinfect tools immediately after use; store in alcohol-filled jars.
Tympanometry	Avoid testing on bleeding or discharging ears; dispose probe tips after every client.
Hearing Aid Handling	Use gloves or tissue barriers; clean devices with antibacterial wipes before and after handling.

*Sterilizing equipment used in Australia

- **Benchtop Autoclaves (Steam Sterilization):** Small autoclaves (class B or S) are used for packaged or unpacked specula, using distilled water, validated by printouts or data logs.
- **Washer-Disinfectors:** These automated machines provide cleaning and thermal disinfection (e.g., 80- 86°C).
- **Instrument Grade High-Level Disinfectants:** Used when autoclaving is not possible (chemical sterilization).
- **Cleaning Tools:** Enzymatic detergents for soaking and scrubbing brushes

11. Home and Community Visits

- Carry portable hand sanitiser, disposable gloves, and wipes.
- Clean hearing aids and accessories before placing them in cases or bags.
- Dispose of all waste responsibly.

12. Staff Responsibilities

- Maintain personal hygiene and report any open wounds or illnesses.
- Keep workspaces clean and disinfected daily.
- Attend regular infection control training and updates.
- Lead by example to reinforce hygiene culture within the clinic.

ACAud Inc. and HAASA – Recommended Procedure: Ear Examination (Otoscopy)

Date of Publication: October 2025
Date for Review: October 2028
Approved by: Audiology Australia College of Audiologists (ACAud Inc.) and Hearing Aid Audiometrists Society of Australia (HAASA)
Review Cycle: Every three years

1. Introduction

1.1 Background and Scope

This document sets out the recommended procedure for performing ear examinations, also known as otoscopy, within audiological practice. It provides a consistent framework to support safe, accurate, and effective examination of the external ear, ear canal, and tympanic membrane in both adults and children.

The purpose of this procedure is to promote high standards of clinical care by outlining essential principles of best practice. It is intended for use by qualified audiologists, audiometrists, and trainees under supervision. While the steps described are comprehensive, the procedure allows flexibility for professional judgment to accommodate individual client needs and specific clinical circumstances.

The overall aim is to ensure that otoscopy is carried out in a systematic, safe, and client-centred manner, protecting both examiner and client from harm and ensuring accurate clinical observation.

For the purpose of this document, only procedures for adults will be discussed.

1.2 Development of the Recommended Procedure

This procedure was developed collaboratively by ACAud Inc. and HAASA, drawing upon established audiological standards, infection control protocols, and educational frameworks for clinical training.
It represents a revision and integration of prior guidance documents, updated to align with current best practice, technological advances, and national infection control principles.
The content reflects expert consensus and is designed to support competency development and clinical governance across both professional associations.

2. General Considerations

Before performing otoscopy, the examiner shall be competent in the procedure or be under direct supervision of a qualified clinician. Competence should be supported by relevant training, supervised experience, and ongoing assessment.

Maintaining infection control and hygiene is fundamental to safe otoscopy.
The examiner shall:

- Perform hand hygiene before and after each procedure.
- Cover any cuts or abrasions on the hands.
- Avoid contact with bodily fluids.
- Use a new disposable speculum for each ear and each client.
- Dispose of used specula appropriately after each use.
- Ensure a selection of speculum sizes is available to accommodate anatomical differences.

The examiner must also adopt a communication approach suited to the client's needs, considering age, hearing ability, and cognitive status. Clear verbal instructions should be given, supported by visual cues when possible, and reassurance provided throughout the process.

Accurate and confidential **record-keeping** is essential. Documentation should include:

- Relevant history and presenting symptoms.
- Any medications taken that could affect otoscopy (e.g. blood thinners)
- Findings observed during otoscopy.
- Any advice, actions, or referrals made.

Records must comply with workplace privacy and data protection standards, and images obtained during the examination should be stored securely with identifying information.

3. Subject Preparation

Before starting the examination, the examiner shall establish rapport and gather a brief case history. The client (or caregiver) should be asked about:

- Current ear-related symptoms such as pain, discomfort, discharge, or itching.
- Any ongoing treatment, medication, recent ear surgery, or history of recurrent infection.

The examiner should explain the purpose and process of the procedure in clear, simple language, demonstrating the otoscope if needed. The client should be advised to report any pain or discomfort immediately. Informed consent (verbal or written) must be obtained before proceeding.

The client should be seated comfortably and remain still throughout the examination. Obstructions such as hearing aids, earmoulds, or jewellery must be removed. The examiner should also adopt a stable, preferably seated, position to maintain control and safety.

4. Examination Procedure

The examination typically begins with the ear least likely to show abnormality, unless there is a specific reason to start with the other ear.

If the client experiences pain, bleeding, or distress, the procedure should be discontinued immediately, and medical attention considered if necessary.

4.1 Examination of the Pinna and Surrounding Area

The initial step is a visual inspection of the outer ear, mastoid area, and skin surrounding the pinna. The examiner should look for:

- Redness, swelling, or inflammation.
- Lesions, scars, or discharge.
- Signs of previous ear surgery or trauma.

This inspection helps identify external abnormalities that may affect otoscopy or indicate underlying pathology. Adequate illumination should be used, and although magnification is not essential, it may enhance visibility in some cases.

4.2 Examination of the Ear Canal and Tympanic Membrane

Equipment and Preparation

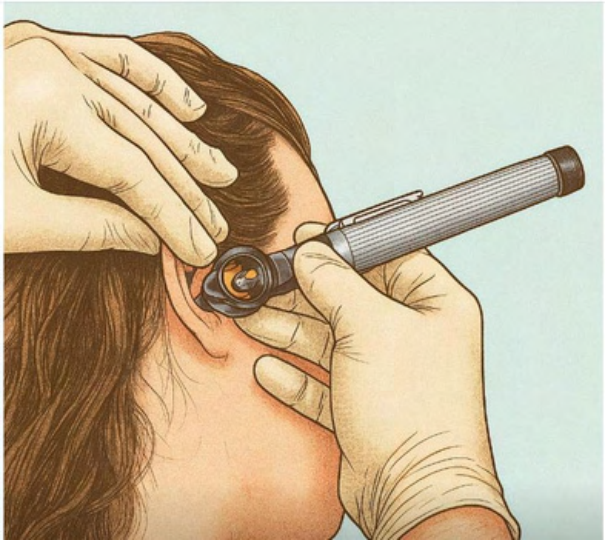
The ear canal and tympanic membrane should be examined using an otoscope or video otoscope that provides sufficient illumination and magnification.
Before use, the examiner shall ensure that the otoscope is clean, operational, and has undergone any necessary safety checks.

Video otoscopes may be advantageous as they allow the capture of still or moving images for educational, clinical, or record-keeping purposes.

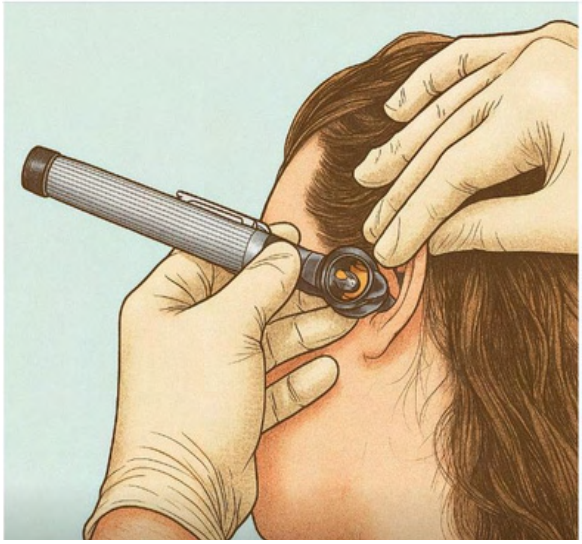
Technique and Examiner Position

The examiner should be seated and adopt a stable position, holding the otoscope securely with the hand
braced against the client's head. Many clinicians change hands when changing sides, using the right hand to look into the right ear, and using the left handing to look into the left ear. However, it is acceptable practice to
use the dominant hand for both ears, bracing either on the cheek or behind the pinna on the mastoid bone, depending on the hear/hand being used. Proper bracing prevents injury should the client move unexpectedly. The examiner should avoid leaning over the client or working from an unstable stance.

Correct bracing technique for otoscopy

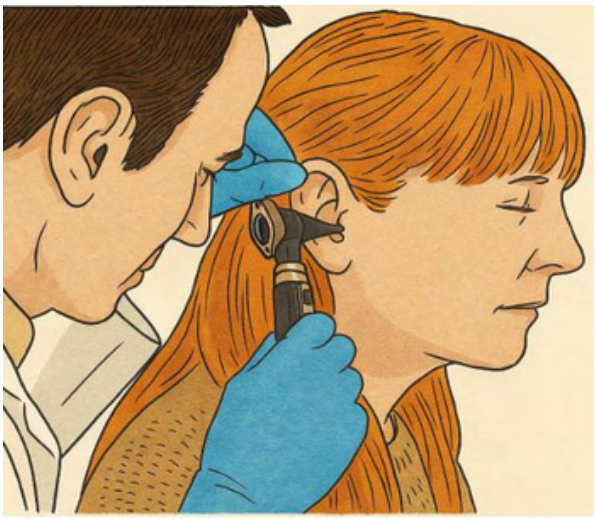


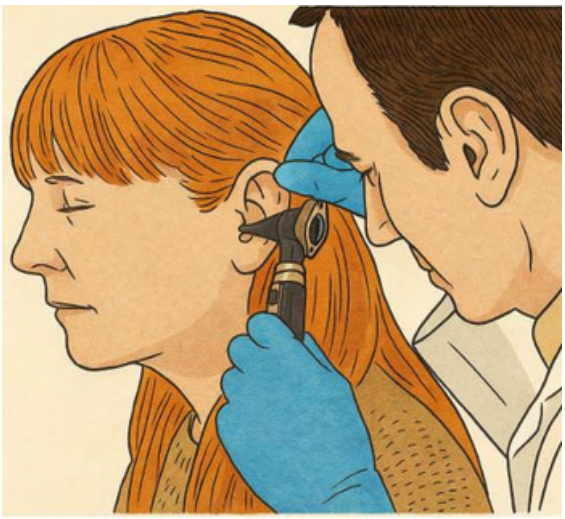
Right ear



Left ear

Incorrect procedure for otoscopy:





A disposable speculum of appropriate size should be selected — large enough to provide a clear view but small enough to insert comfortably. The speculum must be attached hygienically and securely.

Insertion and Visualisation

To straighten the ear canal, the pinna should be gently manipulated:

- In adults, pull the pinna upward and backward.
- In children, pull the pinna back and down.

Please note: the above suggestions are the optimal manipulations, however canal direction/shape can differ and clinician may need to adjust as per individual client.

The speculum should then be inserted carefully into the canal entrance, avoiding contact with the canal walls. The examiner should proceed slowly, observing the canal as insertion continues.

During the examination, the following should be noted:

- Presence of cerumen (wax), debris, or foreign bodies.
- Inflammation, swelling, or discharge in the ear canal.
- Condition and colour of the tympanic membrane.
- Visibility of landmarks such as the handle of the malleus and cone of light.
- Evidence of perforation, retraction, scarring, or fluid level behind the tympanic membrane.
- Evidence of ear canal cavities from previous ear surgeries which may affect impression taking.

The full tympanic membrane may not be visible at once; gentle adjustment of the otoscope angle, the examiner's position, or the client's head may be required to view all areas.

The bony portion of the ear canal is particularly sensitive; care should be taken to avoid trauma, especially when the customer takes blood thinners. When using a video otoscope, the examiner should remain aware of the client's movements, even when focusing on the viewing screen.

After completing the examination, the otoscope should be withdrawn carefully and the speculum disposed of appropriately.

4.3 Recording, Reporting, and Management of Findings

Immediately following the examination, the examiner should record findings in the client's clinical notes. Observations should include:

- Any abnormalities such as redness, swelling, discharge, or wax occlusion.
- Condition of the tympanic membrane and ear canal.
- Any symptoms reported during the procedure.

If images or video were captured, they must be stored securely with identifying details (client name, examiner, date, and time).

The examiner should use professional judgment to determine the next steps:

- If findings appear normal, no further action may be required.
- If an abnormality or pathology is detected, appropriate referral for medical assessment should be initiated.

Clients should receive relevant advice on ear care, wax management, and when to seek further review.

5. Review and Quality Assurance

This recommended procedure should be reviewed at least every three years to ensure continued alignment
with best practice, infection control standards, and technological developments in audiology. Practitioners are encouraged to:

ACAud Inc. HAASA Tympanometry Assessment

Guidelines Table of Contents

1. Overview

This guideline outlines ACAud Inc. HAASA's standards for performing tympanometry, drawing from established international practices to promote precise evaluations and supports consistent audiological testing for all clients. Adherence ensures reliable middle ear assessments by all audiology personnel.

Tympanometry serves as an objective tool in hearing evaluations, assessing middle ear functionality by tracking its response to acoustic input and pressure variations. It is typically integrated into a full diagnostic
suite after visual ear inspection.

Proceed only if there are no contra-indications are present.

2. Contra-indications to Tympanometry

Tympanometry may not be appropriate when certain ear conditions are present, as these can influence the accuracy of the results. Impacted cerumen or the presence of an active ear infection or discharge can interfere with the measurement, meaning the test may not accurately represent the true function of the middle ear. However, with wax impaction a normal tympanogram may indicate that one can still continue with the hearing assessment (probably using headphones and not inserts). Tympanometry can also confirm if wax is occluding with low ear canal volume.

A structural abnormality, such as a perforated tympanic membrane, may also reduce the usefulness of tympanometry because the measurement may not provide meaningful information about middle ear function.
If a perforated tympanic membrane is suspected, tympanometry can confirm this via elevated/increased ear canal volume.

Patient comfort should also be considered. If the individual is experiencing pain in the outer ear, inserting the probe tip may be difficult or intolerable. Similarly, if otoscopic examination suggests that the pain originates from the middle ear, the pressure changes used during tympanometry may cause discomfort and the procedure may not be well tolerated. It is also important to use clinical judgement in the light of recent ear surgery or active bleeds in the ear canal.

It is important to note that some modern tympanometry systems include non-pressurised middle ear measurement options. These features can allow clinicians to obtain middle ear information in situations where traditional pressurised tympanometry would normally be contraindicated.

3. Device Setup and Verification

Use equipment compliant with international standards. Select clean probe tips (umbrella or mushroom style) sized for a secure fit without discomfort. Tips are disposable and must not be reused across clients or ears to prevent cross-contamination.

Daily checks involve placing the probe in a manufacturer-provided test chamber to confirm flat-line output and volume accuracy within specified limits (e.g., ±5% for cavities of 0.5, 2.0, or 5.0 cm^3). Additionally, validate on a known normal ear to ensure pump functionality. Annual professional servicing is required.

Follow hygiene protocols: sanitize hands before and after, cover skin breaks, and safely discard used items.

4. Probe Tone Frequency

Different probe tone frequencies can be used in tympanometry, and the selection depends largely on the patient’s age.

For individuals older than six months, a 226 Hz probe tone is most commonly used. This frequency provides more accurate ear canal volume measurements, leading to its adoption as the standard for adults and older children.

