QS8 Electroacoustic checks must be performed regularly and whenever a part of the system is changed.

For *Cochlear Implants and Bone Conduction Devices* see the supplementary QS8 guidance.

What is meant by 'regular' testing?

- These procedures should be repeated in line with how often the user of the device(s) seen, e.g., termly, or half-termly etc. When support visits are less frequent, testing should take place every time.
- More frequent electroacoustic testing is desirable for infants and preschoolers or those with complex needs who are less able to report faults.
- Testing is also required if a cause for concern is reported, or the user reports any problems.

When possible, the same test conditions should be used each time the system is checked; if a different test box is used, this should be noted, or new baseline curves should be recorded.

An example from practice: Electroacoustic testing in a small metropolitan borough school with four teachers of deaf children and young people (QToD).

This service aimed to put the hearing aids of all pupils receiving weekly support from the QToDs or classroom assistants through a test box *monthly***.** The recognised reality was that testing took place at least half-termly, with monthly checks for younger pupils or less sophisticated listeners.

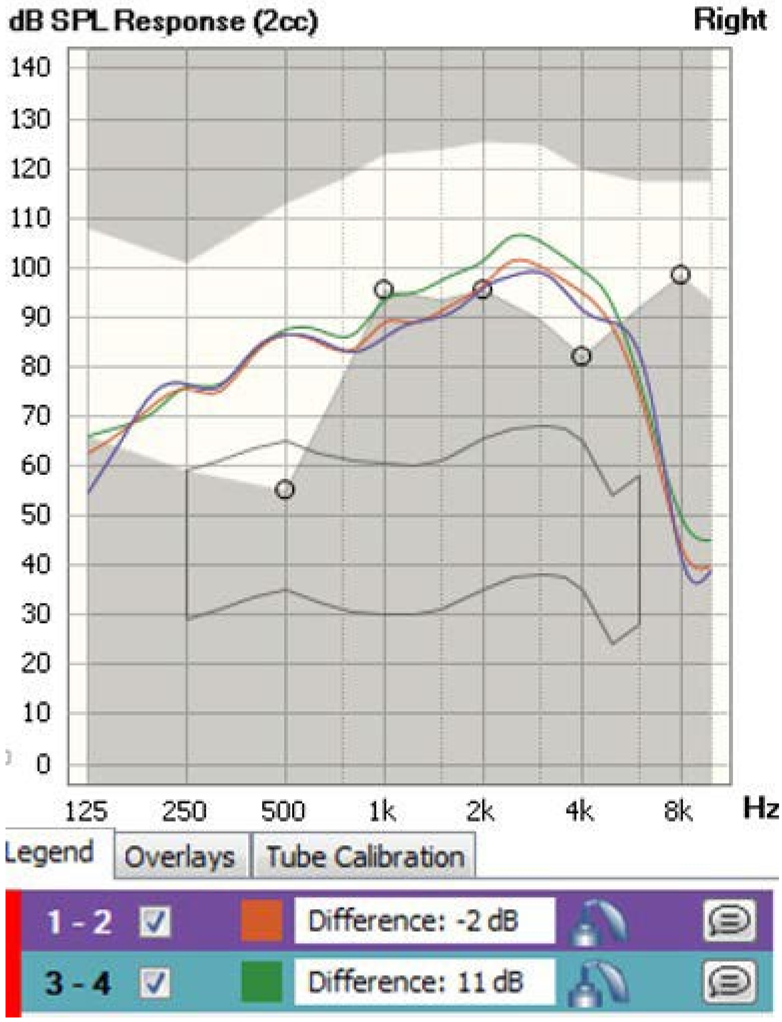
Comparative checking

It is important to ensure all systems are working optimally as at initial set up. See also section QS3 for electroacoustic set up of radio aid systems.

So, for all hearing instruments repeat the relevant electroacoustic procedures outlined in QS3 and compare current data with that obtained and circulated at the time of set up of the personal radio aid system.

One example of checking comparative curves for balancing a Phonak hearing aid and Roger radio aid in the Aurical HIT (Figure 1).

Figure 1.



curve 1 65dB ____________
curve 2 65dB ____________
curve 3 80dB ____________

Test signal levels for Hearing Aids (HA) and Remote Microphone (RM) systems

Table 1.

Device	SPL level to HA	SPL level to RM
Hearing Aids	65 dB	65 dB

Telecoil responses are known to be reduced in the lower frequencies to avoid interference in this area (Putterman & Valente, 2012). So, with induction-loop radio aid systems the curve will be reduced in the lower frequencies and the response curves are more likely to match above 1 kHz.

Similarly, when testing devices with open fittings, especially for individuals with hearing within normal limits, these devices might seem to lose low-frequency information in a test box (electroacoustic check). This happens because the test environment doesn't account for the natural input the ear would receive in real life, potentially giving a misleading impression of the device's performance.

How to record the responses.

A calibrated hearing instrument test (HIT) box is required.

- Present to the hearing aid (HA): a frequency response curve with a digital speech signal or speech-weighted signal at 65dB input.
- Present to the remote microphone (RM): a frequency response curve with a digital speech signal or speech-weighted signal at 65dB input.

