RM500SL HEARING INSTRUMENT FITTING SYSTEM

USER'S GUIDE

Version 3.2

ã November 2008

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The Audioscan® RM500SL User's Guide Version 3.2

Main Display Unit

Power Cord Management

Power Switch

Hearing Aid Test Chamber

Keypad

1 About RM500SL

1.1 Section overview

This section provides a listing of features **new in this software release**, instructions for **accessing the electronic User's Guide**, contact, **warranty** and trademark information, and **notices** for the **European Community**.
Help is available on the following topics by pressing <Help>

2: Getting Started	12: On-ear Screen Setup
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In addition you will find a glossary, references and more information in the electronic user's guide on the Audioscan software CD.

FastFacts 1.1: RM500SL Help topics

1.2 New in this software release

Software 3.2 introduces the following additions and changes:

1) **Barcodes are appended to print to file images** allowing the user to automatically reenter the audiometric data associated with the image

2) **Context-sensitive help** buttons have been added to all error messages, prompts and menus to provide a more user-friendly experience

Software 3.0 introduced the following significant additions and changes:

1) **Noise reduction test** quickly demonstrates benefit for real-world noises

2) **Feedback suppression** test shows effectiveness in reducing feedback tendency and the impact of feedback suppression on speech

3) **DSL 5.0a** incorporating the latest revisions to the DSL 5.0 fitting method

4) **CAMFIT** – a fitting method for adults developed at the University of Cambridge

5) **Store complete sessions** to a USB memory stick or a network file in XML format and return them to the SL at any time for viewing. **Please note** that this new feature may result in the creation of Individually Identifiable Health Information which must be protected under the HIPAA Security Rule. See 6: Printing and Storing Results .

6) **Both graphic and tabular data** on one printout

7) **Receiver in the ear** (RITE) hearing instruments supported in Speechmap

8) **Speech envelope** can be hidden or displayed for each speech curve and is automatically hidden when a new test is run.

9) **Scrolling on-line help pages** – more help on each page

Please consult the relevant section of this User's Guide or Help for more details.

FastFacts 1.2: New in this software release

1.3 Electronic user's guide

A printable electronic user's guide always accompanies Audioscan software. A .pdf file viewer, such as Acrobat Reader (5.0 or higher) or Foxit Reader is required to view the User's Guide. Foxit Reader is supplied on the CD-ROM.

1) Insert the CD-ROM into the CD drive on your computer.

2) Select My Computer, then the CD drive and the User's Guide folder.

3) To install Foxit Reader, copy FoxitReader.exe to an appropriate location on your PC. To run FoxitReader.exe double click it.

4) To view the User's Guide, double-click the RM500SLUsersGuide.pdf file.

The User's Guide may also be downloaded from www.audioscan.com.

FastFacts 1.3: Electronic users guide

1.4   Warranty, Trademarks, Acknowledgements

The **Audioscan RM500SL** is an electro-acoustic test system used to verify the performance of a hearing aid in an ear simulator (2cc coupler) or in the ear of a wearer. It is manufactured by Etymonic Design Inc., 41 Byron Ave., Dorchester, Ontario, Canada, N0L 1G0.   www.audioscan.com
Phone: 800-265-2093 (USA only); 519-268-3313   **Fax:** 519-268-3256
Email: info@audioscan.com or service@audioscan.com

Warranty: The RM500SL is warranted against defects for two years from date of purchase. Within this period, it will be repaired without charge for parts, labor or return shipping when returned prepaid to your authorized Audioscan service agent. **This warranty does not apply to battery substitutes (pills)**, which carry a 90 day warranty, or to equipment that, in our sole judgement, has been subject to misuse, or unauthorized alteration or repair.

Trademarks: Audioscan, Verifit, and Speechmap are registered trademarks of Etymonic Design Inc. DSL is a registered trademark of The University of Western Ontario. HP LASERJET is a registered trademark of Hewlett-Packard Company. IBM is a registered trademark of International Business Machines Corporation. K-AMP is a registered trademark of Etymotic Research Inc. KEMAR is a registered trademark of Knowles Electronics Inc. QUEST is a trademark of Quest Technologies Inc. PostScript is a registered trademark of Adobe Systems, Inc.

Acknowledgements: DSL 5.0 is used under license from the University of Western Ontario (UWO) which is soley responsible for its content. We acknowledge the support received from past and present staff at the National Centre for Audiology at UWO in implementing the DSL method. CAMFIT is used under license from Prof. Brian C.J. Moore, University of Cambridge, UK. We are indebted to the University of Memphis Hearing Aid Research Laboratory for permission to use some of their recorded speech material.

FastFacts 1.4: Warranty, trademarks, acknowledgements

1.5   Notices for the European Community

Electromagnetic Compatability (EMC)

Medical electrical equipment needs special precautions regarding EMC and needs to be installed and put into service according to the following information:

∨ The RM500SL should not be used adjacent to or stacked on other equipment. If this is necessary, its operation should be verified as normal in this configuration.

∨ Portable and mobile RF communications equipment can affect medical electrical equipment and may affect the performance of the RM500SL.

∨ The RM500SL has not been tested for immunity to electromagnetic disturbances. Performance degradation due to such disturbances (including electrostatic discharge) is considered normal and acceptable.

FastFacts 1.5: Notices for the European Community

1.6   Declaration of EMC compliance for the European Community

The compliances listed in the following table are met with the Audioscan SL-100 RECD transducer connected. The use of other accessories may result in increased emissions.

Guidance and manufacturer's declaration - electromagnetic emissions		
The RM500SL is intended for use in the electromagnetic environment specified below. The user of the RM500SL should assure that it is used in such an environment.		
Emissions test	Compliance	Electromagnetic environment - guidance
RF emissions CISPR 11	Group 1	The RM500SL uses RF energy only for its internal function. Therefore, its RF emissions are very low and not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class A	The RM500SL is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/ flicker emissions IEC 61000-3-3	Complies	

FastFacts 1.6: Declaration of EMC compliance for the European Community

2   Getting Started

2.1   Section overview

This section provides help on unpacking the RM500SL and connecting various components and accessories. Note that **battery pills** (SL-110), the **RECD transducer** (SL-100)**,** the **barcode scanner** (VA-120) and a **microphone extension cable** (VA-130) are accessories for the RM500SL and must be ordered separately.

The following topics are covered in this section:

2.2: Unpacking and connecting

2.3: Microphone connection

2.4: Microphone care

2.5: Battery pill use and care

2.6: Mouse, keyboard, barcode scanner

2.7: External printer, auxiliary audio outputs

FastFacts 2.1: Getting started

2.2   Unpacking and connecting

1) Carefully unpack the RM500SL and check the contents of the shipping box against the enclosed packing list. Note that some parts may be packed inside the test chamber.
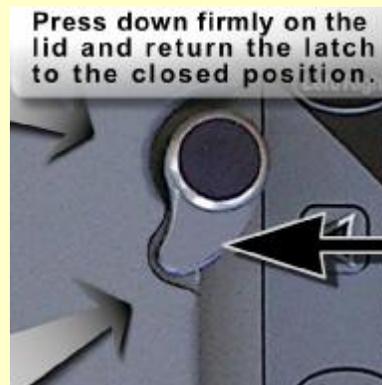
2) Unwrap the power cord from its stowage hooks - noting carefully how it has been packed. **To avoid serious damage to the display screen, always repack the cord this way.**

3) Connect the power cord to the socket next to the power switch on the right side of the unit. Plug the other end into a **grounded** 100 – 240 volt power outlet.

FastFacts 2.2: Unpacking and connecting

2.3 Microphone connection

1) Plug the reference microphone and the coupler microphone into the connectors in the test chamber as shown.
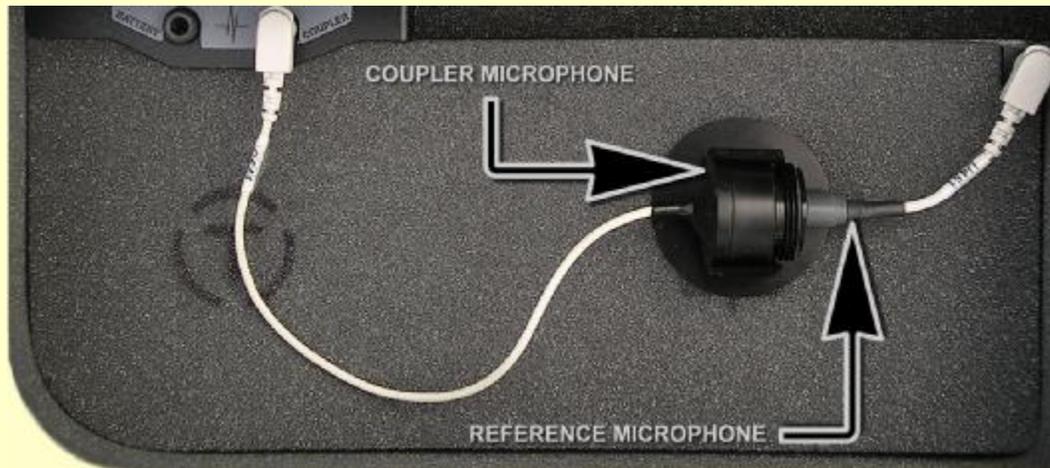
2) Plug the probe microphone assembly into the probe connector located at the left of the test chamber as shown.

NOTE: A microphone extension cable (VA-130) is available from Audioscan. Standard audio extension cables should not be used. They will substantially increase noise levels.
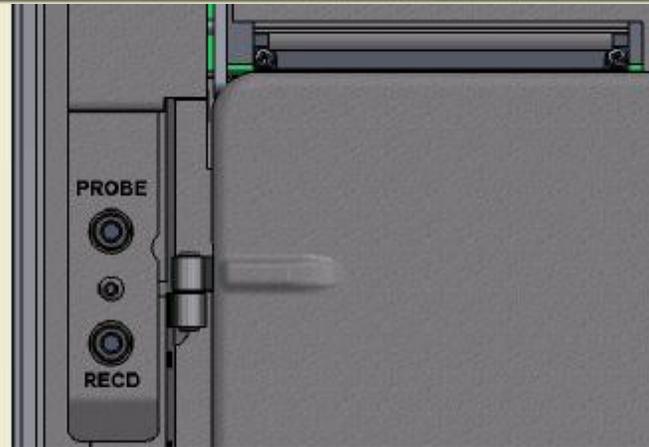
FastFacts 2.3: Microphone connection

2.4 Microphone care

Coupler microphone:

1) **DO NOT** twist the cable when attaching a coupler to the coupler microphone. Turn only the coupler or unplug the coupler microphone before turning it.

2) **DO** store the coupler microphone in its mounting clip when transporting.

3) **DO** make sure that the 2cc coupler is tightly screwed to the coupler microphone when performing hearing instrument tests. **Coupler leakage can cause feedback and erratic response curves.**

4) **DO** ensure there are no cracks in the #13 tubing on the BTE (HA-2) coupler.

5) **DO** replace the tubing on the BTE coupler with 3/8" (10 mm) of #13 tubing.

Probe microphone:

1) **DO NOT reuse probe tubes**. Debris and liquid from cleaning attempts can lodge in the enlarged base of the probe tube and subsequently clog the probe microphone port.

2) **DO NOT** attempt to open or repair the probe microphone. Attempting to repair the probe module may lead to damage or alteration of the factory calibration.

3) **DO** keep the probe module and probe tubes in a clean area.

4) **DO** stow the probe module when not in use or when transporting the RM500SL.

FastFacts 2.4: Microphone care

2.5 Battery pill use and care

Battery pills are optional. The **thin connecting strip** of each battery pill **is fragile**. When inserting pills into hearing instrument battery compartments, take care that this strip is not pinched or bent severely as the battery door is closed.

1) Select a battery pill that is appropriately sized for the hearing instrument that you are testing.

2) Insert the pill into the hearing instrument, carefully closing the battery door over the thin connecting strip.

3) Plug the pill's cable into the battery pill jack inside the RM500SL Test box. (to the left of the coupler microphone connection).

4) Turn the hearing instrument on.

FastFacts 2.5: Battery pill use and care

2.6   Mouse, keyboard, barcode scanner

The RM500SL may be operated from the **built-in keypad**, a USB **mouse** (not included) or a standard USB computer (QWERTY) **keyboard** (not included), which may also be used to enter headers and comments on printouts: See 3.2 Input device operation.

An optional **barcode scanner** may be connected to the USB port to enter threshold, UCL and RECD data directly from a RM500SL or Verifit printout. Barcoded threshold data printed by some Grason-Stadler audiometric equipment may also be scanned. Scanners other than that supplied by Audioscan may not work and are not supported by Audioscan.

Multiple USB devices may be used together by connecting them to the RM500SL USB port via a USB hub.
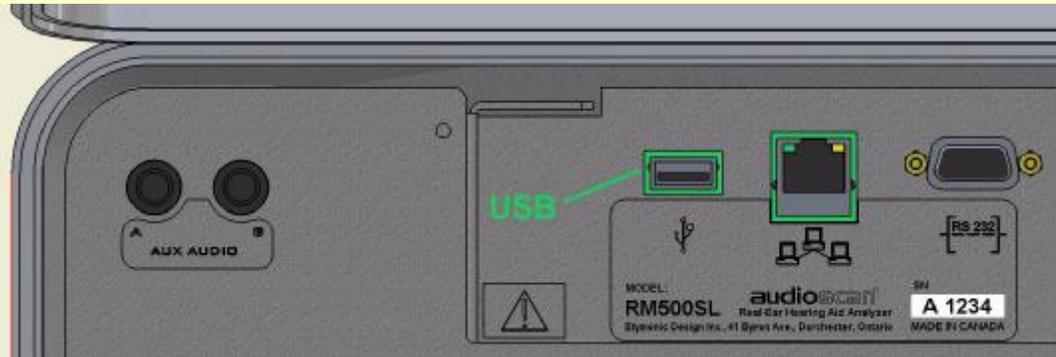
⚠️..In the European Community, if this device is connected to one or more other devices to make a system, the CE mark on this device is only valid if the other devices in the system carry a CE mark in respect of the Medical Device Directive and if the supplier has stated that the requirements of the Medical Device Directive will be met for this particular combination.

FastFacts 2.6: Mouse, keyboard, barcode scanner

2.7 External printer, auxiliary audio outputs

An **external printer** may be connected to the the USB port. It may be color or black & white but it **must be PCL3, PCL5 or PostScript compatible**. The external printer must first be selected in Setup. See 6: Printing and Storing Results
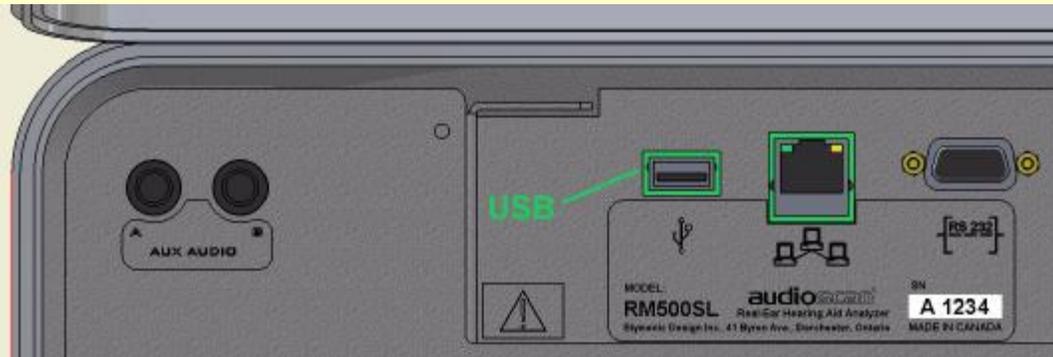
Auxiliary audio output jacks are not active with this version of software.

⚠..In the European Community, if this device is connected to one or more other devices to make a system, the CE mark on this device is only valid if the other devices in the system carry a CE mark in respect of the Medical Device Directive and if the supplier has stated that the requirements of the Medical Device Directive will be met for this particular combination.

FastFacts 2.7: External printer, auxiliary audio outputs

3 General Operation

3.1 Section overview

The RM500SL is operated by using the built-in keypad, a USB QWERTY keyboard (not included) or a USB computer mouse (not included). Any of these pointing devices can be used to select items from menus, operate on-screen buttons and to enter audiometric data. In addition, audiometric data printed in barcode form by the RM500SL, the Verifit VF1 or some Grason-Stadler products, may be scanned into the RM500SL.

This section covers the following topics:

3.2: Input device operation

3.3: Barcode data input

3.4: Keypad keys

3.5: Menus, lists and buttons

3.6: Screen messages

3.7: Program memory removal and replacement

3.8: Software updating

FastFacts 3.1: General operation

3.2　Input device operation

The RM500SL may be operated by means of the **built-in keypad**, an external **mouse** (not included) or an external QWERTY **keyboard** (not included). These devices are used to summon on-screen menus and select items from them, to operate on-screen buttons and to input data. The **scroll wheel** on a mouse will scroll through long lists in list boxes and in Help. **Clicking the right mouse** button generates an **image of the keypad** which may be operated by the mouse. **Clicking the left mouse button** when the mouse pointer is on a graph will display a **screen cursor** with a digital readout of X and Y co-ordinates. Clicking again will dismiss the cursor.

Function	Keypad	QWERTY	Mouse
Summon Help menu	<Help>	F1	Right click
Summon Setup menu	<Setup>	F2	Right click
Summon Test menu	<Tests>	F3	Right click
Summon Session menu	<Session>	F4	Right click
Switch between ears or Switch between A/B Data	<Left/Right>	F5	Right click
Print	<Print>	Print Scrn	Right click
Move across screen columns	⟷ Arrows	⟷ Arrows	Roll
Move within a screen column	⭥ Arrows	⭥ Arrows	Roll
Select a highlighted item or operate a screen button	Round key (<PICK> key)	Numeric Enter Key	Left click
Enter numeric data	Select point on chart	Numeric keypad	Left click on a point on chart
Enter text	Not possible	Any key	Not possible
Proceed from current state	<Continue>	Enter ↵	Click Continue
Revert to previous state	<Cancel>	Esc	Click Cancel
Also see 2.6: Mouse, keyboard, barcode scanner and 3.3: Barcode data input			

FastFacts 3.2: Input device operation

3.3 Barcode data input

In **Speechmap** and **Insertion gain** tests, audiometric data in barcode form on a RM500SL or Verifit printout may be entered by scanning the appropriate barcode. In Speechmap, threshold, UCL, RECD, transducer, age and ABR nHL to eHL conversion factors are encoded. In Insertion gain, threshold and transducer type are encoded. The type of data and the ear (left, right) is shown below the barcode. Only data for the displayed ear are imported. Barcodes may be scanned in any order and it does not matter if the barcode is "upside down".
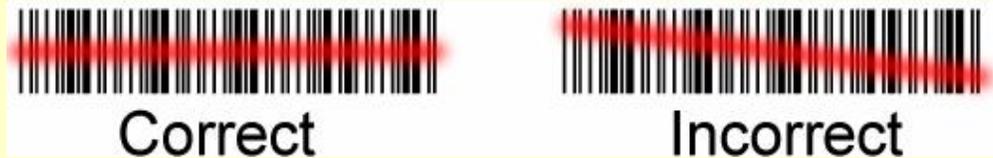
1) Select Speechmap or Insertion gain from the Tests menu.

2) Hold the printout so that the barcode to be scanned is flat. With the scanner 6" - 8" from the barcode, press the trigger on the scanner and center the illuminated red line along the length of the barcode.

3) When the scan is successful, the scanner will "beep", the red line will extinguish and a Barcode Entry poster will appear on the screen. A green checkmark on the poster shows which data have been accepted. A message will advise if the barcode does not contain data for the screen you are viewing.

4) When all desired data have been accepted, select [Done] to apply the data.

See 6.3: Barcodes, headers and comments on printouts. Barcodes on some Grason-Stadler printouts may also be scanned into the RM500SL.

FastFacts 3.3: Barcode data input

3.4 Keypad keys

Keypad Button	Function
<Help>	Summon context-sensitive Help Screen.
<Setup>	Summon Setup Menu containing a list of RM500SL features that can be modified. Any modifications made will be maintained after power off.
<Tests>	Summon Test Selection Menu containing a list of the available test procedures.
<Session>	Summon Session Data Menu to erase or export data
<Left/Right>	Used to alternate between ears or A/B Data.
<Print>	Print on internal or external printer or print to file.
⟵⟶ Arrows	Move across screen columns.
⟰⟱ Arrows	Move within a screen column.
Round Key (<PICK> key)	Select a highlighted item or operate a screen button.
<Continue>	Proceed from current state.
<Cancel>	Revert to previous state.

FastFacts 3.4: Keypad keys

3.5 Menus, lists and buttons

Menu	Setup Box	List Box
On-ear measures	**Audiometry**	BTE
Speechmap/DSL ⊙	Ear — Right	ITE
Insertion gain ⊙	Transducer — Headphone ⊙	ITC
Manual control ⊙	Threshold — Entered	CIC
Calibration ⊙	REUR — Average ⊙	Body
	Cancel — Continue	
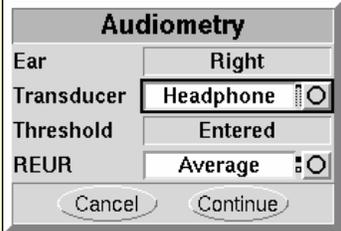
Screen Buttons are identified by a circle within a raised block ⊙ and are located at the right hand end of a line of screen text. A screen button highlighted using the keypad or a QWERTY keyboard is surrounded by a heavy line. A screen button highlighted by the mouse pointer changes color from light to dark gray. A highlighted screen button is operated by pressing the <PICK> (round) key on the keypad, the numeric Enter key on a keyboard or by clicking the left mouse button. This process also selects the highlighted item in a list box.

There are three different types of screen buttons:

When selected, a **Menu Button** displays a menu, a setup box or a test screen.

Insertion Gain ⊙

When selected, a **List Button** displays a drop-down list box.

BTE ⊙   The current list item is shown in the window.

When selected, a **Toggle Button** alternates between states.
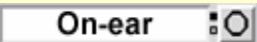
On-ear ⊙   The current state is shown in the window.

FastFacts 3.5: Menus, lists and buttons

3.6   Screen messages

The **Title bar** (top line of the display screen) informs you of the selected Test (e.g., Multicurve).

The **Message bar** (bottom line of the display screen) suggests the next step in a test or informs you of the state of the instrument or conditions that could affect your data. For example, it will inform you if the microphones need to be calibrated.

FastFacts 3.6: Screen messages

3.7   Program memory removal and replacement

Operating software is contained on a USB flash drive located in the test chamber under the printer paper roll cradle as shown. Software updates are shipped on a CD-ROM and must be transferred to the USB flash drive in order to be used. This requires that the USB flash drive be removed from the RM500SL and plugged into the USB port on a PC that has a CD-ROM drive.

To remove the USB flash drive, ensure that the RM500SL power is off and:

1) Open the test chamber and remove the foam from the test chamber floor.

2) Pull the USB flash drive straight toward the front of the unit until it is free.

To install the USB flash drive, ensure that the RM500SL power is off and:

1) Open the test chamber and remove the foam from the test chamber floor.

2) Gently insert the USB flash drive into the USB port, <u>with its foam pad down.</u>

3) Replace the foam in the floor of the test chamber.

NOTE that the USB flash drive has been especially configured for the RM500SL. Replacing this flash drive with another can cause erratic operation. Such replacement should be done only when authorized and ONLY by an Audioscan service representative.
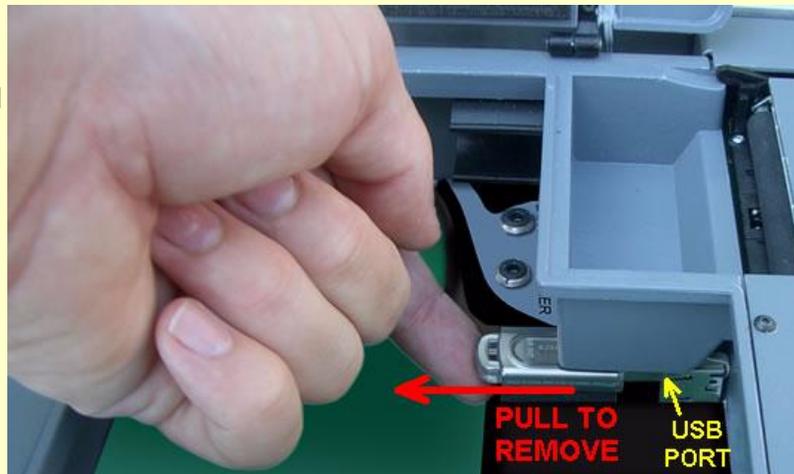
FastFacts 3.7: Program memory removal and replacement

3.8 Software updating

Software updates, along with a new User's Guide, are shipped on a CD-ROM. The software must be transferred to the USB flash drive in the RM500SL in order to be used. This transfer requires a PC with a CD-ROM drive and a USB port. To update the RM500SL software:

1) Refer to 3.7: Program memory removal and replacement and remove the USB flash drive from the RM500SL.

2) Insert the software update CD-ROM into the CD-ROM drive on your PC.

3) Double-click on My Computer, then double-click on the CD-ROM drive.

4) Double-click on rm500sl_update.exe and follow instructions to complete the update.

5) Remove the USB memory stick from the PC.

6) Refer to 3.7: Program memory removal and replacement and install the USB flash drive in the RM500SL.

See 1.3: Electronic user's guide for help in accessing the new User's Guide.

FastFacts 3.8: Software updating

4 General Setup

4.1 Section overview

This section covers the following topics:

4.2: Date and time setup

4.3: Display settings

4.4: Saving test setup

FastFacts 4.1: General setup

4.2 Date and time setup

To set the date and time that appears on printouts and calibration screens:

1) Press <Setup>, then highlight and <PICK> [Date & Time] on the Setup poster.

2) To change the date, highlight and <PICK> the month window to display a drop-down list of months.

3) Highlight and <PICK> the desired month on the list.

4) Repeat the previous step to change the date, year and time in the appropriate windows.

5) When the new date and time information has been set, press <Continue> to exit.

FastFacts 4.2: Date and time setup

4.3   Display settings

This feature sets the screen saver timing and the background color used on the graphic test displays. The screen saver blanks the screen after 60, 90 or 120 minutes of inactivity to prolong the life of the display.

To change display settings:

1) Press <Setup>, then highlight and <PICK> [Display].

2) To change the **screen saver timing**, highlight and <PICK> the current setting

3) Highlight and <PICK> the desired screen saver timing from the drop-down list.

4) To change the **background color** of the graphic display on the various test screens, highlight and <PICK> [Color] to toggle between black and white.

5) Press <Continue> to exit setup.

FastFacts 4.3: Display settings

4.4   Saving test setup

This feature lets you retain the last-used stimulus type and level for most tests when the power is turned off. It also lets you retain the last-used target method and transducer type in Speechmap and Insertion Gain tests.

To enable/disable this feature:

1) Press <Setup>, then highlight and <PICK> [Save option]

2) Highlight and <PICK> [Save test setup] to toggle between Yes and No.

FastFacts 4.4: Saving test setup

5   Networking

5.1   Section overview

The RM500SL may be connected to a network using a Cat 5, RJ-45 cable. This allows screen images to be printed on a network printer or on a shared printer on a networked PC. Images and underlying data may also be saved to a shared folder on a networked PC. See 6: Printing and Storing Results for details. The RM500SL may also be connected to a single computer using a network hub.

This section covers the following topics:

5.2: Networking requirements

5.3: Networking setup

5.4: Single computer connection

FastFacts 5.1: Networking

5.2   Networking requirements

The RM500SL may be connected to a network using a Cat 5, RJ-45 cable. The network connector is next to the serial number label on the recessed connector panel. For automatic address assignment, the network must have a Dynamic Host Configuration Protocol (DHCP) server.

For manual addressing, the remote computer must be running Windows 95 or higher, File and Printer Sharing for Microsoft Networks must be enabled and the TCP/IP Connection must be configured so that the IP address of the remote computer is on the same subnet as the RM500SL. These settings should be obtained from your network administrator.
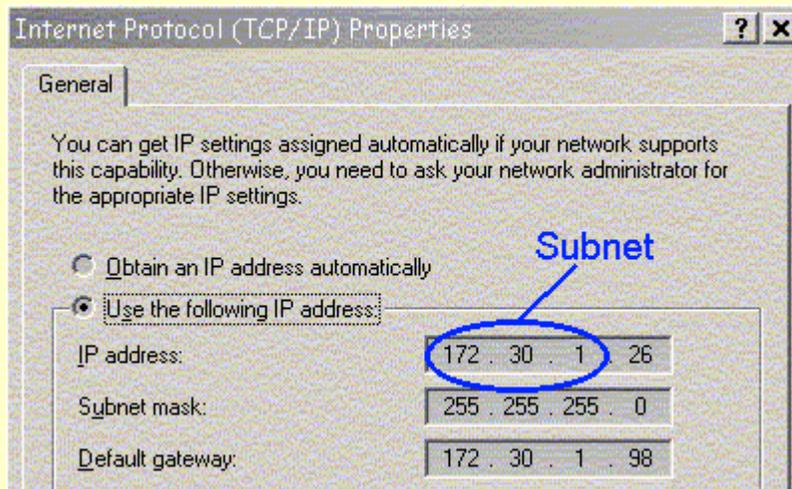
FastFacts 5.2: Networking requirements

5.3   Networking setup

Check 5.2: Networking requirements and connect the RM500SL to your network.

1) Press <Setup> then highlight and <PICK> [Network]

2) In the Network poster, highlight and <PICK> [Enable networking].

3) If your network supports automatic address assignment (DHCP), highlight and <PICK> [Obtain automatically]. Highlight and <PICK> [Test connection].

4) For manual configuration, highlight and <PICK> [Obtain manually]. Then highlight each of the 4 boxes in each row and highlight and <PICK> the numbers, provided by your network administrator, from the drop-down lists.

5) Highlight and <PICK> [Test connection]. The RM500SL will prompt you for an IP address of a computer or router on your network. In a single PC-to-RM500SL network, this is the IP address of the PC you are connecting to.

Max TM SPL	○	Enable networking ☑ ○	
Frequencies	○		
Test setup	○	Network address	*Numbers assigned by network administrator for the RM500SL*
ABR nHL to eHL	○		
Speakers	○	Obtain automatically ▣ ○	
ANSI	○	Obtain manually ▣ ○	
Display	○	IP Address 172 ○ 30 ○ 1 ○ 110 ○	
Network	○	Network 172 ○ 30 ○ 1 ○ 0 ○	
Printing	○	Broadcast 172 ○ 30 ○ 1 ○ 255 ○	
Date & Time	○	Netmask 255 ○ 255 ○ 255 ○ 0 ○	
Self test	○		
CD-ROM	○	Test connection ○	

FastFacts 5.3: Networking setup

5.4   Single computer connection

The computer must be running Windows 95 or higher, with a functioning network card connected to one port on a Ethernet **network hub or switch**. Connect a Cat 5, RJ-45 cable from a hub port to the RM500SL connector. **To set up the PC**:

1) Right click Network Neighborhood (or My Network Places) & select Properties.

2) Right click Local Area Network Connection & select Properties.

3) If Internet protocol TCP/IP is not installed, install it from your Windows disk.

4) Highlight Internet Protocol (TCP/IP) & select the Properties button.

5) Check "Use the following IP address" and enter the following in the IP address box: 172. 30. 1. 1. Enter 255. 255. 255. 0 in the Subnet mask box.

On the RM500SL, see 5.3 Networking setup and manually configure as shown:

IP Address	172	30	1	2
Network	172	30	1	0
Broadcast	172	30	1	255
Netmask	255	255	255	0

FastFacts 5.4: Single computer connection

6 Printing and Storing Results

6.1 Section overview

Pressing <Print> will cause the current screen image to be **printed** on the internal printer, on an external local printer, on a network printer, on a Windows-shared printer on a networked PC, or **saved** to file on a USB memory stick, or a Windows-shared file on a networked PC. Date, time, barcoded audiometric data and fixed or variable headers and comments (via a connected keyboard), may be added to printouts (but not when saving to a file). Session data may also be saved as an xml file to a USB memory stick or in a Windows-shared folder on a networked PC for further analysis or to be restored to the RM500SL or a Verifit for future use.

NOTE: If a header, comment, or client ID field, or file name, identifies the printed or saved data as belonging to an individual, it becomes Individually Identifiable Health Information and must be protected under the HIPAA Security Rule. See Appendix 1: Manufacturer Disclosure Statement for Medical Device Security.