For infants under six months of age, a 1000 Hz probe tone is generally recommended. Young infants have more compliant ear canal walls, which can affect measurements when lower frequencies such as 226 Hz are used and may lead to inaccurate results. Higher-frequency probe tones are less influenced by this factor and therefore provide more reliable measurements in this age group.

More recently, wideband tympanometry has been introduced. This method uses a broad range of frequencies rather than a single probe tone and can provide more detailed information about middle ear function across different age groups.

5. Client Readiness and Guidance

Inquire about current ear issues, treatments, or past surgeries. Position the client comfortably and remove any obstructions like hearing devices. Always precede with otoscopy to rule out barriers.

Obtain verbal agreement to proceed, ensuring the client understands they can halt the test if needed. Explain: "I'll place a soft-tipped probe in your ear canal to create a seal. You'll feel brief pressure changes as we evaluate your middle ear. Stay still, avoid swallowing or talking once started, and signal if it's uncomfortable by raising your hand or saying 'stop'."

6. Indications for Testing

Perform tympanometry in these scenarios:

- Initial visits to baseline middle ear status.
- Reported history of ear disorders.
- Detected differences in air and bone conduction thresholds at any pitch.
- Returning clients showing air-bone gaps or signs of middle ear issues.
- As best practice for ongoing monitoring in established clients, as per HSP requirements.

7. Restrictions on Testing

Avoid tympanometry if:

- Recent surgery: This may differ depending on the surgical procedures and ENT recommendations. Enquire about your workplace's procedures regarding post-surgical tympanometry. Some suggestions include:
  - 4 Weeks after grommet insertion
  - 2-6 Weeks after other middle ear surgeries
  - Some suggest 12 weeks after eardrum repair
  - Or 6-8 weeks after ossicle procedures, unless cleared by an ENT specialist (document approval).
  - Active infections, discharge, redness, swelling, or fungal presence.
  - Pain, dizziness, or tenderness reported during setup or testing.
  - Canal blockages like foreign objects, excessive cerumen (remove only if qualified),
  - or complete closure (use handheld probe if feasible).
  - Bulging or inflamed eardrum suggesting acute inflammation.
  - Start with the unaffected ear if one side is symptomatic.

Seek medical input if uncertain and refer to general practitioner if conditions deteriorate or lack prior clearance.

8. Step-by-Step Testing Process

- Choose and attach a fitting tip for hermetic closure.
- Brief the client on expectations.
- Align the probe toward the eardrum, gently retracting the outer ear if needed.
- Initiate the sweep from +200 daPa downward (to -300 daPa typically, or -600 daPa if no peak).
- Stop early for normal results to reduce unease.
- Capture data: canal size, maximum mobility, pressure at peak, and curve shape.
- If seal fails, adjust tip, ear position, or advise against movement; note failures.
- Retest unusual outcomes after re-inspection and device check. Dispose of tip post-use.

9. Classification of Results Using Jerger System

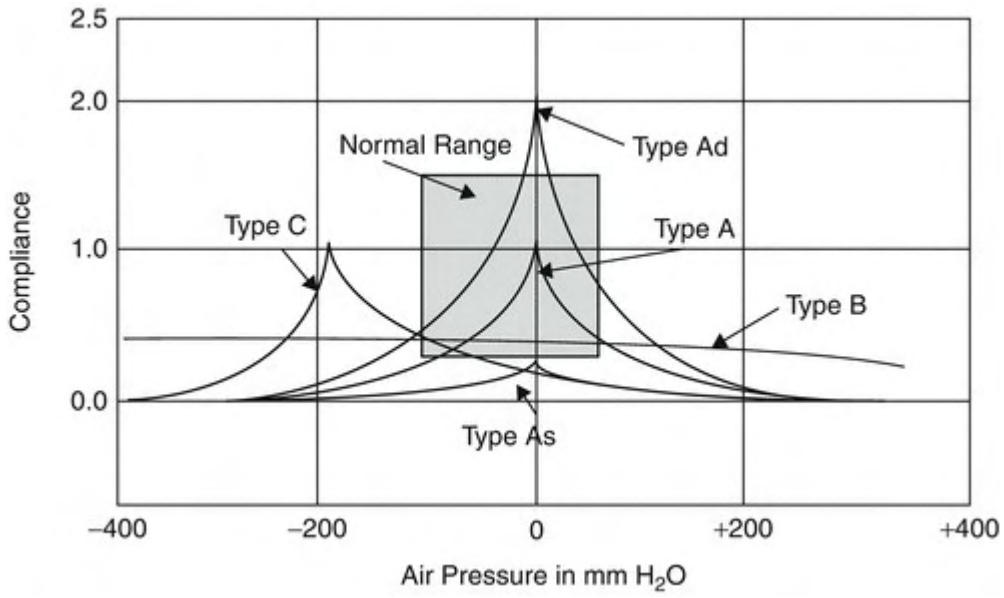
There are a number of different classifications we can use to determine the type of tympanogram, but the Jerger classification system is perhaps the most commonly one use

Type	Characteristics
A	Standard curve with peak in typical mobility and pressure zones; suggests healthy middle ear pressure and compliance function. *
As	Reduced mobility in air-filled space; possible stiffening from bone fixation, tissue scars, fluid residue, or benign causes.

Type	Characteristics
Ad	Elevated mobility in air-filled space; may indicate chain breaks, thin or lax drum, or no issue.
B	Flat line, no peak; implies rigid system with intact drum, often from fluid buildup; low canal measure hints at blockage or poor fit.
B (High)	Flat line with enlarged cavity measure; points to drum breach like hole, collapse, open tube, or surgical void.
C	Peak present but shifted to negative pressure; aligns with tube blockage.

*Take note that one could still obtain a Type A Tympanogram even when there is middle ear pathology present, so beware of using the term 'normal' middle ear function when discussing Type A tympanograms. Always take all the audiometric data into consideration.

Visual Depiction of the Tympanogram Types:



10. Standard Reference Values

Type	Mobility (cc)	Pressure (daPa)	Adult Canal (cc)	Child Canal (cc)	Likely Hearing Impact	Frequent Conditions
A	0.3-1.6	-100 to +50	0.65-1.8	0.3-1.0	None or sensorineural	None
As	<0.3	-100 to +50	0.65-1.8	0.3-1.0	Mild conductive	Bone anchoring
Ad	>1.6	-100 to +50	0.65-1.8	0.3-1.0	Mild conductive	Chain separation
B	None	None	0.65-1.8	0.3-1.0	Conductive	Fluid accumulation

Type	Mobility (cc)	Pressure (daPa)	Adult Canal (cc)	Child Canal (cc)	Likely Hearing Impact	Frequent Conditions
B (Low)	None	None	<0.65	<0.3	Conductive	Tip misalignment or wax
B (High)	None	None	>1.8	>1.0	Conductive	Opening in drum, tube patency, cavity
C	0.3-1.6	<-100	0.65-1.8	0.3-1.0	Conductive	Tube impairment

Note: Values are equivalents at 226 Hz; interpret alongside full diagnostics.

11. Analysis and Documentation of Findings

Tympanometry results alone do not provide a diagnosis. Information must be cross-referenced with visual inspection of the tympanic membrane, case history, and other audiometric tests. We usually expect single- peaked curves. If irregular peaks are observed, retest multiple curves, flats, or irregularities. Results should be compared to the Jerger standards and discussed accordingly.

It is important to remember that tympanometry results do not necessarily point towards middle ear pathology or the lack thereof. It is possible to see a Type A tympanogram with a condition like otosclerosis or see a Type
As tympanogram with no conductive component in the audiogram. It is therefor important to look at all the information as a whole when making clinical decisions.

Within the Australian Hearing Services Program (HSP), audiologists and service providers must carefully review tympanometry findings for signs of possible middle ear pathology before proceeding with hearing aid fitting. Certain results may indicate underlying conditions such as middle ear fluid, infection, or structural
abnormalities of the tympanic membrane. When these findings are present, medical assessment—typically by a general practitioner (GP) or an ear, nose and throat (ENT) specialist—is usually required prior to fitting hearing aids.

11.1. Tympanometry results that may require medical clearance include:

Type B (flat tympanogram):
A flat trace indicates little or no movement of the tympanic membrane. This pattern may be associated with middle ear effusion, infection, or a perforation of the eardrum.

Type C (negative middle ear pressure):
This result reflects significantly negative pressure within the middle ear space, which may suggest Eustachian tube dysfunction.

Abnormal ear canal volume (when seen with a Type B):
Ear canal volume measurements help interpret flat tympanograms.

- A very small volume may indicate obstruction of the ear canal (such as cerumen) or the presence of middle ear fluid.
- A very large volume may indicate a tympanic membrane perforation or the presence of a patent ventilation tube (grommet).

12. Tympanometry clinical requirements and best practice guidelines.

This table outlines the clinical requirements and best practice recommendations for performing tympanometry within an audiology practice.

Task
Perform otoscopic examination before tympanometry
Use a new probe tip for each client
Perform tympanometry for all new clients
Perform tympanometry for return clients where clinically indicated
Conduct tympanometry when an air–bone gap is identified during audiometry
Conduct tympanometry when case history suggests possible middle ear involvement
Refer to a GP or medical practitioner when medical clearance is required or when new or worsening ear conditions are identified

Pure Tone Testing Protocol for ACAud inc. HAASA

1. Summary

This protocol outlines standardized guidelines for conducting pure tone threshold testing, drawing from established audiological best practices to ensure precise and reliable hearing evaluations. It applies to all clinicians performing assessments for various client categories, including private, workers' compensation, disability support, veterans' affairs, and government hearing programs. The aim is to promote consistency in testing procedures while allowing professional judgment for individual cases.

2. Introduction

This protocol serves as a reference for determining hearing thresholds via air and bone conduction, with or without masking, in routine clinical settings. It reflects current evidence and consensus on effective practices for pure tone audiometry. Clinicians must exercise discretion based on the client's needs, test objectives, and their own expertise. Essential practices are denoted by "must," while recommended ones use "should." This document does not cover advanced techniques like high-frequency testing, automated audiometry, or free field testing.

3. Scope

3.1. Clients

Suitable for adults and older children capable of reliable responses. Modifications may be needed for those with cognitive challenges, young children, or other barriers, potentially affecting accuracy.

3.2. Procedures

Focuses on manual pure tone threshold determination using air and bone conduction, including masking when indicated. Excludes screening protocols, tone bursts, self-administered tests, or discomfort level assessments.

4. Equipment and Test Environment

4.1. Audiometric Equipment

The audiometer, earphones (supra-aural, circum-aural, or insert types), bone vibrator, and response button must be clean and compliant with relevant ISO standards (e.g., BS EN ISO 389 series). Insert earphones are preferred to minimize canal collapse and enhance interaural attenuation, if correct, deep insertion is done. At times it is better to use supra-aural earphones because incorrect insertion of the insert earphones can lead to incorrect data being collected. Narrowband noise should be available for masking, calibrated to effective masking levels.

4.2. Test Environment

Testing should occur in a quiet room where ambient noise does not exceed permissible levels
per ISO standards (typically ≤35 dB A-weighted). The client's face must be visible to the clinician, but controls should not be observable. Use visual monitoring (window or camera) and intercom if separated. Avoid intermittent noises; postpone testing if conditions are suboptimal, especially for bone conduction due to lack of ear occlusion.

5. Preparation for Testing

5.1. Client Preparation

Conduct otoscopy before testing and document findings, including wax presence. Remove occluding cerumen only if qualified. Inquire about recent noise exposure, tinnitus, and
perceived better ear. If noise exposure is reported, note it and consider retesting later. The Australian/New Zealand standard is that there should be no noise exposure 16 hours prior to the test. Remove hearing aids, eyewear, or accessories that interfere with transducer placement. Inform clients of communication tools if applicable..

6. Air-Conduction Testing Without Masking

6.1. Instructions

Use clear, age-appropriate language: "You'll hear tones. Press the button as soon as you detect the tone and release the button again. Please press the button even if the tones are very soft." For tinnitus, advise ignoring it and report confusion; note affected frequencies. One could also present a pulsating or warble tone if the steady pure tones are confused with the tinnitus. Reinstruct if responses are inconsistent.

6.2. Transducers

The tester must place the earphones securely without discomfort and align openings with ear canals. Use inserts to avoid collapse; avoid infected or obstructed ears, but it is essential that a deep insertion is obtained to ensure accurate thresholds. If the tester is inexperienced, or
unsure of the correct placement of the inserts, it is best to use earphones.

6.3. Test Sequence

Begin with the better ear (client-reported or right if unclear) at 1000 Hz, then 2000, 3000, 4000, 6000, 8000 Hz; retest 1000 Hz (accept ≤5 dB difference or investigate). Proceed to 500, 250 Hz. Test inter-octaves (750, 1500 Hz) if ≥20 dB octave differences. Repeat for the other ear without 1000 Hz retest unless variable.

6.4. Stimulus Timing

Tone presentation duration should be 2 seconds and presented at irregular intervals (unpredictably) to avoid false positives.

6.5. Starting Level

Start at audible level (e.g., 30 dB HL). If no response is elicited from the client, increase the presentation level to 50dB HL. If still no response is elicited, reinstruct. If the client cannot hear the tone at 50dB HL, increase to a louder presentation level and present the tone again, but never more than 80dB HL. If no response is obtained at 80dB HL, increase by 10 dB then 5 dB until a response is obtained. If no response is obtained, use the appropriate symbols but make sure to monitor for discomfort as the loudness of the tones increase.

6.6. Threshold Determination Method (Hughson Westlake Procedure)

- When the subject responds to the tone at an audible level, decrease the intensity in 10- dB increments until the tone is no longer detected.
  Increase the intensity in 5-dB increments until the subject responds again.
  After the first response obtained during this ascending sequence, lower the level by 10 dB and begin another series of 5-dB increases until a response is recorded.
- Continue the pattern of decreasing by 10 dB and increasing by 5 dB until the subject responds at the same level in at least half of the ascending trials (for example, two responses at the same level out of two, three, or four presentations). This level is considered the hearing threshold.
- The threshold is defined as the lowest intensity at which responses occur on at least 50% of ascending presentations, with a minimum of two responses at that level.
- Move to the next test frequency, beginning at a clearly audible intensity (for example, approximately 30 dB above the neighbouring threshold).
  Apply the same 10-dB down, 5-dB up procedure until the threshold criterion is reached.

6.7. Variations

For fatigue-prone clients, reduce frequencies (i.e. leaving out the inter-octave frequencies like 3000 and 6000Hz) and document the reason why fewer frequencies were recorded. Use pulsed tones or warble tones if tinnitus makes it difficult to hear the pure tones, noting the need to use adifferent presentation tone.

7. Bone-conduction audiometry without masking

7.1. General considerations

When masking is not applied during bone-conduction (BC) testing, it is not possible to identify which ear is detecting the signal because both cochleae can be stimulated simultaneously. Thresholds measured without masking may appear slightly better (around 5 dB) due to the effects of binaural stimulation.

7.2. Bone vibrator placement

The bone oscillator is typically positioned first on the mastoid of the ear with the poorer hearing levels, determined from air-conduction thresholds averaged between 500 Hz and 4000 Hz. The contact surface of the oscillator must be firmly placed against the skull, positioned just behind the pinna (on the mastoid) without touching the pinna and without resting on hair. A headband should hold the vibrator securely against the mastoid with the appropriate amount of pressure. The side on which the oscillator is positioned should be documented on the audiogram with the appropriate symbol.

