RECD and CBF made easy with the new AURICAL

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otometrics

What are RECD and CBF?

It has long been known that the hearing aid output delivered into the ear of an individual will be louder than the same sound delivered into a 2cc coupler (Sachs & Brukhard, 1972). Since the early 1990's clinically feasible methods for measuring the real-ear to 2cc coupler difference (RECD) have been described (Fikret-Pasa & Revit, 1992). Seewald (1992) recommended the RECD measurement as a viable hearing aid verification alternative for predicting aided sound pressure level for hearing aid fitting for young children. RECD values are derived by comparing the real-ear levels, measured by a probe microphone for a given test signal, to the levels measured in a 2-cc coupler for the same test signal across frequencies. The procedure is used most commonly for hearing aid fitting/verification, when traditional probe microphone measurements (PMM) cannot be made for infants and for difficult to test populations. It has been described in detail and enhanced in the literature (Moodie et al., 1994, Tharpe et al., 2001, Bagatto et al., 2002 & 2006). In 2000 Seewald et al reported on the validity of 2-cc Coupler-Based Measures with a Coupler-to-Real-Ear Transform as one of three commonly used measurement options at the verification stage of the pediatric fitting process. They found that RECDs and Coupler Based Fitting (CBF) resulted in highly accurate predictions of real-ear hearing instrument performance.

According to Moodie et al. (1994), this approach to pediatric hearing instrument fitting offers several advantages relative to conventional sound field aided threshold testing and probe-microphone measures. First, use of the RECD and CBF procedures eliminates the variability associated with sound field measures. Second, the approach allows clinicians to perform all hearing instrument programming and verification under the highly controlled acoustic conditions of the hearing instrument test chamber. Third, RECD and CBF are fast, efficient and reduce the degree of cooperation required from each infant or young child.

However, the use of CBF is not limited to measuring individualized RECD and fitting to a prescriptive target. Other uses include verification of specific HI features (such as directionality and noise reduction), and also

include coupler measures without RECD, which can provide invaluable information about the HI performance. An additional application allows for 'matching' the frequency response of a new hearing instrument to a previously worn device for clients with severe to profound hearing loss, i.e., a highly reduced dynamic range.

This group of clients often presents unique fitting challenges. Their ability to adapt to changes in sound is very limited. This, in turn, means the potential benefits of new hearing instruments can be delayed due to a prolonged adaptation period during the replacement process. CBF with the AURICAL provides an option for a smoother replacement procedure. By making comparative coupler measures of the "current" and the "new" hearing instruments at various levels, the clinician can ensure that initial programming of the new hearing instrument is appropriate for that individual client. The measurements include the use of 55 dB SPL International Speech Test Signal (ISTS), 80 dB SPL ISTS and a measure of Maximum Power Output (MPO). These levels were chosen to make sure that the hearing instrument's dynamic properties are assessed. For further details about this process, please see the 'Hearing Instrument Transition' section at the end of this article.

I see primarily adults, why do I care about RECD or CBF?

For adults, the approach to fitting generally involves traditional probe microphone measurements, or more often relying on the default programming from the hearing instrument manufacturers' fitting software. These defaults are based on standardized 2 cc coupler measurements used to establish the hearing instrument performance. However, the 2cc coupler, which is based on the average adult ear canal, is not a very good approximation for an individual ear, as it typically has a smaller volume. Furthermore, the simple cavity does not reflect individual differences such as acoustic impedance of the ear, ear mold acoustics, and acoustic leakage between the ear mold and ear canal wall. For this reason, a hearing instrument connected to a coupler might produce a different sound pressure level than in the real ear. More and more manufacturers are finding ways to incorporate actual RECD measures into their prescriptions and even facilitate RECD measurements using the hearing instruments themselves. And clinicians are beginning to adopt these practices to streamline the fitting process for adult clients as well.

RECD is used in several stages of the hearing aid fitting process. The most common application is in verification, as part of the acoustic transform to predict an individual's real ear instrument performance from 2cc coupler measurements. This is derived by taking the output from the hearing aid measured in the 2-cc coupler and adding the RECD, head diffraction (HD) and microphone location effects (MLE) (Moodie et al. 1994).

Using individualized RECD for HL to SPL conversion can replace traditional In-Situ audiometry for accurately establishing SPL hearing threshold measurements (Bagatto et al., 2005, Scollie et al. 1998).

This is particularly beneficial since "SPL audiometry" is typically not used in the initial hearing assessment when the audiogram was measured, whereas there is a good chance that insert phones were used. This means that in addition to being the basis for the coupler based fitting approach, individualized RECD values impact prescriptions for real ear fittings using PMM, as well. Accuracy in threshold estimation and in coupler target calculation is just as relevant for adults as it is for pediatric clients.

From a practical, clinical standpoint CBF has several applications for the adult population. The most obvious benefit of CBF is the ability to pre-program the hearing instruments based on the client's own RECD. This allows the clinician to actually spend more time with the client on the important things like counselling. If the device is programmed in advance of the appointment then the fitting process and the client's time will not be rushed .

It can also help when working with new fitting software (FSW). The clinician can familiarize themselves with the new FSW and program the client's devices without the added pressure of "an audience."