The following topics are covered in this section:

6.2: Internal printer paper loading

6.3: Barcodes, headers and comments on printouts

6.4: Local printer setup

6.5: Printing to a USB memory stick

6.6: Network printer setup

6.7: Printing to a network file

6.8: Storing and restoring data - setup

6.9: Storing and restoring data

FastFacts 6.1: Printing and storing results

6.2 Internal printer paper loading

On-screen instructions on paper replacement are provided if you try to print to the internal printer when it is out of paper or when the paper lever has been raised.

To load a new roll of paper:

1 Lift the printer head using the small black lever to the left of the printer.

2 Press the <Print> key for on-screen instructions.

3 Remove the empty spool from the paper tray and any remaining paper from the printer.

4 Hold a new roll in front of the paper tray with paper feeding from the top of roll.

5 Insert the paper's leading edge into the lower slot at rear of tray.

6 Feed the paper by highlighting the on-screen 'Paper Feed' button and pressing <PICK>.

7 Advance the paper until it comes out of the upper slot.

8 Place the roll in the paper tray and advance another 10" (25 cm) of paper.

9 Lower the printer head using the small black lever. Press <Continue> to print or <Cancel> to cancel the print job.

If nothing shows on the paper when you press <Print> and the paper is coming out –check that the glossy side is up as it comes out of the printer.

Thermal paper may darken if stored for prolonged periods at elevated temperatures and lose contrast if subjected to light. Keep long-term supplies and printouts in a cool dry place out of direct light.

FastFacts 6.2: Internal printer paper loading

6.3 Barcodes, headers and comments on printouts

The date and a header, such as a facility name, may be added to printouts. Barcodes representing hearing threshold, UCL and RECD, where applicable, may be added to printouts of Speechmap, Insertion gain and RECD tests. Tabular data, where applicable, may be appended to printouts. Lines for hand-written notes or typed comments may also be added. **If a header or comment links the data to an individual, the printout becomes Individually Identifiable Health Information which must be protected under the HIPAA Security Rule.**

1) Connect a computer keyboard to the USB port on the connector panel.

2) Press <Setup>, then highlight and <PICK> [Printing].

3) Highlight [Page setup] and press <PICK> to display the page setup poster.

4) To print the **date and time** on each printout, highlight and <PICK> [Date].

5) To print **lines** for handwritten notes, highlight and <PICK> [Lines].

6) To add **barcodes** for audiometric data, highlight and <PICK> [Barcode].

7) To add **tabular data**, highlight and <PICK> [Graph with table].

8) To print a **fixed header** on printouts, highlight and <PICK> [Header]. Connect a keyboard to the USB port and enter the desired header (up to 35 characters). Press <PICK> (or Enter key on the keyboard **number** pad) to complete the entry. To be prompted for a **new header** for each printout, highlight and <PICK> [Ask].

9) To print **fixed comments** following a printout, highlight and <PICK> [Description]. Connect a keyboard to the USB port and enter comments. Press <PICK> (or Enter on the keyboard **number** pad) to complete the entry. To be prompted for **new comments** for each printout, highlight and <PICK> [Ask].

10) To be prompted for a **new file name** each time you print to a USB memory stick or a network file, highlight and <PICK> [Ask]. **Do not use space $ \ / or tab in the file name.** USB file names are limited to 8 characters. See 6.5: Printing to a USB memory stick or 6.7: Printing to a network file.

11) A print layout for the selected printer is displayed.

12) Press <Continue> to exit page setup and <Continue> to exit Setup.

FastFacts 6.3: Barcodes, headers and comments on printouts

6.4   Local printer setup

1) Connect an external printer to the USB port. **Only PCL3, PCL5 or PostScript compatable, HP Deskjet D4160 and 460 printers are supported.**

2) Press <Setup>, then highlight and <PICK> [Printing].

3) Highlight & <PICK> [USB].

4) Highlight & <PICK> [Printer details] (automatic if printer type is set to None).

5) Highlight & <PICK> [Printer type].

6) Highlight & <PICK> your printer type. Select Color(1) for a printer with a single ink cartridge; color(2) for a printer with separate color and black ink cartridges; Other HP for a list of supported specific printer models. Check [Black only] for black printouts on a color printer. Press <Continue>.

```
None
HP Deskjet Color (1)
HP Deskjet Color (2)
HP Laserjet Black
PostScript
Other HP
```

7) If Other HP is selected, select a Printer model and press <Continue>.

8) Press <Continue> to exit printer setup and <Continue> to exit Setup.
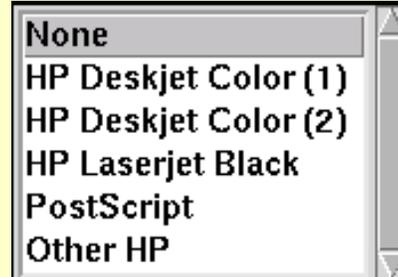
FastFacts 6.4: Local printer setup

6.5   Printing to a USB memory stick

1) Plug a USB memory stick into the USB port on the recessed connector panel. The RM500SL may be either on or off.

2) Press <Setup>, then highlight and <PICK> [Printing].

3) Highlight and <PICK> [Print to USB file].

4) Highlight and <PICK> [Printer details] to change the file type [Bitmap (bmp)] or [Internet GIF (gif)] and the captured area [Full screen], [Main window] (full screen without the message line or [Active window] (foreground image only).

5) To save a screen image to a file, press <Print>. After about 4 seconds, a message will advise that the USB stick is being accessed. **Do not unplug the USB stick until this message disappears.**

6) To input a file name from a connected keyboard each time you print, highlight and <PICK> [Page setup], then highlight & <PICK> [Ask]. File names are limited to 8 characters plus .bmp or .gif. **Do not use space $ \ / or tab in the file name. This may create electronic Protected Health Information (ePHI).** See 6.1: Section overview and Appendix 1 of the User's Guide.

7) To save all test data as an xml file, first press <Setup>, then highlight and <PICK> [Session]. Highlight and <PICK> [Enable file based data exchange] then highlight and <PICK> [USB drive] and <Continue>.

8) Press <Session>, then <PICK> the [Erase all data] button to show a list of options. Highlight and <PICK> [Store session to file] and press <Continue>.

A style sheet (audioscan.xsl) which allows the stored xml file to be viewed with a web browser or Excel (right click and select Open with Excel) is automatically saved with the data file.

FastFacts 6.5: Printing to a USB memory stick

6.6   Network printer setup

To print to a network printer or to a Windows-shared printer on the network, you must first enable networking. See section 5: Networking. To print to a printer on a Windows PC connected to a network, you must also share the printer on the PC by selecting Start, Settings and Printers. Then right click on the printer you wish to share and select Sharing. **Only PCL 3, PCL 5 or PostScript compatible, HP Deskjet D4160 and 460 printers are supported.** In Windows2003 Server you must add permission to allow Anonymous Logon to print to the shared printer.

1) Press <Setup>, then highlight and <PICK> [Printing].

2) Highlight & <PICK> [Other network printer] or [Windows shared printer].

3) Highlight & <PICK> [Printer details] (automatic if printer type is set to None).

4) Highlight & <PICK> [Printer type], then select from Deskjet Color(1) (single ink cartridge), Deskjet Color(2) (both color and black ink cartridges), Laserjet Black, PostScript or Other HP (a list of supported specific printer models). Check [Black only] for black printouts on a color printer.

5) Connect a computer keyboard to the USB port and fill in the boxes with the requested information. Highlight and <PICK> each box to open it for data entry and again to close it (or use the Enter key on the keyboard's numeric keypad). Obtain needed information from your network administrator.

FastFacts 6.6: Network printer setup

6.7 Printing to a network file

To save the screen image as a file on a network PC, you must first enable networking. See 5: Networking. You must also "share" a folder in the PC root directory (e.g. c:\MyData) and ensure that Change permissions are enabled.

1) Press <Setup>, then highlight and <PICK> [Printing].

2) Highlight and <PICK> [Print to file].

3) Highlight and <PICK> the file type [Bitmap (bmp)] or [Internet GIF (gif)].

4) Highlight and <PICK> [Full screen], [Main window] (full screen without the message line or [Active window] (foreground image only).

5) Connect a computer keyboard to the USB port and fill in [Computer], [Share name], [Username] and [Password] (not needed for Windows 95/98). Highlight and <PICK> each box to open it for data entry and again to close it (or use the Enter key on the keyboard's numeric keypad).

6) Highlight and <PICK> [Test connection] and wait for a successful report.

7) To input a file name each time you <Print>, highlight and <PICK> [Page setup], then highlight & <PICK> [Ask]. **Do not use space $ \ / or tab in the file name. This may create electronic Protected Health Information (ePHI).**

Network file	
File type	Bitmap (bmp)
Print frame	Main window
Computer	edi
Share name	tmp
Username	dave
Password	********
	Test connection
Cancel	Continue	Help

FastFacts 6.7: Printing to a network file

6.8 Storing and restoring data - setup

All measurement data (curves) displayed at the end of the test are stored until overwritten by repetition of the same test, invalidated by a related test (in such cases, the message bar will inform you of impending data loss), erased by selecting <Session> and one of the [Erase data] choices or the power is turned off. (Setup data will be retained even after the power is turned off.)

The RM500SL database may be stored and restored via xml files on a USB drive or a networked PC share. If the data exchange location is a network share, you must first enable networking. See 5: Networking. You must also "share" a folder in the PC root directory (e.g. c:\MyData) and ensure that Change permissions are enabled.

To enable and configure file-based data exchange:

1) Press <Setup>, then highlight and <PICK> [Session].

2) Highlight and <PICK> [Enable file based data exchange].

3) Highlight and <PICK> the storage file location [USB drive or Network share].

4) For Network share connect a computer keyboard to the USB port and fill in [Computer], [Share name], [Username] and [Password] (not needed for Windows 95/98). Highlight and <PICK> each box to open it for data entry and again to close it (or use the Enter key on the keyboard's numeric keypad).Highlight and <PICK> [Test connection] and wait for a successful report.

FastFacts 6.8: Storing and restoring data – setup

6.9 Storing and restoring data

To store session data to a file:

1) Press the <Session> key, then highlight and <PICK> the top list button.

2) Highlight and <PICK> [Store session to file] from the list.

3) Highlight and <PICK> the Client ID list button.

Fill in Client ID with a computer keyboard (see 2.6: Mouse, keyboard, barcode scanner) or leave it blank and the file will be named session.#.xml. **The Client ID may not contain ! ~ ` @ # $ % ^ & * + = \ / ? < , . >** **If the Client ID links the data to an individual, the printout becomes ePHI (electronic Protected Health Information) which must be protected under the HIPAA Security Rule.**

4) Press <Continue>

To restore a session from a file:

1) Press the <Session> key, then highlight and <PICK> the top list button.

2) Highlight and <PICK> [Restore session from file].

3) Highlight and <PICK> the Client ID list button to generate a list of previously entered client identification codes.

4) Highlight and <PICK> a client identification code from the list.

5) Highlight and <PICK> the Session list button to generate a list of previously stored sessions for the indicated Client ID.

6) Highlight and <PICK> a session and press <Continue>.

A style sheet (audioscan.xsl) which allows the stored xml file to be viewed with a web browser or Excel (right click and select Open with Excel) is automatically saved with the data file.

FastFacts 6.9: Storing and restoring data

7   Test Box Measures Setup

7.1   Section overview

For most tests, two completely separate sets of test results, labelled A and B, may be retained and displayed. The appearance of Test box measures screens may be changed in several ways. Most screens may be formatted to show results in graphical or tabular format. The Multicurve screen may be scaled in dB SPL or dB Gain. Individual curves may be hidden (but not erased).

This section covers the following topics:

FastFacts 7.1: Test box measures setup

7.2   Test box A or B display

For most tests, two completely separate sets of test results, labelled A and B, may be retained and displayed. To switch between A and B test results, press the <Left/Right> key.

FastFacts 7.2: Test box A or B display

7.3   Graph or table format

Except for Distortion, Input/Output, Battery drain and Manual control screens, you have the option of selecting either a graphic or tabular format.

To change the **data format**, highlight, then <PICK> [Graph] or [Table].

FastFacts 7.3: Graph or table format

7.4   Output or gain scale

On the Multicurve test screen, you have the option of displaying test results in SPL (dB) or gain (dB).

To change the **scale**, highlight, then <PICK> [dB SPL] or [dB Gain]

FastFacts 7.4: Output or gain scale

7.5   Hide or Show Test box curves

On screens capable of showing a speech envelope, you may show or hide the speech envelope for clarity of display. Hiding a curve does not erase it. To erase curves use the <Session> key.

To hide or show test curve(s):

1)   Highlight, then <PICK> Curve [Hide/Show].

2)   Highlight, then <PICK> the desired test to toggle between the Hide or Show options. The curve will toggle on or off when selected.

3)   Where available, you may also highlight and <PICK> the envelope to toggle it on or off.

4)   Press <Continue> to return to the test screen.
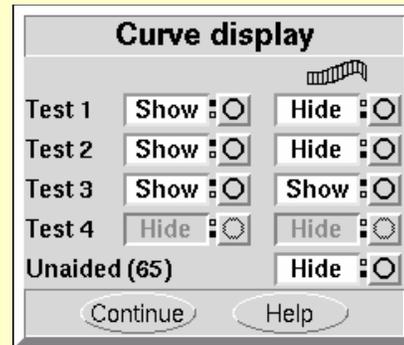
FastFacts 7.5: Hide or Show Test box curves

7.6   1996 or 2003 ANSI standard

Automated tests of linear and AGC hearing aids may be conducted according to either the ANSI S-3.22-1996 or ANSI S3.22-2003 test standards. For differences, see 8.2: ANSI S3.22-1996 facts and 0: ANSI S3.22-2003 facts.

To select the standard to be used:

1)   Press <Setup>, then highlight and <PICK> [ANSI]

2)   Highlight and <PICK> the version of the ANSI standard you wish to use.

3)   Press <Continue> to exit

FastFacts 7.6: 1996 or 2003 ANSI standard

7.7   ANSI test frequencies

The Frequencies feature allows hearing instruments to be evaluated at the Special Purpose Average (SPA) frequencies defined by ANSI S3.22, rather than the default High Frequency Average (HFA) frequencies. The choice of SPA (or HFA) frequencies influences the average OSPL90, average full-on gain, reference test gain, bandwidth and equivalent input noise. The frequencies at which distortion is measured are one-half the selected SPA frequencies. You can also select the frequencies at which attack and release times are measured.

To change the averaging frequencies:

1)   Press <Setup>, then highlight and <PICK> [Frequencies].

2)   Highlight and <PICK> the HFA/SPA frequencies box, to generate a drop-down list box of alternate test frequencies.

3)   Highlight the desired HFA/SPA test frequencies and press <PICK> to select.

To change the frequencies for attack and release time measurements:

In the list of available frequencies, highlight and <PICK> the frequencies to be used to measure attack and release time. Press <Continue> to exit.

FastFacts 7.7: ANSI test frequencies

7.8 Test box calibration facts

Test box microphone calibration establishes a correction curve for the uncalibrated test box reference microphone by comparison with the factory calibrated coupler microphone. It may be performed as often as desired but will be invalidated at 1 am the following day or at 1 am the following Monday, depending on the choice of Daily or Weekly calibration interval. After the calibration has expired, you will be prompted to calibrate whenever you attempt a test that uses the test box microphones.

Note that there are two styles of test box reference microphones. The newer style is larger but responds beyond 16 kHz and has a lower noise floor. The two have different correction curves, as shown below, but will produce the same test results, once calibrated. Your calibration curve should be similar to one of these and should remain stable over time. Irregularities in the calibration curve may be the result of positioning errors. See 7.9: Calibration of test box reference mic.
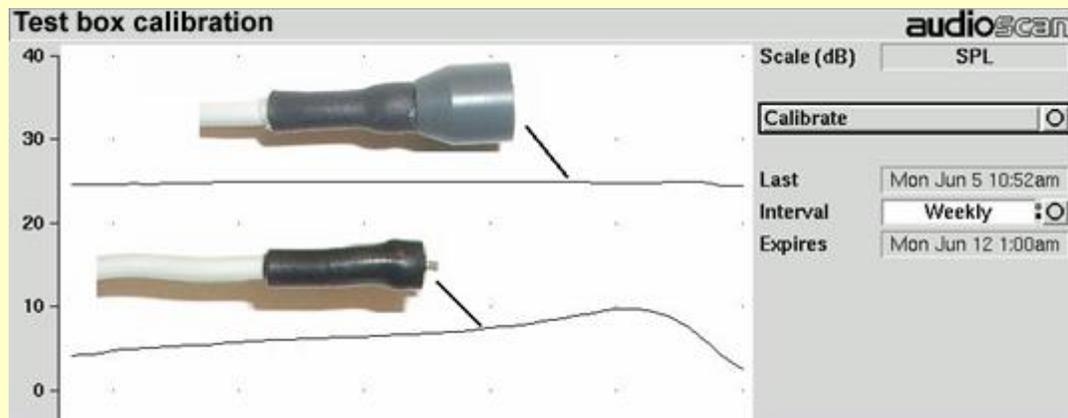
FastFacts 7.8: Test box calibration facts

7.9 Calibration of test box reference mic

Remove any coupler from the coupler microphone before calibration.

1) Position the test box reference microphone opening concentric with the coupler microphone opening and about 1 – 2 mm from as shown below.

2) Close and seal the test chamber by tightening the latch at the front of the lid.

3) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Calibration].

4) Highlight, then <PICK> [Daily] or [Weekly] to select the calibration interval.

5) Highlight and <PICK> [Calibrate]. See 7.8: Test box calibration facts

It is recommended that you print a copy of the initial calibration curve and compare it with your daily or weekly curve. Any change in this curve indicates a drift in either the coupler or the reference microphone which needs further investigation. See 7.10: Calibration check for coupler microphone for an additional check.
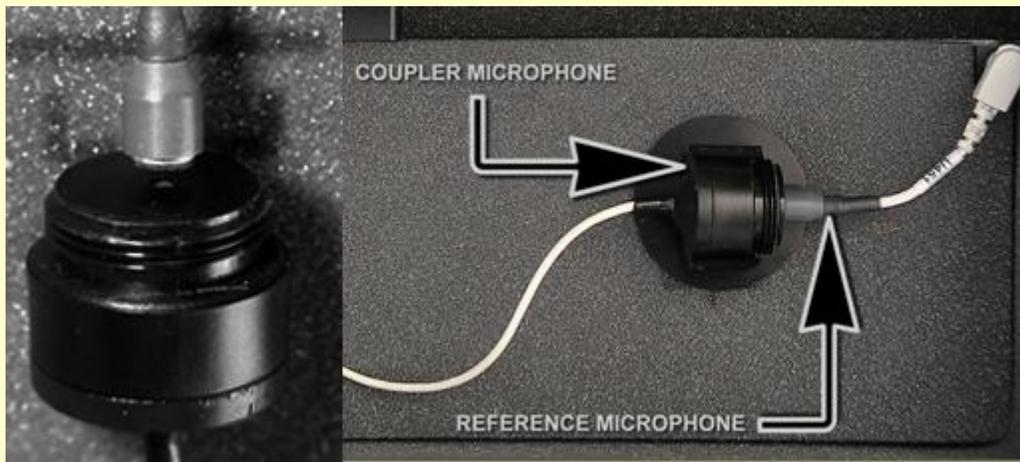
FastFacts 7.9: Calibration of test box reference microphone

7.10 Calibration check for coupler microphone

Accuracy of test box measurements depends on the calibration of the coupler microphone. This should be checked regularly using a microphone calibrator with an adapter ring. The RE780 (1 1/8") and RE781 (1") rings are designed for Quest CA22 and QC-10/20 respectively. To verify the coupler microphone calibration:

1) Calibrate the test box reference microphone. See 7.9: Calibration of test box reference mic

2) Screw the appropriate calibrator ring onto the coupler microphone.

3) Insert the coupler microphone with the attached calibrator ring into the calibrator opening.

4) Turn the calibrator on and adjust it to present one of the available frequencies and levels (e.g., 94 dB SPL at 1000 Hz).

5) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Manual control].

6) Highlight and <PICK> the [Level] window, then highlight and <PICK> 0 from the drop-down list.

7) Highlight, then <PICK> the [Frequency] window, then highlight and <PICK> the frequency of the calibrator (e.g. 1000 Hz) from the drop-down list.

8) Highlight, then <PICK> the [Filter] window, then highlight and <PICK> 1/12th octave from the drop-down list.

9) Highlight, then <PICK> [Start test] (which changes to [Stop test]).

10) Check that the Coupler microphone level is within 1 dB of the calibrator level setting, +/- the calibrator accuracy. For a 94 dB calibrator with +/- 0.3 dB accuracy, the indicated coupler microphone level should be 94 +/- 1.3 dB.

11) To stop the measurement, highlight and <PICK> [Stop test].

FastFacts 7.10: Calibration check for coupler microphone

7.11 Coupling the hearing instrument

The RM500SL is supplied with 2 metal couplers, a type HA-1 (ITE) and a type HA-2 (BTE). Note that an **ANSI standard coupler for CICs does not exist**. These must be tested in the HA-1 coupler.

When threading the couplers onto the coupler microphone, **it is very important that they be firmly tightened** to ensure a good acoustic seal. Avoid twisting the coupler microphone cable – turn the coupler not the microphone or unplug the microphone while tightening the coupler.

BTE instruments are coupled to the HA-2 coupler by means of a 3/8th " (10 mm) length of heavy wall #13 (2mm) earmold tubing. The only purpose of this tubing is to seal the tip of the earhook to the coupler inlet. All of the tubing required by ANSI S3.22 is machined into the metal stem of the HA-2 coupler. The #13 tubing should be inspected regularly for cracks which will cause feedback.

Custom instruments are sealed to the HA-1 coupler with putty so that the end of the eartip is flush with the inside of the coupler opening. Putty should not extend into the coupler cavity or block the sound outlet of the instrument. **Vents should be sealed at the faceplate end**. It is very important that the instrument be well-sealed to the coupler. **Excess low frequency output is usually due to open vents or a poor seal to the coupler.**

Open fit instruments must use the coupler and coupling system specified by the manufacturer. This may involve a hook that replaces the open fit tubing or an adapter tube that may be sealed to the opening of the HA-1 coupler with putty.

Receiver-in-the-ear instruments are coupled to the HA-1 coupler using putty to seal the receiver module or soft tip to the coupler opening.

Excess low frequency output is usually due to open vents or a poor seal to the coupler.

For health reasons, hearing instruments should be clean before putty is applied and putty should be replaced frequently.

FastFacts 7.11: Coupling the hearing instrument

7.12 Positioning the hearing instrument

1) The hearing instrument should be coupled to the appropriate coupler and a battery or battery pill installed. See 7.11: Coupling the hearing instrument and 2.5: Battery pill use and care.

2) Place the instrument and coupler in the test chamber so that the microphone opening(s) of the instrument are on the crossbar >> within the test zone.
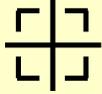
3) Position the test box reference microphone as close as possible to the (front-facing) microphone opening of the hearing instrument without touching it.

4) Close and seal the test chamber.
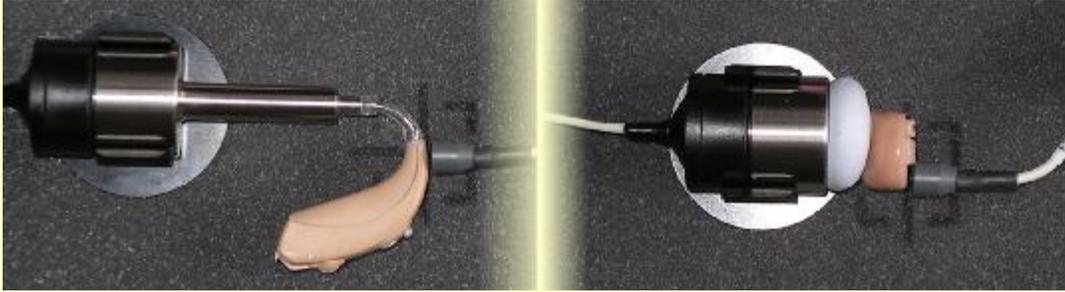
FastFacts 7.12: Positioning the hearing instrument

8 ANSI S3.22 Hearing Aid Tests

8.1 Section overview

These Hearing Instrument Tests follow the procedures of ANSI S3.22-1996 or ANSI S3.22-2003 as selected in Setup. See 7.6: 1996 or 2003 ANSI standard :

Linear: An automated test sequence for linear hearing aids per ANSI S3.22.

AGC: An automated test sequence for AGC hearing aids per ANSI S3.22.

Input/Output: 1 - 4 curves of coupler SPL vs input SPL at .25, .5, 1, 2 and 4 kHz.

Telecoil: **STS** (1996 - simulated telephone sensitivity) or **RSETS** (2003 - relative simulated equivalent telephone sensitivity) using a coil in the test chamber floor.

This section covers the following topics:

8.2: ANSI S3.22-1996 facts 8.6: ANSI input-output curves

0: ANSI S3.22-2003 facts 8.7: ANSI telecoil terminology

8.3: ANSI 1996 Linear and AGC tests 8.8: ANSI telephone simulator (TMFS) test

8.4: ANSI 2003 Linear and AGC tests 8.9: Telecoil test results

8.5: ANSI test results

FastFacts 8.1: ANSI S3.22 hearing aid tests

8.2   ANSI S3.22-1996 facts

The RM500SL performs selected hearing instrument tests in accordance with ANSI S3.22-1996. This standard expresses some outputs and gains as High Frequency Average (HFA) values. The HFA is the average of values at 1000, 1600 and 2500 Hz. If a hearing aid meets certain conditions, the manufacturer may choose other averaging frequencies called Special Purpose Average (SPA) frequencies. The current averaging frequencies are indicated explicitly on test results where space permits and also appear as tick marks on the frequency axis of graphs. To change the averaging frequencies, see 7.7: ANSI test frequencies.

This standard also requires some tests with the gain control full on and some with the gain control in the Reference Test Position (RTP). This requirement applies to both Linear and AGC aids that have a HFA (or SPA) full-on gain greater than the HFA (or SPA) OSPL90 minus 77 dB. Otherwise the RTP is full on. If required, the RM500SL will pause in its testing and guide you in setting the gain control to the RTP.

All other controls on the hearing instrument should be set to provide the widest frequency response, the greatest gain and the highest maximum output. AGC controls or programmable settings should be as designated by the manufacturer.

At full-on gain the **[Linear]** and **[AGC]** test sequences provide a curve of OSPL90 (Output Sound Pressure Level for a 90 dB input SPL), the HFA (or SPA) and peak value of this curve, the frequency of the peak and the HFA (or SPA) gain for a 50 dB input SPL.

With the gain control at RTP, these sequences also provide a frequency response curve with an input SPL of 60 dB (Linear) or 50 dB (AGC), the HFA (or SPA) gain for a 60 dB input SPL, the frequency range, battery drain, equivalent input noise, harmonic distortion, attack and release time (AGC only).

FastFacts 8.2: ANSI S3.22-1996 facts

ANSI S3.22-2003 facts

ANSI S3.22-2003 has been designated a recognized standard by the FDA but is not yet mandatory. Manufacturers may use either version for reporting test data.

The most significant change from the 1996 version is the requirement for the hearing aid to be set in its most linear mode for the setting of the gain control to Reference Test Setting (changed from Reference Test Position) and for all tests except attack and release and input-output (I/O) curves. These two tests are to be conducted with the AGC function set for maximum effect. The AGC test sequence will pause to allow AGC to be set prior to measuring attack and release time.

Full-on gain is determined with 50 dB input SPL (60 dB was formerly an option) and frequency response curves are run at 60 dB SPL for Linear **and** AGC aids.

The OSPL90 curve, the HFA (or SPA) and peak value of this curve, the frequency of the peak, the HFA (or SPA) full-on gain are determined at full-on gain setting. The response curve, frequency range, Reference Test Gain, battery drain, equivalent input noise, distortion, attack and release times are determined at RTS.

These changes result in more consistent values for reference test gain, equivalent input noise and attack and release time. See 7.6: 1996 or 2003 ANSI standard, 8.2: ANSI S3.22-1996 facts and 8.4: ANSI 2003 Linear and AGC tests.

FastFacts 8.3: ANSI S3.22-2003 facts

8.3   ANSI 1996 Linear and AGC tests

1) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Linear] or [AGC].

2) Highlight and <PICK> [Start test]; test setup instructions will be displayed.

3) Refer to 7.11: Coupling the hearing instrument, 7.12: Positioning the hearing instrument and 2.5: Battery pill use and care to prepare the instrument for testing.

4) Turn the instrument ON.

5) Set the gain control (manual or programmable) to maximum with all other controls set to provide the widest frequency response, greatest gain and highest maximum output. AGC controls and/or programmable parameters should be set as designated by the manufacturer.

6) Press <Continue> to run the test or press <Cancel> to abort the test. Note that, if required, the RM500SL will pause during the test to request that the volume control be adjusted to the Reference Test Position (RTP). Open the test chamber if necessary and, without moving the hearing instrument, adjust the user gain control until the large vertical arrow on the screen prompt disappears. Press <Continue> to resume the test.

If you are unsure which test sequence to run, try [AGC] first. If attack and release times are all near zero, the instrument is probably linear.

FastFacts 8.4: ANSI 1996 Linear and AGC tests

8.4 ANSI 2003 Linear and AGC tests

1) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Linear] or [AGC].

2) Highlight and <PICK> [Start test]; test setup instructions will be displayed.

3) Refer to 7.11: Coupling the hearing instrument, 7.12: Positioning the hearing instrument and 2.5: Battery pill use and care to prepare the instrument for testing.

4) **Turn the instrument ON**.

5) Set the gain control (manual or programmable) to maximum with all other controls set to provide the widest frequency response, greatest gain and highest maximum output. AGC controls and/or programmable parameters should be set to **minimize** AGC action (AGC off or threshold high, compression ratio close to 1).

6) Press <Continue> to run the test or press <Cancel> to abort the test. Note that, if required, the RM500SL will pause during the test to request that the gain control be adjusted to the Reference Test Setting (RTS). If necessary, open the test chamber and, without moving the hearing instrument, adjust the gain control until the large vertical arrow on the screen prompt disappears. Press <Continue> to resume the test.

During the AGC test, the RM500SL will pause to request that AGC controls or programmable parameters be set for **maximum** AGC effect. If the manufacturer does not provide settings to produce maximum AGC effect, use settings that result in the highest gain for soft sounds and the lowest gain for loud sounds. This will typically result in the lowest compression threshold, a flat I/O curve and the longest attack/release times. These are not "typical" characteristics but indicate the adjustment range possible for these parameters.

If you are unsure which test sequence to run, try [AGC] first. If attack and release times are all near zero, the instrument is probably linear.

FastFacts 8.5: ANSI 2003 Linear and AGC tests

8.5 ANSI test results

ANSI S3.22-1996 AGC

(Graph readings)

Format	Graph	:O
Scale	dB SPL	
Start test		O

Volume control full on
OSPL90 curve
Max OSPL90 (dB) 118 @ 1400 Hz
Average OSPL90 114 dB
Average gain @ 50dB 52 dB ①

Volume control at RTP
Response curve @ 50dB
Average gain @ 60dB 37 dB ②
Frequency range 200 - 6200 Hz
Battery drain 0.73 mA
Equivalent Input noise 34 dB
500 Hz distortion @ 70 dB 4 %
800 Hz distortion @ 70 dB 1 %
1600 Hz distortion @ 65 dB 1 % ③

Frequency	Attack	Release	
250 Hz	195	670	ms
500 Hz	190	580	ms
1000 Hz	185	540	ms
2000 Hz	170	570	ms
4000 Hz	180	540	ms

HFA/SPA: 1000 1600 2500 Hz

In 1996 tests: Full-on average gain j is measured at 50 dB SPL, average gain at RTP k is usually (but not always) measured at 60 dB SPL and the frequency response l is run at 60 dB SPL for linear aids or at 50 dB SPL for AGC aids.

In 2003 tests: Full-on average gain is measured with a 50 dB input SPL, average gain at RTS is always measured at 60 dB input SPL and the frequency response curve is always run at 60 dB input SPL.

FastFacts 8.6: ANSI test results

8.6 ANSI input-output curves

An input/output curve shows the output level of a hearing instrument as a function of input level and frequency. It is a steady-state pure-tone curve and does not reflect performance with complex signals such as speech.

You may run the tests at any setting of the instrument controls but ANSI S3.22 requires that certain settings be used. See 8.2: ANSI S3.22-1996 facts and 0: ANSI S3.22-2003 facts. The [Input/Output] test allows you to generate up to 4 separate input/output curves at each of 5 individual frequencies (250, 500, 1000, 2000, 4000 Hz) as provided in ANSI S3.22.