7.3. Test frequencies and order

The sequence of frequencies generally follows the same pattern used for air-conduction testing, beginning at 1000 Hz. Bone-conduction testing is typically limited to the range of 500 Hz to 4000 Hz, and a repeat measurement at 1000 Hz is not required.

7.4. Test stimuli

The duration and timing of the stimulus presentations should be consistent with the procedures used in air-conduction audiometry.

7.5. Patient instructions

Instructions provided to the patient are similar to those used for air-conduction testing. However, the patient should be reminded to respond whenever the tone is heard, regardless of which ear they perceive it in.

7.6. Determining threshold

If ear-specific BC thresholds are required, masking must be used in the non-test ear.

When ear-specific information is not necessary, testing may be completed without masking. The ear canal of the test ear should remain unblocked. Thresholds are determined using the same procedure applied in air-conduction testing.

7.7. Vibrotactile responses

When the oscillator is placed on the mastoid, vibrations may be felt rather than heard at certain intensities, particularly at low frequencies. Vibrotactile responses may occur at approximately 25 dB at 250 Hz, 55 dB at 500 Hz, and 70 dB at 1000 Hz, although there is significant variation between individuals. Clinicians must ensure these tactile sensations are not mistaken for auditory responses. Any responses believed to be vibrotactile should be clearly recorded on the audiogram. During the instructions for bone conduction testing, instruct the client to let you know as soon as they 'feel' the sensation of the bone conductor, rather than hear the tone.

8. Audiometric Descriptors and Degree of Hearing Loss

Hearing thresholds for each ear are often summarised using descriptive categories rather than listing the exact values measured at each frequency on a pure-tone audiogram. These descriptors provide a general indication of the severity of hearing impairment. A commonly used method calculates the average pure-tone threshold at 500, 1000 and 2000Hz while other use 250, 500, 1000, 2000, and 4000 H**z** to estimate the overall level of hearing loss. Some suggest using 500, 1000, 2000 and 3000Hz.

Descriptive labels for degrees of hearing loss are necessary because they provide a convenient way to categorize impairment. However, these labels are not standardized, and their meanings can vary significantly between professionals. As a result, the same level of hearing loss may be described differently (e.g., slight, mild, or moderate), leading to confusion when interpreting audiologic reports. Therefore, greater standardization in the use of these terms is needed to ensure consistency and clarity. Seeing that different professionals also disagree how to determine impairment (e.g. using 500, 1000, 2000Hz only, or using 500 – 4000Hz etc), also adds
to the confusion.

It is important to recognise that an average value does not describe the specific configuration or pattern of hearing loss across frequencies. Additional descriptors (for example, *profound high- frequency hearing loss*) may therefore be used when relevant.

The classification system in Table 1 is suggested by Dr J.G. Clark and it groups hearing loss into the following categories based on the average hearing threshold level (dB HL):

Table 1: Hearing Loss Classification

Table 1: Hearing Loss Classification

Degree of Hearing Loss	Hearing Loss Range (dB HL)
Normal	–10 to 15
Slight	16 to 25
Mild	26 to 40
Moderate	41 to 55

Degree of Hearing Loss	Hearing Loss Range (dB HL)
Moderately	56 to 70
severe Severe	71 to 90
Profound	91+

Source: Clark, J. G. (1981). Uses and abuses of hearing loss classification. Asha, 23, 493–500. Modified from Goodman (1965).

Table 2 below shows a summary of some of the other classifications used. **Table 2: Different Hearing Loss Classification Examples**

Degree of Loss	Northern & Downs (2002)	Clark (1981) used by ASHA	Jerger & Jerger (1980)	British Society of Audiology (2018)	Davis (1978)	Goodman (1965)
Normal	<16	<16	<21	<21	<25 not significant 26-40	<26
Slight	16-25	16-25				
Mild	26-30	26-40	21-40	21-40	41-55	26-40
Moderate	30-50	41-55	41-60	41-70	56-70 marked	41-55
Moderately - severe	51-70	56-70				56-70
Severe	>70	71-90	61-80	71-95	71-90	71-90
Profound		91+	>80	95+	>90 extreme	>90

Seeing that no one exceptional categorisation system exists, academic institutions teach different systems. In the light of trying to find a consistent way of classification, it is worth following the proposal in the article by Clark, J. G. (1981) displayed in Table 1 as it is a logical system that even accounts for slight losses, and a threshold of 90 dB HL or greater is widely accepted as marking both a quantitative and qualitative boundary between hearing and deafness.

9. Cross-hearing and the need for masking

9.1. What is cross-hearing

Although headphones allow sounds to be delivered to one ear at a time during audiometric testing, it cannot always be assumed that the ear receiving the signal (the test ear) is the one detecting it. When there is a large difference in hearing sensitivity between the two ears, the better ear may perceive the test tone even when the sound is presented to the poorer ear. This occurs because some of the sound energy can travel through the skull to the opposite ear.

The reduction in sound level as it travels from one ear to the other is known as interaural attenuation. The amount of attenuation differs between individuals and depends on the type of earphone used. With supra-aural or circumaural headphones, interaural attenuation is typically

40dB. Insert earphones usually provide greater attenuation, with a minimum value of approximately 55 dB when properly fitted. In contrast, bone-conduction testing produces little or no interaural attenuation.

If the difference in hearing thresholds between the ears exceeds the interaural attenuation, the non-test ear may detect the signal. In such cases, the measured threshold for the poorer ear may represent a “shadow” response from the better ear rather than the true sensitivity of the test ear.

Patients should not be relied upon to indicate which ear perceived the sound, as many individuals cannot accurately localise faint tones and the sound may not be clearly lateralised.

9.2. Principles of Masking

Masking is used to prevent the non-test ear from detecting the test signal. This is achieved by presenting masking noise to the non-test ear while the tone is delivered to the test ear. The masking noise temporarily elevates the hearing threshold of the non-test ear so that it cannot respond to the test tone.

9.3. Masking Noise

Masking is usually carried out using narrow-band noise centred around the frequency of the test tone. The bandwidth of the noise is typically between one-third and one-half of an octave, ensuring that it effectively masks the tone without unnecessarily stimulating other frequencies.

10. Air Conduction Masking

10.1. When to Perform

Masking decisions are made separately for each test frequency. The test ear is the ear being evaluated, while the non-test ear is the ear receiving masking noise.

- Masking is required when the difference between the not-masked air-conduction thresholds of the two ears is:

  - **≥ 40 dB** when using supra-aural or circumaural headphones
  - **≥ 60 dB** when using insert earphones (Interaural Attenuation Values - Ask the Experts 307 – Paul Dybala, 2007)

Note: Killion et al., Konig, and Sklare & Denenberg reported average interaural attenuation (IA) values of approximately 80 dB, with minimum values around 70 dB. Based on this, 70 dB can be used as a practical IA value for insert earphones. However, in clinical practice, many audiologists adopt a more conservative estimate of 60 dB.

This large difference increases the likelihood that the better ear could detect the test signal.

- Even when the above does not indicate masking, it may still be required if the bone- conduction threshold of one ear is significantly better than the air-conduction threshold of the opposite ear. Specifically:

  - **≥ 40 dB difference** with supra-aural or circumaural headphones
  - **≥ 60 dB difference** with insert earphones (Interaural Attenuation Values - Ask the Experts 307 – Paul Dybala, 2007)

This situation may occur when the non-test ear has a conductive component, allowing it to detect the tone through bone conduction more easily than the test ear.

10.2. Instructions Given to the Patient

Before masking begins, the patient should be given clear instructions. For example:

- They should press the response button as soon as they hear a tone and release it when the tone stops, no matter where they hear the sound (left, right or central).
- Very soft sounds should still be responded to.
- A continuous noise may be heard in one ear, which should be ignored.
- They should report if any sounds become uncomfortable or if they require clarification.

Patients should not be told which ear should hear the tone, since the purpose of masking is to determine this objectively.

10.3. Plateau Method for Air Conduction Masking

The recommended approach for masked threshold determination is the plateau method, which can be used for both air- and bone-conduction testing.

The basic steps include:

- Confirm the unmasked threshold in the test ear to remind the patient what to listen
- for. Stimulus masking noise = Narrowband Noise
- Present masking noise in the non-test ear at threshold + 10dB
- Present pure tone at established threshold in the test ear
- If no response, increase pure tone by 5dB
- If client responds, increase masking noise 10dB
- You must increase masking noise in 10dB increments 3 times at the same threshold before you mark your response on the audiogram.

When the tone threshold remains unchanged across increasing masking levels, a plateau has been reached. This plateau indicates that the measured value represents the true threshold of the test ear, and further masking is unnecessary.

If the plateau cannot be reached due to equipment limits or patient discomfort, the threshold should be recorded as unreached.

11. Masking in Bone-Conduction Testing

11.1. When to Perform

Masking is required when the not-masked bone-conduction threshold is 10 dB or more better than the air-conduction threshold of either ear. In this situation, the poorer ear (based on air conduction) becomes the test ear, and the better ear should be masked.

However, clinical judgement is important. In some situations—such as very small air-bone gaps or when masking would not change clinical management—it may not be necessary to mask every bone-conduction frequency

11.2. Instructions

Instructions are the same as for air conduction masking. Ask the client to indicate if they ‘feel’ the presentation, rather than ‘hear’ it, in case the response is based on a vibrotactile response.

11.3. Method

- Place headphone/insert tip in the test ear
- Stimulus masking noise = Narrowband Noise Procedure (Plateau method):
- Present masking noise into the non-test ear (NTE) at threshold (NTE) +
- 10dB
- Present pure tone at established BC threshold in the TE
- If no response, increase threshold 5dB
- If client responds, increase masking noise 10dB
  You must increase masking noise in 10dB increments 3 times at the same threshold before you mark your response on audiogram

11.4. Safety Considerations

High levels of masking noise should be used cautiously, particularly when testing multiple frequencies, to minimise the risk of excessive sound exposure. Special care is required when testing individuals with tinnitus, as intense masking noise may worsen their symptoms. In some situations, masking may need to be avoided or limited.

12. Interpretation of Masking Results

Threshold measurements inherently involve some uncertainty, typically around ±5 dB, so real masking functions may not perfectly match theoretical patterns.

• When Cross-hearing Is Not Present

If the masked thresholds remain within 5 dB of the original unmasked threshold, it indicates that the initial result likely represented the true hearing sensitivity of the test ear.

• When Cross-hearing Occurs

If cross-hearing was present, the initial unmasked threshold reflects the better ear’s response. As masking noise increases, the tone threshold rises until it eventually stabilises at the true threshold of the test ear, forming the plateau.

- **Central Masking**

Central masking occurs when the brain has difficulty detecting a tone in the presence of noise, even though they are presented to opposite ears. This may produce a slight increase in the measured threshold at high masking levels.

- **Cross-masking**

If the masking noise becomes sufficiently intense, it may travel across the skull and affect the test ear. This phenomenon, known as cross-masking, can interfere with accurate threshold measurement and is more likely when high masking levels are required. This is further discussed under the next heading – Masking dilemma

13. **Masking Dilemma and Management**

A masking dilemma arises in audiometry when it becomes impossible to adequately mask the non-test ear without also masking the test ear. This situation is caused by the limited interaural attenuation of the masking transducer combined with a large air-bone gap in the non-test ear.

13.1. **Identification**

A masking dilemma should be suspected when any of the following occur during testing:

- A clear plateau cannot be achieved even after systematic increases in masking intensity.
- The masking noise crosses over and begins to elevate the threshold measured in the test ear.
- The test-ear threshold continues to rise in direct proportion to increases in the masking level applied to the non-test ear (typically shifting more than 5 dB for every 10 dB increase in masker).
- During speech testing, word-recognition scores in the test ear drop unexpectedly because the masking noise is interfering with audibility.

13.2. **Management**

When a masking dilemma is identified, clinicians should follow these evidence-based steps:

- Change to insert earphones if available. This increases interaural attenuation (often to 70 dB or more) and provides a wider range of safe masking levels before crossover occurs.
- If a true plateau still cannot be reached, stop testing at the highest safe level and document the limitation precisely. Record the highest threshold obtained before crossover (e.g., “25 dB plateau achieved prior to onset of masking dilemma”).
- When accurate masked bone-conduction thresholds cannot be measured in one ear, report only the most reliable cochlear information available (usually the better ear) and clearly note the technical limitation in both the audiogram and the written report.
- Always document the issue explicitly in the audiological report. Use standard clinical phrasing such as: “Masking dilemma present; masking plateau could not be established.” Include the exact masking levels attempted, the transducer used, and the reason masking was discontinued.

This approach ensures accurate interpretation, maintains professional standards, and protects the validity of the final audiogram.

14. Calibration

14.1. Stage A: Routine inspections and subjective evaluations

These checks verify that the audiometer is operating correctly across its full range. They must be performed by a person with sufficiently good hearing to notice any faults (such as those listed below). Carry them out in the usual test room with the equipment set up exactly as it is used for patients. If any issue is detected, do not use the equipment until its correct performance has been confirmed.

Daily tests (1–8)

1. Clean and inspect the audiometer and every accessory. Examine earphone cushions, connectors, power cords and all other leads for wear or damage. Replace any badly worn or damaged parts straight away. Replacing any transducer requires a full Stage B check afterwards.
2. Turn the equipment on. Complete any initial adjustments required by the manufacturer. On battery-operated units, verify the battery condition using the stated method. Confirm that the serial numbers on the earphones and bone vibrator match those on the calibration certificate. Transducers must never be swapped without a complete Stage B calibration.
3. Confirm that air- and bone-conduction outputs are approximately correct by presenting tones at a low, just-audible level (e.g. 10 dB HL or 15 dB HL). Test every relevant frequency with both earphones and the bone vibrator.

4. Verify that masking noise is approximately correct at all frequencies when delivered through each earphone at 60 dB HL.
5. Perform a high-intensity listening check on air and bone conduction at every frequency used, across all relevant functions and both earphones (e.g. 60 dB HL air conduction, 40 dB HL bone conduction). Listen for normal operation, absence of distortion, no clicks or other unwanted sounds when the tone starts, and similar faults.
6. Test every earphone and the bone vibrator for distortion or intermittent output. Also check plugs and leads for any intermittent connections.
7. Ensure all switches and controls are secure and that every indicator light or display functions properly.
8. Confirm that the patient response button operates correctly.

Weekly tests (9–11)

9. At low intensities, listen for any background noise, hum, unwanted sounds or changes in tone quality when masking is switched on. Verify that attenuators reduce the signal smoothly across their entire range and that those meant to be adjusted during tone presentation produce no electrical or mechanical noise. Check that interrupter keys work silently and that no sound from the instrument can be heard at the patient's position.
10. Test the patient speech-communication circuits.
11. Check the tension of the headset headband and bone-vibrator headband. Make sure swivel joints move freely but are not excessively loose. Inspect headbands and joints for wear, strain or metal fatigue.

14.2. Stage B: Periodic objective measurements

These objective checks must be performed every 12 months and must be carried out by an accredited company or manufacturer.