Adjust the volume/gain of the remote microphone, or 'FM advantage' or 'EasyGain' level of the radio aid receiver so that the combined system response curve matches the HA response curve and achieves 'transparency' or 'balance'. *If the difference is 2 dB larger than the measurement tolerance* (Table 2), *then two output signals are different, and transparency is not achieved – continue adjusting*. For example, in the Aurical HIT, if the two responses are within 3 dB, then transparency is achieved.

Adjusting the receiver should preferably be done by starting at a low gain and then increasing.

Table 2.

Tolerance or signal accuracy up to 5000 Hz		Transparency difference overall
Affinity	< ± 1.5 dB	± 3.5 dB
Audioscan	± 1.0 dB	± 3.0 dB
Aurical	± 1.0 dB	± 3.0 dB
FP35	± 2.5 dB	± 4.5 dB

How to evaluate transparency

There are two standard methods to evaluate transparency (1 and 2), an extended method (3), and two methods that require examination of the source files, XML conversion and more complex calculations (4 and 5).

1. **By eye** - The HA responses without and with the and the remote microphone should overlap. If using an Aurical HIT, the gain difference table should show suitable values for each pair of curves (CI) and (CI + RM).
2. **Standard protocol** – compare the mid-frequency average for HA responses without and with the and the remote microphone.

Frequency (Hz)	750	1000	2000	Average	Difference
CI dB (SPL)	a	b	c	A1 = (a+b+c)/3	
CI & RM dB (SPL)	x	y	z	A2 = (x+y+z)/3	A2 – A1

3. **Adapted offset protocol** – calculate a wider frequency average for HA responses without and with the and the remote microphone, 750 Hz to 4000 Hz.

Frequency (Hz)	750	1000	1500	2000	3000	4000	Average	Difference
CI dB (SPL)	a	b	c	d	e	f	A1	
CI & RM dB (SPL)	u	v	w	x	y	z	A2	A2 – A1

A1 = (a+b+c+d+e+f)/6 A2 = (u+v+w+x+y+z)/6

4. **New RMS protocol** - calculate the broad average for HA responses without and with the and the remote microphone and compare (BSI, 2021).

Compute the root mean square of the difference in one-third octave levels from 800 Hz to 5 kHz of the output signal of the HA with the output signal of HA and RM combined. If the difference is 2 dB larger than the measurement tolerance*, then two output signals are different.

Frequency (Hz)	800	1000	1250	1600	2000	2500	3150	4000	5000	RMS	Difference
CI dB (SPL)	a	b	c	d	e	f	g	h	i	R1	
CI & RM dB (SPL)	r	s	t	u	v	w	x	y	z	R2	R2 – R1

$R1 = \sqrt{((a2+b^2+c^2 + d^2 + e^2 + f^2 + g^2 + h^2 + i^2)/9)}$ $R2 = \sqrt{((r2+s^2 + t^2 + u^2 + v^2 + w^2 + x^2 + y^2 + z^2)/9)}$

5. **New EUHA protocol** (EUHA, 2017; Husstedt et al., 2021)

1. Measure the output characteristic of the hearing device using an ISTS of 65 dB in a frequency range between 800 Hz and 3.5 kHz.
2. Connect the hearing device to the RM system and place the remote microphone at a quiet position outside the test box. Measure the output characteristic of the hearing device using an ISTS of 65 dB in a frequency range between 800 Hz and 3.5 kHz. In this frequency range, the output characteristic should equal (±5 dB) the characteristic of step 1.
3. Place the remote microphone inside the test box and place the hearing device at a quiet position outside the test box. Measure the output characteristic of the hearing device connected to the RM system using an ISTS of 65 dB in a frequency range between 800 Hz and 3.5 kHz. The measurement result is to equal the characteristic measured in step 1 (±5 dB). If necessary, adjust the setting of the RM system accordingly.

4. *Verification of the measurement conditions* (empty test box): Place both the hearing aid and the remote microphone outside the test box. Make sure that there is a connection between the hearing aid and the WRM system, as in step 2 and step 3. Measure the output characteristic of the hearing aid. In a frequency range between 800 Hz and 3.5 kHz, this characteristic needs to be *at least 10 dB below the characteristic of step 1.*

Regardless of method, at the end of the testing, Save, Print, and Share the information (QS11).

Of utmost importance is the perception of the user and speech testing will help evaluate the fitting. Having verified the fitting, the most important things to consider are behavioural responses, user perception and to ***validate*** *with speech in noise testing with and without the remote microphone system to assess benefit.*

References

EUHA (2017) Wireless remote microphone systems – configuration, verification and measurement of individual benefits [Online]. https://www.euha.org/content/uploads/2020/12/euha-guideline-04-06-en.pdf: European Union of Hearing Aid Acousticians. (Accessed 01 March 2024).

Husstedt H, Kahl J, Fitschen C, Griepentrog S, Frenz M, et al. (2022) Design and verification of a measurement setup for wireless remote microphone systems (WRMSs). *International Journal of Audiology*, 61, 34-45.

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