1) Press <Tests>, then highlight and <PICK> [Input/Output].

2) Refer to 7.11: Coupling the hearing instrument, 7.12: Positioning the hearing instrument and 2.5: Battery pill use and care to prepare the instrument for testing.

3) Turn the instrument ON; set AGC controls or programming parameters as in 8.3: ANSI 1996 Linear and AGC tests or 8.4: ANSI 2003 Linear and AGC tests

4) Highlight and <PICK> [Curve 1]. Test setup instructions will be displayed.

5) Press <Continue> to generate a set of 5 input/output curves.

6) To measure another set of 5 input/output curves, highlight and <PICK> another [Curve #].

7) To summon a cursor to determine curve values, position the mouse pointer on a graph area and click the left mouse button. Click again to turn it off.

NOTE: Noise in the test area may cause erroneous results at low input levels (particularly at 250 and 500 Hz). Ensure that the test chamber is well sealed and ambient noise is low.

FastFacts 8.7: ANSI input-output curves

8.7 ANSI telecoil terminology

The RM500SL test chamber contains an integrated telephone magnetic field simulator (TMFS) meeting the requirements of ANSI S3.22, that enable the measurement of coupler SPL produced by a hearing instrument with a telephone pickup coil. ANSI uses the following terms in telecoil testing:

RTG (reference test gain) is the average gain measured with the gain control in the reference test position (1996) or reference test setting (2003). See 8.2: ANSI S3.22-1996 facts and 0: ANSI S3.22-2003 facts.

TMFS (Telephone magnetic field simulator). A 38.4-mm diameter coil spaced 16.5 mm below a test surfaced driven by a specified test signal. Intended to simulate a telephone handset receiver.

SPLITS (Coupler SPL for an inductive telephone simulator). SPL developed in a 2cc coupler by a hearing instrument with the gain control in the RTP (1996) or RTS (2003) when the input is the magnetic field generated by a TMFS.

HFA (or SPA) –SPLITS. Average of the SPLITS at HFA or SPA frequencies.

STS (1996 - simulated telephone sensitivity) or **RSETS** (2003 - relative simulated equivalent telephone sensitivity) is calculated as HFA (or SPA) SPLITS minus (RTG + 60). A positive STS or RSETS indicates greater output when using the telephone than when using the microphone.

FastFacts 8.8: ANSI telecoil terminology

8.8   ANSI telephone simulator (TMFS) test

ANSI S3.22 requires that the gain control be set to RTP (1996) or RTS (2003) before running this test. The reference test gain (RTG) is required in order to calculate the STS (1996) or RSETS (2003). The easiest way to meet both requirements is to run a [Linear] or [AGC] test before running this test. See 8.3: ANSI 1996 Linear and AGC tests; 8.4: ANSI 2003 Linear and AGC tests

1) First, complete a [Linear] or [AGC] test, then press <Tests>.

2) Highlight & <PICK> [Test box measures]

   then highlight and <PICK> [Telecoil].

3) Set the aid to 'T' (telecoil input).

4) Highlight and <PICK> [Start TMFS test]. Test setup instructions are displayed.

5) Position the aid on the **'T'** inscribed on the test chamber floor. BTE aids should lie as flat as possible on the test chamber surface, while custom aids should be oriented with their faceplate parallel to the top surface (if possible) and touching it as shown.

6) Press <Continue> to start the test.

7) While maintaining the orientation of step 5, move the hearing instrument around on the test chamber surface to maximize the number shown in the 'Maximize Average-SPLITS Value' box.

8) Without moving the hearing instrument, press <Continue> to store the Average (HFA-or SPA) SPLITS value and run the SPLITS curve.

FastFacts 8.9: ANSI telephone simulator (TMFS) test

8.9   Telecoil test results
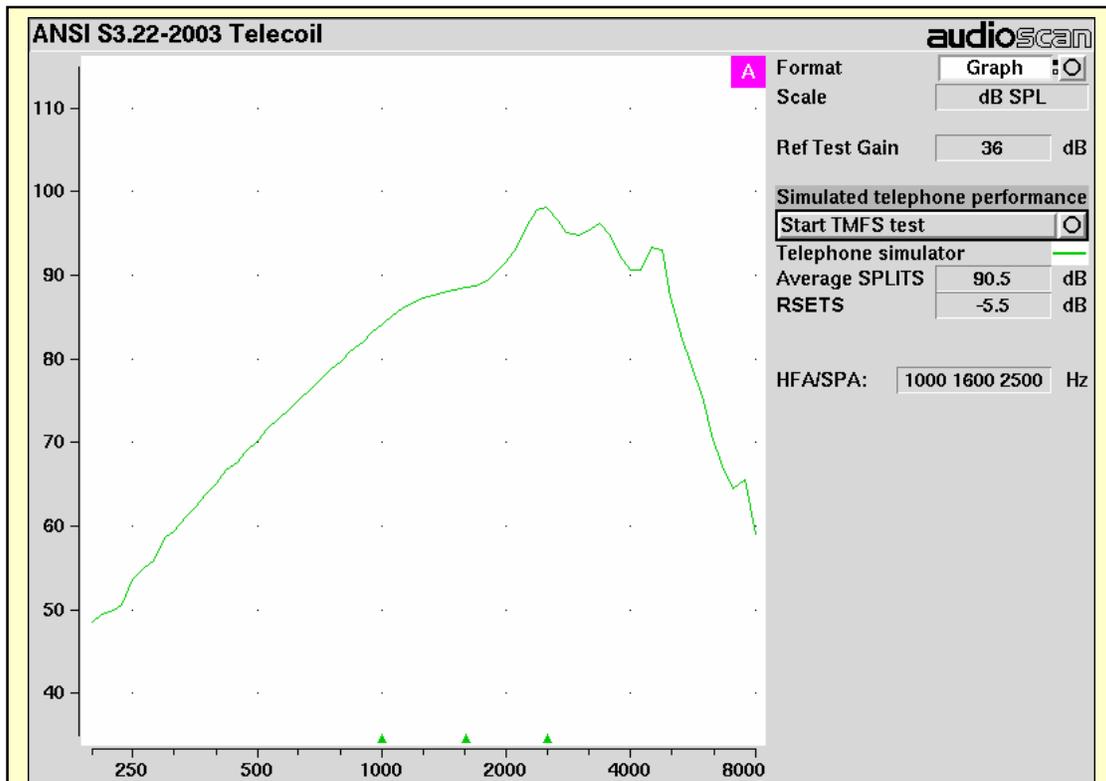
See 8.7: ANSI telecoil terminology for explanation of abbreviations.

Note that the 2003 standard requires that the telecoil test be performed with the AGC set for minimum effect. See 0: ANSI S3.22-2003 facts.

The 1996 standard requires the manufacturer to specify the AGC settings used for the telecoil test.

FastFacts 8.10: Telecoil test results

9 Other Test Box Tests

9.1 Section overview

In addition to the tests of ANSI S3.22, the RM500SL provides the following:

Distortion: Harmonic distortion at 2nd or 3rd harmonics and 2nd plus 3rd with input levels varying from 60 – 90 dB SPL.

Noise Reduction: This test shows the amount of noise reduction provided by the hearing instrument.

Multicurve: 1 – 4 curves of coupler SPL or coupler gain for swept tones or pink noise in 1/12th octaves at selected input SPL of 0 or 40 to 90 dB in 5 dB steps. Can be used as a 1/12th octave **spectrum analyzer** by setting stimulus to 0 dB.

Battery drain: A 10 second test of battery current drain with no acoustic input, a 1 kHz 65 dB input SPL, and an average for 90 dB input SPL at the HFA or SPA frequencies selected in Setup. **Optional battery pills are required**.

Manual control: Coupler and Test box reference mic. SPL at selected 1/12th octave frequencies and stimulus SPL of 0 and 40 – 90 dB in 5 dB steps. Can be used as a dual channel **sound level meter** with 1/12th octave, A and C filters.

This section covers the following topics:

9.2: Noise reduction   9.6: Spectral analysis in Multicurve

9.3: Harmonic distortion   9.7: Battery drain

9.4: Multicurve procedure   9.8: Manual control procedure

9.5: Multicurve results   9.9: Sound level meter using manual control

FastFacts 9.1: Other hearing instrument tests

9.2 Noise reduction

This test captures a response curve before the hearing instrument reacts to the presence of noise; a comparison curve shows the hearing instrument reacting in real-time. The thick curve is the output before the noise reduction is activated and the thin line is the output as the noise reduction takes effect. The test also provides an overall rms noise reduction value in dB.

1) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and pick [Noise reduction].

2) Highlight and <PICK> Test 1, 2 or 3.

3) Highlight and <PICK> a stimulus type from the list box.

4) Highlight and <PICK> a stimulus level from the list box.

5) Highlight and <PICK> [Start test]

6) Highlight and <PICK> [Continue] to capture the comparison curve once the noise reduction function has responded.

FastFacts 9.2: Noise reduction

9.3   Harmonic distortion

This test measures harmonic distortion at 2nd or 3rd harmonics with input levels varying from 60 – 90 dB SPL. It also presents the sum of 2nd and 3rd harmonics as total harmonic distortion (THD). For hearing aids, this differs little from true THD.

1) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Distortion].

2) Refer to 7.11: Coupling the hearing instrument, 7.12: Positioning the hearing instrument and 2.5: Battery pill use and care to prepare the instrument for testing.

3) **Turn the hearing instrument ON**.

4) Highlight and <Pick> [Start test].

5) Highlight and <PICK> [Harmonics], then highlight and <PICK> THD, 2nd or 3rd from the drop-down list.

6) Highlight and <PICK> [Input], then highlight and <PICK> the desired input level (60 – 90 dB SPL) from the drop-down list.

7) Press <Continue> to run the test. Distortion will be displayed at 1/3 octaves in graphic and in tabular form.

FastFacts 9.3: Harmonic distortion

9.4   Multicurve procedure

Multicurve generates 1 to 4 output or gain response curves using either pink noise or swept pure tones at input levels ranging from 40 – 90 dB SPL and 0 dB (off).

1) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Multicurve].

2) Refer to 7.11: Coupling the hearing instrument, 7.12: Positioning the hearing instrument and 2.5: Battery pill use and care to prepare the instrument for testing.

3) **Turn the instrument ON.**

4) Highlight and <PICK> button 1, 2, 3 or 4 in the Test column.

5) Highlight and <PICK> the Stimulus window, then highlight and <PICK> either [Pink noise] or [Swept] from the drop-down list.

6) Highlight and <PICK> the Level window for the selected Test, then highlight and <PICK> a stimulus level from the drop-down list.

7) Press <Continue> to run a sweep or to capture a pink noise curve; press <Cancel> to abort the test.

8) To measure another response curve, highlight and <PICK> another test button; to overwrite a curve, highlight and <PICK> its test button.

To change scale from dB SPL to dB Gain, highlight & <PICK> the Scale window.

FastFacts 9.4: Multicurve procedure

9.5 Multicurve results

1) **Output** curves for the noise signal are in 1/12th octave bands. They will be approximately 18 dB lower than pure tone curves for a linear instrument.

2) **Gain** curves for a linear instrument will be the same for both swept and pink noise test signals.

3) For compression instruments, both gain and output curves may be expected to differ for the two test signals.

4) See 7: Test Box Measures Setup to change screen appearance.
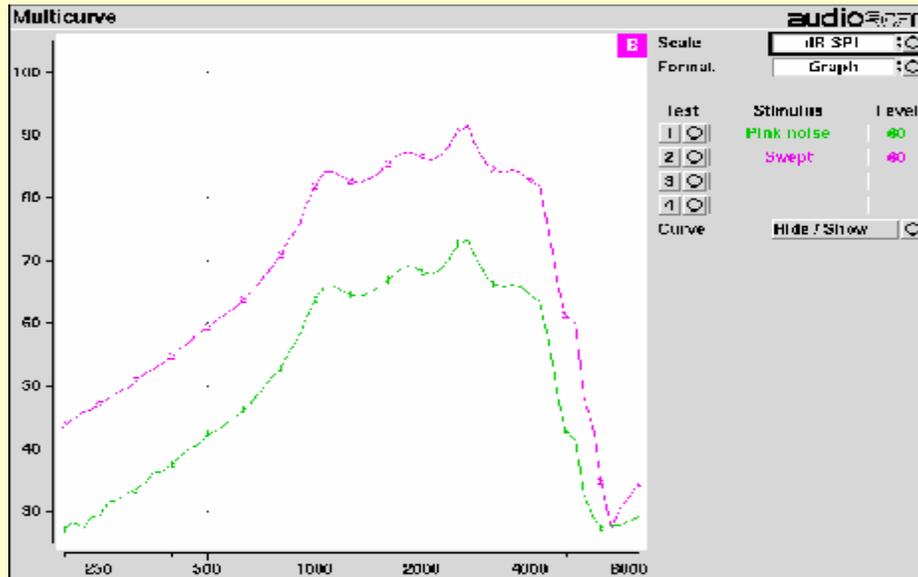
FastFacts 9.5: Multicurve results

9.6 Spectral analysis in Multicurve

Selecting a stimulus level of 0 dB (off) in [Multicurve] presents a spectral analysis of the coupler microphone signal (Scale = dB SPL) or the difference between the coupler and reference microphone spectra (Scale = dB Gain).

If the stimulus type is [Pink noise], the analysis is performed in 1/12th octave bands and displayed in real time. Pressing <Continue> captures the displayed spectrum.

If the stimulus type is [Swept], a swept filter analysis is performed in 1/12th octave bands and displayed at 1/3rd octave frequencies. Pressing <Continue> causes the swept filter analysis to be performed in 1/12th octave bands and displayed at 1/12th octave frequencies.

FastFacts 9.6: Spectral analysis in Multicurve

9.7 Battery drain test

The battery drain test automatically measures the battery current when there is no input signal (quiescent), when the input signal is a 1 kHz tone at 65 dB SPL and the average of the currents when the input signal is 90 dB SPL at the HFA or SPA frequencies (Avg @ 90 dB). Battery life is estimated assuming 80% quiescent and 20% Avg @ 90 dB use. **Optional battery pills are required.**

 With the hearing instrument set as normally used:

1) Install and connect the proper battery pill. See 2.5: Battery pill use and care

2) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Battery drain].

3) Highlight and <PICK> [Battery type] and select from drop-down list.

4) Highlight and <PICK> [Hours per day] and select from drop-down list.

5) Highlight and <PICK> [Start test]
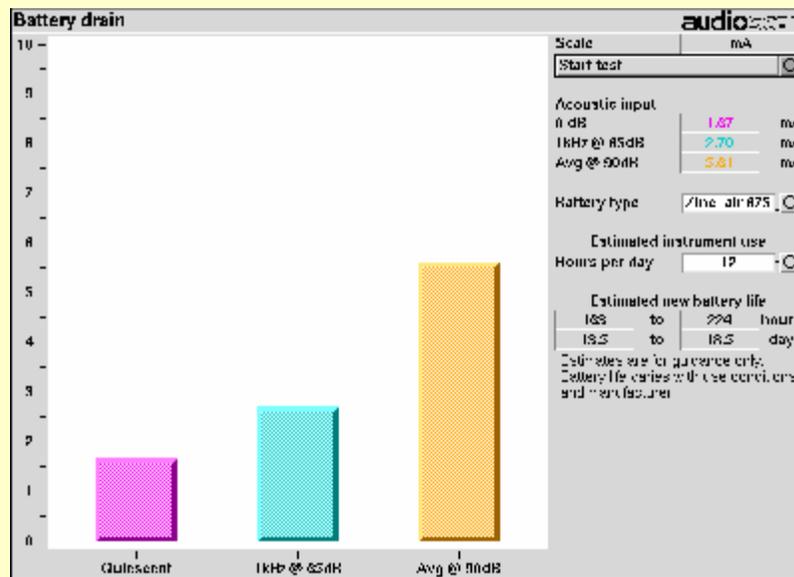
FastFacts 9.7: Battery drain test

9.8 Manual control procedure

Manual control displays the reference microphone SPL, the coupler microphone SPL, their difference in dB (gain) and coupler microphone signal distortion at any selected 1/12th octave frequency and at a selected input level from 40 to 90 dB (in 5 dB steps) and at 0 dB (off).

1) Press <Test>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Manual control].

2) Highlight and <PICK> the Level window, then highlight and <PICK> the desired stimulus level from the drop-down list.

3) Highlight and <PICK> the Frequency window, then highlight and <PICK> the desired frequency from the drop-down list. (Distortion measurement data is available only from 200-4000 Hz.)

4) Highlight and <PICK> [Start test] to start the test. [Start test] changes to [Stop Test]. To stop the measurement, highlight and <PICK> [Stop test]. You may change Level and Frequency without stopping the test.
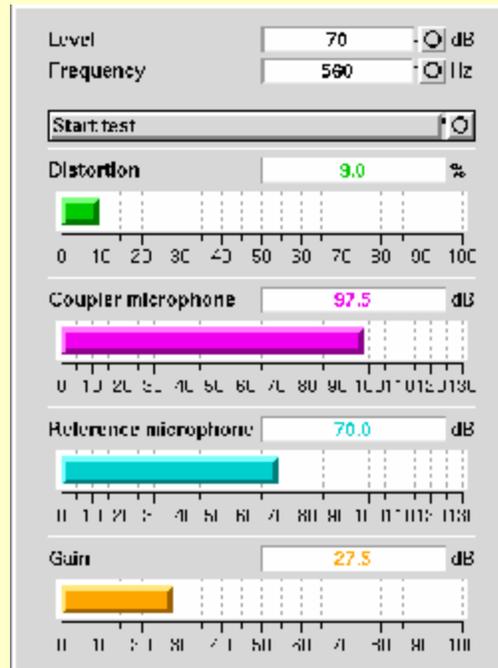
FastFacts 9.8: Manual control procedure

9.9 Sound level meter using manual control

When set for a stimulus level of 0 dB (off), the Manual control mode allows the RM500SL to be used as a sound level meter. Sound at the test box reference microphone and the coupler microphone may be analyzed by 1/12th octave, A-weighted or C-weighted filters. A and C-weighted measurements are limited to frequencies above 100 Hz and the averaging time and update rate are 384 ms.

1) Press <Tests>, then highlight and <PICK> [Test box measures], then highlight and <PICK> [Manual control].

2) Highlight and <PICK> the Level window, then highlight and <PICK> 0 dB stimulus level from the drop-down list.

3) Highlight and <PICK> the Filter window, then highlight and <PICK> 1/12th octave, A-weighted, or C-weighted from the drop-down list.

4) For 1/12th octave filter, highlight and <PICK> the Frequency window, then highlight and <PICK> the desired frequency from the drop-down list.

5) Highlight and <PICK> [Start test] to start the test. [Start test] changes to [Stop Test]. To stop the measurement, highlight and <PICK> [Stop test]. You may change Level and Frequency without stopping the test.

NOTE: A microphone extension cable (VA-130) is available from Audioscan. Standard audio extension cables should not be used. They will substantially increase noise levels.

FastFacts 9.9: Sound level meter using manual control

10 Sensory Loss Simulator

10.1 Sensory loss simulator description

A pure conductive loss attenuates loud and soft sounds equally, and is easily simulated by just turning down the volume or inserting an earplug. Losses of a sensory nature are more complex and more difficult to simulate.

The most common sensory loss is caused by **outer hair cell** damage and results in loss of audibility for soft sounds but near-normal loudness for loud sounds**. Inner hair cell** damage elevates threshold and reduces loudness for both soft and loud sounds, possibly somewhat more for soft sounds.

This sensory loss simulator (SLS) is intended to allow normal-hearing listeners to hear sounds as if they had the elevated threshold and altered loudness perception caused by outer and inner hair cell damage. It is based on the cochlear hearing loss model described in Moore & Glasberg (2004).

In this simulation, losses less than 58 dB SPL are considered to be due entirely to outer hair cell damage. Any loss greater than this is considered inner hair cell loss.

This SLS does not simulate broadening of the auditory filters or other distortions that may accompany cochlear hearing loss.

For comparison purposes, a simulation of a purely conductive loss is also provided.

To properly experience the simulation, listeners should be within 1m of the sound-field speakers and in a quiet room.

FastFacts 10.1: Sensory loss simulator description

10.2 Sensory loss simulator operation

Listeners should be within 1m of the On-ear speaker and in a quiet room.

1) Press <Test>, then highlight and <PICK> [Sensory loss simulator].

2) If an audiogram has previously been entered in Speechmap or Insertion gain, go to step 4. Otherwise, highlight and <PICK> [Audiometry].

3) Enter HL threshold values using a mouse or the keypad. Left click the mouse on the audiogram form to enter a point. Click again to delete the point. On the keypad use the arrow keys to change frequency and level and press <PICK> to enter or delete a threshold point.

4) Press <Continue> when all points have been entered. See 16.4: Audiometric data entry or 18.2: Assessment data entry for more details.

5) Highlight and <PICK> [Start test]. Sound, processed to simulate the entered hearing loss, will be presented via the On-ear speaker.

6) Highlight and <PICK> [Stimulus], then highlight and <PICK> a sound to play.

7) Highlight and <PICK> [Hearing], then highlight and <PICK> from [Normal, ½ Entered loss, Entered loss].

8) Highlight and <PICK> [Type of loss] to toggle between [Sensorineural] and [Conductive] hearing loss simulations.

9) Highlight and <PICK> [Cancel] to stop the simulation.

FastFacts 10.2: Sensory loss simulator operation

11   On-Ear Measurement Setup

11.1   Section overview

For safe and effective operation, the hearing instrument fitting system must be properly set up and calibrated, the client must be properly positioned and the probe tube must be properly positioned in the ear canal. Note that the On-ear speaker is in the lid of the test chamber which must be open to a near-vertical position for all on-ear measurements.

Real-Ear Unaided Response (**REUR**): SPL, or band SPL, in the open (unaided) ear canal for a given stimulus.

Real-Ear Unaided Gain (**REUG**): Difference, in dB, between the REUR and the stimulus SPL, or stimulus band SPL.

Real-Ear Aided Response (**REAR**): SPL, or band SPL, in the ear canal for a given stimulus, with a working hearing aid in place.

Real-Ear Aided Gain (**REAG**): Difference, in dB, between the REAR and the stimulus SPL, or stimulus band SPL.

Real-Ear Saturation Response (**RESR**): The REAR obtained using a narrow-band signal at a level high enough to saturate the hearing aid (usually 85 - 90 dB SPL).

Real-Ear-to-Coupler Difference (**RECD**): Difference, in dB, between the real-ear SPL and the 2cc coupler SPL produced by the same transducer driven by the same signal.

This section covers the following topics:

11.2: On-ear calibration facts   11.6: ABR nHL to eHL setup

11.3: Calibration of On-ear probe microphone   11.7: Positioning the client

11.4: Calibration check for probe module   11.8: Positioning the probe tube

11.5: Max TM SPL setup

FastFacts 11.1: On-ear measurement setup

11.2   On-ear calibration facts

The probe microphone and its associated tubing does not have a flat frequency response. The On-ear calibration process compares this response with the flat, factory-calibrated response of the On-ear reference microphone and compensates all subsequent probe-tube measurements for this difference. It may be performed as often as desired but will be invalidated at 1 am the following day or at 1 am the following Monday, depending on the choice of Daily or Weekly calibration interval. After the calibration has expired, you will be prompted to calibrate whenever you attempt a test that uses the on-ear measurement microphones.

It is suggested that a copy of the calibration curves for the probe modules when new be posted near the RM500SL for comparison with daily or weekly curves. If there is a drift in calibration with time, the module may need replacement. See 11.4: Calibration check for probe module.

Calibration should be repeated if probe modules are switched or if a probe-tube with different dimensions is installed.

FastFacts 11.2: On-ear calibration facts

11.3 Calibration of On-ear probe microphone

Ensure the probe microphone assembly to be calibrated is plugged into the appropriate jack. See 2.3: Microphone connection and 11.2: On-ear calibration facts

1) Open the test chamber and elevate the speaker to its vertical position.

2) Press <Test>, then highlight & <PICK> [On-ear measures], then highlight and <PICK> [Calibration].

3) Press the enlarged end of a probe tube as far as it will go, into the recessed opening at the top of the probe module.

4) Position the open end of the probe tube in front of the reference microphone inlet and press it between the posts as shown.

5) Hold the probe module 5 – 6 inches (12.5 - 15 cm) away from and directly in front of the loudspeaker. Orientation of the probe module is not critical.

6) Press <PICK> to calibrate. The resulting curve should be similar in shape to that shown but may be shifted ± 5 dB.

7) To change the calibration interval, highlight & <PICK> [Daily] or [Weekly].
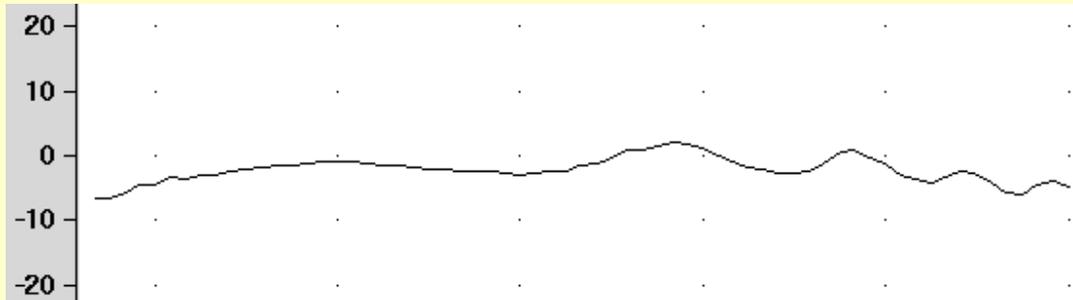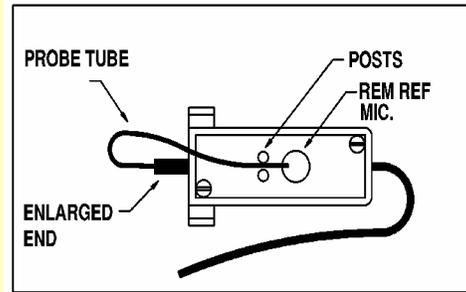
FastFacts 11.3: Calibration of On-ear probe microphone

11.4 Calibration check for probe module

The calibration curve for the probe module is a comparison of the response of the probe microphone (with tube) to the response of the on-ear reference microphone. Any change in the curve indicates a change in one of these microphones (or the probe tube). See 11.3: Calibration of On-ear probe microphone. As part of a regular calibration schedule, or to investigate changing calibration curves, the on-ear reference microphone may be checked against a high quality sound level meter.

1) Press <Test>, then highlight and <PICK> [On-ear measures], then highlight and <PICK> [Manual control].

2) Highlight & <PICK> [Level], then highlight & <PICK> 70 from the drop-down list.

3) Highlight and <PICK> [Frequency], then highlight and <PICK> 2000 Hz from the drop-down list.

4) Highlight, then <PICK> [Start test] (which changes to [Stop test]).

5) Hold the probe module about 18" (0.5 m) in front of the On-ear speakers.

6) Hold the microphone of a calibrated sound level meter next to the On-ear reference microphone as shown. Set the sound level meter to C weighting and slow.

7) The sound level meter should read 70 ±2 dB.

8) Repeat with the frequency at 250 Hz.

9) To stop the measurement, highlight and <PICK> [Stop test].

The probe module should be replaced if it fails this test.
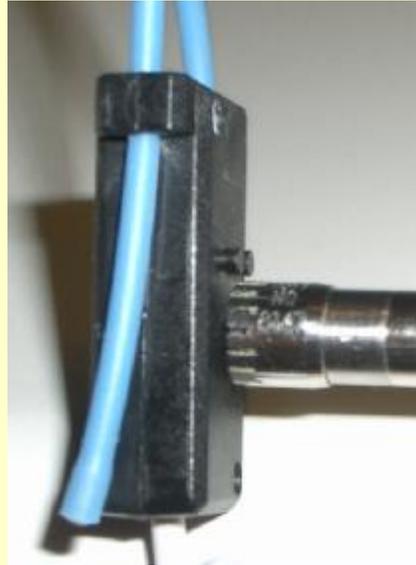
FastFacts 11.4: Calibration check for probe module

11.5 Max TM SPL setup

The Max TM SPL safety feature allows you to set a limit on the SPL, measured by the probe microphone, above which a test terminates. The MAX TM SPL limit is shown on all On-ear screens. The default limit is 120 dB.

To choose a different Max TM SPL setting:

1) Press <Setup>, then highlight and <PICK> [Max TM SPL].

2) Highlight and <PICK> the current Max TM SPL setting.

3) Highlight and <PICK> the desired Max TM SPL setting from the drop-down list.

4) Press <Continue> to exit Setup.

This Max TM SPL setting will be in effect until you change it.

If the limit is exceeded during a real-ear test, the RM500SL will terminate the test and display the message "**MAX TM SPL EXCEEDED**". You must then decide to either adjust the maximum output limiting of the hearing instrument or increase the Max TM SPL setting following the steps above.

If the MAX TM SPL limit has been disabled, a notice will appear on each real-ear screen. Also, a message reminding you that the MAX TM SPL limit has been disabled will appear when you select a real-ear test.

FastFacts 11.5: Max TM SPL setup

11.6 ABR nHL to eHL setup

Estimated Hearing Level (eHL): An estimate of the behavioral pure tone threshold that accounts for a measured ABR threshold.

Normalized Hearing Level (nHL): (a) Stimulus peak-to-peak equivalent SPL (pe SPL) at ABR threshold relative to the average stimulus pe SPL at ABR threshold of a normal-hearing jury OR (b) stimulus SPL at ABR threshold relative to the average stimulus SPL at behavioral threshold of a normal-hearing jury for the same stimulus. (Note that in this latter case, nHL is equivalent to eHL).

In Speechmap/DSL you have the option of entering ABR thresholds in either eHL or nHL. If eHL is selected, the threshold is treated as if it were a behavioral pure-tone threshold. If nHL is selected, the entered data will first be converted to eHL before SPL threshold and fitting targets are calculated. To do this, appropriate eHL to nHL conversion factors must be applied. You can choose to apply default conversion factors or enter new ones for each client.

This setup allows you to select the **default** conversion factors that are applied in Speechmap/DSL to convert ABR nHL threshold to eHL threshold.

1) Press <Setup>, then highlight and <PICK> [ABR eHL to nHL].

2) Highlight and <PICK> [DSL defined] or [User defined]

3) For [User defined], enter conversion factors using a mouse, the keypad or a keyboard. See 18.2:Assessment data entry.

When using the barcode option, both entered nHL data and the nHL to eHL conversion factors are printed as a single barcode. See 3.3: Barcode data input.

FastFacts 11.6: ABR nHL to eHL setup

11.7 Positioning the client

Sound reflections from nearby surfaces (including the operator) can cause large measurement errors. Room noise can increase test time, cause errors and alter the operation of the hearing instrument being evaluated.

1) Choose a quiet location and position the client and the real-ear speaker at least 1.5 m (5 feet) away from any hard surfaces.

2) The speaker mounted in the lid of the test chamber is used for real-ear measurements. It is normally used with the lid in a near-vertical position but the elevation may be changed by opening the lid past vertical.

3) Position the client directly in front of, and facing, the front On-ear speaker at a distance of 18" to 36" (45 to 90 cm) from the center of the head. The speaker and the head should be at approximately the same level.

FastFacts 11.7: Positioning the client

11.8 Positioning the probe tube

1) Use an otoscope to ensure there is no ear canal obstruction (e.g. cerumen) and to get a sense of ear canal length.

2) Install a new probe tube on the probe module. Set the black marker ring approximately 28 mm from end of probe tube for adult females, approximately 30 mm from end of probe tube for adult males and approximately 20-25 mm from end of probe tube for children. These positions may be modified based on the otoscopic examination. (Tip - the probe module body is 28 mm long.)

3) Hang the probe module on the ear, as shown. **The reference microphone should face outwards**.

4) Adjust the blue cord until the probe module is snug against the head, directly below the earlobe (cheek level). To facilitate this, clip the probe module cable to clothing on the side opposite the test ear and draw the cable snug.

5) Hold the front blue cord so that it passes behind the ear canal entrance and pass the end of the probe tube in **front** of the blue cord and into the ear canal.

6) Carefully slide the probe tube into the ear canal until the marker ring approaches the intertragal notch. Then let the front blue cord move forward to hold the probe tube in place. **Use an otoscope to verify that the tube is 2 to 5 mm from the eardrum.**

FastFacts 11.8: Positioning the probe tube

12 On-ear Screen Setup

12.1 Section overview

To accommodate your working preferences, the appearance of On-ear screens may be changed in several ways.