Measure and compare the results against the relevant standards for:

1. Test-signal frequencies
2. Sound-pressure levels produced by earphones in an acoustic coupler or artificial ear
3. Vibratory force levels produced by bone vibrators on a mechanical coupler
4. Masking-noise levels
5. Attenuator step accuracy over a substantial part of the range
6. Harmonic distortion

Comprehensive Speech Audiometry Protocol

1. Introduction and Clinical Purpose

Speech audiometry encompasses a range of behavioural tests that use spoken language as the stimulus to evaluate auditory function. Traditionally it was believed that speech audiometry provides insight into how an individual processes and understands meaningful acoustic information. It was thought that this distinction is clinically important because the primary concern of most patients is not whether they can detect tones, but whether they can effectively communicate in everyday listening environments. However, research has shown that Word Recognition testing in quiet conducted at high presentation levels, tells us almost nothing about everyday communication.

Richard Wilson's analysis of more than 3,000 patients demonstrated the core problem: approximately 70% of individuals who scored "good" or "excellent" on words lists in quiet still showed abnormal performance on speech-in-noise tests. In other words, excellent quiet scores do not predict real-world success, and poor quiet scores are uncommon unless the loss is severe. Quiet testing fails to detect pathologies beyond what pure-tone thresholds already reveal, does not predict hearing-aid benefit in most cases, and correlates poorly with self- reported handicap—especially in background noise, which is the number one complaint of nearly every client who walks through the door.

In contrast, speech-in-noise (SIN) testing directly measures the functional difficulty patients experience daily, quantifies the Singal to Noise Ratio (SNR) loss, identifies candidates who need advanced hearing-aid features (directional microphones, remote microphones, noise- reduction algorithms), and provides concrete data for counselling and outcome validation. Adding SIN tests to routine word recognition test in quiet (WRQ) with SIN testing (or at least prioritising SIN) is the single most evidence-based change you can make. WRQ is still required (HSP requirements, for medical-legal documentation, serial monitoring, or physician referral) if conducted correctly, or the results are of little value.

It is well recognised that individuals with similar pure tone thresholds may demonstrate markedly different abilities in speech understanding. For this reason, speech audiometry is an essential component of a comprehensive audiological assessment. It contributes not only to diagnosis but also to management decisions, including amplification strategies and counselling regarding expected outcomes.

In clinical practice, speech audiometry supports several key objectives:

- It serves as a cross-check against pure tone findings
- Assists in identifying discrepancies suggestive of non-organic hearing loss or retrocochlear pathology
- Aids in hearing aid selection (although research shows it may not be effective)
- Supports accurate hearing-aid selection and verification; and Delivers counselling data.
- If done correctly, it serves as a test-retest function over time

2. Pre-Test Considerations

Speech audiometry must never be conducted in isolation. It is essential that otoscopy, tympanometry and pure tone audiometry are completed beforehand, as these provide the clinical context required to interpret speech results accurately.

Otoscopic examination ensures that the external auditory canal is clear and free from conditions that may contraindicate testing. The presence of impacted cerumen, debris, foreign bodies, or active infection such as otitis externa may compromise test validity or patient
comfort. In such cases, speech testing via air conduction should be deferred or modified. Alternative approaches, such as bone conduction speech testing or sound-field assessment, may be more appropriate depending on the clinical scenario.

Pure tone audiometry provides the baseline measure of hearing sensitivity against which
speech results are compared. Without this reference, it is not possible to determine whether speech performance is consistent with auditory thresholds or indicative of additional
pathology.

Client-related factors must also be considered carefully. Speech testing requires a level of linguistic comprehension and the ability to respond reliably. Therefore, the clinician must adapt the test materials and procedure to suit the individual. This is particularly important in younger populations, individuals with cognitive impairment, and patients for whom English is not their primary language. In cases where expressive speech is limited, detection-based measures may still be feasible even if recognition testing is not.

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3. Test Environment and Equipment

Speech audiometry must be conducted in a controlled acoustic environment, typically a sound-treated booth, to minimise background noise and ensure accurate results. The audiometer used must be capable of delivering calibrated speech stimuli through a variety of transducers, including insert earphones, supra-aural headphones, bone conduction oscillators, or loudspeakers for sound-field testing.

The method of stimulus delivery has a significant impact on test reliability. Recorded speech material is considered the gold standard, as it ensures consistency in presentation level, speech rate, and articulation. In contrast, live voice presentation introduces variability that cannot be standardised or calibrated, making it less reliable for diagnostic purposes. While live voice may occasionally be used in specific circumstances, it should not be the primary method of testing in routine clinical practice.

Routine equipment checks must be performed daily to confirm that the system is functioning correctly, and formal calibration must be carried out annually in accordance with relevant standards. These procedures ensure that speech stimuli are presented at accurate and reproducible intensity levels.

4. Word Recognition (WR) Test

The WR test is a suprathreshold test performed in quiet. In many countries the Performance- Intensity for Phonetically Balanced Words (PI-PB) function is used. This is a test mapping word recognition scores at varying intensity levels. Lists of 50 words phonetically balanced words (e.g., NU-6) are presented at multiple intensities to plot a curve, showing how scores change with intensity. These words are scored correct or incorrect and the percentage is calculated out of 50 and plotted on the speech audiogram.

In Australia, as in the United Kingdom, AB word lists are used, named after the developer Arthur Boothroyd. These are a set of 150 phonetically balanced (10 words per list), monosyllabic (Consonant-Vowel-Consonant) words. The lists consist of phonetically balanced monosyllabic words designed to reflect the distribution of speech sounds in everyday language. Their structure allows for consistent and meaningful assessment of speech discrimination across different intensity levels. This is the only speech-in-quiet test standardised for Australian speakers.

The AB word lists are used to generate a speech audiogram where multiple word lists are presented at varying intensity levels, and the patient's performance is plotted on a speech audiogram. By examining the results, the clinician can identify characteristics such as the speech recognition threshold, the maximum word recognition score, and any decline in performance at higher intensities (identifying a roll-over). This test assists in diagnostic interpretation and supports more informed clinical decision-making.

The WRQ test in itself cannot predict how well a client will function with hearing aids or provide enough information to make clinical decisions. What it does is it gives us a way to correlate data over time. If the test is performed correctly by obtaining the softest intensity level where a client receives the highest scores (as well as possible roll-over), the data can be compared over time. To obtain this level (the softest intensity where the client obtains the highest score), one should test in 10dB increments and not jump 20 or 30dB at a time to just show a 'good' score and a 'lower' score. This is important to note, seeing that the 20 or 30dB jumps are a common shortcut and is not best practice. Consider that the AB words allow the clinician to only present 10 words per list, which significantly reduces test times as compared to the 25 or 50 word lists used in other countries.

Key Features of the AB Word Lists

- **Structure:** Consists of 15 lists, with each list containing 10 CVC (Consonant-Vowel- Consonant) words.
- **Phonemes:** Each list includes 30 phonemes (10 vowels and 20 consonants).
- **Scoring:** Scored by phonemes (3 per word, 30 per list) rather than just whole-word correct, allowing for detailed analysis of consonant/vowel recognition
- **Test starting level:** It is assumed that the best score is usually obtained at 30dB above the pure tone average of the audiogram.

The traditional categorisations include excellent, good, fair, poor, and very poor. These categories are defined as:

Excellent or within normal limits = 90 - 100% on whole word scoring

Good or slight difficulty = 78 -

88% Fair to moderate difficulty =

66 - 76% Poor or great difficulty =

54 - 64 % Very poor is < 52%

5. Speech Recognition Threshold (SRT)

In some countries the SRT is obtained with spondee words and is the level where the client obtains a 50% score. The SRT is performed first and then determines the starting point of the other supra-threshold speech tests. For example, SRT + 30dB or +40dB is considered the best starting point for word recognition testing that should result in the best possible word score.

However, in Australia we follow the British protocol where the SRT is derived from the Word Recognition (WR) results and is taken as the point where the client obtains 50% of the WR results. No other word lists are used to obtain the WR score. This means that in Australia, the WR is the main speech test to perform in quiet, and the SRT is derived from that by reducing the intensity in 10dB increments at which the words are presented, until one obtains the score closest to 50%.

The SRT cross-checks the pure-tone thresholds by correlating the score to be plus or minus 10dB of the PTA of the audiogram.

6. Speech Detection Threshold (Optional)

Speech detection testing represents the most basic form of speech audiometry. It assesses the patient's ability to perceive the presence of speech without requiring them to understand or repeat what is heard. During this test, speech stimuli are presented at varying intensity levels, and the patient indicates when they can detect that speech is present. The outcome of this procedure is the speech detection threshold, defined as the lowest level at which the patient detects speech in approximately half of the presentations. Although this measure does not provide information about speech understanding, it is clinically useful as a cross-check of the pure tone average. In most cases, the speech detection threshold should align closely with the average of thresholds at key speech frequencies. When there is a significant discrepancy between the speech detection threshold and the pure tone average, further investigation is required. Such inconsistencies may indicate unreliable responses, non-organic hearing loss, or other underlying issues that warrant additional assessment. The SDT test is not compulsory but can be performed at the clinician's discretion.

7. Speech-in-Noise Testing

Clinicians generally assume that performing the otoscopy examination, pure tone audiogram, tympanometry and speech testing in quiet is the complete test battery. However, most of the clients one will see in practice do not complain about not hearing words in quiet. Most of them complain about not hearing speech in background noise. Therefore, it is important to perform a test that addresses the main complaint of many clients.

7.1. Rationale for Speech-in-Noise Testing

Speech-in-noise (SIN) testing is essential in audiological assessment because it provides a more accurate representation of a patient's real-world communication abilities than traditional speech testing in quiet.

Firstly, speech recognition in quiet is a poor predictor of real-world performance, particularly for individuals with sensorineural hearing loss. Deficits such as reduced frequency and temporal resolution are not adequately captured in quiet conditions, meaning patients may score well on word recognition tests yet still struggle significantly in everyday listening environments.

Secondly, SIN testing improves both sensitivity and validity of assessment. Adding background noise places greater demand on the auditory system, allowing clinicians to better differentiate between normal hearing and hearing impairment. Testing across multiple signal-to-noise ratios (SNRs) provides clearer separation between patient groups and reveals difficulties that would otherwise remain hidden.

Importantly, patients with hearing loss experience disproportionately greater difficulty in noise, often requiring an SNR that is 10–15 dB better than normal-hearing individuals to achieve similar understanding. This highlights why testing in quiet alone underestimates the functional impact of hearing loss.

Evidence also shows that speech-in-quiet scores do not predict speech-in-noise performance, whereas SIN results are more reflective of everyday communication challenges. Many clients with "normal" scores in quiet demonstrate significant deficits in noise, reinforcing the limitation of relying solely on traditional measures.

From a clinical management perspective, SIN testing provides valuable information to:

- Guide hearing aid candidacy and technology selection
- Identify asymmetries not seen on audiogram
- Support patient counselling and expectation setting
- Demonstrate and validate hearing aid benefit
- Monitor changes over time

Additionally, SIN testing aligns with patient-centred care, as difficulty hearing in noise is the most common complaint reported by individuals seeking help. Assessing this directly ensures the evaluation addresses the patient's primary concern.

Speech-in-noise testing is critical because it:

- Reflects real-world listening demands
- Detects deficits missed by speech-in-quiet testing
- Improves diagnostic sensitivity and clinical decision-making
- Enhances counselling, rehabilitation, and hearing aid outcomes

7.2. QuickSIN

There are several SIN tests available on the market such as the Bamford-Kowal-Bench Speech- in-Noise test (BKB-SIN), Hearing In Noise Test (HINT) or Words In Noise Test (WIN). The
QuickSIN is widely used in Australia and we will discuss it here in more detail.

The QuickSIN is the most practical and widely validated tool for routine use. This is the measure that directly addresses the patient's primary complaint and should be performed on every adult patient unless contraindicated.

There are different sentence lists to use, but these three lists groups are the ones that will be used most of the time:

- Lists Lists A-C are practice lists to familiarise the client with the test procedure.
- Lists 3-14 Standard QuickSIN lists. These twelve lists are equivalent.
- Lists 36-47 30 dB high-frequency emphasis (HFE). The HFE is used to make speech sounds audible for persons with ski-slope loss and can be used for typical noise induced hearing loss audiograms.

Presentation level

Present the testing material at 70 dB HL or the patient's MCL (whichever is more representative of conversational speech). Use the standard six-sentence lists with five key words each. The SNR begins at +25 dB and decreases by 5 dB per sentence. Score the number of correctly repeated key words and calculate SNR loss as 25.5 minus the total correct score. Test both ears unaided; repeat aided when validating hearing-aid fittings. Interpretation follows published norms: 0–3 dB loss is normal, 4–7 dB mild, 8–15 dB moderate, and greater than 15 dB severe.

The variable-SNR design eliminates floor and ceiling effects. Floor and ceiling effects are when test material is too difficult or too easy for the client, resulting in their scores to cluster at the maximum (100%) or minimum (0%) possible values. The design also provides reliable 50% correct points, and allows rapid comparison between ears, sessions, or aided/unaided conditions. Results guide technology selection (e.g., strong directional microphones for moderate SNR loss), quantify the exact listening challenge for counselling, and predict real-world benefit far better than quiet scores.

One limitation of testing at 70dB HL is that it tests at an amplified level to provide the best possible results of amplified hearing in noise. With this being a supra-threshold test, it does not provide the clinician with information on how the client does without amplification. Many clinicians find it helpful to present the QuickSIN sentences at 50dB HL as well as at 70dB which will provide more information on how a client may hear before amplification and with amplification.

Scoring

Each sentence contains five key words, which are underlined on the score sheets. Award one point for every key word that is correctly repeated. Record the number of correct words for each sentence in the space provided, then calculate the total number of correct responses for the list.

SNR Loss is determined for each list using the formula:
SNR Loss = 25.5 − Total Correct

Note: For improved accuracy, average the results from two or more lists.

Interpretation

The average score obtained after completing 2 or 3 sentences is presented in dB and provides
the clinician with a degree of SNR loss, and an expected improvement the client could expect with directional microphones.

SNR	Degree of SNR	Expected Improvement with Directional Mics
0-3dB	**Loss** Normal/Near Normal	May hear better than normal hearing persons hear in noise
3-7dB	Mild SNR Loss	May hear almost as well as normal hearing persons hear in noise
7-15dB	Moderate SNR	Directional microphones will help. Consider array mic
>15dB	Loss Severe SNR Loss	Maximum SNR improvement is needed. Consider FM system (or ALD)

8. Masking in Speech Audiometry

Masking is an essential consideration in speech audiometry when there is a risk that the non-test ear may detect the stimulus. This is particularly relevant when testing at higher intensity levels, as speech signals are typically presented well above threshold.

Unlike pure tone audiometry, where narrowband noise is used, speech audiometry requires the use of speech-shaped noise to effectively mask the non-test ear. The masking noise must be carefully calibrated to ensure that it is sufficient to prevent cross-hearing without introducing unnecessary discomfort.

The need for masking is determined by factors such as interaural attenuation, the presence of an air-bone gap, and the intensity of the speech signal. Accurate application of masking ensures that the results obtained are truly representative of the test ear. To determine if speech masking is necessary, one can use the following formula:
PL of Test Ear – IA ≥Average of BC of Non Test Ear

It is important to use speech masking protocols that have been created from research and clinical trials. There are several suggested speech masking formulae, for example:

- Presentation Level (PL) + Average across 500-4000Hz + 30dB
- Many clinicians use 3FAHL of 500, 1 & 2 kHz +30dB
- Minimum masking for speech (for audiometers not calibrated for speech): PL - IA +
- Effective Speech Masking Level + Average ABG (NTE)
- If calibrated for speech - Minimum masking for Speech: PL - IA + Average ABG
- (NTE)
  PL + Max Air-bone gap of the non-test ear - 40 + Effective Masking
  Minimum Masking = PL of Test Ear – IA + Max AB Gap NTE + ESML (10dB)

The result should be replicable within 5 – 10 dB despite the method used.

9. Interpretation of Results

The interpretation of speech audiometry results must always be conducted within the context of the full audiological assessment. The cross-check principle is fundamental in audiology and states that no single test result should be accepted in isolation. Speech results should align with pure tone findings, and any inconsistencies must be explored further.

Particular attention should be paid to asymmetries between ears, as significant differences in word recognition scores may indicate different underlying pathologies. Similarly, unusually poor performance relative to the audiogram may suggest retrocochlear involvement or other complex conditions.

One important phenomenon to consider is roll-over, which refers to a decline in speech recognition performance at higher intensity levels. This pattern may be indicative of neural pathology and should prompt further investigation using additional diagnostic tests such as acoustic reflexes or auditory brainstem response testing.

Speech testing in quiet does not necessarily provide information on how well a client will perform with amplification. Seeing that speech testing in quiet cannot provide adequate information on how well a client will perform with amplification, it should be used as test to correlate pure tone testing and test-retest reliability over time.

Speech testing in background noise should carry more weight when it comes to predicting amplification success as well as used in client counselling regarding their speech understanding and rehabilitation options.

10. General Clinical Considerations That Apply to the Entire Battery

Use recorded materials for all suprathreshold and SIN testing to ensure standardisation. Always mask appropriately. Document every detail—material, method, presentation level, list number, and scoring method—directly on the audiogram and report.

In order to achieve reliable and clinically meaningful results, speech audiometry must be conducted in a standardised and methodical manner. Recorded speech material should be used wherever possible, and clinicians must ensure that presentation levels are appropriate and clearly documented. It is important to select speech materials that are suitable for the client and to provide clear instructions to ensure accurate responses. Adequate time should be allowed for testing to avoid fatigue, particularly when multiple word lists are used.

11. Summary and Clinical Recommendations:

Word recognition testing in quiet is a requirement of the Hearing Services Program so it is compulsory during audiometric testing. For this reason, make sure that it serves a purpose by completing the test correctly. Recording a maximum and 50% (SRT) score is not providing enough information to ensure that the test provides enough information to compare future tests to. Thus, obtain the best score at the lowest intensity so future tests can be compared to that value.

Make speech-in-noise testing a routine part of every adult evaluation; it is the only speech measure that consistently predicts real-world function and hearing-aid outcomes. Implement it consistently and you will see measurable improvements in both diagnostic accuracy and hearing-aid success rates.

Speech audiometry is a vital component of audiological assessment that provides insight into a client's ability to understand speech, which is the ultimate goal of hearing. By integrating all test results, and by utilising standardised materials such as the AB word lists commonly used in Australia, clinicians can obtain a comprehensive understanding of auditory function. When performed in accordance with this protocol, speech audiometry supports accurate diagnosis, guides effective rehabilitation, and ensures that patient care is both evidence-based and clinically robust.

Loudness Discomfort Level (LDL) Testing

1. What is Loudness Discomfort Level (LDL) testing?

Loudness Discomfort Level testing is also known as Uncomfortable Loudness Level (UCL). The test measures the intensity at which sounds become uncomfortably loud for a patient. This helps determine the patient's residual dynamic range — the difference between their hearing thresholds and the upper limit of comfortable loudness.

LDL results are used to determine safe and effective hearing aid fitting, as they guide the setting of the Maximum Power Output (MPO) or Output Sound Pressure Level (OSPL90) to prevent over- amplification, discomfort, or annoyance from loud sounds.

2. Key Reasons for Performing LDL Testing

- **Hearing Aid Fitting**

LDLs ensure the hearing instrument's maximum output remains within the patient's tolerance. This prevents loud sounds from becoming painful or unpleasant and allows for accurate, personalised mapping of the device's output.

- **Diagnosis and Management of Hyperacusis**

Reduced LDLs can indicate decreased sound tolerance (hyperacusis). Measuring LDLs helps quantify the degree of hypersensitivity and informs appropriate management strategies.

- **Dynamic Range Mapping**

By establishing the upper limit of comfortable loudness, LDLs allow clinicians to map the full dynamic range. This supports customised amplification that balances audibility and comfort.

- **Tinnitus Management**

LDL results provide valuable information about how high-intensity sounds affect the patient, assisting in the selection and programming of hearing aids or sound generators for tinnitus relief. Tinnitus can also be a contra-indication to performing LDL's and should be determined on a case-by-case basis.

3. Contra-indications to performing LDLs.

- Hyperacusis / Decreased Sound Tolerance: In patients with severe hyperacusis, the test
- may cause significant discomfort or potentially exacerbate symptoms. In such cases, multi- item questionnaires are a safer alternative.
- Reduced Maximum Levels: The test should either be avoided or conducted with significantly reduced maximum intensity levels in sensitive populations or when obtaining fully informed consent is challenging.
- Recent Trauma or Pain: LDL testing should not be performed if the patient has experienced ear pain or notable discomfort within the past 30 days.
- Unreliable Subjects: The test is not considered valid if the patient is unable to understand or reliably communicate what constitutes “uncomfortably loud.”
- Physical Irritation: Testing should be postponed in patients with active middle ear infections, other ear infections, or excessive and irritating cerumen until the condition has resolved.

4. **When to Perform LDL testing**

It is most efficient to complete Loudness Discomfort Level (LDL) testing when the patient is already positioned in the test booth for PTA Even if hearing aid fitting is not immediately anticipated, obtaining LDLs at this stage is advisable.

The most time-consuming aspects of an appointment are typically preparing the patient— bringing them into the booth, fitting the transducers, and completing preliminary interactions. Once testing is underway, incorporating LDL measurements adds minimal additional time. Furthermore, LDLs are generally stable over time and are unlikely to change unless there is a significant shift in hearing thresholds. Therefore, collecting this data early ensures it is available for future use, even if the patient returns months or years later.

5. **Stimulus**

Frequency-specific information is essential when measuring LDLs, so pulsed pure tones are the preferred stimulus. These provide precise data that can be directly applied when setting hearing aid parameters such as MPO.

Speech-based LDL measures are generally not recommended, as they do not yield the frequency-specific values required for hearing aid programming. Narrowband noise may be used as an alternative, provided that it is sufficiently narrow and well-calibrated.

6. **Psychophysical Procedure**

The recommended approach is an ascending method, consistent with standard psychophysical procedures. In this method, stimulus intensity is gradually increased until the patient indicates that the sound has reached an uncomfortable level.

According to Mueller (2011), testing should begin at an estimated Most Comfortable Level (MCL), without spending excessive time formally measuring it. From this starting point, intensity is increased in 5 dB increments. For patients with a reduced dynamic range, smaller step sizes (e.g., 2 dB) may be more appropriate.

Once the patient identifies the sound as uncomfortably loud, the level should be reduced back to MCL and the process repeated. Conducting two to three runs helps ensure reliability and consistency of the LDL measurement.

7. **How to Define 'Uncomfortable'**

Clear definition of "uncomfortable" is critical for obtaining valid results. Clients require structured reference points, rather than vague instructions such as indicating when a sound is "too loud" or "painful."

A standardised loudness rating scale, such as that used in the Cox Contour Test, provides these reference points (loudness anchors). These scales include graded descriptors of loudness, allowing clients to anchor their responses consistently.

It is not enough to simply ask the client to raise a hand when the sound is uncomfortable, intolerable, or when it hurts. Giving them points of reference by which to judge what they are hearing, is far more effective. The chart below is adapted from the Loudness Chart from the

Cox Contour Test (Cox, et al., 1997), as well as suggestions by Gus Mueller (2011) as used in his clinic.

NUMBE	LOUDNESS CATEGORIES
R 7	UNCOMFORTABLY LOUD
6	LOUD, BUT OKAY
5	COMFORTABLE, BUT SLIGHTLY
4	LOUD COMFORTABLE
3	COMFORTABLE, BUT SLIGHTLY
2	SOFT SOFT
1	VERY SOFT
0	CANNOT HEAR

The '0' category helps to reduce confusion at the beginning of the test. Give this chart to the client to hold and read during the test, making sure the chart is large enough and easy to read. They can indicate their choice by verbalising it and observation of their responses (e.g. hesitation) can give insights into how they are judging the loudness levels.

8. **Instructions**

Instructions play a significant role in shaping patient responses and must be delivered carefully. When using a structured loudness scale such as the Cox Contour Test, it is best practice to use the standardised instructions associated with that tool. These instructions emphasise that an "uncomfortable" sound is one the patient would not choose to listen to under any circumstances.

It is advisable to present the instructions verbatim and clarify any components the patient does not understand. Additional guidance may also be beneficial, such as informing the patient that they may skip categories or assign the same category to multiple stimuli. This helps prevent the misconception that each increase in intensity must correspond to a higher category rating,
which can otherwise distort results—particularly in patients with a narrow dynamic range.

9. **Frequencies**

LDLs typically show minimal variation across frequencies, so it is not necessary to measure them at every test frequency. Instead, focus should be placed on clinically relevant frequencies.

The most important region is typically between 2000 and 3000 Hz, as this often corresponds to the peak output region of hearing aids. For relatively flat hearing losses, measurements at 500 Hz and 3000 Hz are usually sufficient.

Clinical judgement is essential when selecting test frequencies. There is little value in measuring LDLs in frequency regions where hearing is normal or where amplification will not be applied (e.g., in cases of severe high-frequency loss where amplification is avoided). When uncertain, testing at 2000 Hz is generally a reliable choice, as it is both clinically relevant and commonly within the amplification range.

If time and client comfort allows, other frequencies can be added e.g. 500, 1000 or 4000Hz.

10. Procedure

The clinician should:

- Continuously observe the patient's facial expressions and behaviour during testing, watching closely for any indication to stop. It is acceptable if the patient can see the clinician operating the equipment, as this may provide reassurance. Stop testing immediately if the patient shows discomfort, distress, or a startle response.
- At that point, confirm whether the sound was uncomfortable and ask whether the patient is willing to proceed. If appropriate, provide further instructions and recommence testing. Testing should also be discontinued if it becomes evident that the patient does not understand the task.
- Begin at 60 dB HL or at the patient's hearing threshold for that frequency in the test ear, whichever is higher. For patients with tinnitus or hyperacusis, begin at threshold level (noting the additional precautions required for these populations). If known, commence testing with the better ear or the ear without pathology.
- Present a tone of approximately one second in duration, followed by a silent interval of at least one second. If using the Loudness Chart suggested above, wait for the client to respond with the appropriate number before proceeding to the next presentation. Increase the intensity in 5 dB increments, maintaining the same presentation pattern.
- Continue until the patient responds, exhibits discomfort, or the maximum permissible level is. At the first
indication of discomfort, confirm that the patient considers that level to be uncomfortably loud and would not tolerate any further increase.

- The timing of tone presentations does not need to be strictly regular; a consistent rhythm may assist some patients. Allow sufficient time between stimuli (typically 2–5 seconds) for the patient to respond, adjusting this interval based on individual needs and clinical judgement.
- The intensity level at which the patient indicates discomfort is recorded as the LDL. If testing is stopped due to an involuntary reaction such as flinching prior to a formal response, that level may still be accepted as the LDL provided the patient confirms that the final tone, and not the preceding one, was uncomfortable.
- After obtaining the first LDL, verify that the patient's response corresponded to the point of discomfort. If there is any uncertainty, repeat the measurement to ensure accuracy.

11. Maximum Testing Levels

For patients with mild to moderate hearing loss, when assessing LDL to evaluate reduced dynamic range, stimulus levels should generally not exceed 90 dB HL. This precaution helps limit exposure to high-intensity sounds.

In more complex cases—such as patients with more severe hearing loss or those reporting significant loudness intolerance—there may be clinical justification for testing above 90 dB HL. In these situations, determining frequency-specific discomfort levels can be important formanagement decisions, including hearing aid programming. Any testing above 90 dB HL must be justified, clearly documented, and conducted only by an experienced clinician.

12. Recording

LDLs should be documented using standard audiometric symbols. If the patient does not respond before reaching the maximum recommended level or the audiometer's output limit, the result should be recorded as "greater than" that level.

Any deviations from the standard procedure, use of alternative stimuli, or changes in the behavioural criteria used to determine LDL must be clearly noted alongside the audiogram.

13. Summary

LDL measurement is a straightforward yet highly valuable component of audiological assessment. When performed efficiently and interpreted correctly, it provides essential information for optimising hearing aid output and ensuring patient comfort. Subsequent clinical application includes integration with fitting software, selection of compression strategies, and verification through objective measures such as probe microphone testing and speech mapping.

ACAud / HAASA Protocol: Aural Impression-Taking

Purpose

Provide a safe, standardised, evidence-based protocol for taking aural impressions for custom earmoulds, hearing aids, and earplugs. This document outlines preparation, clinical technique, safety measures, contraindications, troubleshooting and post-procedure care.

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1. Client Management & Preparation

1.1. Explain & Consent

- Clearly explain the full procedure, expected sensations (fullness, pressure, possible cough reflex), and the need to minimise movement.
- Inform tinnitus clients they may temporarily notice increased awareness of tinnitus.
- Obtain verbal and/or written consent as per clinic policy.
- Advise client to remain silent and keep jaw relaxed unless doing an open-jaw impression.

1.2. Hygiene

- Wash hands before and after the procedure.
- Follow clinic infection control and equipment hygiene standards.
- Use gloves where required.

1.3. Assess Client History

Ask about:

- Ear surgeries
- Pain, infections,discharge
- History of perforated eardrum
- Known mastoid cavity

- Remove glasses or earrings only if they obstruct access. If worn daily, they may remain on for accurate concha shape.

2. Pre-Impression Otoscopic

Examination 2.1. Examine Both Ears

Inspect canal and tympanic membrane thoroughly using otoscope or videootoscope.

Identify:

- Wax blockages
- Foreign bodies
- Active infection
- Anatomical variations (e.g., stenosis, exostoses, sharp bends)
- Mastoid cavities or surgical changes

2.2. Contraindications

Do **not** take impressions

when:

- Active infection is present (outer or middle ear)
- Blood is visible in the ear canal
- Pain on examination
- Unresolved foreign body or heavy wax occlusion
- Recent ear surgery or unhealed tissue

Refer to GP/ENT where appropriate.

3. Preparation for Impression-taking

3.1. Client & Work Area

- Place towel or tissue over the client's shoulder.
- Trim excessive outer-ear hair only with their permission and using safe scissors.
- Avoid petroleum-based products inside the canal (risk of airtight seal and barotrauma).

3.2. Stabilisation

- Clinician must brace their hand against the client's head during otostop/otoblock insertion to prevent accidental injury.