This section covers the following topics:

FastFacts 12.1: On-ear screen setup

12.2 On-ear right or left display

The RM500SL can retain and display On-ear test results for two ears. To switch between left and right test results, press the <Left/Right> key.

FastFacts 12.2: On-ear right or left display

12.3 Graph, table or 2cc target format

Most On-ear test screens may be viewed in graphic or tabular format.

∨ In RECD, highlight and <PICK> [Format] to toggle between [Graph] and [Table] views.

∨ In Speechmap and Insertion gain, highlight and <PICK> [Format], then highlight and <PICK> [Graph], [Table] or [2cc targets] from the drop-down list.

∨ In [2cc targets] format, reserve gain and fitting formula may be changed. Highlight & <PICK> the appropriate window, then highlight & <PICK> the reserve gain or fitting formula from the drop-down list.

In Speechmap, if DSL, NAL-NL1 or Camfit has been selected as a target method, then 2cc coupler targets for user gain, full-on gain and OSPL90 are provided. The full-on gain is just the user gain plus the reserve gain. If no target method has been selected, only 2cc OSPL90 values are indicated. **Target gains are for speech-like signals at a 70 dB input SPL; OSPL90 targets are for 90 dB pure tones.**

On-ear targets are converted to 2cc coupler values by using age-appropriate average or measured (if available) RECD values and the appropriate microphone location effects for the desired style of hearing instrument.

The gain values given assume the hearing instrument is linear for a 70 dB speech input. This assumption is necessary to allow the microphone location effects to be incorporated.

For BTE and body aids, the 2cc coupler values provided assume a fully-occluding earmold with #13 tubing extending to the medial tip of the earmold. If a different type of mold is used, alterations to these values should be made to account for the different acoustic characteristics. For CIC instruments, the 2cc values take into account that the instrument, when deeply inserted into the ear canal, will produce a greater SPL in the ear than that measured in the ITE coupler.

FastFacts 12.3: Graph, table or 2cc target format

12.4 SPL or HL scale

In Speechmap and Insertion gain tests you may view results in either dB HL or dB SPL.

Insertion gain tests view the hearing aid as improving the sound-field threshold. In Insertion gain, the HL scale presents aided results as improved sound-field thresholds while the speech region remains fixed.

Speechmap tests view the hearing aid as increasing the ear canal SPL. Speech gets louder but the threshold remains fixed. On the HL scale in Speechmap, normal ear canal threshold becomes the 0 dB HL line and all data is replotted using this reference. A physical interpretation of the data is difficult and the use of **HL in Speechmap is not recommended.** All instructions given in this guide assume the SPL Speechmap scale.

Highlight and <PICK> [Scale] to toggle between a dB SPL and dB HL scale.

FastFacts 12.4: SPL or HL scale

12.5 Hide or show On-ear curves

On screens capable of showing a speech envelope, you may show or hide the speech envelope for clarity of display. You may choose to show the envelope with the LTASS or only the LTASS. Hiding a curve does not erase it. To erase curves use the <Session> key.

To hide or show test curve(s):

1) Highlight, then <PICK> Curve [Hide/Show].

2) Highlight, then <PICK> the desired test to toggle between the Hide or Show options. The curve will toggle on or off when selected.

3) Where available, you may also highlight and <PICK> the envelope (right column) button to toggle it on or off.

4) Press <Continue> to return to the test screen.

Curve display		
Test 1	Show :O	Hide :O
Test 2	Show :O	Hide :O
Test 3	Show :O	Show :O
Test 4	Hide :O	Hide :O
Unaided (65)		Hide :O
Continue		Help
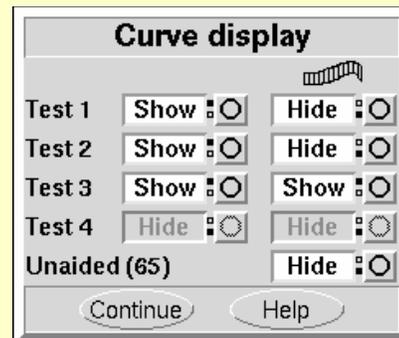
FastFacts 12.5: Hide or show On-ear curves

13 On-Ear Instrument Measures

13.1 Section overview

A number of the tests covered in Test box measures can also be performed with the hearing instrument coupled to the ear of a client rather than to a 2cc coupler. The on-ear results may be expected to differ from the test box results because of the different acoustic environment and the different acoustic load.

This section covers the following topics:

FastFacts 13.1: On-ear instrument measures

13.2 On-ear feedback test

This test shows the SPL and the power concentration ratio (PCR) in each 1/3 octave band for a speech signal. Feedback results in a peak in the speech spectrum and in the PCR. Incipient feedback results in a peak in the PCR curve.

Refer to 11: On-Ear Measurement Setup to prepare the system for use and for proper positioning of the client and the probe tube.

1) Insert the earmold/tip or custom hearing instrument into the ear, being careful not to advance the probe tube further into the ear canal. A lubricant applied in the vicinity of the probe tube will ease insertion and prevent slit leaks.

2) Set the instrument as it will be used, with feedback suppression enabled and initialized.

3) Press <Tests> then highlight and <PICK> [On-ear measures], then highlight and <PICK> [Feedback].

4) Highlight and <PICK> Test 1 and set the Stimulus to Speech-std(1) or (2) and the level to 50 or 60 dB SPL. As the speech passage plays, observe the feedback bar and the lower graph. A yellow Feedback bar and peaks with yellow markers in the lower curve indicate incipient feedback which may impact sound quality. A red Feedback bar and peaks with red markers in the lower curve indicate feedback that may be audible and should be mitigated. Press <Continue> to run the full speech passage and capture average results for the passage.

5) Repeat for Test 2 and 3 as needed. These tests may be used to explore the effects of jaw movement and the presence of hands, hats and telephone handsets.

FastFacts 13.2: On-ear feedback test

13.3 On-ear noise reduction test

This test captures a response curve before the hearing instrument reacts to the presence of noise; a comparison curve shows the hearing instrument reacting in real-time. The thick curve is the output before the noise reduction is activated and the thin line is the output as the noise reduction takes effect. The test also provides an overall rms noise reduction value in dB.

Refer to 11: On-Ear Measurement Setup to prepare the system for use and for proper positioning of the client and the probe tube.

1) Press <Tests>, then highlight and <PICK> [On-ear measures], then highlight and pick [Noise reduction].

2) Highlight and <PICK> Test 1, 2 or 3.

3) Highlight and <PICK> a stimulus type from the list box.

4) Highlight and <PICK> a stimulus level from the list box.

5) Highlight and <PICK> [Start test]

6) Highlight and <PICK> [Continue] to capture the comparison curve once the noise reduction function has responded.

FastFacts 13.3: On-ear noise reduction test

13.4 On-ear manual control

1) Refer to 11: On-Ear Measurement Setup to prepare the system for use and for proper positioning of the client and the probe tube.

2) Press <Test>, then highlight and <PICK> [On-ear measures], then highlight and <PICK> [Manual control].

3) Highlight and <PICK> the Level window, then highlight and <PICK> the desired stimulus level from the drop-down list.

4) Highlight and <PICK> the Frequency window, then highlight and <PICK> the desired frequency from the drop-down list. (Distortion measurement data is available only from 200-2500 Hz.)

5) Highlight and <PICK> [Start test] to start the test. [Start test] changes to [Stop Test]. To stop the measurement, highlight and <PICK> [Stop test]. You may change Level and Frequency without stopping the test.
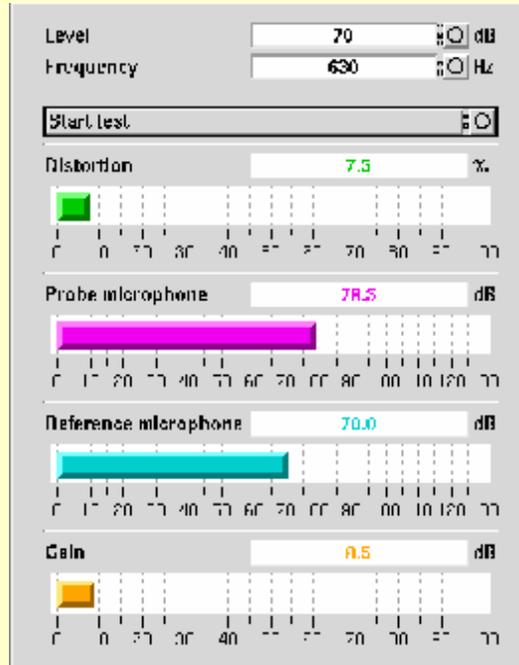
FastFacts 13.4: On-ear manual control

13.5 Sound level meter using on-ear microphones

The manual control feature enables the RM500SL to be used as a sound level meter to perform C-weighted, A-weighted or 1/12th octave analysis of sound as measured by the probe and reference microphones. A and C-weighted measurements are limited to frequencies above 100 Hz and the averaging time and update rate are 384 ms.

1) Refer to 11: On-Ear Measurement Setup to prepare the system for use and for proper positioning of the client and the probe tube.

2) Press <Test>, then highlight and <PICK> [On-ear measures], then highlight and <PICK> [Manual control].

3) Highlight and <PICK> the Level window, then highlight and <PICK> 0 dB stimulus level from the drop-down list.

4) Highlight and <PICK> the Filter window, then highlight and <PICK> 1/12th octave, A-weighted, or C-weighted from the drop-down list.

5) For 1/12th octave filter, highlight and <PICK> the Frequency window, then highlight and <PICK> the desired frequency from the drop-down list.

6) Highlight and <PICK> [Start test] to start the test. [Start test] changes to [Stop Test]. To stop the measurement, highlight and <PICK> [Stop test]. You may change Level and Frequency without stopping the test.

FastFacts 13.5: Sound level meter using On-ear probe

14 Occlusion Effect Test

14.1 Section overview

The occlusion effect refers to the unnatural sound of one's own voice that results from occluding the external ear. It is the result of the high SPL produced at the back of the throat during a closed vowel utterance coupling to the closed ear canal via bone conduction. Ear canal levels in a closed ear canal can exceed 90 dB SPL for closed vowels such as "ee". The effect is greatest below 1000 Hz. Clients with mild-moderate low frequency hearing loss may describe their own voice as sounding "hollow" or as if they were talking "in a barrel".

The occlusion effect is measured by comparing the SPL in the ear canal to that outside the external ear while the client vocalizes "ee" with the hearing aid in place and turned off. Differences greater than 10 dB may result in complaints. This occlusion effect measurement is useful in quantifying the extent to which venting or deep insertion is addressing the underlying cause of the complaint.

FastFacts 14.1: Occlusion effect test

14.2 Occlusion effect measurement

1) Refer to 11: On-Ear Measurement Setup to prepare the system for use and for proper positioning of the client and the probe tube.

2) Insert the earmold or custom hearing instrument into the ear, being careful not to advance the probe tube further into the ear canal. A lubricant applied to the earmold or custom instrument shell in the vicinity of the probe tube will make insertion easier and prevent slit leaks around the tube.

3) **Turn the hearing aid OFF.**

4) Press <Test>, then highlight and <PICK> [On-ear], then highlight and <PICK> [Occlusion].

5) Highlight and <PICK> [Start test] to start the test. [Start test] changes to [Stop Test].

6) While the client vocalizes "ee" in a normal voice, highlight and <PICK> [Stop test] to stop the test and freeze the screen. A red occlusion bar indicates an occlusion problem, a yellow bar indicates a possible problem and a green bar indicates no problem.

7) Increase venting and repeat the test until a green bar is obtained.
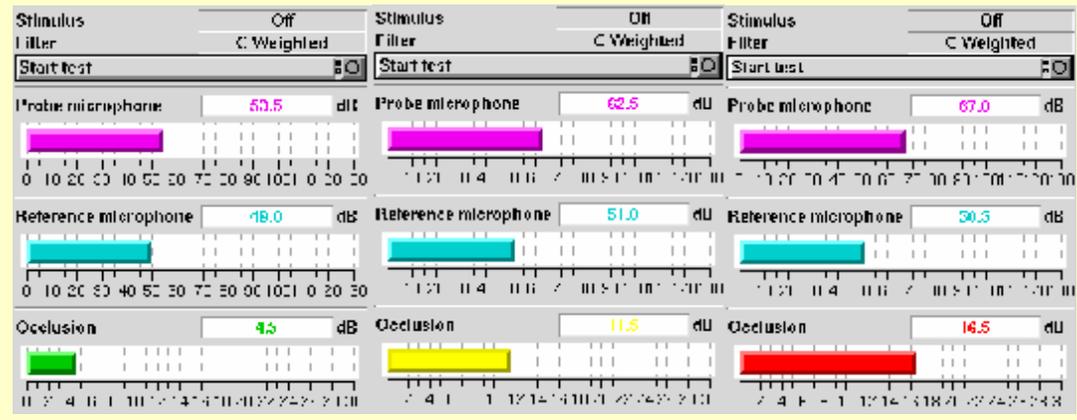
FastFacts 14.2: Occlusion effect measurement

15 RECD (real-ear to coupler difference)

15.1 Section overview

> The RECD measurement procedure may be accessed by selecting RECD from the **On-ear tests** list or from the Audiometry poster within **Speechmap**. An **optional RECD transducer** is required for RECD measurements.
>
> **This section covers the following topics:**
>
> 15.2: RECD facts
>
> 15.3: RECD coupler response
>
> 15.4: RECD real-ear response
>
> 15.5: RECD results

FastFacts 15.1: RECD (real-ear to coupler difference)

15.2 RECD facts

> Individual RECD values are derived by comparing the real-ear SPL for a given test signal to the 2cc coupler SPL for the same test signal. These RECD values are used to: (1) convert HL threshold and UCL obtained using insert phones to SPL values, (2) simulate on-ear measurements from 2cc coupler measures; and (3) derive 2cc coupler targets from real-ear aided targets.
>
> **If you use insert ear phones** for audiometry **OR if you verify using Simulated On-ear**, you should **measure RECD** (preferred) or use age-related average RECD.
>
> **If you use headphones or sound field** for audiometry **AND** you **use On-ear measures** for verification, **RECD is not applied in any way** and need not be measured.
>
> If you use 2cc coupler targets, you should use measured or age-related RECD.
>
> Insert phone audiometry with measured RECD and On-ear verification provides the best fitting accuracy, with Simulated On-ear verification being slightly less accurate. Insert phone HL data with age-related average RECD is next best.
>
> This software provides average RECDs for 1 - 60 months, 6 - 10 years of age and Adult. A sampling of age-related foam-tip **HA-2 RECD** values is shown below.
>
> | Age/Freq | 250 | 500 | 750 | 1000 | 1500 | 2000 | 3000 | 4000 | 6000 |
> |---|---|---|---|---|---|---|---|---|---|
> | 1 month | 3 | 8 | 9 | 12 | 15 | 15 | 16 | 20 | 23 |
> | 12 months | 3 | 6 | 8 | 10 | 10 | 11 | 11 | 15 | 17 |
> | 24 months | 3 | 5 | 7 | 9 | 9 | 10 | 10 | 14 | 15 |
> | 36 months | 3 | 5 | 7 | 9 | 8 | 9 | 9 | 13 | 14 |
> | 60 months | 3 | 5 | 7 | 9 | 7 | 8 | 8 | 13 | 13 |
> | 8 yrs - Adult | 3 | 4 | 6 | 8 | 7 | 7 | 8 | 13 | 13 |
>
> Values are from DSL 5.0 but differ from DSL in that values for 119 months have been used for ages >119 months. **DSL 5.0 RECDs differ from DSL 4.1 RECDs.**

FastFacts 15.2: RECD facts

15.3 RECD coupler response

Prepare the system for Test box tests. See 2.3: Microphone connection, 7.9: Calibration of test box reference mic. Connect the **optional** RECD transducer to the RECD jack to the left of the test chamber.

1) Press <Test> then highlight and <PICK> [On-ear measures], then highlight and <PICK> [RECD].

2) If a valid coupler response exists, go to 15.4:RECD real-ear response.

3) If no coupler response exists or the measurement interval has been exceeded, connect the RECD transducer to the BTE coupler.
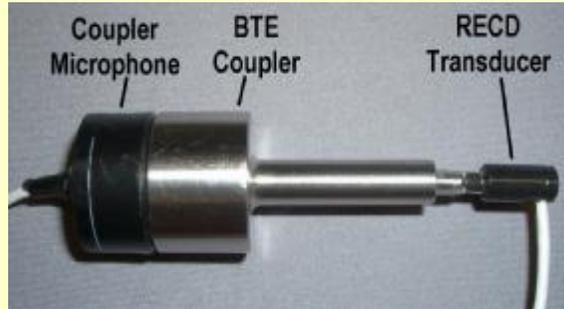
4) Highlight and <PICK> [Measure coupler] and follow the setup instructions.

5) Press <Continue> to generate the coupler response curve (green). When this curve is stable, press <Continue> to save it.

6) Highlight and <PICK> [Daily] or [Weekly] to toggle the measurement interval for the coupler response.

For comparison purposes, an age-related average RECD is shown as a dotted curve on the screen. If you have accessed RECD from the On-ear tests list, you may highlight and <PICK> the Age box to change the age for this reference curve.

FastFacts 15.3: RECD coupler response

15.4 RECD real-ear response

Connect the RECD transducer to the RECD jack to the left of the test chamber. Prepare the system for On-ear tests. See 11.3: Calibration of On-ear probe microphone.

2) Press <Tests> then highlight and <PICK> [On-ear measures], then highlight and <PICK> [RECD].

3) If no coupler response exists or the measurement interval has been exceeded, go to 15.3:RECD coupler response.

4) If a valid coupler response exists, highlight and <PICK> [Measure real ear].

5) Refer to 11.8: Positioning the probe tube and insert the probe tube into the ear canal to within 2 - 5 mm of the eardrum.
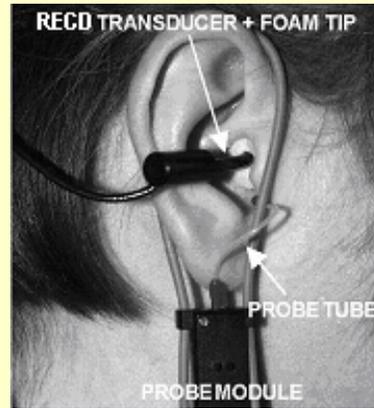
6) Insert the foam tip into the ear, being careful not to advance the probe tube further into the ear canal. Insertion depth should be as used with insert phones. **Allow the foam tip to fully expand in the ear.**

7) Press <Continue> to generate the real-ear response curve (pink) and the RECD curve (cyan). If the RECD curve is **negative and unstable** in the low frequencies, check the seal of the foam tip. Increase the tip size and/or apply a lubricant to the foam tip to improve the seal. If the RECD curve deviates more than 10 dB from the average in the 4 - 6 kHz region, check for proper probe placement and possible blockage of the tube by the foam tip or cerumen.

8) When these curves are stable, press <Continue> to save them.

For comparison purposes, an age-related average RECD is shown as a dotted curve on the screen. If you have accessed RECD from the On-ear tests list, you may highlight and <PICK> the Age box to change the age for this reference curve.

FastFacts 15.4: RECD real-ear response

15.5 RECD results

The RECD measurement screen shows the response of the RECD transducer in the real ear (pink) and in the 2cc coupler (green). The difference between these curves is the RECD (cyan). An age-appropriate average RECD is shown for reference (dotted). A negative RECD below about 1 kHz may indicate a poor seal between the foam tip and the ear canal. A negative RECD above about 3 kHz may indicate the foam tip is blocking the probe tube. See 15.2: RECD facts, 15.3: RECD coupler response, 15.4: RECD real-ear response.
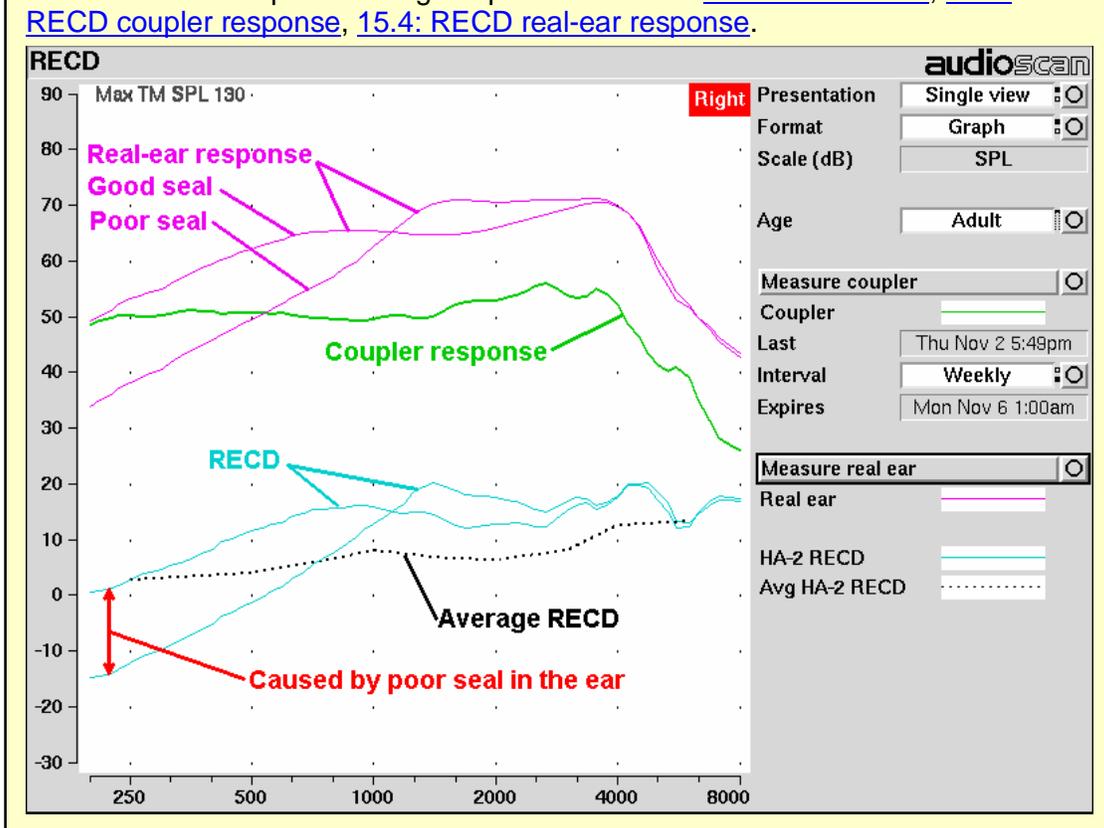
FastFacts 15.5: RECD results

16 Insertion Gain

16.1 Section overview

Insertion gain is the difference between aided and unaided ear canal SPL (REIG = REAG - REUG). It inherently assumes a sound-field audiogram. For non-linear hearing aids, REIG is stimulus-dependent and the dependency is specific to each hearing aid. Insertion gain fitting methods ignore these facts. **Speechmap is recommended for fitting all non-linear hearing instruments.**

Refer to 11: On-Ear Measurement Setup and 12: On-ear Screen Setup for terminology and information on preparing the system for use and for proper positioning of the client and the probe tube.

This section covers the following topics:

16.2: Insertion gain in SPL

16.3: Insertion gain in HL

16.4: Audiometric data entry

16.5: REUR measurement procedure

16.6: REAR measurement procedure

16.7:SII calculation in Insertion gain

FastFacts 16.1: Insertion gain

16.2 Insertion gain in SPL

See 11: On-Ear Measurement Setup and 12: On-ear Screen Setup

1) Press <Test>, then highlight and <PICK> [On-ear measures], then highlight and <PICK> [Insertion gain].

2) Highlight and <PICK> [Instrument] to chose from BTE, ITE, ITC, CIC, Body. This changes the CORFIG used for 2cc targets.

3) Highlight and <PICK> fitting method to chose from FIG6, NAL-NL1, NAL-R, POGO II, Berger, Libby, User, None
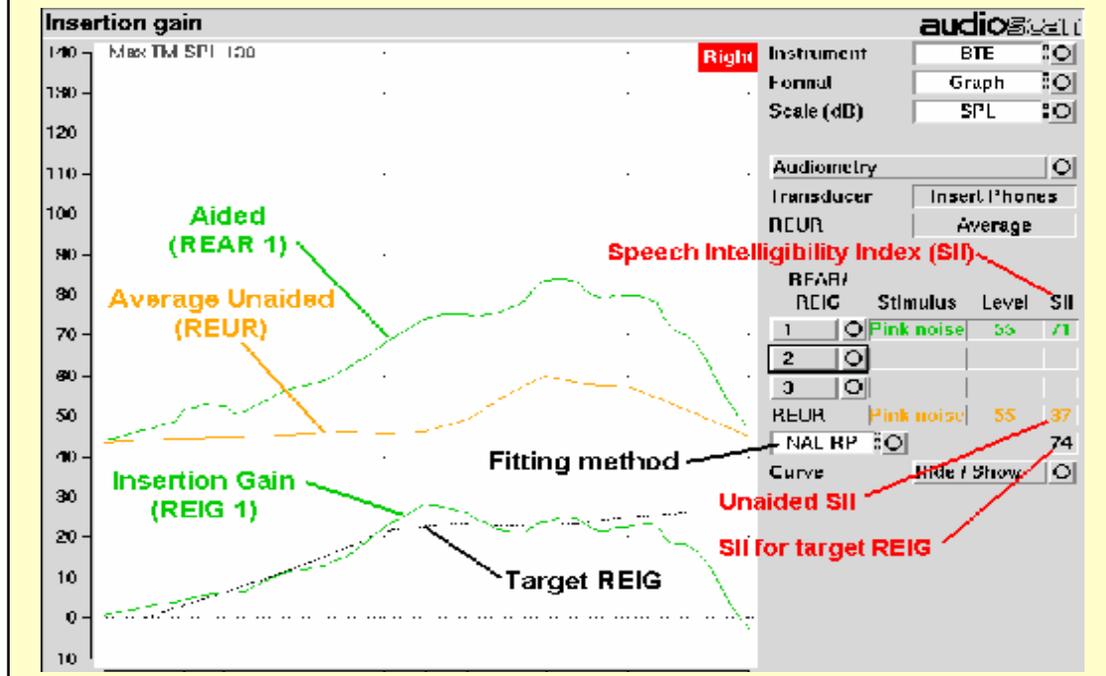
FastFacts 16.2: Insertion gain in SPL

16.3 Insertion gain in HL

See 11: On-Ear Measurement Setup and 12: On-ear Screen Setup

1) Press <Test>, then highlight and <PICK> [On-ear measures], then highlight and <PICK> [Insertion gain].

2) Highlight and <PICK> [Instrument] to chose from BTE, ITE, ITC, CIC, Body. This changes the CORFIG used for 2cc targets.

3) Highlight and <PICK> fitting method to chose from FIG6, NAL-NL1, NAL-R, POGO II, BERGER, LIBBY, USER, NONE.

An estimated aided threshold curve is calculated by shifting the unaided threshold curve upward by the REIG. This estimate assumes a) the **unaided threshold is a sound-field threshold** and b) a **linear aid** (i.e. REIG doesn't depend on level).

The REUR curve uses the right-hand SPL scale and is shown for reference only.
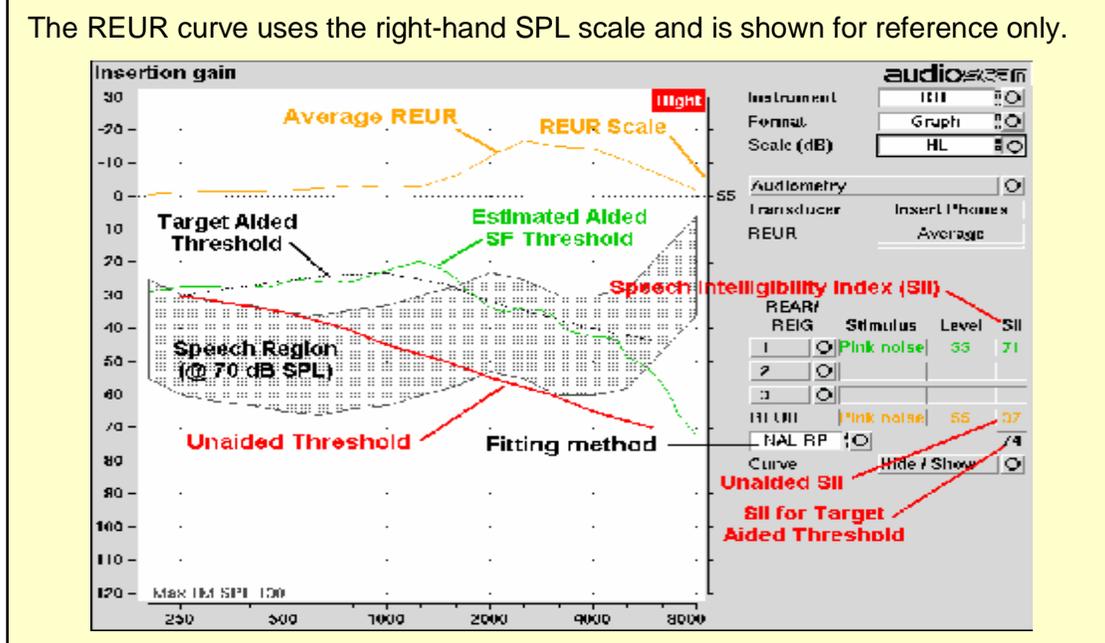
FastFacts 16.3: Insertion gain in HL

16.4 Audiometric data entry

Threshold data and parameters may be entered by scanning a barcode on a previous RM500SL or Verifit printout or manually using a mouse, the keypad or the numeric keypad on an external keyboard. See 2.6: Mouse, keyboard, barcode scanner, and 3.2: Input device operation.

To enter data from a barcode see 3.3: Barcode data input and:

1) Press the barcode trigger and center the red line on the barcode from a distance of 6 - 8". The scanner will beep and the Barcode Entry poster opens.

2) Highlight and <PICK> [Done] to accept the data indicated on the poster.

To enter assessment data and parameters manually:

1) Highlight and <PICK> [Audiometry].

2) Highlight and <PICK> [Transducer], then highlight and <PICK> from the list.

3) Highlight and <PICK> [REUR], then highlight and <PICK> to toggle selection.

Measured REUR should be used with a soundfield threshold because individual REUR is part of the threshold. **Average REUR should be used with headphone or insert phone thresholds** because individual REUR isn't part of these thresholds.

4) When all selections have been completed, press <Continue>.

5) Enter HL threshold values using a mouse or keypad. Left click the mouse on the audiogram form to enter a point. Click again to delete the point. On the keypad use the arrow keys to change frequency and level and press <PICK> to enter or delete a threshold point.

6) Press <Continue> when all points have been entered.

FastFacts 16.4: Audiometric data entry

16.5 REUR measurement procedure

Performing a REUR test erases all existing REAR and REIG data for the current test ear. **REUR should be measured only if Transducer = Soundfield**. Otherwise it is more accurate to use average. See 16.4: Audiometric data entry.

1) Press <Test>, then highlight and <PICK> [On-ear measures], then highlight and <PICK> [Insertion gain].

2) Referring to 11: On-Ear Measurement Setup and 12: On-ear Screen Setup, prepare the system, position the patient and insert the probe tube.

3) If REUR is set to Average, highlight and <PICK> [Audiometry] then highlight and <PICK> [REUR] to toggle to [Measure]. Press <Continue> to advance to the Threshold entry poster. You may enter threshold data at this time (see 16.4: Audiometric data entry) or press <Continue> to proceed with the measurement.

4) Highlight and <PICK> REUR (below REAR/REIG test 3).

5) Press <Continue> to accept the default 55 dB SPL Pink noise stimulus and capture the REUR curve OR highlight and <PICK> [Stimulus] and [Level] to select other values. These choices have no impact on the resulting REIG.

6) If there is a notch in the 4000 to 8000 Hz region, try advancing the probe tube 2 mm and repeating step 3. If the notch moves to a higher frequency, repeat this step until the notch moves beyond the highest frequency of interest.

Because it is analyzed in 1/3 octave bands, the Noise stimulus produces a REUR 12 dB below that produced by the Swept stimulus at the same overall level.

The Average REUR used is shown at right. Measured REUR will vary from this.
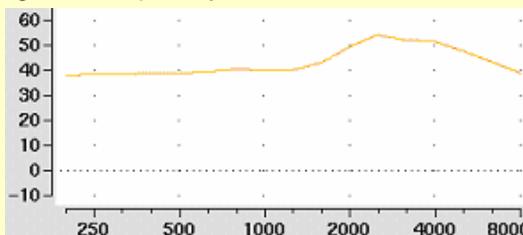
For small children the peak may shift to the right and become sharper. Drainage tubes and perforated ear drums will cause large differences - usually around 1 kHz.

FastFacts 16.5: REUR measurement procedure

16.6 REAR measurement procedure

1) Press <Test>, then highlight and <PICK> [On-ear measures], then highlight and <PICK> [Insertion gain].

2) Referring to 11: On-Ear Measurement Setup and 12: On-ear Screen Setup, prepare the system, position the patient and insert the probe tube. (For tight-fitting hearing aids or earmolds, the probe tube may be inserted through a vent.)

3) Without disturbing the probe tube, insert the hearing instrument or earmold.

4) Referring to 16.4: Audiometric data entry, enter threshold data.

5) Highlight and <PICK> button 1, 2, or 3 in the REAR/REIG column. This will present a signal from the On-ear speaker and display the REAR Setup box.

6) Highlight and <PICK> [Stimulus], then highlight and <PICK> [Pink noise] or [Swept]. Use pink noise when using the NAL-NL1 fitting formula. Use Swept when testing maximum output capabilities.

7) Highlight and <PICK> [Level], then highlight and <PICK> a stimulus level from the list box. Use the level shown on the target REIG curves. If no level is shown, use the lowest level required to overcome background noise.

8) Adjust the hearing instrument so that the REIG curve (SPL scale) or Aided threshold curve (HL scale) approximates the dotted target curve. For multi-level targets, match each curve using the stimulus level indicated.

9) Press <Continue> to complete the test and capture the data.

See 16.2: Insertion gain in SPL and 16.3: Insertion gain in HL for an explanation of screen curves. See 16.7:SII calculation in Insertion gain

NOTE: Because it is analyzed in 1/3 octave bands, the Noise stimulus produces a REAR up to 12 dB below that produced by the Swept stimulus at the same overall level. The REIGs will be similar except at levels which cause non-linear operation of the hearing instrument.

FastFacts 16.6: REAR measurement procedure

16.7 SII calculation in Insertion gain

The RM500SL calculates a Speech Intelligibility Index (SII) value (in %) for unaided speech at 70 dB SPL (REUR), the target REIG and for each aided test. The calculations use the 1/3 octave band method of ANSI S3.5 –1997 without the 160 Hz band and without masking effects. Level distortion effects are included but no hearing loss desensitization is applied. An idealized speech region of LTASS +/- 15 dB is used.

The speech recognition associated with a given SII is a function of the test material and the cognitive abilities of the listener. There is considerable individual variability in relating the SII to speech recognition, especially amongst impaired listeners. The following shows expected nominal recognition scores vs SII for normals on the Connected Speech Test (Sherbecoe and Studebaker 2003).

SII (%)	Score (%)
10	1
15	8
20	20
25	45
30	60
35	74
40	84
45	90
50	94
55	96
60	98
70	99
80	100
90	100

FastFacts 16.7: SII calculation in Insertion gain

17 Speechmap ®

17.1 Section overview

Speechmap presents hearing threshold, UCL and amplified speech spectra as SPL in the ear canal. The fitting goal is to make amplified speech audible and comfortable while avoiding discomfort for loud sounds. Speechmap is normally used in SPL and this guide describes only this usage. See 12.4: SPL or HL scale.

This section covers the following topics:

17.2: Speechmap facts

17.3: DSL 5.0 in Speechmap

17.4: DSL 5.0 changes

17.5: NAL-NL1 in Speechmap

17.7: Using Speechmap

17.8: Screen tour – unaided screen

17.9: Screen tour - aided screen

17.10: On-ear or Test box mode

17.11: SII calculation in Speechmap

Related sections are 18: Speechmap Fitting Procedures and 19: Speechmap Technical Details

FastFacts 17.1: Speechmap

17.2 Speechmap facts

Speechmap is a trademarked hearing instrument fitting environment introduced by Audioscan in 1992. It presents hearing threshold, UCL and amplified speech spectra as SPL in the ear canal. The fitting goal is to make amplified speech audible and comfortable while avoiding discomfort for loud sounds. Originally speech was simulated using amplitude-modulated tonal signals. The RM500SL replaces these simulated speech signals with real speech, both recorded and live. For details of the test signals and analysis methods, see 19: Speechmap Technical Details.

Speechmap departs from insertion gain target methods in presenting amplification goals in the context of the residual auditory area, not as an isolated target line, and in the use of real speech, not tones or broad-band noise. This is extremely important for non-linear hearing aids, analog or digital, because their processing is signal-dependent. It also makes provision to correct audiometric data and 2cc coupler measurements for age-related or individually-measured acoustic differences between real ears and the couplers used for calibration and testing.

The Speechmap environment provides two hearing instrument verification options: **On-ear** and **Test box measures**. See 17.10: On-ear or Test box mode for details.

FastFacts 17.2: Speechmap facts

17.3 DSL 5.0 in Speechmap

The **Desired Sensation Level (DSL)** method is a systematic eardrum sound pressure level (SPLogram) approach to hearing instrument fitting that seeks to ensure amplified speech will be audible and comfortable while loud sounds will not be uncomfortable. It takes into account individual acoustic factors in audiometric and electroacoustic data. DSL was developed by the National Centre for Audiology (NCA), London, Ontario. Audioscan has implemented DSL within its Speechmap fitting system since 1994.

In 2005, DSL underwent an extensive revision resulting in DSL 5.0. It was further revised in 2007 to version 5.0a. See 17.4: DSL 5.0 changes for details of the changes.

The Audioscan version of DSL 5.0 may differ from others in the following ways:

1) DSL 5.0 uses RECD values for ages > 119 months from a different source than for ages ≤ 119 months; Audioscan has used the RECD values for a 119 month old for ages > 119 months so all values come from the same study.
2) Input-output curve targets and compression threshold targets are not provided. Such steady-state parameters are of little value in estimating amplified speech levels. Matching amplified speech to the LTASS targets at levels from 50 to 75 dB SPL provides much better assurance that fitting goals are being met.
3) There is no provision to input the number of compression channels. This may be useful when the signal used for verification is not the signal for which the targets were developed. It is irrelevant when using real-speech signals to match speech targets and when using narrow-band signals to match narrow-band maximum output targets.
4) The term Uncomfortable Level (UCL) is used rather than Upper Limit of Comfort (ULC) in referring to the ear canal SPL that should never be exceeded.
5) Broadband output limiting targets are not provided.

FastFacts 17.3: DSL 5.0 in Speechmap

17.4 DSL 5.0 changes

The Audioscan version of DSL 5.0 includes provision for **bone conduction** and **ABR** threshold, **binaural** targets, targets for speech levels from **50 to 75 dB SPL**, **new targets** for children, **targets for adults** and **new RECD** default values for children (1 month to 10 years) and adults. The **UWO child's spectrum** has been removed and an **"own voice"** spectrum has been added. As a result of a re-analysis of published data, the **vocal effort effects for Soft and Average** speech levels have been made the same. In addition, the target symbol has been elongated to indicate that the fit-to **target is a range, not a point**.

The children's LTASSa targets for 70 dB speech are lower than those in previous versions of DSL. These differences are functions of the hearing loss and age (where average RECDs are used). Revisions made in version 5.0a reduce these differences at 250 Hz and for more severe losses. The differences will be more significant when the individual RECD values have not been measured for the child being fitted.

Audioscan assumes no responsibility for the validity of these changes; that responsibility rests with the National Centre for Audiology.

FastFacts 17.4: DSL 5.0 changes

17.5 NAL-NL1 in Speechmap

The **NAL-NL1** procedure seeks to amplify speech such that all bands of speech are perceived with equal loudness while maximizing speech intelligibility and ensuring that the wearer perceives speech to be no louder than that which a normal hearing person would perceive. Although NAL-NL1 states its goals for speech, it derives insertion gain targets assuming noise as a verification signal. Because it is more accurate to verify a non-linear fitting using the signal for which the procedure was developed, Audioscan converts the NAL-NL1 insertion gain targets to LTASS targets for amplified speech in the Speechmap environment, resulting in **Speechmap/NAL-NL1**. The conversions use the same adult average RECD and REUG as used in DSL. The RESR targets are from Hearing Aids (Dillon, Thieme Publishing, 2001, p274).

An insertion gain version is available by selecting [Insertion gain] from the test box menu. The pink noise stimulus should be used.

FastFacts 17.5: NAL-NL1 in Speechmap

17.6 Camfit in Speechmap

Camfit is an approach to fitting hearing aids developed by Brian Moore at the University of Cambridge, UK. It specifies the level-dependent gain required to correct abnormal loudness as modelled by his cochlear hearing loss simulation. It provides two approaches to correcting for the hearing loss:

Camfit restoration aims to amplify sounds that are soft, comfortable and loud for a person with normal hearing so that they are soft, comfortable and loud for a hearing aid wearer. This is the stated goal of the IHAFF (International Hearing Aid Fitting Forum) fitting method.

Camfit equalisation aims to amplify speech to produce the same loudness in each critical band. It has been argued that this is likely to give the highest intelligibility for a given overall loudness. This is the rationale behind the NAL fitting methods and will generally produce similar targets.

FastFacts 17.6: Camfit in Speechmap

17.7 Using Speechmap

The Speechmap fitting environment provides a number of distinctly different stimuli. Speech and noise are analyzed in 1/3 octave bands and (except for pink noise) data are presented as 3 curves. The top curve is the level exceeded 1% of the time (speech peaks), the lower curve is the level exceeded 70% of the time (speech valleys) and the middle curve is the average. Starting a test causes the signal to be presented continuously - the speech signals run in a loop - and the curves are updated frequently to show any changes you make to the hearing instrument. Pressing <Continue> restarts the speech passage and the curves are then calculated for the entire passage, producing an accurate display of the speech region and LTASS, and an accurate SII calculation. When using live speech, a <Freeze curve> button captures short-term speech features. See 17.11: SII calculation in Speechmap and 19: Speechmap Technical Details.

Before starting, please review 11: On-Ear Measurement Setup, 17.2:Speechmap facts, 17.10: On-ear or Test box mode.

∨ **To access Speechmap**, press <Tests>, then highlight and <PICK> [On-ear measures] or [Test box measures], then highlight and <PICK> [Speechmap].

∨ **To change screen setup**, see 12: On-ear Screen Setup, and 17.10: On-ear or Test box mode.

∨ **To set up hearing instrument type**, highlight & <PICK> [Instrument], then highlight & <PICK> BTE, ITE, ITC, CIC, RITE (receiver in the ear), Open, Body, CROS or FM. This changes microphone location effects and the RECD used in test box measures and 2cc targets, and the reference microphone used for FM and CROS.

∨ **To enter audiometric data,** see 18.2: Assessment data entry.

∨ **To run a test**, highlight and <PICK> one of the 4 REAR buttons. Then highlight and <PICK> [Stimulus] to select the stimulus type. Highlight and <PICK> [Level] to select stimulus level. Press <Continue> to run the test and display the data. See, 17.8: Screen tour & 18: Speechmap Fitting Procedures.

FastFacts 17.7: Using Speechmap

17.8 Screen tour – unaided screen
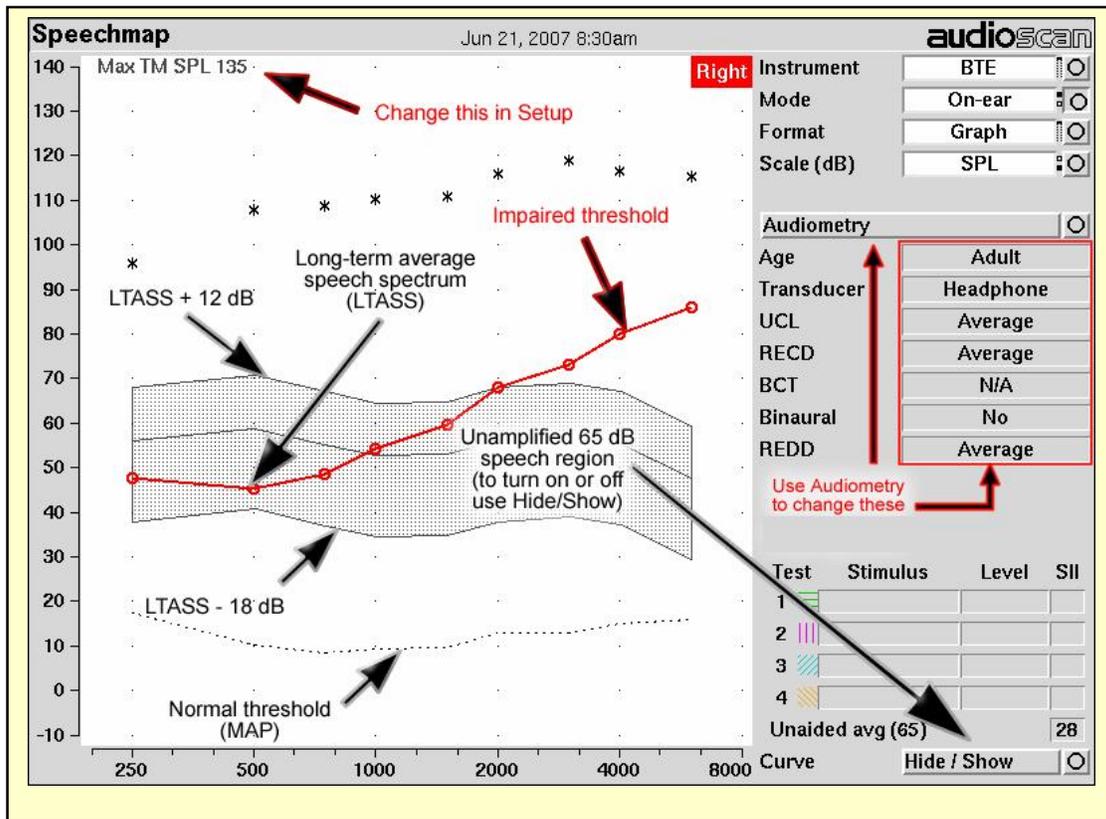
FastFacts 17.8: Screen tour – unaided screen

17.9 Screen tour - aided screen
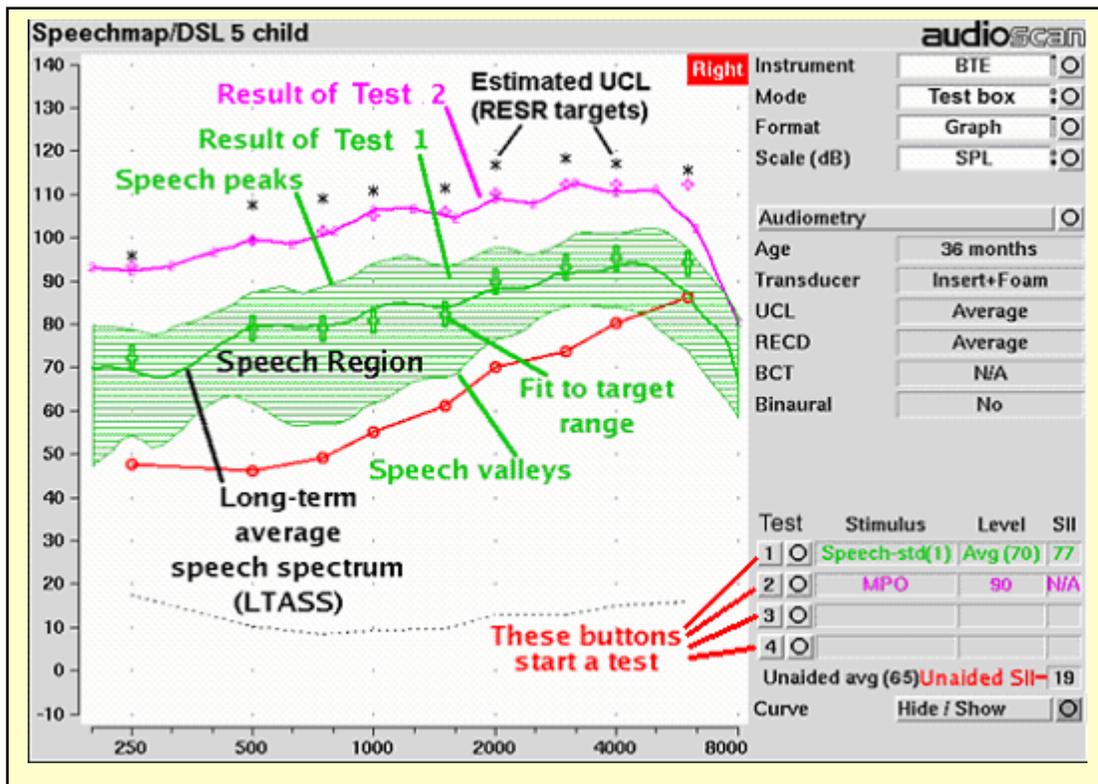
FastFacts 17.9: Screen tour - aided screen

17.10 On-ear or Test box mode

The Speechmap environment provides two hearing instrument verification options: **On-ear measures** and **Test box measures**. Using on-ear mode, the stimulus is controlled by the on-ear reference microphone below the ear and SPL in the ear canal is measured by the probe microphone. In test box mode, levels measured in the 2cc coupler are converted to estimated ear canal levels using the RECD values (age-appropriate average, entered, or measured). In addition, the stimulus delivered to the hearing instrument microphone is modified to include average microphone location effects for the hearing instrument type indicated. The screen display for both modes is the same, showing SPL, measured or simulated, in the ear canal.

For On-ear mode, press <Tests>, then highlight and <PICK> On-ear measures and highlight and <PICK> Speechmap. Review 11: On-Ear Measurement Setup,

For Test box mode, press <Tests>, then highlight and <PICK> Test box measures and highlight and <PICK> Speechmap. Review 7.9: Calibration of test box reference mic, 7.11: Coupling the hearing instrument, 7.12: Positioning the hearing instrument.

To switch modes, highlight and <PICK> [Mode].

It is suggested that hearing instruments be preset in test box mode with fine tuning done in on-ear mode.

Note that on-ear mode should be used for vented or open fittings. Vent effects depend on the vent, the ear and the hearing aid settings and cannot be reliably predicted from 2cc coupler measurements.

FastFacts 17.10: On-ear or Test box mode

17.11 SII calculation in Speechmap

The RM500SL calculates a Speech Intelligibility Index (SII) value (in %) for unaided speech at 65 dB SPL and for each aided test. The calculations use the 1/3 octave band method of ANSI S3.5 –1997 without the 160 Hz band and without masking effects. Level distortion effects are included but no hearing loss desensitization is applied. An idealized speech region of LTASS +/- 15 dB is used.

The speech recognition associated with a given SII is a function of the test material and the cognitive abilities of the listener. There is considerable individual variability in relating the SII to speech recognition, especially amongst impaired listeners. The following shows expected nominal recognition scores vs SII for normals on the Connected Speech Test (Sherbecoe and Studebaker 2003).

SII (%)	Score (%)
10	1
15	8
20	20
25	45
30	60
35	74
40	84
45	90
50	94
55	96
60	98
70	99
80	100
90	100

Score for Connected Speech Test vs SII

FastFacts 17.11: SII calculation in Speechmap

18 Speechmap Fitting Procedures

18.1 Section overview

> The procedures in this section assume a familiarity with 11: On-Ear Measurement Setup, 12: On-ear Screen Setup and 17: Speechmap ®.
>
> This section covers the following topics:
>
> 18.2: Assessment data entry   18.7: Fitting to targets for mid-level speech
>
> 18.3: Assessment data choices - 1   18.8: Open fittings in Speechmap
>
> 18.4: Assessment data choices - 2   18.9: FM fitting and verification
>
> 18.6:Fitting to targets for loud sounds
>
> Related sections are 17: Speechmap ® and 19: Speechmap Technical Details

FastFacts 18.1: Speechmap fitting procedures

18.2 Assessment data entry

> Threshold data and parameters may be entered by scanning a barcode on a previous RM500SL or Verifit printout or manually using a mouse, the keypad or the numeric keypad on an external keyboard. See 2.6: Mouse, keyboard, barcode scanner, and 3.2: Input device operation.
>
> **To enter data from a barcode see** 3.3: Barcode data input and:
>
> 1) Press the barcode trigger and center the red line on the barcode from a distance of 6 - 8". The scanner will beep and the Barcode Entry poster opens.
>
> 2) Highlight and <PICK> [Done] to accept the data indicated on the poster.
>
> **To enter assessment data manually:**
>
> 1) Highlight and <PICK> [Audiometry].
>
> 2) Highlight and <PICK> an item to toggle its setting or generate a list box. Age can be changed only if Targets = [DSL child]. See 18.3: Assessment data choices - 1 and 18.4: Assessment data choices - 2.
>
> | Audiometry | |
> |---|---|
> | Ear | Right |
> | Targets | None |
> | Age | Adult |
> | Transducer | Headphone |
> | Threshold | Entered |
> | Bone conduction | N/A |
> | UCL | Average |
> | RECD | Average |
> | Binaural | No |
> | REDD | Average |
> | Cancel | Continue | Help |
>
> 3) Press <Continue> to proceed to data entry.
>
> 4) Enter HL threshold using a mouse,keypad or keyboard. Left click the mouse on the audiogram to enter a point. Click again to delete the point. On the keypad the arrow keys change frequency and level and <PICK> enters or deletes a threshold point. On a keyboard enter HL values on the numeric keypad.
>
> 5) Press <Continue> when all points have been entered.
>
> 6) Repeat the process for Bone conduction, UCL and RECD if [Enter] has been selected for any. If RECD is set to [Measure], see 15: RECD (real-ear to coupler difference).

FastFacts 18.2: Assessment data entry

18.3 Assessment data choices - 1

The following audiometric assessment parameters can be specified in the Speechmap Audiometry setup box. Defaults are the last-used choices if test setup memory has been turned on. See 4.4: Saving test setup.

1) **Target**: Select fitting targets from [DSL adult, DSL child, NAL-NL1, Camfit restoration, Camfit equalization, None]. DSL 5, Camfit, and NAL-NL1 differ in the derivation of amplified LTASS and RESR targets. Selecting [None] eliminates the LTASS targets; UCL estimates are from DSL.

2) **Age**: This is permitted for [DSL child] target only. Select client's age in months from [1 months to 60 months] or years from [6 years to 10 years]. For children older than 10 yrs, previously fit using DSL, choose Adult.

3) **Transducer**: Type of audiogram. Select from [Headphone, Insert + Foam, Insert + Mold, Soundfield, ABR (eHL), ABR (nHL)]. **If Insert + Foam or Mold** is selected, the appropriate RECD will be used to convert entered HL values to SPL values. **If Soundfield** is selected appropriate real-ear unaided gain (REUG) values @ 45 degrees azimuth, will be used to convert HL values to SPL values. **If ABR (eHL)** is selected, entered thresholds will be treated as behavioral pure tone thresholds. **If ABR (nHL)** is selected, nHL to eHL conversion factors may be selected from [Default, Enter]. In either case, an insert earphone is assumed for sound delivery and the appropriate RECD will be applied. Note that, in some facilities, nHL is defined in such a way that it is effectively eHL; in these cases, ABR (eHL) should be selected. See 11.6: ABR nHL to eHL setup and 18.4: Assessment data choices - 2.

4) **Bone conduction**: Select from [N/A, Enter]. If [Enter] is selected, an entry screen will be provided after the air conduction thresholds have been entered.

Continued in: 18.4: Assessment data choices - 2

FastFacts 18.3: Assessment data choices - 1

18.4 Assessment data choices - 2

Continued from: <u>18.3: Assessment data choices - 1</u>

5) **UCL**: Uncomfortable Level. Select from [Enter, Average]. If measured UCL values are entered, these values will be converted to real-ear SPL and used as real-ear saturation response (RESR) targets. Note that DSL 5.0 has changed this term to Upper Limit of Comfort (ULC). Regardless of the acronym, it is a narrow-band SPL that should never be exceeded.

6) **RECD**: Select from [Measure, Enter, Average]. If Average is selected, age-appropriate real-ear to coupler difference (RECD) values will be used. If Measure is selected, you will be required to measure the client's RECD values or accept values from the RECD test. If Enter is selected, **HA-2** RECD values may be entered and are required **at all 9 audiometric frequencies.**

7) **Binaural**: Select from [Yes, No]. Determines if fitting targets will be adjusted for binaural summation effects.

8) **REDD**: Real-ear-to-Dial Difference. [Average] (this cannot be changed). REDD values are similar for adults and children. If Headphone is selected as the transducer type, adult average values will be used to transform dB HL audiometry to dB SPL.

ABR nHL to eHL: Normalized HL to estimated HL conversion factors. Permitted only if [Transducer] = ABR (nHL). Select from [Default, Enter]. If [Enter] is selected, an entry screen will be provided after threshold data have been entered. Otherwise default factors will be used. These may be set to DSL values or to values that you have entered in Setup. Note that, in some facilities, nHL is defined in such a way that it is effectively eHL; in these cases, ABR (eHL) should be selected and no conversion factors will be applied. See <u>11.6: ABR nHL to eHL setup</u> and <u>18.3: Assessment data choices - 1</u>.

FastFacts 18.4: Assessment data choices - 2

18.5 Fitting to targets for soft speech

See 17.10: On-ear or Test box mode, 17.7: Using Speechmap and 18.2: Assessment data entry for setup and audiometric data entry.

1) Select [Audiometry] to choose the target method and enter audiometric data.

2) Select Test 1 and set stimulus to [Speech-std(1)] or [Speech-std(2)] and level to 50. Elongated **+** symbols show the target range for 50 dB speech LTASS.

3) Adjust frequency shaping and gain for soft sounds so that the middle curve (the LTASS) falls within the target range, especially between 500 - 4000 Hz. Press <Continue> to run the complete passage. Repeat as necessary.
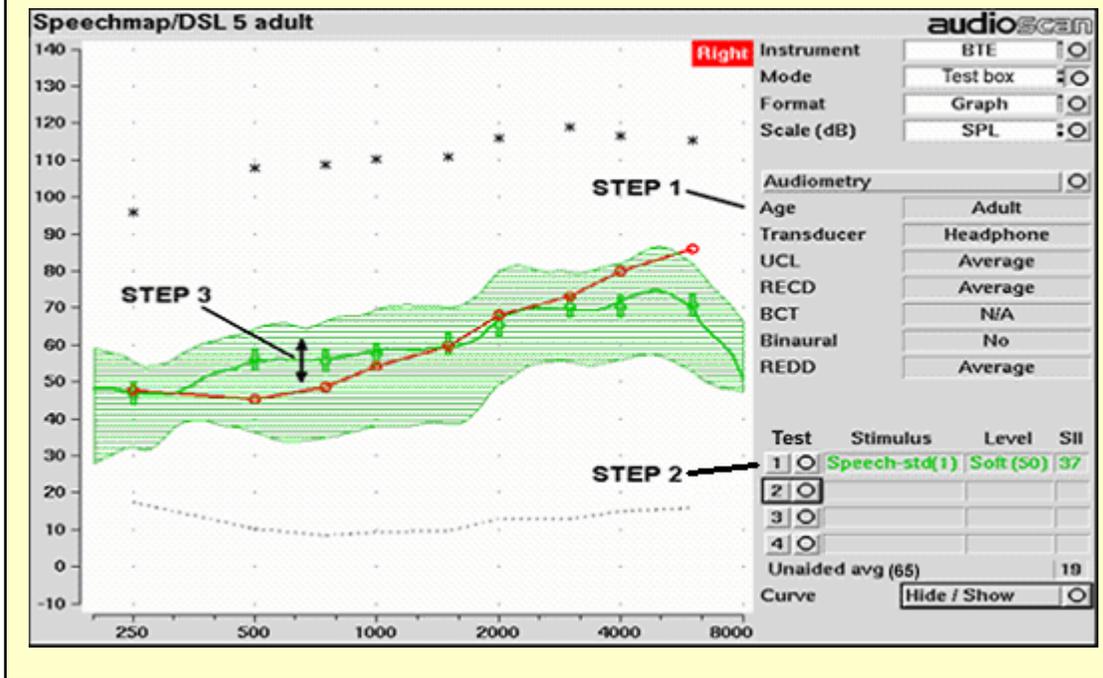
FastFacts 18.5: Fitting to targets for soft speech

18.6 Fitting to targets for loud sounds

4) Select Test 2 & set stimulus to [MPO]. **In test box mode**, a 90 dB tone sweeps continuously. **In on-ear mode, the tone sweeps when you press <Continue>**.

5) **In Test box mode**, adjust high-level gain and/or output limiting (e.g.,MPO, PC) so the curve matches the **+** REAR90 targets (DSL) or approaches but doesn't exceed the * RESR targets (NAL-NL1) at all frequencies. Press <Continue> to record the MPO curve. **In On-ear mode**, advise the client to point to the screen if a sound becomes too loud during the test (see 11.5: Max TM SPL setup). Press <Continue> to run and record a single sweep. Adjust the gain and output for loud sounds as for Test box, factoring in client response. Repeat as necessary.

When you start a new test, the speech envelope of the previous test is automatically hidden. To redisplay, highlight and <PICK> Hide/Show, then highlight and <PICK> the envelope display (right column) button for the test.
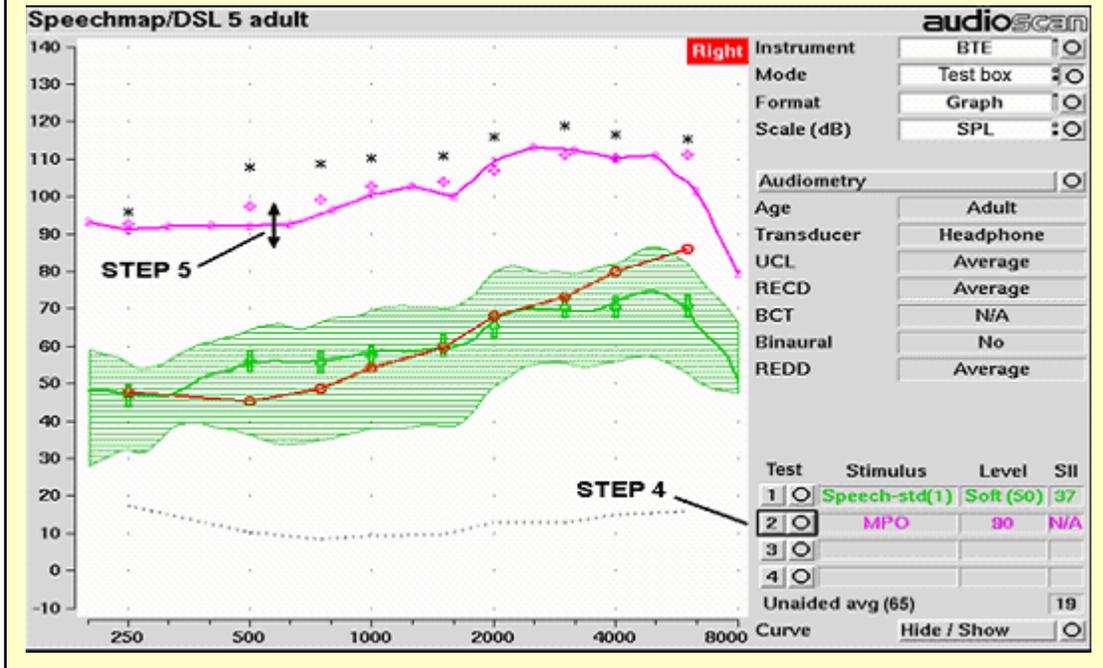
FastFacts 18.6: Fitting to targets for loud sounds

18.7 Fitting to targets for mid-level speech

6) Select Test 3 and set stimulus to [Speech-std(1)] or [Speech-std(2)] and level to 70. Elongated **+** symbols show the target range for 70 dB speech LTASS.