4. Otoblock/Otostop

Placement 4.1. Selection

- Choose correct size based on otoscopy: large enough to seal canal without causing pressure.
- Ensure the removal string is intact and accessible.
- If more than one otostop/otoblock is necessary to fill the ear canal, use more than one.

4.2. Insertion Technique

- Use an illuminated earlight or otolight.
- Pull pinna up and back to straighten canal.
- Insert otoblock just past the second bend, avoiding unnecessary depth.
- Re-check placement with otoscope to confirm:
  - Full circumferential seal
  - No gaps for material to pass beyond the block
- Keep the otoblock string visible and positioned for stability while injecting material.

5. Preparing Impression Material

5.1. Material Types

- Addition silicone (preferred for flow and stability)
- Condensation silicone (requires catalyst mixing)

5.2. Mixing & Loading

- Follow manufacturer instructions.
- Avoid air bubbles while mixing or loading syringe/gun.
- Ensure viscosity allows smooth, controlled injection.

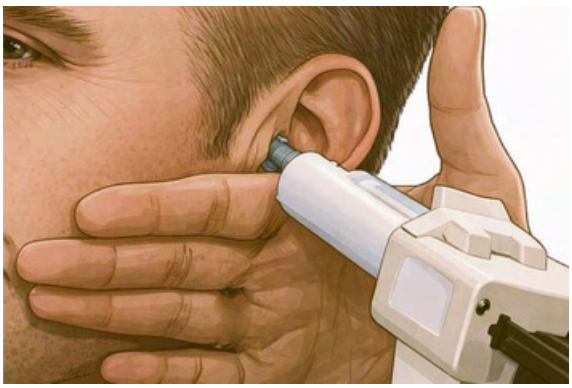
6. Injecting the Impression Material

6.1. Client Instructions

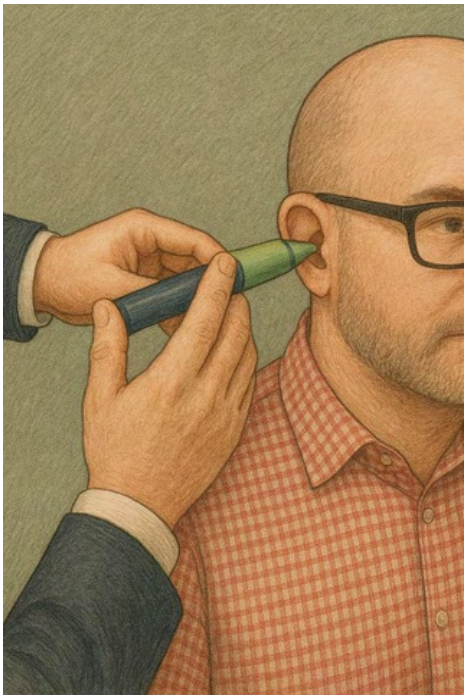
- Sit upright, remain still, no speaking.
- Keep mouth relaxed unless using open-jaw technique.

6.2. Syringing Technique

- Brace one hand against client's head if possible



- To avoid changing the shape of the canal by accidental pressure, some people prefer not to brace near the ear, and prefer to syringe without contact. One must however make sure that the client understands that they have to sit still for the procedure and not move their head.



- Insert nozzle toward otoblock without touching it.
- Begin injecting at the deepest point to prevent air trapping.
- Slowly withdraw syringe while maintaining continuous flow and keeping nozzle embedded in material.

Fill:

  - Ear canal
  - Cavum and cymba concha
  - Helix and tragus surfaces

- Avoid overfilling; excessive weight can distort the natural shape.

6.3. Curing

- Allow impression to set fully (typically 5–10 minutes).
- Do not touch or manipulate the material while curing.

7. Removing the Impression

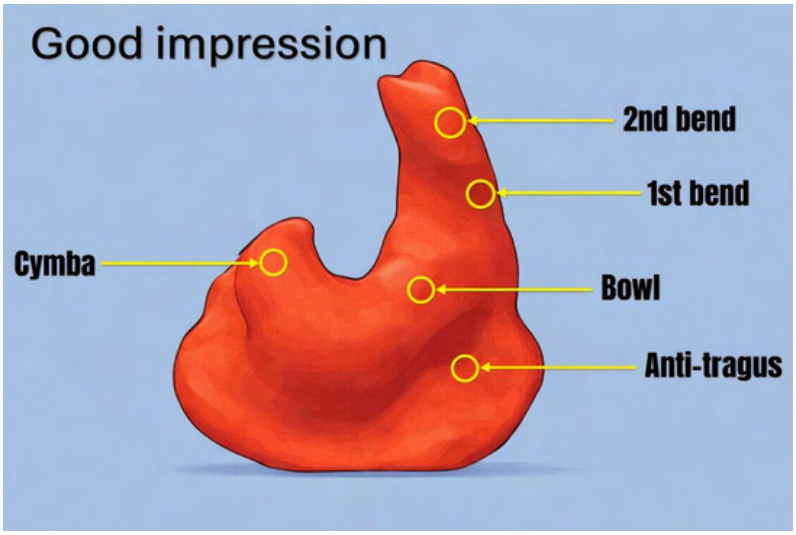
- Test for full cure by pressing lightly with a fingernail (no imprint = ready).
- Gently move the pinna to break the seal.
- Slowly rotate and ease the impression out, ensuring the otoblock is removed with it.
- Client may gently move their jaw to assist release.

8. Post-Impression

Checks 8.1. Inspect the

Impression Ensure:

- Full canal length appropriate to device type
- Inclusion of second bend (unless contraindicated)
- Complete concha/helix/tragus details
- No voids, folds, tears, or bubbles



If inadequate → Retake the

impression. **8.2. Re-examine the Ear**

- Confirm no material is left behind.
- Check for irritation, redness, abrasions, bleeding.
- Clean outer ear only if necessary.

9. Open-Jaw Impression Technique (When Required)

Used for:

- Deep canal fittings (e.g., CIC)
- Clients with significant mandibular canal movement
- Improved retention for specific products

Procedure:

- Insert otoblock first.
- Place a clean bite-block between side/rear teeth. Standardised bite blocks should be available from suppliers who supply impression materials.

- Re-check otoblock seal withotoscope.
- Proceed with impressioninjection.
- Remove bite-block **before**removing the impression.
- Take extra care as impression will fit more tightly.
- Suggestion: The bite block placement may cause the client to not have control over salivating.
- Hand them a paper towel or tissue to avoid this.

10. Special Cases & Modifications

10.1. Post-Surgical Ears

- Avoid until fully healed.
- For mastoid cavities:
  - Only trained clinicians should pack the cavity with multiple otoblocks.
  - Confirm complete seal with otoblocks before injecting material.
- If untrained rather refer to an experienced clinician.

10.2. Perforated Tympanic Membrane

- Impression may be taken if no active infection.
- Extra caution during removal to avoid barotrauma.

10.3. Stenosis (Narrow Canals)

- Higher risk of material locking behind the narrow point.
- Insert otoblock at or just beyond stenosis.
- Impressions may need to be shorter.

10.4. Deep-Fit Devices

- Only clinicians trained in deep-canal impressions should attempt these.
- Avoid if canal anatomy is unsuitable or unsafe.

10.5. Excess Wax or Foreign Body

- Must be removed before impression-taking.

10.6. Unusual or High-Risk Situations (e.g. blood thinners)

- Seek supervision from a more experienced clinician.

11. Post-Procedure Care & Documentation

11.1. Client Aftercare Advice

- Mild temporary fullness is normal; pain is not.
- Report any:
  - Persistent discomfort
  - Bleeding
  - Ongoing tinnitus changes
  - Suspected retained material

11.2. Labelling & Storage

- Label each impression immediately with the following information to avoid mistakes:
  - Client name
  - Date
  - Any special notes
- Store in protective case to prevent distortion while shipping.

11.3. Documentation

Record:

- Date and reason for impression
- Ear examination findings Material used
- Any complications
- Actions taken (e.g., referral)

12. Troubleshooting: Impression Stuck in

Ear If impression will not remove easily:

- Stop immediately; do **not** pull forcibly.
- Keep client calm and still.
- Refer urgently to ENT or trained clinician skilled in foreign-body removal.
- If canal abrasion is present and clinically appropriate, topical vasoconstriction (e.g., medicated
- spray on cotton bud) may assist—ensure no allergies.
- Complete incident report and document fully in client records.

13. Health & Safety

- Maintain stable clinician posture; avoid performing while unsupported.
- Client should not be left unattended during impression curing.
- Ensure all equipment is clean and functional.
- Follow infection control standards for disposal and disinfection.

1. Infection Control & Safety

Core for all clinics and required for accreditation.

- Hand hygiene procedures
- Cleaning and disinfection of equipment
- Personal protective equipment (PPE) when necessary
- Cerumen management hygiene
- Probe tip sterilisation / single-use protocols
- Management of blood/body fluid exposure
- Waste disposal

2. Patient Management & Consent

Administrative + ethical procedures.

- Informed consent (assessment, impressions, fitting)
- Confidentiality and record keeping
- Case history procedures
- Risk screening and red flags
- Referral pathways (ENT, GP, emergency signs)
- Cultural safety considerations (incl. Aboriginal & Torres Strait Islander health)

3. Otoscopy & Ear Examination

- Safe otoscopy procedure
- Identification of contraindications
- Documentation standards
- When to refer for wax removal or medical review

4. Diagnostic Audiology Procedures Pure Tone & Speech Testing

- Air conduction audiometry
- Bone conduction audiometry
- Masking procedures
- Speech recognition testing
- Speech-in-noise testing

Middle Ear Assessment

- Tympanometry
- Acoustic reflex testing
- Eustachian tube function testing

Additional Diagnostics (if applicable)

- Otoacoustic emissions (OAE)
- Auditory brainstem response (ABR) referral protocols
- Vestibular screening/referral procedures
- Referral protocols for BAHA and CI

5. Hearing Aid & Device Management Pre-Fitting

- Candidacy criteria
- COSI Goal setting and needs assessment
- Device selection protocols

Fitting Procedures

- Real ear measurements (REM)
- Verification and validation
- Orientation and counselling

Follow-Up

- Adjustment protocols
- Outcome measures (e.g., COSI)
- Troubleshooting guidelines

6. Ear Impressions & Physical Procedures

- Contraindications to impressions
- Otoblock placement procedure
- Safe impression material use
- Infection control during impressions
- Management of complications (retained material, bleeding)
- Documentation and incident reporting

9. Documentation & Reporting

- Audiogram recording standards
- Report templates
- Communication with referrers
- Incident reporting processes
- Data storage requirements

10. Emergency & Incident Procedures

- Medical emergencies in clinic
- Retained foreign body protocol
- Adverse reaction to impression material
- Sudden sensorineural hearing loss referral pathway
- Complaint management process

11. Quality Assurance & Competency

- Calibration schedules
- Equipment and biological calibration checks
- Clinical supervision requirements
- Continuing professional development

Clinical Practice Guidance

Probe Microphone Measurements for Hearing Aid Verification (Adults)

1. Introduction

Probe microphone measurements, also referred to as real-ear measurements (REM), are a critical component of modern hearing aid verification. These objective assessments allow clinicians to measure the sound pressure level produced by a hearing aid directly within the patient's ear canal. By doing so, clinicians can determine whether the hearing aid is delivering the appropriate level of amplification according to the prescribed fitting targets.

During these measurements, a probe tube connected to a miniature microphone is inserted into the ear canal so that the tip is positioned within approximately 5 mm of the tympanic membrane and at least 3 to 5 mm beyond the sound outlet (medial tip) of the hearing aid, receiver/dome or ear mould where safe to do so. Acoustic stimuli delivered from a loudspeaker are recorded at this point, allowing clinicians to measure the acoustic output generated by the hearing aid within the ear canal environment.

Because each ear canal has unique anatomical characteristics—including length, diameter, and resonance properties—the acoustic signal delivered by a hearing aid can vary substantially from one individual to another. Probe microphone measurements provide the only direct and reliable method of accounting for these individual acoustic differences during hearing aid programming.

Verification using probe microphone measurements enables clinicians to confirm that the hearing aid response matches the prescribed amplification targets. This process improves listening comfort, optimises speech audibility, and supports better communication outcomes.

Several evidence-based prescriptive formulas are commonly used within hearing aid fitting software, including:

- **NAL-NL2 (National Acoustic Laboratories – Non-Linear 2)**
- **NAL-NL3**
- **DSL m[i/o] v5.0**

Research consistently demonstrates that fittings aligned with these prescriptive targets result in improved speech intelligibility, listening comfort, and overall hearing aid satisfaction compared with fittings that deviate significantly from target values (Byrne & Cotton, 1988; Moore & Glasberg, 1998; Moore et al., 2001; Bentler et al., 2016).

Probe microphone measurements therefore provide a precise and dependable method for verifying whether a hearing aid is delivering the intended amplification and for making necessary adjustments to improve this match (Azah & Moore, 2007). In addition to gain verification, these measurements can also be used to evaluate advanced hearing aid features such as directional microphones, noise reduction systems, and frequency-lowering technology.

This guidance recommends the routine use of probe microphone verification during the initial hearing aid fitting process, as well as follow up and review appointments. The procedures described in this document are primarily intended for adult fittings, consistent with clinical practice standards for members of ACAud Inc. and HAASA.

2. Background Information

2.1 Prescriptive Targets

Prescriptive targets used during hearing aid fittings generally fall into two categories:

1. **Manufacturer-specific proprietary targets**, designed for individual hearing aid brands.
2. **Standardised evidence-based prescriptions**, such as NAL-NL2, NAL-NL3 or DSL.

Studies have shown that proprietary manufacturer targets may vary substantially from standardised prescriptive approaches (Keidser, 2003; Hawkins & Cook, 2003; Bentler, 2004; Aarts & Caffee, 2005; Leavitt & Flexer, 2012; Sanders et al., 2015; Munro et al., 2016). In some cases, proprietary targets may also be unavailable within independent verification systems.

For consistency across different hearing aid manufacturers, this guideline recommends the use of standardised prescriptions.

Most manufacturer fitting software allows clinicians to change proprietary targets to these standardised prescriptions.

Clinicians should exercise caution when changing the prescription of an existing hearing aid user, as alterations in the acoustic characteristics of amplification may negatively affect speech recognition performance (Convery & Keidser, 2011).

2.2 Acceptable Tolerance Limits

Ideally, measured hearing aid responses should fall within ±5 dB of the prescriptive target across the frequencies 250, 500, 1000 and 2000 Hz, but +/- 8 dB is acceptable for 3000 and 4000 Hz.

Additionally, the slope within each octave band (250 Hz to 6000 Hz) should remain within ±5 dB per octave relative to the prescribed target (Bentler et al., 2016).

If achieving the target response is not possible due to factors such as acoustic feedback, physical limitations of the hearing aid, or patient discomfort, clinicians should apply professional judgement and document the reasons for any deviations in the patient's clinical record. Ideally, factors such as feedback or gain limits should be addressed by prescribing different acoustic coupling and/or different hearing devices altogether (if possible).

2.3 Choice of Stimulus

Modern probe microphone systems provide several stimulus options for verification.
A calibrated, modulated speech signal, such as the International Speech Test Signal (ISTS), is recommended for most clinical measurements.