7) Adjust gain for mid-level sounds so that the middle curve (the LTASS) falls within the target range. Press <Continue> to run the complete passage. Repeat as necessary. Achieving this goal may require adjusting gain for soft speech, which will reduce its audibility. This may be a necessary compromise with some hearing instruments and for clients with a very narrow dynamic range.
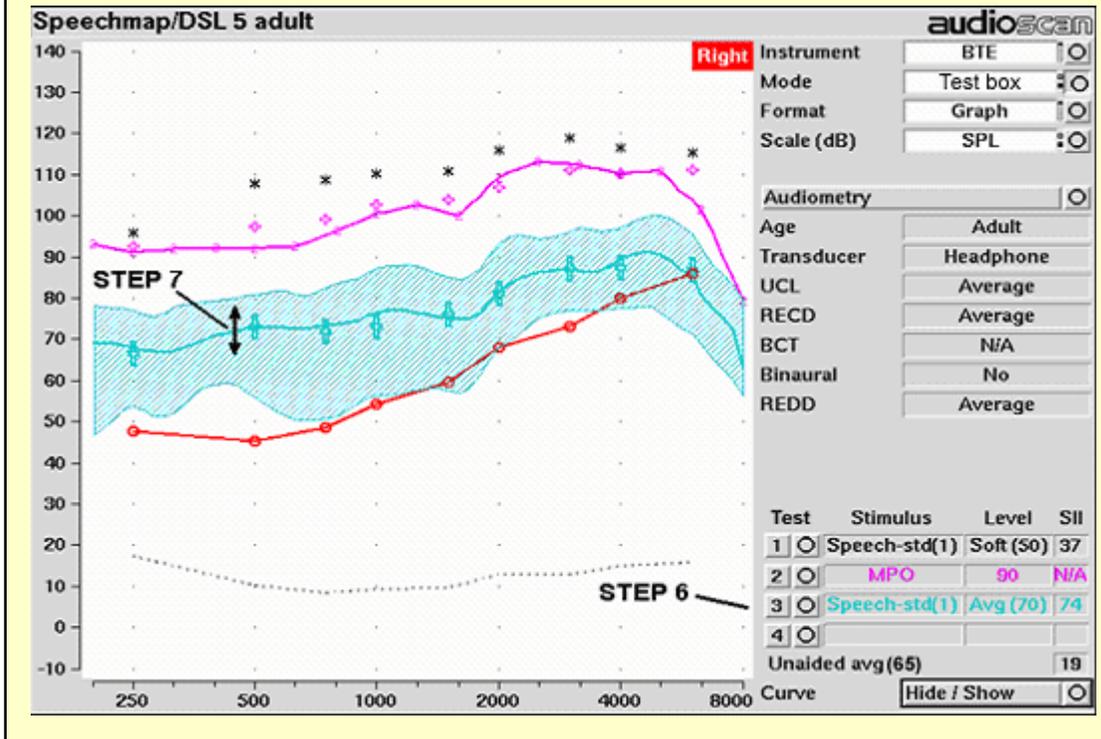
FastFacts 18.7: Fitting to targets for mid-level speech

18.8 Open fittings in Speechmap

On-ear mode should be used for open and vented fittings. There are no special real-ear SPL targets for open fittings - it doesn't matter how the sound reaches the TM, the perception is the same. However, the sound that escapes from a vent or open fitting may be detected by the On-ear reference microphone, interfering with the sound-field equalization. For this reason, <u>the hearing instrument must be muted during sound-field equalization</u>.

1) Position the client and probe tube and enter audiometric data. See 11: On-Ear Measurement Setup, 17: Speechmap ®, 18: Speechmap Fitting Procedures.

2) Highlight and <PICK> Instrument and select Open from the list.

3) Highlight and <PICK> a REAR test. If this is the first Open test in a session, you will be prompted to mute or turn off the hearing instrument and select the Equalize button on the setup poster. Otherwise, you are reminded to equalize whenever the client or nearby objects are moved. After equalization, unmute or turn the instrument on and follow the fitting procedures in 18.5: Fitting to targets for soft speech to 18.7: Fitting to targets for mid-level speech.

FastFacts 18.8: Open fittings in Speechmap

18.9 FM fitting and verification

FM Offset or FM Transparency method in Speechmap (after Platz 2004)

It is assumed that the hearing aid has been set up for optimal audibility and maximum output. See other sections of 18: Speechmap Fitting Procedures.

1) Before attaching the FM receiver, couple the hearing aid to the 2cc coupler in the test box and select Speechmap from the Test box measures menu. Select the appropriate hearing Instrument type (typically BTE).

2) Highlight and <Pick> Test 1 and choose Speech-std(1) or (2) at a Level of 65 dB. Press <Continue> to run and record the speech passage.

3) Attach the FM receiver to the hearing aid and set the FM receiver to the default setting. The FM transmitter should be ON and set to MUTE. Repeat step 2 but use Test 2 instead of Test 1. If the results of Test 1 & Test 2 are not similar, the presence of the FM receiver has changed the intended performance of the hearing aid. Where possible, make programming adjustments to compensate - being careful not to make adjustments that will change Test 1 results.

4) Move the hearing aid, attached to the coupler and microphone, outside the test box at least 12" away from the FM transmitter*. Put FM transmitter microphone, set to Omni, within 2mm of the reference microphone in the test box.

5) With the FM transmitter unmuted, repeat step 2. **Note that the hearing aid is outside the test box during this test - Quiet please!** The results should be within +/- 2 dB of the results from step 3. If not, change FM settings and repeat.

* A coupler mic. extension cable is available. See 2.3:Microphone connection.

Real-ear verification of FM-only open fittings in Speechmap (based on draft AAA Clinical Practice Guidelines – 2007)

Open fittings must be verified in On-ear mode.

1) Enter Audiometry data and select FM from the Instrument list box.

2) Position the transmitter microphone as in step 4 above. Place the probe tube in the ear canal and couple the FM-only device to the ear canal as in normal use.

3) At maximum volume setting, select the MPO stimulus. Adjust the receiver settings to meet targets. See 18.6: Fitting to targets for loud sounds

4) At use volume setting, select Speech-std (1) or (2) and choose FM chest (84 dB SPL) or FM boom (93 dB SPL) for the level. Adjust the FM receiver gain/volume settings to meet targets in the 1000 – 4000 Hz range.

5) Repeat step 3 at use volume setting.

FastFacts 18.9: FM fitting and verification

19   Speechmap Technical Details

19.1   Section overview

> Speechmap provides a variety of stimuli for the testing of non-linear hearing aids with a range of digital processing features.
>
> **This section covers the following topics:**
>
> 19.2: Speechmap stimuli   19.4: Microphone location effects
>
> 19.3: Stimulus levels   19.5: Speech signal analysis
>
> For additional information see 25: Appendix 2: AudioNote 2.1 VERIFIT and RM500SL Test Signals and Analysis

FastFacts 19.1: Speechmap technical details

19.2   Speechmap stimuli

> The Speechmap fitting environment provides a number of well-controlled, distinctly different stimuli. These include three varieties of speech - standard (previously "shaped"), female, child, ICRA noise (digitally distorted speech) and pink noise at levels of 50 to 75 dB SPL in 5 dB steps and a tone burst at 85 or 90 dB SPL.
>
> The two standard speech signals are by the same male talker. The spectrum has been filtered to closely match the Cox & Moore (1988) long-term average speech spectrum (LTASS). The ICRA noise, female and child speech signals are presented as recorded with no spectral shaping. Live speech may also be used.
>
> As a result of reanalysis of published data, the previous distinction between "soft" and "average" vocal effort has been eliminated. Consequently, the speech and ICRA signals are presented unfiltered for levels from 50 to 70 dB SPL. At 75 dB SPL, the spectrum is filtered to represent a "loud" vocal effort. An "own voice" filter is also available at the 75 dB SPL level. This is intended to produce a spectrum and level at a BTE microphone location similar to that produced by the voice of an average wearer.
>
> A tone burst (MPO) stimulus provides 128 (changed from 64) ms bursts at 1/3 octaves with a level of 90 dB SPL in Test box mode and 85 dB SPL in On-ear mode.
>
> In Test box mode, all signals are filtered to include BTE, ITE, ITC, CIC, Body microphone location effects. The selected overall rms level is established prior to filtering.
>
> For fitting FM systems, the stimuli may be modified to represent the level (84 dB SPL) and spectrum at a chest microphone location and the level (93 dB SPL) and spectrum at a boom microphone location. These are presented in the test box in both On-ear and Test box modes.
>
> The overall SPL, 1/3rd octave band SPL, vocal effort and microphone location effects are given in the following tables for the various broad-band signals available.

FastFacts 19.2: Speechmap stimuli

19.3 Stimulus levels

	1/3 octave band SPL					Add to band SPL for			
	Speech			ICRA	Pink	Loud	Own	FM	FM
Hz	Standard	Female	Child	Noise	Noise		Voice	Chest	Boom
200	56.8	54.9	32.3	52.9	53	-2.2	.5	9.0	19.2
250	56.0	53.1	51.5	55.9	53	3.3	10.7	12.0	22.2
315	53.0	48.4	57.3	56.9	53	9.6	11.0	16.6	26.0
400	57.0	55.8	54.1	57.5	53	6.1	10.0	13.3	22.8
500	58.0	57.3	53.2	57.8	53	7.7	10.1	13.2	25.3
630	55.0	58.1	61.2	54.3	53	12.4	10.5	21.0	29.1
800	52.5	54.6	56.5	52.8	53	14.4	10.8	26.4	32.1
1000	51.0	52.0	52.7	50.4	53	15.0	10.5	26.4	32.7
1250	50.5	51.0	45.4	51.3	53	14.8	5.5	22.0	33.6
1600	48.0	51.1	41.1	48.5	53	15.5	4.0	22.1	33.9
2000	45.0	51.2	39.7	47.0	53	16.2	6.0	21.0	33.0
2500	44.0	49.3	35.5	44.7	53	14.8	6.0	18.2	31.9
3150	42.5	46.0	28.8	43.3	53	14.5	2.0	14.4	30.4
4000	42.0	40.0	31.2	41.1	53	13.2	-0.5	11.8	29.0
5000	40.0	36.1	30.6	39.6	53	9.2	-1.0	12.4	27.8
6300	41.5	43.5	32.6	33.5	53	4.2	0.0	11.4	26.2
8000	41.5	39.9	35.2	28.2	53	2.7	-4.0	11.0	25.8
Overall	65.0	65.0	65.0	65.0	65	75.0	75.0	84.0	93.0

LTASS for standard speech is from Cox & Moore (1988). Loud spectrum is from ANSI S3.5-1997. Own voice spectrum is from Cornelisse et al (1991) adjusted to a 1 m reference.

FastFacts 19.3: Stimulus levels

19.4 Microphone location effects

Microphone Location Effects					
Add to all stimuli in Test box mode					
	Hearing instrument type				
Frequency	BTE	ITE	ITC	CIC	BODY
200	0.5	0.3	0.0	0.9	3.0
250	0.5	0.5	0.3	0.8	3.0
315	0.8	0.8	0.3	0.7	3.0
400	1.1	1.0	0.7	0.5	3.0
500	1.2	1.8	0.0	0.4	4.0
630	1.1	2.0	0.1	0.4	3.0
800	0.9	2.0	0.4	0.4	2.0
1000	0.3	1.5	1.2	0.6	0.0
1250	0.6	0.3	-1.6	1.1	0.0
1600	2.5	-0.3	-1.9	2.0	-4.0
2000	4.1	3.8	2.1	3.3	-4.0
2500	3.5	5.0	4.8	5.0	-3.0
3150	2.8	3.3	3.5	6.9	-2.0
4000	3.7	4.3	6.4	8.3	0.0
5000	-1.2	4.3	6.6	7.6	0.0
6300	1.6	-0.4	-1.8	4.2	0.0
8000	3.3	1.0	-1.9	-5.6	0.0

Microphone location effects are added after the overall rms level has been set

FastFacts 19.4: Microphone location effects

19.5 Speech signal analysis

One of the most-used measures of a speech signal is the long-term average speech spectrum (LTASS). This is a 1/3 octave spectrum averaged over a sufficiently long portion of the speech material to provide a stable curve. In practice a 10 second average meets this requirement and, for this reason, all RM500SL passages are at least 10 seconds long.

The dynamic nature of speech is often characterized by the distribution of short-term levels in each 1/3 octave band. These levels are determined by calculating a spectrum for each of a series of short time periods within the passage. Historically, time periods of 120, 125 or 128 ms have been used. The RM500SL uses a 128 ms time period, resulting in 100 levels (or samples) in each 1/3 octave band for a 12.8 second passage. The level in each band that is exceeded by 1% of the samples (called either the 1st or 99th percentile) has historically been referred to as the speech peak for that band. The curve for these 1% levels is approximately 12 dB above the LTASS. The level in each band that is exceeded by 70% of the samples (called either the 70th or 30th percentile) has historically been called the valley of speech for that band. The curve for these 70% levels is approximately 18 dB below the LTASS. The region between these two curves is often called the speech region, speech envelope or speech "banana". The speech envelope, when derived in this way, has significance in terms of both speech detection and speech understanding. Generally, speech will be detectable if the 1 % level is at or near threshold. The Speech Intelligibility Index (SII) is maximized when the entire speech envelope (idealized as a 30 dB range) is above (masked) threshold. This will not be an SII of 100% (or 1) because of loudness distortion factors, but higher SII values will not produce significantly higher scores on most test material. The speech-reception threshold (SRT) is attained when the LTASS is at threshold (approximately - depending on test material and the individual)

FastFacts 19.5: Speech signal analysis

20 Troubleshooting

20.1 Section overview

This section covers common problems encountered when using the RM500SL. If you require further assistance, note your model and serial number (located on the recessed panel) and contact your local distributor, or Audioscan at 519-268-3313 800-265-2093 (USA only), 519-268-3256 (fax) or service@audioscan.com

PLEASE DO NOT SHIP YOUR UNIT BACK TO THE FACTORY. In most cases we can courier you a part that you can quickly and easily replace yourself.

This section covers the following topics:

20.2: Self test failures

20.3: Test box high distortion or noise

20.4: Test box curves inconsistent

20.5: Test box curves differ from spec

20.6: Test box speaker overdriven

20.7: No Test box reference mic. detected

20.8: Invalid Test box calibration

20.9: No On-ear ref. mic. detected

20.10: Invalid On-ear calibration

20.11: Sound-field speaker overdriven

20.12: Barcode scanner malfunction

FastFacts 20.1: Troubleshooting

20.2 Self test failures

Any failure during power-on self test (P.O.S.T.) is indicated on-screen and further use of the instrument is denied. Try the following steps to resolve the failure:

1) To access Self test, press <Setup>, then highlight and <PICK> [Self test].

2) If you received a Max out/in or a Routing failure, remove any hearing aids from the test chamber, and rerun self test.

3) Unplug all microphones (On-ear and Test box). Rerun self test. If self test passes, reconnect the microphones, one by one, running self test each time until a failure occurs. If the failure returns, display and print the test results and contact Audioscan for help.
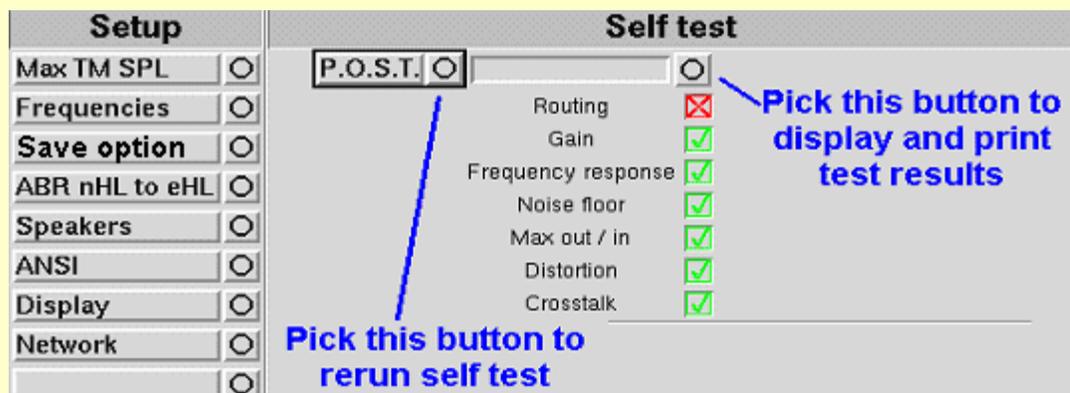
FastFacts 20.2: Self test failures

20.3 Test box high distortion or noise

High distortion and/or noise numbers in an ANSI test

∨ There may be a leak between the hearing instrument under test and the coupler it is connected to. For BTE type instruments, check the integrity of the #13 tubing at the end of the coupler where it joins with the ear hook. Look for cracks. ITE type instruments need to have a good seal between the hearing instrument and the coupler. In addition, all vents need to be closed from the faceplate side of the hearing instrument.

∨ Ambient room noise may be leaking into the test chamber. Air conditioners, computer fans and similar noisemakers can yield artificially high noise figures. Check the sealing of the test chamber. Try turning off suspected noise sources to identify the cause.

∨ Vibration may be coupled into the test chamber from other equipment on the same table or wooden floor. Computers, fans and air conditioners may be the source of the vibration. Try turning off suspected sources to identify the cause. Relocate the source or the RM500SL or mount it on a foam pad.

FastFacts 20.3: Test box high distortion or noise

20.4 Test box curves inconsistent

The test box curves keep changing from test to test.

∨ The battery may be close to end of life or starved for air (zinc-air cells) because of a tight seal on the battery compartment. Try a fresh battery or using the optional RM500SL battery pill.

∨ The test box reference microphone is incorrectly positioned. In order to control sound pressure levels precisely at the microphone inlet of the hearing instrument, the test box reference microphone must be positioned as close as possible to the hearing instrument's microphone without actually touching it.

∨ The noise or feedback reduction features are attempting to reject the test signal. These need to be disabled prior to tests with tones or noise.

∨ The instrument is on the verge of feedback due to a poor seal to the coupler, unplugged vent or a crack in the tubing on the BTE coupler.

FastFacts 20.4: HIT curves inconsistent

20.5 Test box curves differ from spec

The OSPL90 and response curves don't look like the manufacturer's.

- ∨ Check that all controls or program settings are the same as those used by the manufacturer.
- ∨ Check that vents on earmolds or ITE instruments are plugged at the faceplate.
- ∨ Check that ITE instruments are **well sealed** to the coupler.
- ∨ When puttying a hearing instrument into the ITE coupler, be sure to keep the canal portion of the instrument flush with the inside of the 2cc volume.
- ∨ Ensure that the test box is sealed tightly.
- ∨ Ensure that the test box microphone calibration was performed correctly.
- ∨ Check that the coupler is screwed tightly onto the coupler microphone.

FastFacts 20.5: Test box curves differ from specifications

20.6 Test box speaker overdriven

Test box speaker overdriven!

This message indicates that the test chamber speaker is unable to produce the SPL required for a test.

- ∨ Check that the test chamber lid is closed and sealed.
- ∨ Check that the test box calibration looks normal.
- ∨ Check that the hearing instrument under test is not feeding back.
- ∨ Try running an On-ear test.

FastFacts 20.6: Test box speaker overdriven

20.7 No Test box reference mic. detected

No Test box reference mic. detected!

This message may be displayed when starting a hearing instrument test. It indicates that the RM500SL is not measuring any sound at the Test box reference microphone.

- ∨ Ensure that the white Test box reference microphone is secure. Unplug it and plug it in again, ensuring that it 'clicks' into place. Try the test box calibration procedure again.
- ∨ Unplug the test box reference microphone and plug the On-ear probe microphone in its place. Try test box calibration using the reference microphone of the On-ear probe microphone in place of the Test box reference microphone. If this is successful, the On-ear reference microphone is defective and must be replaced.

FastFacts 20.7: No Test box reference mic. detected

20.8 Invalid Test box calibration

Invalid Test Box Calibration!

This message may be displayed during the Test box calibration procedure. It indicates that the calibration curve is significantly different from what is expected. It may be accompanied by a missing test box reference microphone error.

- ⌄ Check that the there is no coupler on the coupler microphone and that the microphones are correctly positioned for Test box calibration.
- ⌄ Check that the coupler microphone is securely plugged into the correct socket.
- ⌄ Follow the suggestions in 20.7: No Test box reference mic. detected.

FastFacts 20.8: Invalid Test box calibration

20.9 No On-ear ref. mic. detected

No On-ear reference mic. detected.

Check connection on the On-ear probe microphone.

- ⌄ Check that a probe microphone assembly is securely plugged into the PROBE socket to the left of the test chamber.
- ⌄ Unplug the Test box reference microphone in the test chamber and plug the On-ear probe microphone in its place. Try Test box calibration using the reference microphone of the On-ear probe microphone in place of the Test box reference microphone. If this is fails, the On-ear probe microphone is defective and must be replaced.

FastFacts 20.9: No On-ear ref. mic. detected

20.10 Invalid On-ear calibration

Invalid On-ear Calibration!

This message may be displayed during the On-ear calibration procedure. It indicates that the calibration curve is significantly different from what is expected. It may be accompanied by a On-ear reference microphone error.

- ⌄ Check that a probe microphone assembly is securely plugged into the PROBE socket to the left of the test chamber.
- ⌄ Try using a new probe tube. Ensure it is correctly attached and positioned.
- ⌄ Try the steps in 20.9: No On-ear ref. mic. detected.
- ⌄ Unplug the coupler microphone from the test chamber and plug the On-ear probe microphone in its place. Position the open end of the probe tube near the Test box reference microphone in the test chamber (use putty to hold it) and close the test chamber lid. Run a Multicurve test at a stimulus level of 70 dB SPL. The result should have the shape of a normal On-ear calibration curve. If it does not, the On-ear microphone is defective and must be replaced.

FastFacts 20.10: Invalid On-ear calibration

20.11 Sound-field speaker overdriven

Sound-field speaker overdriven!

This message indicates that the sound-field speaker is unable to produce the SPL required for a test. This is usually the result of a standing wave null at the on-ear reference microphone caused by reverberation in the environment. It warns of a situation that could cause significant measurement errors.

- v Move the RM500SL and client away from walls and hard objects. Avoid placing the RM500SL under an overhanging shelf or cabinet.

- v Move the RM500SL to the front edge of the table.

- v Move the client slightly closer to or further from the sound-field speaker.

- v Position the test ear more directly in front of the sound-field speaker.

- v Apply sound absorbers to nearby reflective surfaces.

FastFacts 20.11: Sound-field speaker overdriven

20.12 Barcode scanner malfunction

If there is no red scanning beam when the trigger is pulled, tug on the cable where it enters the scanner. If it comes loose easily, push it back in until it clicks in place.

If the scanning beam stays on when the trigger is released or if the barcode scanner fails to read known good barcodes, try the following:

1) Unplug the scanner from the RM500SL, then reconnect it. If the problem persists…

2) Print this page on an external printer (see 2.7: External printer, auxiliary audio outputs) or from the electronic user's guide on the RM500SL software CD (see 1.3: Electronic user's guide).

3) Scan these two barcodes, starting with the top one. This will reset the scanner to its default settings.
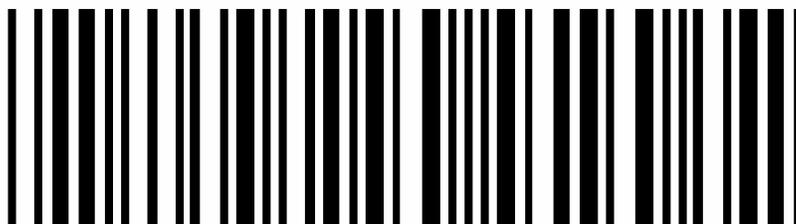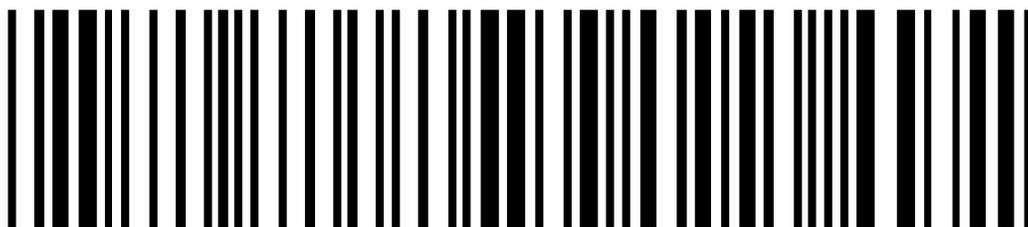
FastFacts 20.12: Barcode scanner malfunction

21 Technical Specifications

Specifications subject to change without notice

Storage & Transportation

Temperature ....- 20°C to +60°C
Relative humidity (non-condensing).......................5% to 95%
Atmospheric pressure....................................500 – 1060 hPa

General

Power source:.....................100 – 240 V, 50 – 60 Hz, 250 VA
Fuse: ....2A type T, 250 V
Overall dimensions ....15.5"x12.75"x4.25"
Weight ....16.4 lb (7.5 kg)
Display type .... fluorescent backlit active color
Display size...12.1" diagonal
Resolution ....800x600 (SVGA)
Printer type...thermal line printer
Printer resolution.. 200 dots per inch
Paper width ....3" (80mm)
Power amplifiers 2
Stimulus Channels...2
Measurement channels 1
Connectors..................1-USB
                              1 - Ethernet (RJ45)
.   1 - RS232 serial (9D)
                              2 - auxiliary audio outputs (1/4"mono)
                              1- RECD transducer(3.5mm st)
                              1 - test chamber ref. mic.(3.5mm st)
                              1 - coupler microphone(3.5mm st)
                              1 - battery substitute(3.5mm st)
                              1 - real-ear mic.(3.5mm st)

Test box

Working Space ....8.8"x3.5"x1.5"
Speaker.. 1 - 2"x3"
Test box isolation @ 1kHz ....>25 dB
Induction Coils. ....1 - Telephone Magnetic Field Simulator
                              (TMFS ANSI S3.22 - 2003)
Battery Simulator ....per ANSI S3.22 2003
Frequency Range .... 200 - 8000 Hz
Coupler microphone noise floor (200 – 8000 Hz) <40 dB SPL
Test Stimuli .... tone, tone burst,pink noise,
                              calibrated or live speech
Test stimulus levels .... 40 to 90 dB SPL in 5 dB steps
Test stimulus levels (inductive) .... 31.6mA/m per
                              (ANSI S3.22 - 2003)
Test stimulus distortion................................ <2% at 90dB SPL
.   <0.5% at 70 dB SPL
Test stimulus accuracy at reference mic. for tones
(200-2000 Hz) ....±1.5 dB SPL
(2000-8000 Hz)..±2.5 dB SPL
Equalization method....................................pressure method
Analysis frequencies per octave 12
Analysis filter bandwidth...1/12 octave
Measurement accuracy at 1 kHz .... ±1db
Measurement accuracy re 1 kHz .... ±1 dB (200-5000 Hz)
                              ±2.5 dB (5000-8000 Hz)
Measurement range .... 30 - 140 dB SPL
Harmonic distortion measurement 2nd, 3rd
                              or 2nd plus 3rd
Harmonic distortion range ....200 to 4000 Hz
Harmonic distortion accuracy... ±1%
Battery drain range ....0 - 20mA
Battery drain accuracy.. ±5%
Battery drain resolution. ....±0.01 mA

ANSI S3.22 - 1996 and 2003 tests available
    a OSPL90
    a Full-on Gain
    a Reference Test Gain
    a Frequency Response
    a Frequency Range
    a Maximum OSPL90
    a Harmonic Distortion
    a Attack & Release time
    a Equivalent Input Noise
    a Input/Output Curves
    a Coupler SPL - Telephone Simulator
    a Simulated Telecoil Sensitivity
    a Battery Drain (optional battery substitutes required)
Other tests Available
    a Speechmap ® real-speech audibility measures
    a Coupler SPL vs frequency
    a Coupler gain vs frequency
    a Spectral analysis
    a Distortion vs frequency
    a Manual measurement of output, gain and distortion

On-Ear

Speakers ....1 - 2"x 3"
Probe microphone tube .... 1.0 mm diameter x 75 mm
Probe microphone noise floor (200 – 8000 Hz)... <45 dB SPL
Frequency Range .... 200 to 8000 Hz
Test Stimuli..................frequency-modulated tone, tone burst,
                              pink noise, calibrated or live speech
Freq. modulation ....sawtooth ±3% over 128 ms
Stimulus levels for tones............40 - 85 dB SPL in 5 dB steps
Test stimulus accuracy at reference mic. for tones
(200 - 2000 Hz) ....±1.5 dB SPL
(2000- 8000 Hz) ....±2.5 dB SPL
Equalization Method ....modified pressure method
                              (stored for open fittings)
Frequencies per octave (swept tones) 12
Frequencies per octave (tone burst) 3
Analysis bandwidth (speech, noise).....................1/3 octave
Measurement accuracy at 1 kHz....................................±1 dB
Measurement accuracy re 1 kHz.........±1.5 dB (200-5000 Hz)
                              ±2.5 dB (5000-8000Hz)
Measurement Range ....20-135 dB SPL (200-2500 Hz)
.   30-140 dB SPL (2500-8000Hz)
ANSI S3.46 - 1997 tests available
    a Real-Ear Unaided Response
    a Real-Ear Aided Response
    a Real-Ear Occluded Response
    a Real-Ear Insertion Gain
Other tests available
    a Speechmap ® real-speech audibility measures
    a On-ear harmonic distortion
    a On-ear spectral analysis
    a On-ear noise reduction verification
    a Manual measurement of output, gain and distortion
Fitting methods available
    a Speechmap with DSL 5.0a, NAL-NL1, CAMFIT
    a Insertion gain with NAL-RP, NAL-NL1, Fig6, PogoII,
    Berger, Libby

Sensory Loss Simulator

Simulation types... Linear conductive
                              Non-linear outer hair cell cochlear loss
Simulation bands 65

22 Glossary

AGC, Automatic Gain Control, the means by which gain is automatically controlled by the level of the signal being amplified. (ANSI S3.22)

AGC-I, input-controlled AGC (see "input compression").

AGC-O, output controlled AGC (see "output compression").

AGRAM, Abbreviation for audiogram.

ANSI, American National Standards Institute.

Attack Time, the time required for HA output to reach +/- 3dB of its steady state level in response to an input step from 55 to 90dB SPL. (ANSI S3.22)

ASP, Automatic Signal Processing, In hearing aids, level dependent frequency response shaping.

AVC, Automatic Volume Control, slow-acting AGC that attempts to maintain a constant average signal level.

BSPL, Band Sound Pressure Level, the SPL within a restricted frequency band.

BTE, Behind-The-Ear (hearing aid).

Compression, a type of AGC in which an incremental change in the input level produces a smaller incremental change in the output level.

CR, Compression Ratio, the ratio of incremental change in input SPL to the resulting incremental change in output SPL. Used to characterize steady state AGC action; can be a function of input level, duration and frequency.

CROS, Contralateral Routing Of Signals; a type of hearing aid in which the microphone is at the ear opposite to the one receiving the amplified sound.

CORFIG, **Coupler Response for Flat Insertion Gain**; the transformation added to real-ear insertion gain to obtain 2-cc coupler gain. Assumes linear amplification.

Coupler, a device used to acoustically couple an earphone or hearing aid to a measurement microphone and to provide an acoustic load.

DSL, Desired Sensation Level Method, a systematic eardrum (SPLogram) approach to the hearing aid fitting process that seeks to ensure amplified speech will be audible and comfortable while loud sounds will not be uncomfortable.
Directional hearing aid, a hearing aid for which the gain is dependent on the direction of sound incidence when measured under free-field conditions (ANSI S3.22).

Equalization, process of controlling the SPL (or band SPL) of the stimulus, as a function of frequency, at the field reference point (ANSI S3.46).

Expansion, a type of AGC in which an incremental change in the input level produces a larger incremental change in the output level.

FM, frequency modulation, a method of transmitting information in which the frequency of a radio wave (carrier) is varied (modulated) by the information (signal). Also, a method of reducing standing waves in a sound field in which the frequency of a test tone (carrier) is varied by a low frequency triangle or sine wave.

FM System, an assistive listening device consisting of a microphone, an fm radio transmitter and an fm receiver. The microphone and transmitter are worn by the speaker and the receiver is worn by the listener.

FOG, Full On Gain, gain for a 50 dB input SPL with the gain control set to maximum ANSI S3.22)

Gain (in dB), output sound pressure relative to input sound pressure, expressed in decibels; gain = $20\log_{10}$ (output sound pressure / input sound pressure); also, gain = (output SPL) - (input SPL).

Gain control, a manually or electronically operated control for the adjustment of overall gain (ANSI S3.22).

HA-1 Coupler, a coupler having a volume of 2 cubic centimetres with direct access to the cavity. Used for testing in-the-ear and in-the-canal hearing aids; can also be used to test behind-the-ear hearing aids with a custom earmold attached. Aka the ITE coupler.

HA-2 Coupler, a coupler having a volume of 2 cubic centimetres with access through a rigid tube. When used for testing BTE hearing aids, the rigid tube consists of 18 mm of 3 mm tubing plus 25 mm of 2 mm tubing (ANSI S3.22). When used for calibrating insert earphones, the 2 mm tubing is not used (ANSI S3.6). Aka the BTE coupler.

Harmonic, a component of a tone complex that is an integer multiple of the lowest frequency component (fundamental).
Harmonic Distortion, the addition of harmonic components to a signal. The rms value of a harmonic component of a signal as a percentage of the rms value of the fundamental. If less than 20%, the rms value of the total signal may be used instead of the fundamental.

HFA, High Frequency Average, the average of values in dB at 1000, 1600, and 2500 Hz. (ANSI S3.22).

HL, Hearing Level, the hearing threshold referenced to the threshold of normal hearing, expressed in dB.

HI, Hearing instrument.

HIT, Hearing instrument test.

Input Compression, a form of AGC in which the signal level is regulated before the volume control.

Input / Output function, steady state, single-frequency plot of the coupler SPL on the ordinate as a function of input SPL on the abscissa with equal decibel scale divisions on each axis (ANSI S3.22).

ITE, In-The-Ear (hearing aid).

Kneepoint (compression threshold), the point on an input/output curve at which the slope digresses from unity indicating the signal level at which a non-linear process begins to take effect.[1]

LCD, liquid crystal display. A thin, planar information display.

Linear Region, that portion of the input-output function which is a straight line at 45 degrees.

Linear Amplification, amplification having the same gain for all input levels until the maximum output of the device is reached.

LTASS, Long-term average speech spectrum, the rms level of a speech passage in 1/3rd octave bands, averaged over the entire passage.

Loop System, an assistive listening device that uses magnetic induction to carry a signal from a microphone/amplifier to a wire loop. The signal is picked up from the loop by a hearing aid set to the telecoil position or by a receiver with built-in telecoil, volume control, and earpiece. Loops are either worn around an individual's neck or can encircle a room, such as a classroom, providing an excellent signal-to-noise ratio.[1]

MAF, minimum audible field, SPL of a tone at the threshold of audibility measured in a free sound field for a subject listening with both ears and facing the sound source. The SPL is measured with the subject removed from the field at the midpoint of an imaginary line joining the centers of the ear canal openings.

MAP, minimal audible pressure, SPL of a tone, measured or inferred at the tympanic membrane, at the threshold of audibility.

MPO, Maximum Power Output, the maximum SPL that a hearing aid can deliver in response to a steady narrow band input. The stimulus may be pulsed (a tone burst) to avoid discomfort and to obtain a worst-case maximum output.

Modulation, the process of varying a characteristic of one signal with another.

NAL, National Acoustic Laboratories (Australia)

NCA, National Centre for Audiology (Canada)

Nonlinear Region, that portion of the input-output function which is not a straight line at 45 degrees.

OSPL90 (output SPL for 90-dB input SPL), The SPL developed in a 2cc coupler when the input SPL is 90 dB, with the gain control of the hearing aid full-on (ANSI S3.22).

Oscillation, in audiology, refers to the undesired tonal output of an amplifier behaving unstably as a result of feedback; whistling.[1]

Output Compression, a form of AGC in which the signal level is regulated at the output.

OLC, Output-limiting Compression (compression limiting), a form of AGC with a high kneepoint and high compression ratio.

PC, Peak-clipping, a method of limiting MPO by truncating the electrical signal supplied to the output transducer. The resulting acoustic signal may not be truncated but will be distorted.

Probe microphone, microphone (which may include an extension tube) having a sound inlet which is small enough to be acoustically unobtrusive when inserted into the ear canal (ANSI S3.46).

Pure tone, a signal containing one, and only one, frequency; a sinusoidal acoustic signal.[1]

REAG, Real-Ear Aided Gain, difference, in dB as a function of frequency, between the SPL (or BSPL) at a specified measurement point in the ear canal and the SPL (or BSPL) at the field reference point, for a specified sound field, with the hearing aid in place and turned on (ANSI S3.46).

REAR, Real-Ear Aided Response, the SPL (or BSPL) as a function of frequency, at a specified measurement point in the ear canal for a specified sound field, with the hearing aid in place and turned on (ANSI S3.46).

RECD, Real-Ear-to-Coupler Difference, difference, in dB as a function of frequency, between the SPL (or BSPL) produced by an insert transducer at the eardrum and in a 2cc coupler. HA-1 or HA-2 coupler should be specified.

REDD, Real-Ear-to-Dial Difference, difference, in dB as a function of frequency, between the SPL (or BSPL) measured at the eardrum and the audiometer dial setting that produced it. It is specific to the client, headphone and audiometer used to generate it.

REIG, Real-Ear Insertion Gain, difference, in dB as a function of frequency, between the REAG and the REUG taken with the same measurement point and the same sound field conditions. REIG = REAG – REUG. ANSI S3.46.

REOG, Real-Ear Occluded Gain, difference, in dB as a function of frequency, between the SPL (or BSPL) at a specified measurement point in the ear canal and the SPL (or BSPL) at the field reference point, for a specified sound field, with the hearing aid in place and turned off (ANSI S3.46).

REOR, Real-Ear Occluded Response, SPL (or BSPL), as a function of frequency, at a specified measurement point in the ear canal, for a specified sound field, with the hearing aid in place and turned off (ANSI S3.46). The REOR is used to evaluate the seal of an earmold. It is not related to the required gain of a hearing aid.

REUG, Real-Ear Unaided Gain , difference, in dB as a function of frequency, between the SPL (or BSPL) at a specified measurement point in the ear canal and the SPL (or BSPL) at a field reference point, for a specified sound field, with the ear unoccluded (ANSI S3.46).

REUR, Real-Ear Unaided Response, SPL (or BSPL), as a function of frequency, at a specified measurement point in the ear canal, for a specified sound field, with the ear canal unoccluded (ANSI S3.46).

Reference microphone, microphone used to measure the stimulus level in the measurement process or to control it in the equalization process.
Release Time, the time required for HA output to fall to within +/-4dB of its steady-state level for an input step from 90 to 55dB SPL. (ANSI S3.22)

REM, Real-Ear Measurement.

RTG, Reference Test Gain, the HFA gain for a 60 dB input SPL with the gain control at RTS (ANSI S3.22).

Reference, Sound-field, the calibration point of a sound-field measurement.

RTS, Reference Test Setting of the gain control, for a 60 dB input SPL, the setting of the gain control required to produce an HFA gain within 1.5 dB of the HFA-OSPL90 minus 17 dB. If the full-on HFA gain is less than the HFA-OSPL90 minus 17 dB, the RTS is the full-on setting of the gain control (ANSI S3.22).

RSETS, Relative Simulated Equivalent Telephone Sensitivity, difference in dB between the HFA-SPLITS (SPA-SPLITS) and the RTG plus 60 in the 'M' (microphone) mode. RSETS = HFA-SPLITS - (RTG+60)

Saturation, in a hearing aid, the limiting of output caused by the output circuitry and transducer reaching their maximum capability.

SPA, Special Purpose Average, the average of values in dB at three third octave frequencies separated by 2/3 of an octave (ANSI S3.22). See also HFA.

Spectrum, the BSPL as a function of frequency for a broad-band signal.

SII, Speech Intelligibility Index, a quantity calculated from measures of speech, noise and hearing threshold that is highly correlated with the intelligibility of speech (ANSI S3.5).

Speech Region, a statistical range of short-term spectra present in a speech passage. The short-term spectra are typically 120 - 130 millisecond averages in 1/3 octaves. The statistical range is typically from the 70th to the 99th percentile.

SPL, **Sound Pressure Level**, rms sound pressure relative to 20 uPa, expressed in decibels. SPL = $20\log_{10}$ (rms sound pressure / 20uPa).

SPLITS, coupler SPL for an inductive telephone simulator, SPL developed in a 2cc coupler by a hearing aid with the gain control at the RTS when the input is the magnetic field generated by a TMFS (ANSI S3.22).

TMFS, Telephone magnetic-field simulator, a device for producing a magnetic field of consistent level and geometric shape when driven by a specified current (ANSI S3.22).

THD, Total Harmonic Distortion, the rms value of all harmonic components as a percentage of the rms value of the fundamental. If less than 20%, the rms value of the total signal may be used instead of the fundamental. For most hearing aids, the inclusion of harmonics above the third will not significantly alter the THD (ANSI S3.22).

Transducer, a device which transforms energy from one form to another. For example, a microphone or earphone.

UCL, Uncomfortable Listening Level, the level for a specified stimulus that is judged to be definitely uncomfortable.
VGA, video graphics adapter.

VC, Volume Control, a user-operated gain control.

Warble Tone, a frequency-modulated sine wave. The modulating signal is often a low frequency triangle wave.

1. Valente, M: *Strategies for Selecting and Verifying Hearing Aid Fittings.* New York:Thieme Medical Publishers, Inc.,1994.

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ANSI S3.6, *Specification for Audiometers*, 1996

ANSI S3.22, *Specification of Hearing Aid Characteristics*, revised 2003.

ANSI S3.46, *Methods of Measurement of Real-Ear Performance Characteristics of Hearing Aids*, 1997.

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24 Appendix 1: Manufacturer Disclosure Statement for Medical Device Security

Manufacturer Disclosure Statement for Medical Device Security--MDS²

Device Category *		Manufacturer *	Document ID		Document Release Date
Hearing Aid Analyzer		**Etymonic Design Inc.**			
Device Model		Software Revision	Software Release Date		Other
Verifit / RM500SL		**See Page 1 of Users Guide**	**See page 1 of Users Guide**		

Manufacturer or Representative Contact Information	Name		Title		Department
	Chris Stokes-Rees		**Technical Services Representative**		
	Company Name		Telephone Number	E-mail	
	Etymonic Design Inc.		**800-265-2093**	chris@audioscan.com	

MANAGEMENT OF ELECTRONIC PROTECTED HEALTH INFORMATION (PHI) *As defined by HIPAA Security Rule, 45 CFR Part 164*	Yes No N/A	Note #
1. Can this device transmit or maintain *electronic Protected Health Information* (ePHI)?	Yes	1
2. Types of ePHI data elements that can be maintained by the device:		
a. Demographic (e.g., name, address, location, unique identification number)?	No	
b. Medical record (e.g., medical record #, account #, test or treatment date, device identification number)?	No	
c. Diagnostic/therapeutic (e.g., photo/radiograph, test results, or physiological data with identifying characteristics)?	No	
d. Open, unstructured text entered by device user/operator?	Yes	1
3. Maintaining ePHI: *Can the device*		
a. Maintain ePHI temporarily in volatile memory (i.e., until cleared on by power-off or reset)?	Yes	2
b. Store ePHI persistently on local media?	No	
c. Import/export ePHI with other systems?	Yes	3
4. Mechanisms used for the transmitting, importing/exporting of ePHI: *Can the device*		
a. Display ePHI (e.g., video display)?	Yes	
b. Generate hardcopy reports or images containing ePHI?	Yes	1
c. Retrieve ePHI from or record EPHI to removable media (e.g., disk, DVD, CD_ROM, tape, CF/SD card, memory stick)?	Yes	1
d. Transmit/receive or import/export ePHI via dedicated cable connection (e.g., IEEE 1073, serial port, USB, FireWire)?	No	
e. Transmit/receive ePHI via a network connection (e.g., LAN, WAN, VPN, intranet, Internet)?	Yes	
f. Transmit/receive ePHI via an integrated wireless connection (e.g., WiFi, Bluetooth, infrared)?	No	
g. Other		

ADMINISTRATIVE SAFEGUARDS	Yes No N/A	Note #
5. Does manufacturer offer operator and technical support training or documentation on device security features?	Yes	4
6. What underlying operating system(s) (including version number) are used by the device? **Linux kernel 2.4.22**		

PHYSICAL SAFEGUARDS	Yes No N/A	Note #
7. Are all device components maintaining ePHI (other than removable media) physically secure (i.e., cannot remove without tools)?	Yes	
8. Does the device have an integral data backup capability (i.e., backup onto removable media such as tape, disk)?	No	
9. Can the device boot from uncontrolled or removable media (i.e., a source other than an internal drive or memory component)?	Yes	5

TECHNICAL SAFEGUARDS	Yes No N/A	Note #
10. Can software or hardware not authorized by the device manufacturer be installed on the device?	No	
11. Can the device be serviced remotely (i.e., maintenance activities performed by service person via network or remote connection)?	No	
a. Can the device restrict remote access to specific devices or network locations (e.g., specific IP addresses)?	No	
b. Can the device log provide an audit trail of remote-service activity?	No	
c. Can security patches or other software be installed remotely?	No	
12. Level of owner/operator service access to device operating system: *Can the device owner/operator?*		
a. Apply device manufacturer-validated security patches?	No	
b. Install or update antivirus software?	No	6
c. Update virus definitions on manufacturer-installed antivirus software?	No	6
d. Obtain administrative privileges (e.g., access operating system or application via local root or admin account)?	No	
13. Does the device support user/operator specific ID and password?	No	
14. Are access sessions terminated after a predetermined length of inactivity (e.g., auto logoff)?	No	
15. Events recorded in device audit log (e.g., user, date/time, action taken): *Can the audit log record*		
a. Login and logout by users/operators?	No	7
b. Viewing of ePHI?	No	7
c. Creation, modification or deletion of ePHI?	No	7
d. Import/export or transmittal/receipt of ePHI?	No	7
16. Does the device incorporate an emergency access ("break-glass") feature that logs each instance of use?	No	
17. Can the device maintain ePHI (e.g., by internal battery) during power service interruptions?	No	
18. Controls when exchanging ePHI with other devices:		
a. Transmitted only via a physically secure connection (e.g., dedicated cable)?	No	
b. Encrypted prior to transmission via a network or removable media?	No	8
c. Restricted to a fixed list of network addresses (i.e., host-based access control list)?	No	9
19. Does the device ensure the integrity of the ePHI data with implicit or explicit error detection/correction technology?	No	

Manufacturer Disclosure Statement for Medical Device Security--MDS²

RECOMMENDED SECURITY PRACTICES

If possible, do not create ePHI. ePHI can only be created if a QWERTY keyboard is connected to the device(s). Not providing a keyboard is an effective way of restricting the creation of ePHI.

In the event that ePHI *must* be produced, the device(s) are capable of outputting ePHI in several different forms as disclosed in this document. Any data containing ePHI should be de-identified before storing the data, whether it is to hard copy, network file, or USB. If de-identification is not possible physical access to the device or hard copies of data should be restricted to authorized personnel and saving to USB sticks should be prohibited.

EXPLANATORY NOTES *(from questions 1 – 19)*

IMPORTANT: Refer to Instructions for the Manufacturers Disclosure Statement for medical Device Security for the proper interpretation of information provided in this form.

1. The device(s), if equipped with a QWERTY keyboard, allows the operator to enter free-form text when saving or printing data. This data can be stored and retrieved from a USB stick or network file.

2. If an operator enters a header for printing, that header will remain on the machine until power is cycled or it is overwritten. Clearing a session does not erase header information an operator may have entered for printing.

3. The device(s) can import and export data and headers that may include ePHI, but only in the event that PHI was entered by the operator. The device(s) can import/export via network connection or transfer via USB stick.

4. This document along with available phone support constitutes our support for HIPAA compliance.

5. The Verifit device boots from a removable CD. The RM500SL device boots from a USB memory stick. The devices can boot from removable media only if it contains software supplied by the manufacturer.

6. There is no virus protection software available for the device(s).

7. The device(s) do not use any password protection and there is no device audit log.

8. The device(s) do not encrypt data and cannot save to encrypted media such as an encrypted USB. Any PHI produced by the device(s) should be de-identified appropriately.

9. The device(s) can connect to any networked computer to store and retrieve data, provided the user name and password is entered. Once the username and password is entered it is maintained by the device(s).

Within the European Community:

EU Authorised representative:

PC Werth Ltd. Audiology House

45 Nightingale Lane, London SW12 8SP UK

Council Directive 93/42/EEC for Medical Devices.

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25 Appendix 2: AudioNote 2.1 VERIFIT and RM500SL Test Signals and Analysis

For additional details of the signals and their analysis, see the appended AudioNote.

VERIFIT TEST SIGNALS

Bill Cole BASc, PEng

1 Introduction

The Verifit is a full-duplex dual-channel audio measurement system designed for the testing and fitting of all types of hearing instruments and many assistive listening devices. It provides an acoustic test chamber with two loudspeakers for the functional testing of directional and non-directional devices coupled to standard 2 cm^3 couplers as well as sound-field speakers for real-ear measurement (REM) of hearing aid performance. Test signals are delivered to the device under test via the test chamber loudspeakers, the test chamber telephone magnetic-field simulator (TMFS), the test chamber magnetic field test loop or the sound-field loudspeakers. Device output signals are measured in the 2 cm^3 coupler via the coupler microphone or in a real ear via the probe microphone. Data from the 2 cm^3 coupler may be viewed as coupler SPL, coupler gain or as estimated SPL in the ear canal (simulated real-ear measurements, S-REM). Data from the probe microphone may be viewed as ear canal SPL, as ear canal SPL re normal hearing threshold (i.e. dB HL), as insertion gain or as ear canal SPL in the context of an auditory area (Speechmap®).

2 The test signals

Four types of test signals are currently available. These are tonal signals, pseudo-random noise, digitized real speech signals and the ICRA distorted speech signal. Test signals may be generated in real time by the digital signal processor (DSP) or played from 16 bit binary audio files stored in the on-board flash memory. These audio files are up-loaded from the internal compact disc (CD) drive at power up. In order to provide a repeatable acoustic signal to the device under test, a reference microphone is used in conjunction with a digital control loop to maintain the desired band level at each frequency. Live audio (speech, music etc.) may also be used as a test signal but it is not controlled for spectrum or level.

2.1 Narrow-band signals

2.1.1 Pure tones

Pure-tones are used in the ANSI hearing aid tests, in Multicurve 2 cm^3 frequency response tests (gain or output), in 2 cm^3 and real-ear single frequency (manual) tests, in real-ear insertion gain tests and in tone-burst maximum output (MPO) tests. Frequencies used are 1/12 octave except for the MPO test which uses 1/3 octave frequencies. Levels from 40 to 90 dB SPL are available at the reference microphone. Control of the level at each frequency is maintained by measuring the frequency response of the signal path to the reference microphone 256 ms before each test using a 256 ms, 50 – 55 dB SPL, multi-tone complex or a 256 ms chirp, depending on the test to follow. Drive levels at each frequency are then set to achieve the desired band levels at the reference microphone.

2.2 Broad-band signals

2.2.1 Pink Noise signal

The pink noise signal is available for Multicurve 2 cm^3 coupler gain and output frequency response measurements and for Insertion gain and Speechmap real-ear measurements. It is a pseudo-random signal composed of 1024 simultaneous tones summed to provide a crest factor of 12 dB. The spectrum of the pink noise signal is controlled by the reference microphone in conjunction with a digital feedback loop with a frequency resolution of 1/12 octave and a response time of about 1/3 of a second. Pink noise was selected as a test signal because it has equal energy per octave, producing a flat spectrum when analyzed in the 1/12 or 1/3 octave bands used in the Verifit. Figure 1 shows the 1/3 octave spectrum of the pink noise signal and the noise signal specified in ANSI

S3.42-1997. Note that the ANSI S3.42-1997 spectrum represents speech peaks not the long-term average.

1/3 OCTAVE SPECTRA for VERIFIT PINK NOISE SIGNAL and ANSI S3.42 NOISE re overall SPL
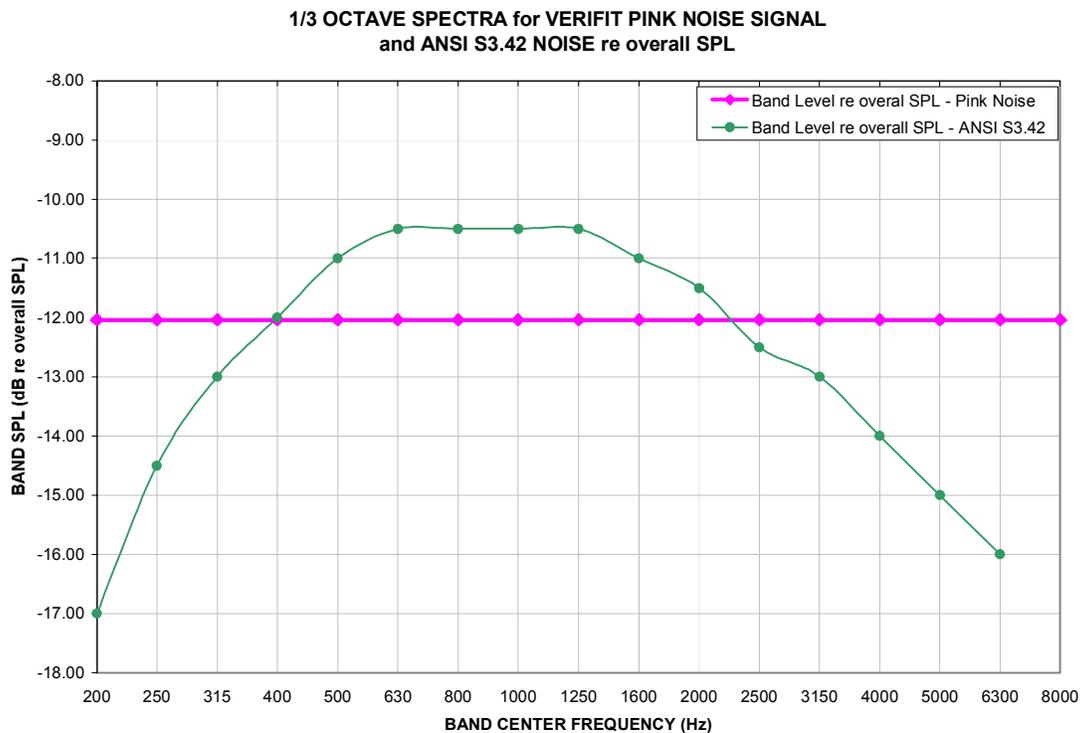
Figure 1: 1/3 octave spectra for Verifit pink noise signal and the noise signal specified in ANSI S3.42-1997.

2.2.2   Dual-direction pink noise signal

This unique test signal is available in the dual-source test chamber and for real-ear measurements by adding an additional sound-field speaker. It is similar to the pink noise signal described previously except that the component tones are presented simultaneously from two speakers, half from each. The level of each tone is independently controlled at the reference microphone. Two frequency response curves are generated simultaneously -one for each speaker. This provides a real-time measure of the functioning of the directional features of hearing aids that is independent of compression or noise reduction algorithms. Measurement methods which sequentially measure response from different directions work only with these features disabled.

2.2.3   Real-speech signals

Real-speech signals are provided in Speechmap for both REM and S-REM measurement modes. Four different digitized speech passages and the single-talker ICRA distorted speech are provided. Each has a duration of 10 – 15 seconds and may be presented as a single passage or in a continuous loop. In order to provide a repeatable speech signal to the device under test, the signal path must be equalized prior to the presentation of the speech signal. This is accomplished by presenting a 256 ms chirp signal at a level of 50 - 55 dB SPL, 256 ms prior to the start of each speech passage and adjusting a digital filter to provide a flat response at the reference microphone.

The "Speech-shaped" signal is a male talker, filtered to provide the long-term average speech spectrum (LTASS) recommended by Cox & Moore (1988) for average vocal effort. This is the LTASS assumed in the Desired Sensation Level (DSL) method of hearing aid fitting. The remaining three signals have been chosen to provide a range of spectra and are presented "as recorded" without any processing. They consist of an adult male talker, an adult female talker and a child female talker. Overall SPLs of 55, 60, 65, 70 and 75 dB (at the reference microphone) are available. Soft and Loud vocal effort effects from DSL 4.1 are filtered into the 55 and 75 dB levels, respectively. These are shown in Figure 2.

The ICRA distorted speech signal is a recording of an English-speaking talker that has been digitally modified to make the speech largely unintelligible. The resultant signal has many of the properties of real speech but has a harsh sound and lacks harmonic structure. The latter may be significant for hearing aids which use this property

of speech to control noise reduction schemes.

The Verifit provides a simulated real-ear mode (S-REM) in which measurements made in the 2 cc coupler in the test chamber are converted to estimated real ear SPL. In this mode, the effects of hearing aid microphone location need to be included in the test signals so spectra are further altered to include the microphone location effects shown in Figure 3.

VOCAL EFFORT EFFECTS re nominal band SPL
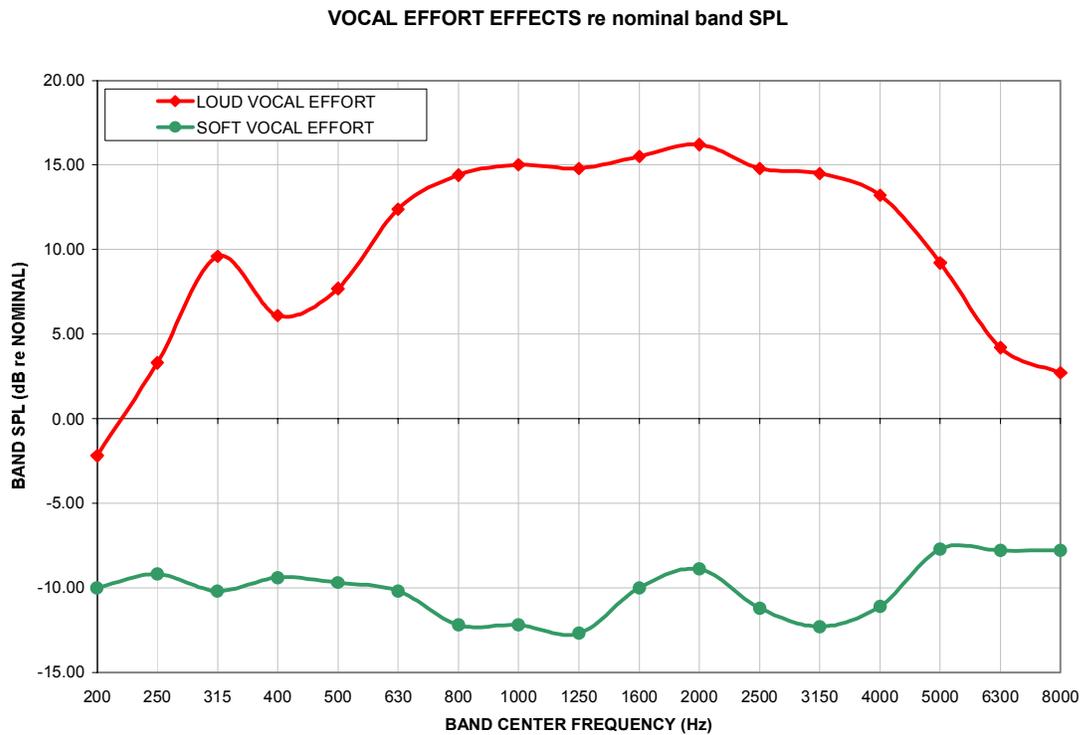
Figure 2: Vocal effort effects in dB re nominal band levels. Nominal band levels are band levels for an overall SPL of 65 dB and average vocal effort. The overall SPL for SOFT speech signals is 55 dB. The overall SPL for LOUD speech signals is 75 dB.
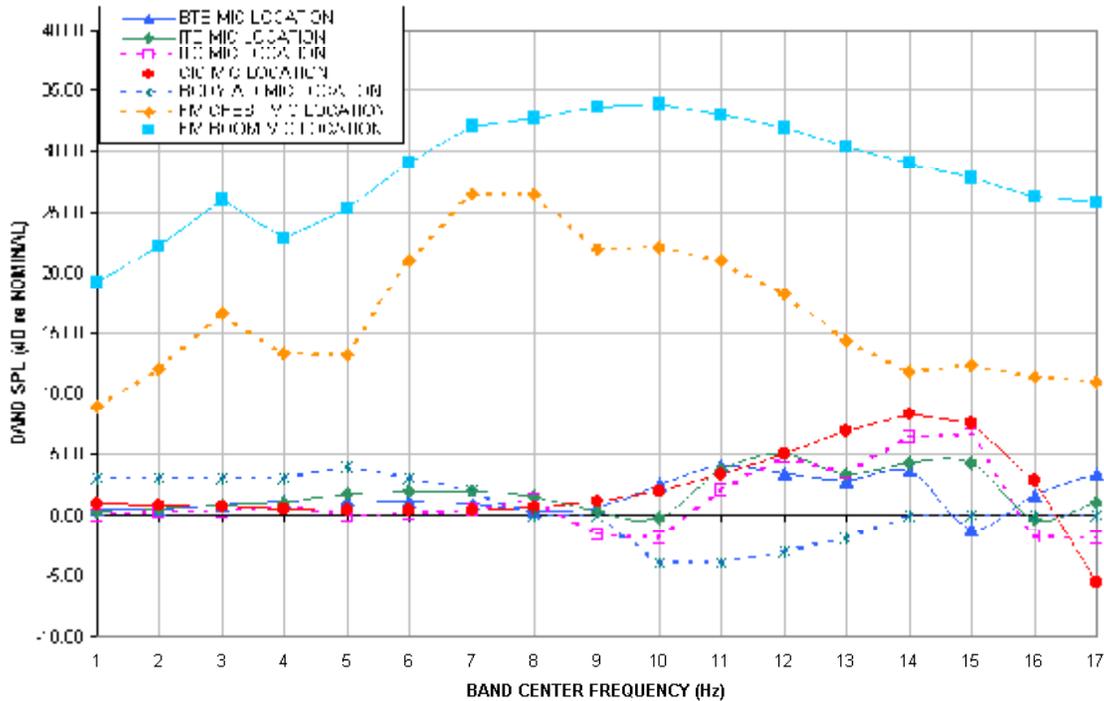
Figure 3: Microphone location effects in dB re nominal band SPL. Nominal band levels are band levels for an overall rms level of 65 dB SPL and average vocal effort in a free sound field.

3 Analysis of broad-band signals

Broad-band signals contain energy at many frequencies simultaneously. Such signals are usually analyzed in a series of narrow frequency bands to produce a spectrum. The auditory system functions on a logarithmic frequency scale and analyzes broad-band signals in critical bands which approximate 1/3 octave bands (Figure 4). Using 1/3 octave bands for analysis of broad-band signals allows measured levels to be compared more readily to narrow-band behavioral measures, such as threshold. For this reason, analysis of broad-band signals in all Real-Ear Measurements (including S-REM in Speechmap) is in 1/3 octave bands. Other analyzers use narrower analysis bands, sometimes having constant bandwidth. As shown in Figure 4, this can result in significantly underestimating the audibility (or comfort or discomfort) of a complex signal.

It should be noted that, in all Real-Ear Measurements, 1/3 octave band SPL is displayed (and reported when saving data to a file) at 1/12 octave frequencies which provides curve smoothing. When calculating overall rms from these data, the SPL at 225 Hz and subsequent 1/3 octave increments should be used.

Analysis of broad-band signals in all Hearing Instrument Tests is in 1/12 octave bands and the band SPL is displayed at 1/12 octave frequencies.

3.1 Pink noise signal analysis

All band levels are calculated with an averaging time of 128 ms.

For a linear hearing aid, a pink noise stimulus will result in a response curve that has the same shape as one obtained using a swept pure tone. However, it must be remembered that, while a swept tone has the same band SPL as overall SPL, the band SPL for a noise signal is significantly lower than the overall SPL. Consequently, for a linear aid, output curves obtained using 1/12 octave analysis will be about 18 dB lower than the output curves obtained using a swept tone at the same overall SPL. As long as the hearing aid is linear, the gain obtained will be the same for both signals. Figure 5 shows output (A) and gain (B) for a linear hearing aid, obtained using a swept tone (1) and pink noise (2) with a 60 dB overall SPL.