ISTS closely resembles natural speech patterns and provides a realistic representation of hearing aid behaviour when adaptive features such as compression and noise reduction are active. It is phonetically and phonemically balanced across six languages and remains unintelligible to the patient, thereby preventing distraction.

To obtain a stable and repeatable Long-Term Average Speech Spectrum (LTASS) measurement, the stimulus should be presented for a minimum of 10 to 14 seconds, although 15 seconds is recommended, and the signal can be run continuously while doing adjustments. It is important to note that the adjustments made will not show on the aided response graphs immediately and one should wait until the adjustments are reflected in the response curves as the LTASS requires a full 10 to 14 seconds to accurately average the response. Most verification devices do allow you to select a short-term averaging window, which allows you to make adjustments that are immediately reflected on the screen for quicker fine-adjustments. However, a final measurement using an LTASS time window is required to finalise to the chosen fitting prescription to target.

Please note - for hearing aids with slow time constants (slow attack and release times), longer measurement times of 15 to 20 seconds may be required.
Digital noise reduction (DNR) should typically remain active during ISTS testing to reflect real-world performance. It should be disabled when using older, non-speech stimuli (like composite noise) to avoid gain reduction artefacts.

However, testing hearing aids with non-speech stimuli—such as tone sweeps or composite noise—may produce different gain measurements due to the interaction between digital signal processing features and the stimulus type (Scollie & Seewald, 2002; Henning & Bentler, 2005).

2.4 Gain versus Response Measurements

Within probe microphone measurements:

- **G** refers to **Gain**
- **R** refers to **Response**

Gain represents the difference between the input signal level and the output produced by the hearing aid.

Response refers to the absolute sound pressure level (SPL) measured at a specified measurement point in the ear canal (ideally within 5 mm of the tympanic membrane) during the test.

Two commonly used measurements include:

Real Ear Aided Response (REAR)

The **Real Ear Aided Response (REAR)** represents the absolute SPL in the ear canal while the hearing aid is operating.

Real Ear Insertion Gain (REIG)

Real Ear Insertion Gain represents the difference between aided and unaided ear canal responses.

REIG = REAG (Real Ear Aided Gain) – REUG (Real Ear Unaided Gain)

However, provided that the same stimulus level has been used for both measurements, Insertion Gain can also be calculated as follows:

REIG = REAR (Real Ear Aided Response) – REUR (Real Ear Unaided Response)

2.5 Why REAR Is Preferred in Practice

Although REIG has historically been used for hearing aid verification, REAR has become the preferred clinical approach in practice.

REAR measurements provide several advantages:

- Direct display of sound pressure level within the ear canal, taking all features of the hearing aids and acoustic parameters into account
- Clear visual representation of amplified speech relative to hearing thresholds
- Improved evaluation of compression behaviour
- Better integration with modern prescriptive targets
- Reduced number of measurement steps (as no unaided baseline is required for the calculation). However, REAR requires greater precision in probe tube placement to ensure high-frequency accuracy.

REAR also enables clinicians to quickly assess:

- Audibility of soft speech (approximately 50–55 dB SPL)
- Comfort of average speech (approximately 65 dB SPL)
- Tolerance of louder inputs (75–80 dB SPL)
- Maximum power output (approximately 85 dB SPL), which is also displayed on the REAR graph (MPO is now known as REAR85 or REAR90, depending on which stimulus level is chosen, in the ANSI standards)

Please note: MPO (or REAR 85/90) measurements should be measured using a pure tone sweep or a signal using short bursts of pure tones at various frequencies. A broadband speech signal (such as ISTS) should not be used.

While both REAR and REIG can be used successfully when applied correctly, REAR provides a more intuitive representation of real-world hearing aid performance and is therefore recommended as the primary verification method.

3. Real-Ear Measurements

3.1 What Are Real-Ear Measurements?

Real-ear measurements are objective tests used to determine how a hearing aid performs inside the patient's ear canal.

A probe tube microphone is placed near the tympanic membrane, and a sound stimulus is delivered via a loudspeaker. The probe microphone records the sound pressure level reaching the tympanic membrane specified measurement point in the ear canal, ideally within 5 mm of the tympanic membrane, allowing clinicians to measure the true acoustic output produced by the hearing aid in that individual ear.

These measurements help clinicians determine whether the hearing aid is delivering the intended amplification across frequencies and whether adjustments are required.

3.2 Why Perform Real-Ear Measurements?

The primary goal of verification is to ensure the hearing aid is performing according to the prescribed targets and providing optimal benefit to the patient.

Real-ear measurements allow clinicians to:

- Confirm that amplification matches the prescribed target
- Account for individual ear canal acoustics
- Evaluate hearing aid features such as directional microphones
- Verify frequency-lowering technologies
- Assess maximum output levels
- Ensure appropriate audibility of speech signals

Without verification, reliance on the manufacturer's suggested (first-fit) settings may result in inaccurate amplification.

3.3 Limitations of Manufacturer First Fit

Research by Valente et al. (2017/2018) demonstrated that manufacturer first-fit settings often deviate substantially from prescriptive targets, particularly at higher frequencies.

When real-ear verification is used to program hearing aids:

- Target matching improves significantly
- Speech recognition scores increase
- Patients demonstrate greater satisfaction

In the same study, patients preferred the verified real-ear fittings 79% of the time, compared with 21% for first-fit settings.

These findings highlight the importance of performing objective verification during the hearing aid fitting process.

Manufacturer defaults typically under-fit targets by 10 to 15 dB (and occasionally up to 20 dB) in the higher frequencies at softer input levels (Ricketts, Bentler & Mueller, 2019).

4. Contraindications for Real-Ear Measurements

Real-ear measurements are generally safe for most adult patients. However, testing may be contraindicated in certain situations involving abnormalities of the ear canal.

Contraindications may include:

- Excessive cerumen (25 % occlusion)
- Ear canal discharge
- Significant ear pain
- Perforations - it is safe to do real ear measures on patients who have stable dry perforations following medical clearance. If a perforation is new or previously undocumented, measurement can proceed following medical clearance. Please note that large perforations may alter the ear canal resonance and measurement results

If excessive cerumen obstructs the ear canal or prevents visualisation of the tympanic membrane, it should be removed prior to testing.

Ear canal infections or pain may also require postponement of measurements until the condition has resolved.

5. Equipment Setup

Accurate probe microphone measurements require a properly configured testing environment.

Patient Positioning

For Real Ear Aided Response measurements:

- The patient should face the loudspeaker at **0° azimuth horizontally and vertically. If not possible in the vertical plane, the loudspeaker must be positioned above the client's ear height**
- The loudspeaker should be positioned **80–100 cm** from the client
- The speaker should be aligned **at ear height-if not possible, the loudspeakers should be higher than ear level**

This configuration minimises measurement errors caused by head diffraction, room reflections, or directional microphone effects.

Reflective surfaces should be, and ambient noise levels must remain sufficiently low so that the test signal exceeds background noise by at least 10 dB across frequencies. The clinician must ensure that the customer is not close to a wall with at least 1.5 meters from the wall and ear closest to the wall. Reflective surfaces could cause inaccurate signal levels, create standing waves which in turn reduces test accuracy. The general rule of thumb is that the nearest reflective surface should be twice the working distance from the customer. The clinician also needs to ensure that they themselves do not become a reflective or diffractive surface and should be positioned well clear of the sound field.

6. Probe Tube Calibration

Before performing real-ear measurements, the probe tube must be calibrated. This calibration must be done for each client and each test session, not just once a day. This calibration compensates for the acoustic effects introduced as sound travels through the probe tube to the probe microphone. It essentially removes the unique acoustic effects of the probe tube itself, making sure the microphone measures the true sound at the tympanic membrane specified point in the ear canal, not the sound altered by the tube. This process makes the probe microphone acoustically invisible.

Because calibration values are applied to all subsequent measurements, it is essential that this process is performed accurately in accordance with the manufacturer's guidelines. Ideally, the calibration must be performed before each REM procedure.
Although different manufacturers will suggest different distances from the speaker, the distance that has proven to be effective for all manufacturers is a distance of 0.5m from the speaker (British Society of Audiology, 2018).

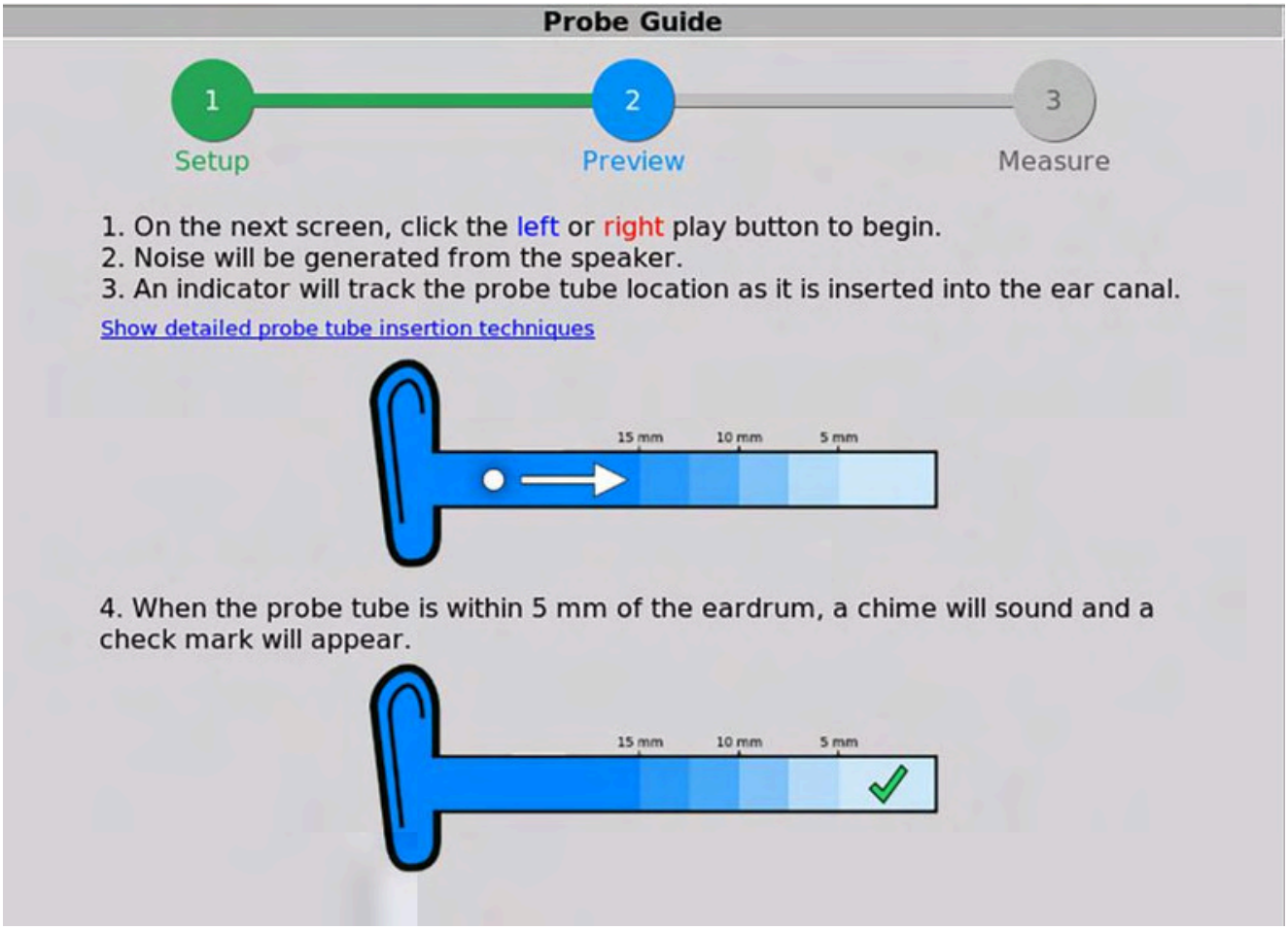
7. Probe Tube Placement

Correct probe tube placement is essential for obtaining reliable measurements, particularly at high frequencies.

Recommended practices include:

1. Use of Probe Placement Guidance Tools

Some verification systems provide visual or auditory indicators to assist with determining the appropriate insertion depth. The display will depend on the equipment used.



2. Perform Thorough Video Otoscopy

Video otoscopy (or traditional otoscopy) should be conducted priorto insertion to assess:

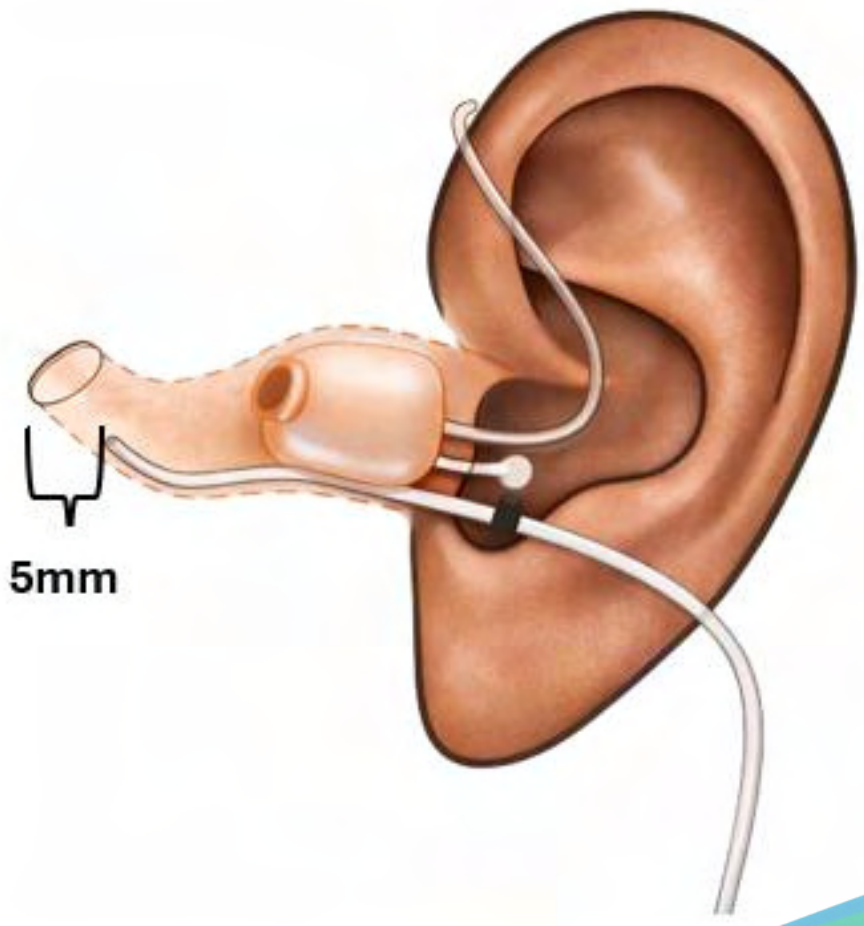
- Ear canal anatomy
- Cerumen presence
- Canal curvature
- Potential obstructions

3. Set the Probe Tube Marker

Typical insertion depth markers are:

- 28 mm for adult females
- 30 -31 mm for adult males

These measurements position the probe tube within approximately 5 mm of the tympanic membrane.