Figure 4: Analysis bandwidths of some real-ear analyzers and critical bands for a normal ear. If the

analysis bandwidth is less than a critical band, aided response curves shown to be at threshold (or UCL) will actually be well above it.
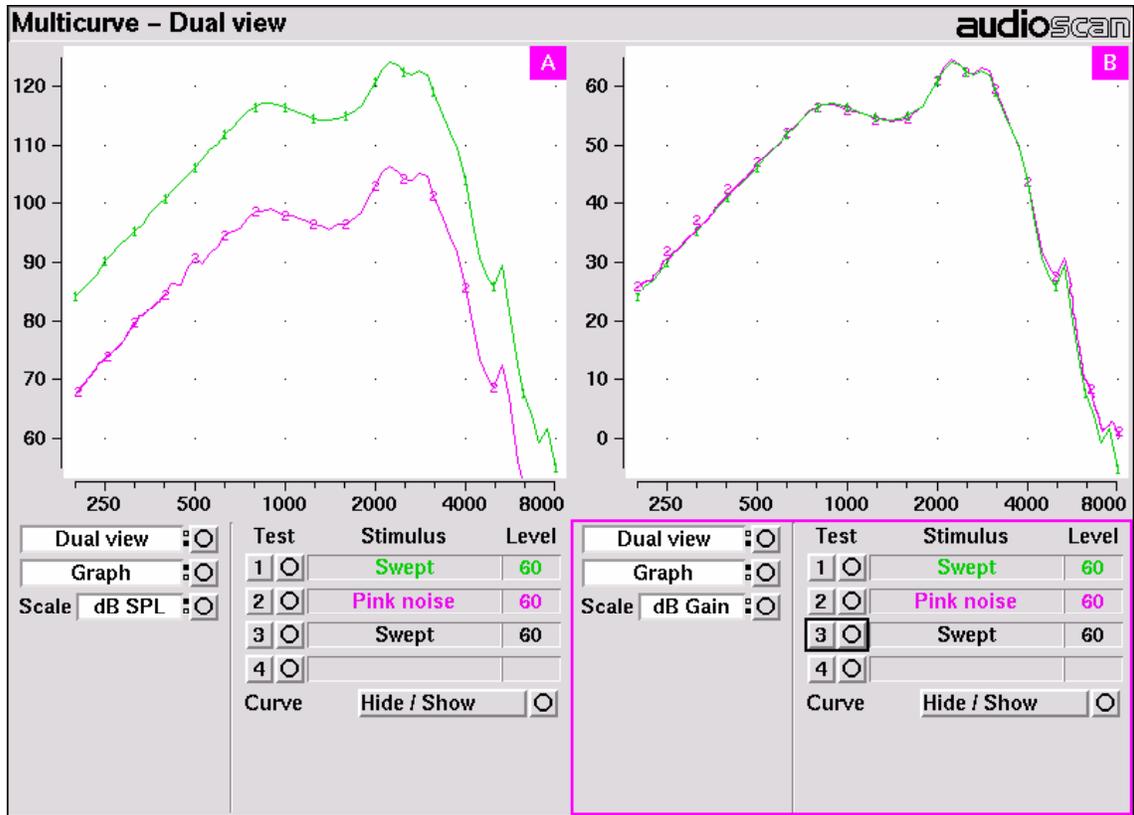
Figure 5: Output (left) and Gain (right) curves for a linear hearing aid, generated using a swept tone (1) and pink noise analyzed in 1/12 octave bands (2).
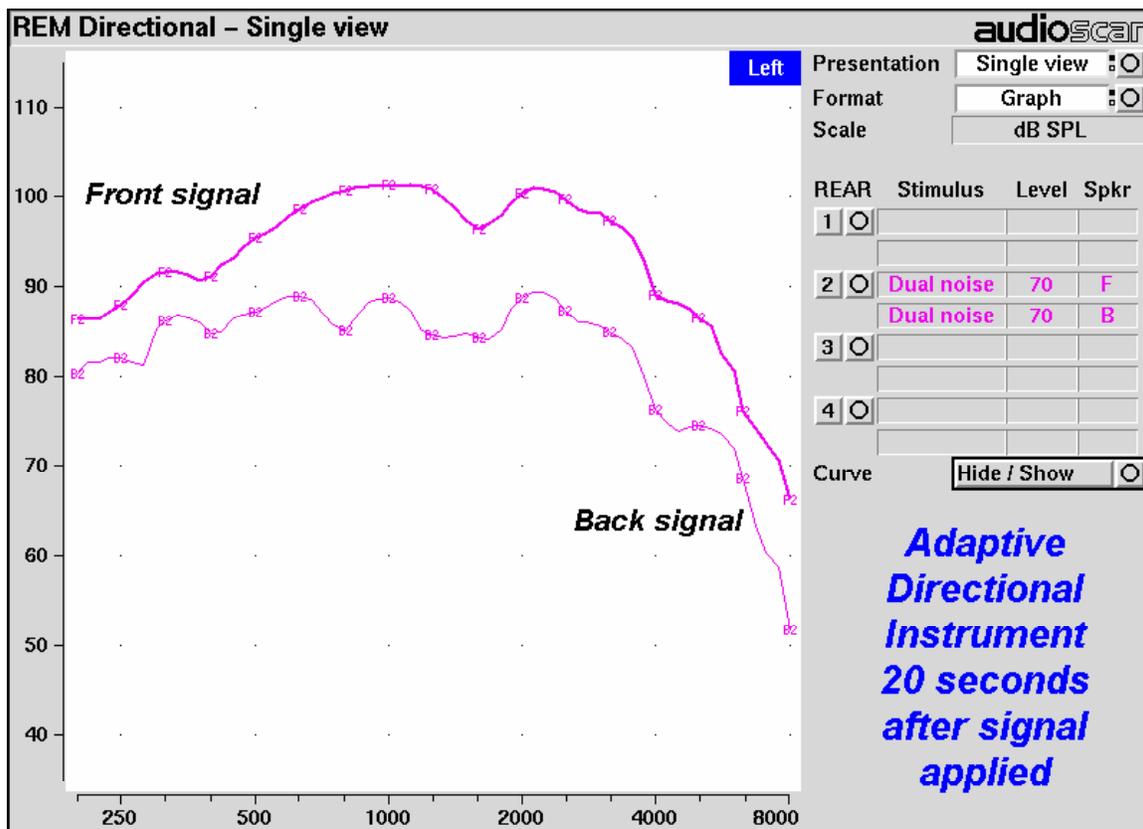
Figure 6: A real-ear directional test on an adaptive instrument with active compression and noise reduction

3.2 Real-speech signal analysis

One of the most-used measures of a speech signal is the long-term average speech spectrum (LTASS). This is a 1/3 octave spectrum averaged over a sufficiently long portion of the speech material to provide a stable curve. In practice a 10 second average meets this requirement and, for this reason, all Verifit passages are at least 10 seconds long.

The dynamic nature of speech is often characterized by the distribution of short-term levels in each 1/3 octave band. These levels are determined by calculating a spectrum for each of a series of short time periods within the passage. Historically, time periods of 120, 125 or 128 ms have been used. The Verifit uses a 128 ms time period, resulting in 100 levels (or samples) in each 1/3 octave band for a 12.8 second passage. The level in each band that is exceeded by 1% of the samples (called either the 1st or 99th percentile) has historically been referred to as the speech peak for that band. The curve for these 1% levels is approximately 12 dB above the LTASS. The level in each band that is exceeded by 70% of the samples (called either the 70th or 30th percentile) has historically been called the valley of speech for that band. The curve for these 70% levels is approximately 18 dB below the LTASS. The region between these two curves is often called the speech region, speech envelope or speech "banana". The speech envelope, when derived in this way, has significance in terms of both speech detection and speech understanding. Generally, speech will be detectable if the 1 % level is at or near threshold. The Speech Intelligibility Index (SII) is maximized when the entire speech envelope (idealized as a 30 dB range) is above (masked) threshold. This will not be an SII of 100% (or 1) because of loudness distortion factors, but higher SII values will not produce significantly higher scores on most test material. The speech-reception threshold (SRT) is attained when the LTASS is at threshold (approximately - depending on test material and the individual). These scenarios are shown in Figures 7 - 9 which follow.

It should be noted that analysis methods which use shorter time periods produce higher peak levels and significantly different speech envelopes. In order to produce results that can be directly compared to measures of threshold (and UCL), the analysis time period needs to approximate the integration time of the ear. Although this varies with frequency and individuals, a value between 100 - 200 ms is likely. The Verifit uses a 128 ms analysis time period as an approximation because it also has considerable historic support.

Because the spectrum of a speech signal varies with time, it is necessary to average measurements over several seconds to obtain a stable, repeatable result. However, the effects of adjustments to hearing aid parameters need to be seen quickly in order to be useful for optimization. To resolve these conflicting needs, speech signals are first presented in a repeating loop with a sound-field equalization test prior to the start of each passage. A running calculation of the short-term speech envelope and average is performed on 2 - 3 seconds worth of data and is displayed in real time so that the effects of adjustments to hearing aid parameters are easily viewed. Pressing the Continue key causes the passage to restart and run in its entirety. The envelope and average are calculated over the full passage to provide stable and repeatable data.
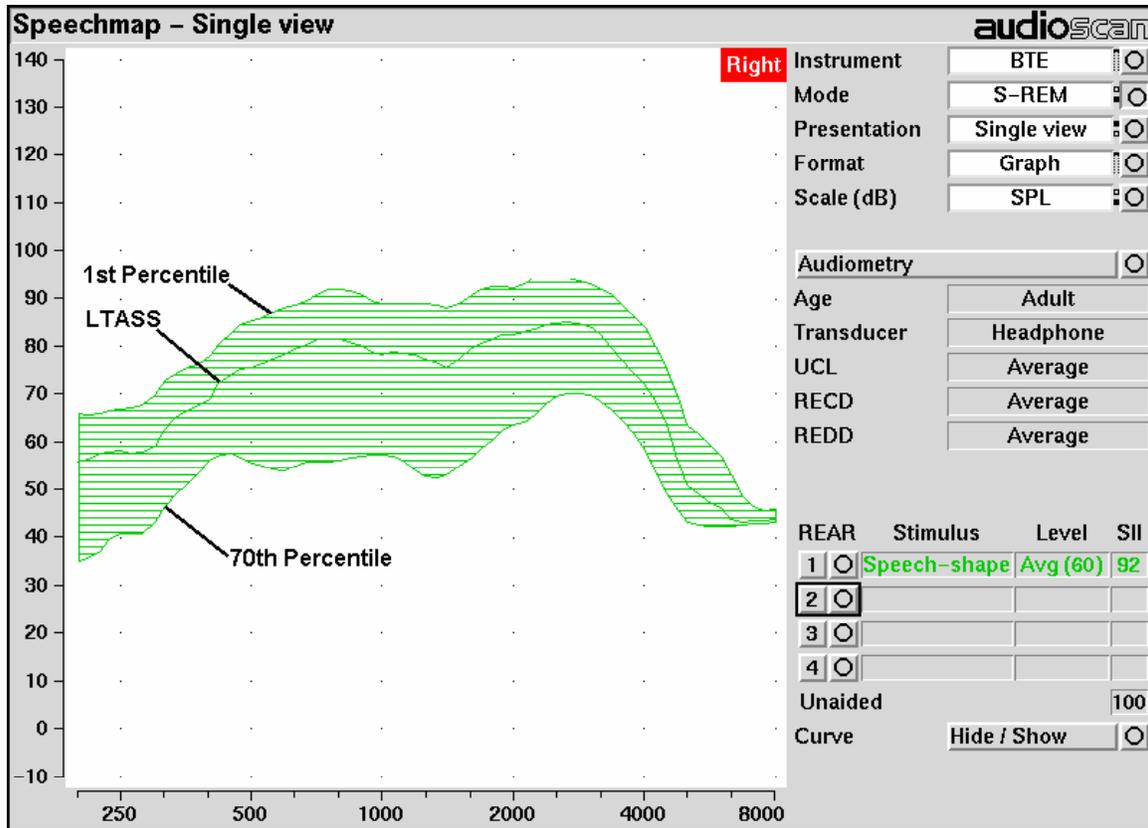
Figure 7: Example of speech envelope and LTASS
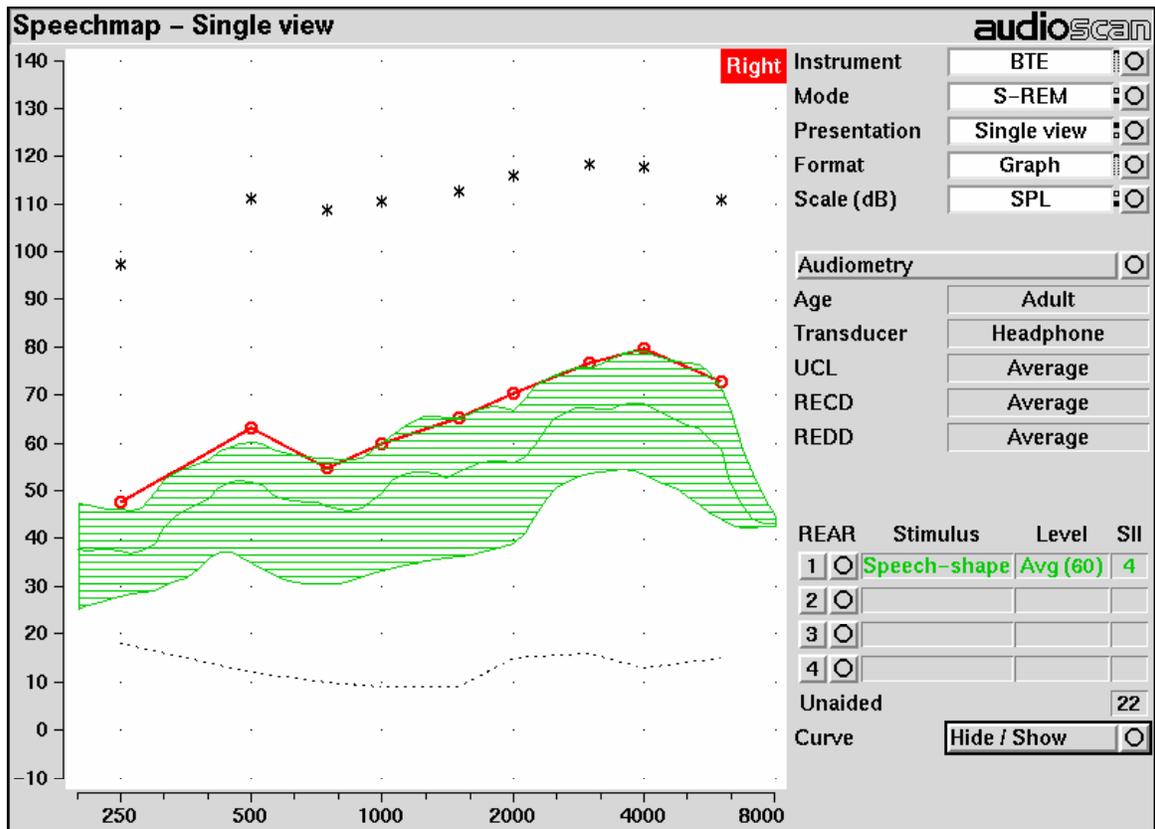
Figure 8: Speech is detectable but not understandable if the 1ˢᵗ percentile is at threshold
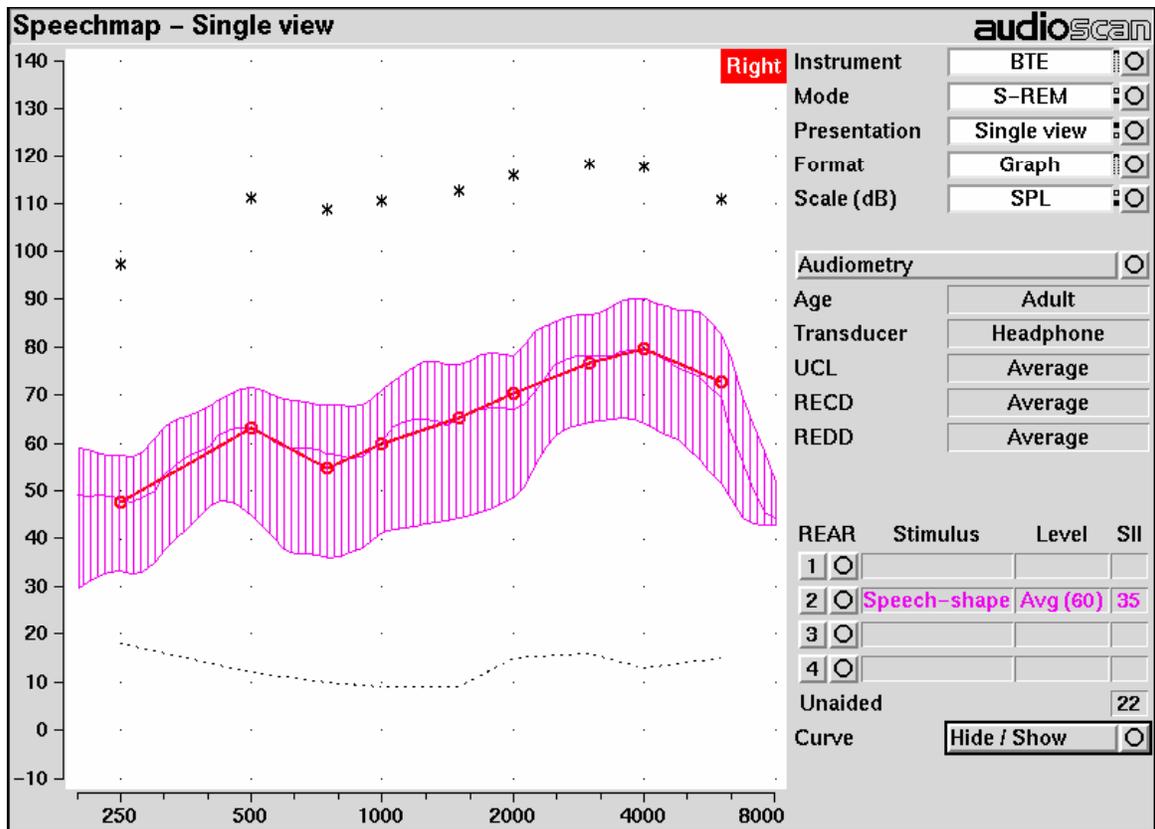
Figure 9: When LTASS is at threshold, SII ≈ 33% which corresponds approximately to SRT
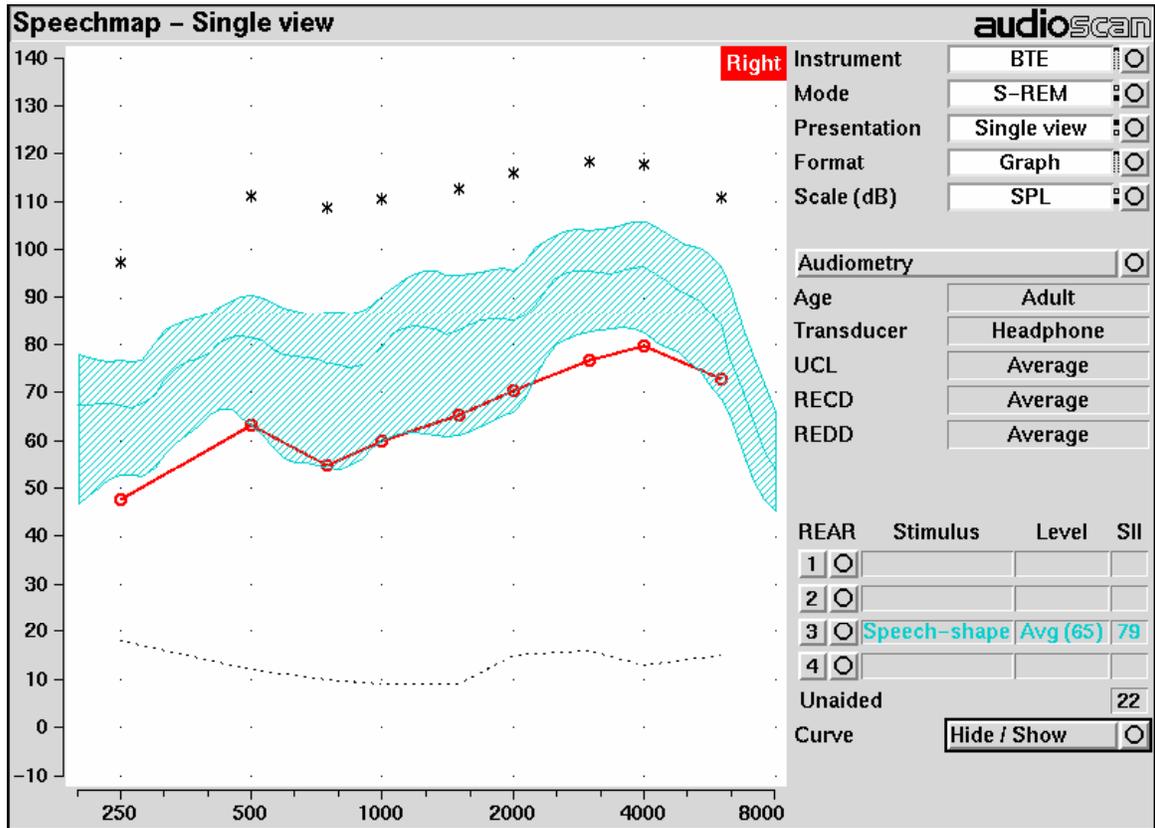
Figure 10: The highest SII is obtained when the entire speech envelope is above threshold
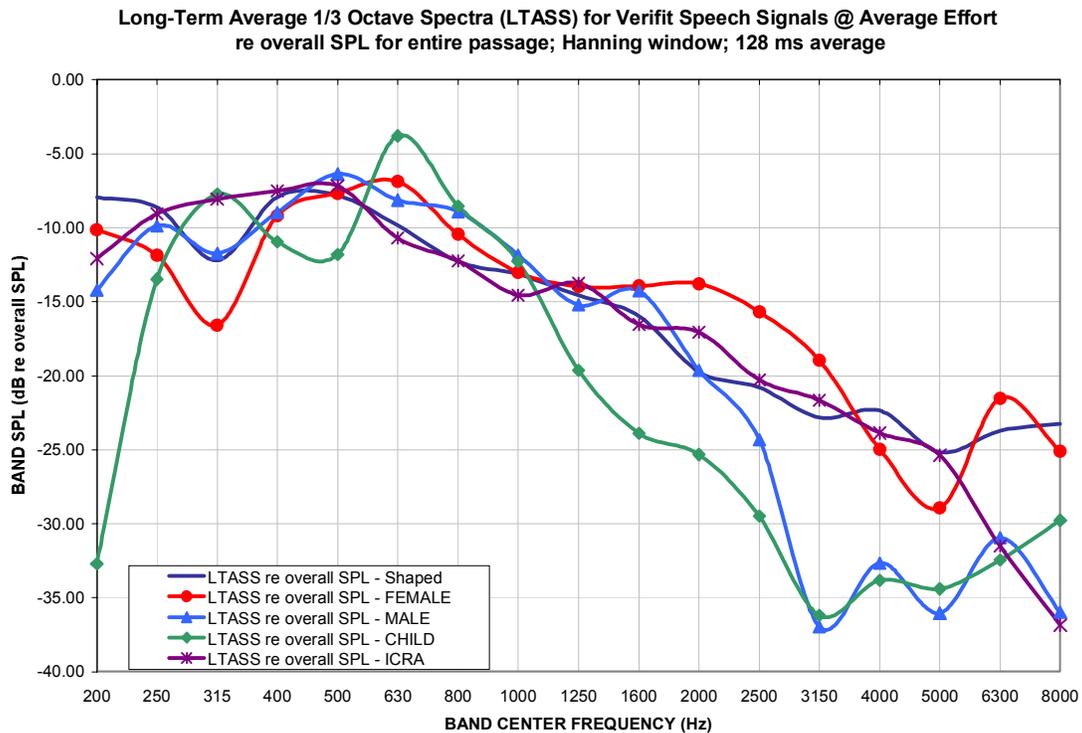
Figure 11: LTASS for Verifit speech signals at average vocal effort

1st Percentile of 1/3 Octave Band SPLs for Verifit Speech Signals @ Average Effort]
re LTASS for entire passage; Hanning window; 128 ms average
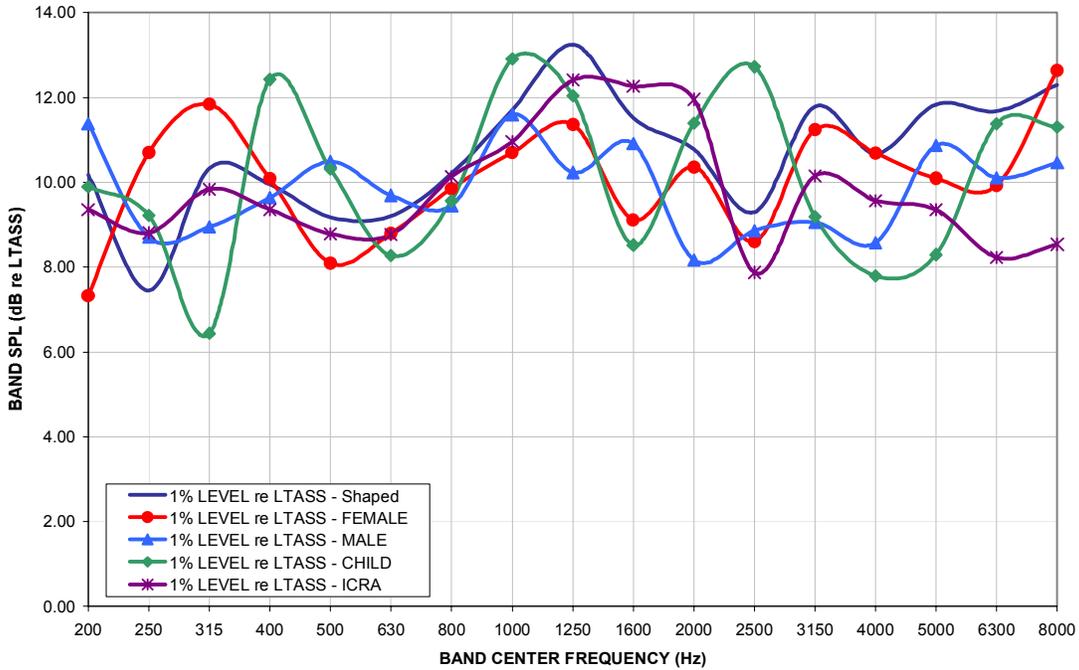
Figure 12: Level of first percentile for Verifit speech signals at average vocal effort

70th Percentile of 1/3 Octave Band SPLs for Verifit Speech Signals @ Average Effort]
re LTASS for entire passage; Hanning window; 128 ms average
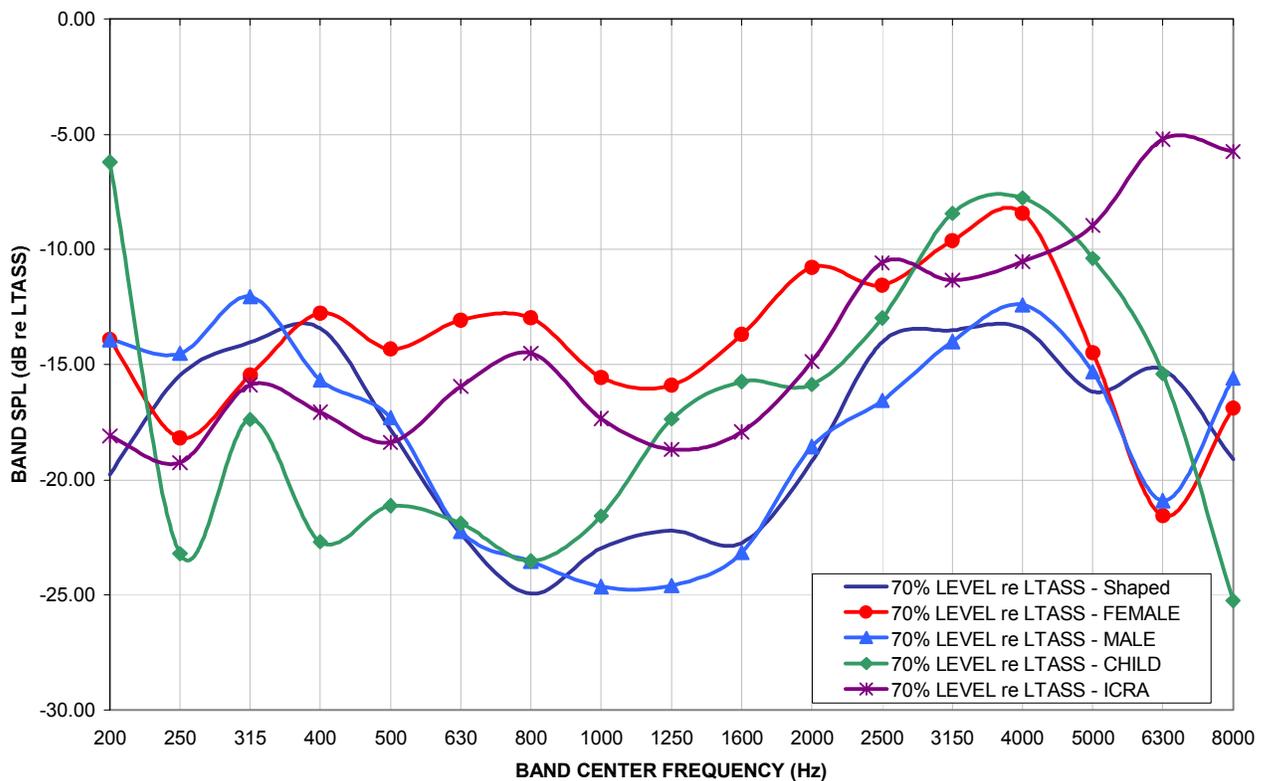
Figure 13: Level of 70th percentile for Verifit speech signals at average vocal effort

Dynamic Range for Verifit Speech Signals @ Average Effort]
re LTASS for entire passage; Hanning window; 128 ms average

Legend:
- DYNAMIC RANGE - Shaped
- DYNAMIC RANGE - FEMALE
- DYNAMIC RANGE-MALE
- DYNAMIC RANGE - CHILD
- DYNAMIC RANGE - ICRA

X-axis: BAND CENTER FREQUENCY (Hz)
Y-axis: DYNAMIC RANGE (dB)
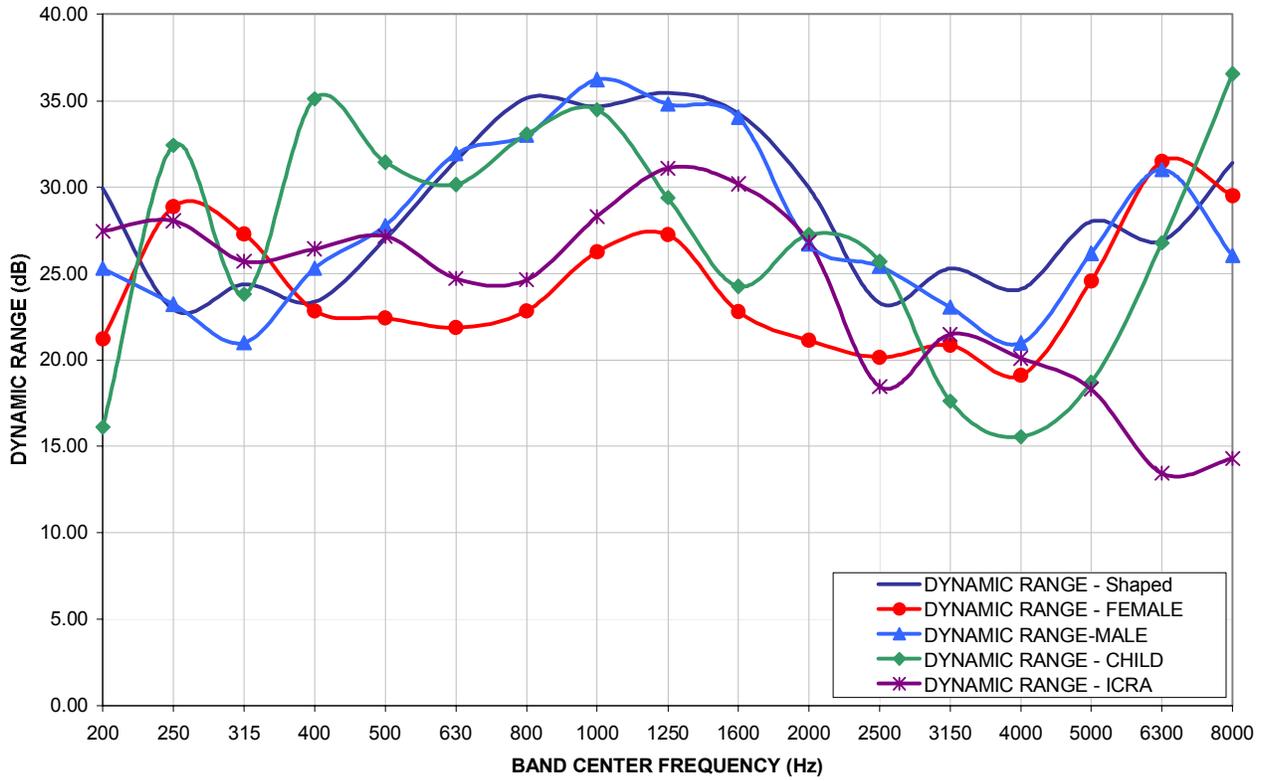
Figure 14: Dynamic range of Verifit speech signals at average vocal effort