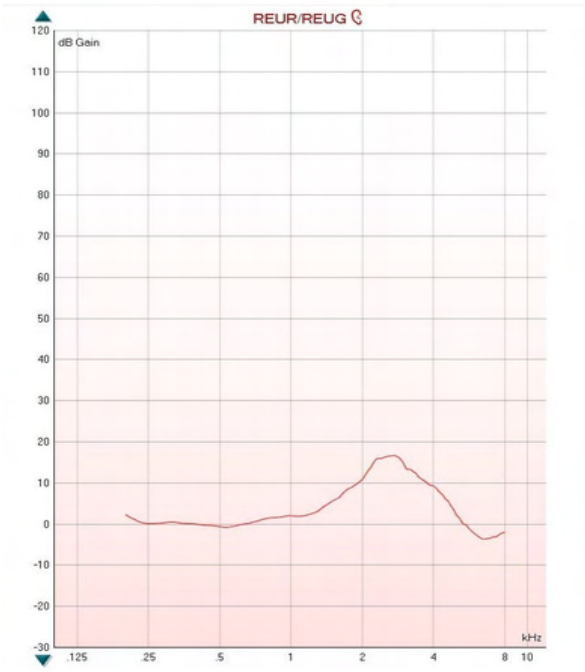


4. Evaluate Placement Using REUG/REUR

The Real Ear Unaided Response (REUR) curve can help confirm correct placement.

A typical adult REUR curve:

- Begins near 0 dB
- Peaks around 2–4 kHz typically around 2.7 kHz at approximately 17 dB, with a secondary peak in the 4-5 kHz range at approximately 12-14 dB gain
- Shows a dip near 6 kHz. This dip should not be more than -5dB. If it is, reinsert the probe tube and ensure the depth is closer to 5mm from the tympanic membrane.
- Returns toward 0 dB at higher frequencies



Abnormal curves may indicate probe placement errors, cerumen blockage, or insufficient insertion depth. If a flat line is observed, instead of a peak, it usually means an occluded probe tube or damage to the probe tube. If the curve at 6kHz drops below -5dB, it usually means that the probe tube is not inserted deep enough or the tip is hitting a canal wall or obstructed by wax or debris in the ear canal. Reinsert the tube and measure again, until the unaided response curve is optimal.

5. Real-Ear Measurement Procedure

5.1 Real Ear Unaided Response/Gain

The REUR/G measurement evaluates the natural acoustic resonance of the ear canal without amplification.

Use PINK NOISE as the signal of choice. Broadband speech signals, such as ISTS, should not be used to measure REUR.

This measurement can help verify correct probe tube placement and identify unusual ear canal acoustics. If the verification system uses a probe placement guidance tool, the software will guide you to the correct placement.

5.2 Real Ear Occluded Response (REOR or REOG if using Insertion Gain)

The REOR/G measurement is performed with the hearing aid inserted but switched off.
Use PINK NOISE as the signal of choice. Broadband speech signals, such as ISTS, should not be used to measure REOR/G.

Comparing REOR with REUR (or REOG with REUG) helps determine whether the fitting is acoustically open or closed, based on the degree to which the hearing aid or earmold occludes the ear canal. If the REOR/G is similar to the REUR/G, the fitting is considered to be open, and the open fit calibration (equalisation method) must be run.

This is an important step to include in your REM procedures (and often not done) as it gives you information you cannot determine for yourself. For example, if someone has a very small ear canal, even a small open dome may occlude the ear canal so much that it is no longer an open fitting. You can use this information to counsel the client and to rethink your choice of acoustic coupling.

5.3 Open Fit Calibration

FFor open fittings or large vented earmolds, an additional calibration may be required to account for sound leakage from the ear canal. Otherwise, without this step, the verification system assumes the test stimulus is too loud (due to amplified sound leaking from the ear). The system reacts by reducing the loudspeaker output, which results in an underestimation of the actual gain by 10 to 20dB.

During this procedure the hearing aid remains muted while the system adjusts measurement parameters to maintain accuracy.

Verifying Open Fittings

The term open fit refers to a hearing aid configuration designed to leave the ear canal largely unblocked, allowing low-frequency sounds—typically those below 1500 Hz—to escape naturally. This approach helps reduce the occlusion effect and can be achieved through various means, such as using open domes or custom earmolds with large vents.
It's important not to equate open fittings with specific hardware types like slim tubes or Receiver-in-Canal (RIC) devices. A vented earmold can still provide an open fit, while a slim tube or RIC with a dome may still result in significant occlusion.

An open fitting is best identified when the Real-Ear Unaided Response or Gain (REUR/G) and Real-Ear Occluded Response or Gain (REOR/G) measurements are nearly identical, indicating that the acoustic coupling is transparent and does not significantly alter the sound entering the ear.

Use the following criteria to determine whether a fitting is open or occluded, which will guide the choice of calibration method:

- **Occluded Fitting:**

If REUR/G and REOR/G differ significantly above 1.5 kHz—such as when REOR/G drops close to or below the input level—the fitting is considered occluded. In this case, the standard Modified Pressure Method with Concurrent Equalisation (which most verifications systems default to) will be used and you can proceed to do your REM as normal. No additional calibration step is necessary, and the reference microphone remains active to dynamically adjust for any patient movement during testing.

- **Open Fitting:**

If REUR/G and REOR/G are closely matched; the fitting is considered open. For these cases, "Open Fit calibration" or "OpenREM" calibration must be undertaken. This method is correctly called the Modified Pressure Method with Stored Equalisation (MPMSE) calibration and should be done with the hearing aid microphones turned off. If the patient's position changes after calibration, the process must be repeated to maintain accuracy.

Open-Fit Calibration (MPMSE)

- The “calibrate for open fit” function is used when verifying open-fit hearing aid fittings. This calibration helps prevent amplified sound from escaping the ear canal and being detected by the reference microphone during aided measurements, which could otherwise affect measurement accuracy.
- The procedure involves a single step. The hearing aid should be positioned correctly on the patient’s ear while the device is switched off or muted using the hearing aid fitting software. Once the hearing aid is in place and inactive, the open-fit calibration can be initiated within the real-ear measurement system.
- After the calibration is completed, the hearing aid should be turned on or unmuted, and the REAR measurement should begin immediately, ensuring the patient does not move between these steps, to maintain probe tube placement and measurement accuracy. Additionally, the measurement needs to be repeated if the clinician needs to move into the sound field or if the position of any reflective or diffusing surfaces is moved during the measurement session.

5.4 Real Ear Aided Response (REAR)

The REAR measurement verifies the hearing aid’s performance while it is operating.

Measurements are typically performed at multiple input levels with any Digital Signal Processing algorithms activated, including:

- **Soft speech**: 50–55 dB SPL ISTS for at least 15 secs (Suggestion: Use 55dB SPL as 50dB SPL could be too close to ambient noise in your room)
- **Average speech**: 65 dB SPL ISTS for at least 15 secs
- **Loud speech**: 75–80 dB SPL ISTS for at least 15 secs (Suggestion: Use 75dB SHPL as 80dB SPL could be too loud or startling for some clients)
- **Maximum output (REAR85/90)**: approximately 85 dB SPL pure tone sweep signal or similar (some manufacturers suggest 90dB SPL, but some equipment will be limited. Also, it may be too loud for some clients.). **Ensure to deactivate frequency lowering when testing this measure.**

Gain adjustments should be made within the fitting software until the measured response closely aligns with the prescribed targets. While the original sequence may be appropriate for some hearing aid devices, most modern hearing aids use nonlinear wide dynamic range compression (WDRC) with compression kneepoints typically around 50 dB SPL. For this reason, many advanced verification protocols recommend beginning with soft speech inputs (50–55 dB SPL).

Adjusting gain for soft speech first establishes an appropriate baseline for audibility. Once soft speech targets are met, gain for loud speech inputs (75–80 dB SPL) can be adjusted by modifying compression ratios and kneepoints. These adjustments generally have minimal impact on the previously established soft speech gain, reducing the need to repeatedly verify and readjust the average speech curve at 65 dB SPL.

A more efficient approach is therefore to:

1. Verify and adjust gain for soft speech (50–55 dB SPL) first.
2. Verify and adjust gain for loud speech (75–80 dB SPL) second.
3. Confirm average speech (65 dB SPL) as a final check.

In most cases, the average speech response will be close to target once the soft and loud speech inputs have been appropriately adjusted. Once acceptable agreement with the targets, as previously described elsewhere in this document, has been achieved across input levels, the objective verification stage of the fitting is complete.
There are many resources on the internet that are specific to the manufacturer of the verification system you employ. Additionally, equipment manufacturers are always happy to facilitate further and ongoing training on your device of choice

6. Background Noise Requirements

Probe microphone measurements should be conducted in an environment where ambient noise does not compromise the test signal.
The stimulus must exceed background noise levels by at least 10 dB across frequencies, and the sound field should remain stable within ±3 dB of the intended signal level.

7. Annual Equipment Calibration

Probe microphone measurement systems must comply with IAS IEC 61669:2024 and undergo full calibration at least once every 12 months.
If equipment damage is suspected, recalibration should be performed immediately.
Calibration dates should be clearly displayed on the equipment for easy reference.

8. Documentation 8. Documentation

All verification measurements should be documented within the patient's clinical record, including:

- Equipment used
- Stimulus type
- Prescriptive target selected
- Measurement curves
- Deviations from standard protocols
- Clinical rationale for any target mismatches

Measurement curves should be stored within the electronic patient management system.

Note: At times clients cannot tolerate the prescribed gain, especially when they receive hearing aids for the first time. It is important to measure the gain at target and save that curve to prove that the hearing aids can achieve the required gain (as per HSP requirements). However, it is also important to show what level of sound the client left your office with. If for example, the gain is turned down 10%, measure the reduced gain curve as well and make notes as to why the second curve is not matching target. Be sure to either switch the automatic acclimatisation (adaptation) on so the hearing aids can gradually increase the gain up to target or make adjustments at the follow up appointment. At times it may take even longer for a new user to move from the reduced gain to the target gain and must be determined on a case-by-case basis.
It is important to counsel the client that even though reducing gain may increase their comfort, it may be compromising their ability to hear soft speech. The ultimate goal is to have speech audible, but comfortable and your verification process is there to obtain this goal. Use your REAR curves to counsel the client about the audibility of sound, and of the objectives you will reach together (with their feedback and your expertise).

9. In Summary

It is important that real-ear measurements (REM) are not viewed solely as a verification procedure required to meet HSP requirements. These measurements play a crucial role in achieving optimal hearing aid fittings, improving client satisfaction, and ensuring the best .possible communication outcomes for individuals with hearing loss

Here are the steps to perform REAR.

Step	Procedure
1. Set up equipment	Ensure the real-ear measurement system is on. Seat the patient facing the loudspeaker at approximately **50 - 100cm** and **0° azimuth horizontally and vertically**. Ensure that, if needed, the verification equipment has been Sound Field Equalised to the test environment. This is essential if the device is moved into position between clients or moved between test sites or rooms.
2. Explain procedure	Explain the test to the patient and ask them to remain still and quiet during measurements.
3. Probe tube calibration	Calibrate the probe tube according to the system instructions before inserting it into the ear. Some systems require a distance of 30cm from the speaker, and some suggest to place the probe tubes on ear level while performing the calibration. If you are unsure of your manufacturer's specific requirements, a 50 cm distance is a good rule of thumb.
4. Insert probe tube	Insert the probe tube into the ear canal so the tip is approximately 5mm from the tympanic membrane and at least 3 to 5 mm beyond the sound outlet of the hearing aid receiver or ear mould
5. Secure probe tube	Make sure the probe tube will not move during testing
6. Perform REUR / Perform automatic probe depth test	Perform the REUR to ensure tube placement depth (approximately 5mm from tympanic membrane) by looking at the REUR curve. Specifically monitor the 6 kHz region. A dip of deeper than -5 dB at 6 kHz is a reliable clinical indicator of shallow probe insertion. If the equipment allows, use the probe depth placement tool. Once placement is satisfactory, run your baseline REUR/G measurement.
7. Insert hearing aid	Place the hearing aid in the ear and ensure it is positioned correctly and comfortably. Make sure not to move the probe tube.
8. Perform REOR	Switch the hearing aids off in the ears and run the REOR test. If the REOR and REUR are the same, your fitting is open. If you confirm your fitting is open, proceed to step 9. If the fitting is not open, proceed to step 10.

Step	Procedure
9. Open-fit calibration (if required)	Perform "calibrate for open fit" when using an open-fit hearing aid or dome. Make sure to run the open fit calibration while the hearing aids are switched off (the MPMSE method)
10. Select stimulus	Choose the test signal (e.g., speech stimulus) and presentation levels. As mentioned before, many will start with medium inputs (65dB SPL), then softer inputs (50/55dB SPL), then loud inputs (75/80dB SPL), and again checking medium to confirm no major changes has occurred. **However, consider testing soft speech first, then loud speech, and then check your average speech. It may speed up your workflow.)** ISTS is the gold-standard signal of choice.
11. Set up your prescriptive target	Choose your prescriptive target (e.g. NAL-NL2, NAL-NL3 or DSL m[i/o] v5.0 Ensure that you appropriately set up the parameters – further information can be found in your equipment manufacturers reference documentation or by reaching out to your equipment manufacturer. Incorrect selections can result in the wrong transform functions (calculations) being applied resulting in the incorrect target being generated.
12. Measure REAR	Record the **Real-Ear Aided Response** while the hearing aid is operating in the ear.
13. Compare to targets	Compare the measured response with the prescriptive targets. Gold Standard: 0.25, 0.5, 1 & 2 kHz = +/- 5 dB to target 3 & 4 kHz = +/- 8 dB to target
14. Adjust hearing aid	Modify hearing aid gain/output if necessary and repeat the measurement.
15. Additional input levels	Repeat for each input level (soft speech, average speech and loud speech and adjust the hearing aid as appropriate.
16. Verify MPO (REAR85/90)	Use a pure tone sweep (or swept warble tones or another appropriate signal) at 85 or 90 dB SPL. Ensure that the recorded measure does not exceed the client's Loudness Discomfort Levels/Uncomfortable Loudness Levels (either measured during audiometry or averaged by your prescription choice (NAL or DSL).
17.Record the "out the door" (client preference)	Make a final 65 dB ISTS measurement of the settings the client is walking out the door with following adjustments. If deviating from target, ensure to notarise the reasoning. Additionally, this step allows a further "troubleshooting" tool further down the client's hearing healthcare journey.
18. Save and document	Save the results and document the measurement curves in the patient record.

Here are several videos demonstrating the main procedures according to Interacoustics. While different real- ear measurement systems may display results differently and vary slightly in their operation, the underlying principles and procedures remain the same.

Interacoustics videos:

1. Preparing for REM: https://youtu.be/OJKMev5Z6qA?si=9b3zJzzmp704awrw
2. Probe tube placement: https://youtu.be/zBgDES0kkqI?si=uzlSWKsTzZnw4uUN
3. Unaided Real Ear Measurements: https://youtu.be/MYwJMsewC2c?si=IJ0BFvbct7vt4-ra
4. Real Ear Aided Response: https://youtu.be/35FaOzHzctw?si=uJMTtC1sq_OvXRpr