CBF with RECD is also valuable for clients with tinnitus or severe hyperacusis. Its use avoids presenting stimuli through the hearing aids for in-situ measurements which, if the manufacturers first fit is poor, could lead to a worsening of their condition. Other adult patient groups include the developmentally delayed and severe-profound populations.

RECD and CBF made easy

In a 2009 interview with Doug Beck for American Academy of Audiology, Richard Seewald advised, "I always recommend that if you have not yet performed RECD measurements, it's best to not start on a child! Let me say that again, it's best to learn the technique with other willing and able adults, so you learn to place the probe mic and get familiar with the hardware and software. It's really fast when you know how to do it, but learning on a child makes it unnecessarily difficult, so start with adults. We measure RECD in some 90 to 95 percent of the babies we see and it usually takes about 3 to 4 minutes from start to finish. It used to take a few minutes for the stimulus, and now it just takes a few seconds once the equipment is in place. So it keeps getting easier."

HA1 with foam tip.

Numerous practical considerations have gone into making RECD and CBF easier when using the new AURICAL.

For the ear response, AURICAL FreeFit and PMM (Probe Microphone Measurements) offer unique benefits. By allowing simultaneous binaural measurements, you have a better chance to base your fitting on individualized RECD data, even with difficult patients. In addition, the measurement of the ear response can be started even if you are not at the computer by just pressing a button on the wireless FreeFit. As an added benefit, the measurements themselves are very fast because the system automatically senses when the measurement is stabilized and stops the measurement accordingly.

Additional features allow for the ability to copy a measured RECD to the opposite ear when ear responses are assumed similar, swap ear measurements or easily apply previously measured RECDs to a current session. While relatively simple, these options can mean a huge time savings. Last, but not least – using the optional long probes makes it even easier to place the FreeFit regardless of where the child is located, making the procedure more comfortable for all involved - the clinician, the parents, and most importantly the child.

Clinicians who are advanced users of RECD and CBF can also specify if they want to make measurements with an HA1 (ITE) or HA2 (BTE) coupler and the coupling (tip versus mold). This facilitates easy comparison with age appropriate average RECD values from the chosen fitting prescription.

By facilitating the use of the various coupler and coupling options, AURICAL supports the clinician's ability to achieve accuracy in fittings. Bagatto and Moodie (2007) explain that if you measure hearing with a foam eartip and the RECD with a personal earmold there will be some error in the dBSPL (ear canal) threshold measurements (by the amount that the real-ear measurement obtained with the foam eartip differs from the earmold); typically in the high-frequency region.

Surveys have shown that many people will use an insert earphone coupled with a foam eartip during the hearing assessment procedure. When transforming these dB HL thresholds to an appropriate dB SPL (ear canal) reference it is recommended that an HA1+tip RECD measurement be used. Therefore for assessment purposes HA1-referenced RECD values are used. When RECDs have been measured using an HA2 coupler, these can be converted in the software to an HA1 reference using standardized HA2 to HA1 coupler transforms.

HA1 with mold.

This difference will transfer to the calculation of targets since they are calculated from the SPL thresholds. The discrepancy should only be present at the initial stages of hearing aid use because subsequent audiometry can be conducted with personal earmolds. For the sake of consistency, it is generally recommended that, when possible, the audiogram is measured with inserts and the client's own mold and that the RECD be measured with the mold coupled to an HA2 coupler.

At the verification stage, when hearing aids styles are ITE, ITC, etc. an HA1 referenced RECD is most appropriate because these hearing aid styles are verified on an HA1 coupler. If an HA1 RECD is not measured, an HA2 referenced RECD could be transformed to an HA1 equivalent using HA2 to HA1 standardized transforms that are automatically applied in the software. Some individuals are more confident measuring the RECD using the HA2 coupler then using putty to couple a foam tip to an HA1 coupler – so both an HA1 measured RECD or HA2 measured RECD are appropriate choices.

When hearing aid styles are BTE, the verification coupler is an HA2 coupler. Therefore, in this instance an RECD measured using an HA2 coupler is generally used. However, if the clinician feels that they can appropriately couple an earmold to an HA1 coupler, then this option is appropriate as well.

Furthering the efficiency of RECD measurements on AURICAL, the coupler values can be stored in the probes of the AURICAL FreeFit. This means that the coupler portion of the RECD doesn't have to be measured with every patient and in fact, the coupler doesn't need to be present during the real ear portion. Facilities can have more than one FreeFit device with RECD probes all using a single HIT chamber. From a central clinic location where the HIT chamber may be stored for convenient use by all clinicians, you only need to measure the coupler response with the RECD probe once, and then you are free to join the client in the fitting room to measure the ear response. The software will read the coupler response values from the probe and calculate the RECD. RECD measurements can then easily be used in Coupler Based Fitting.

The OTOsuite PMM module allows the user to apply essentially the same workflow within the software whether a fitting is being carried out on the ear or in the coupler. It is as simple as switching between real ear and coupler mode; and OTOsuite handles all conversions and compensations necessary to ensure accurate coupler values. As always, OTOsuite's abilities to run customized user tests with predefined measurement sequences makes Coupler Based Fitting as easy as one mouse click.

Measuring RECD with the AURICAL FreeFit and AURICAL HIT

RECD values for coupler based fitting are measured in the PMM module as follows:

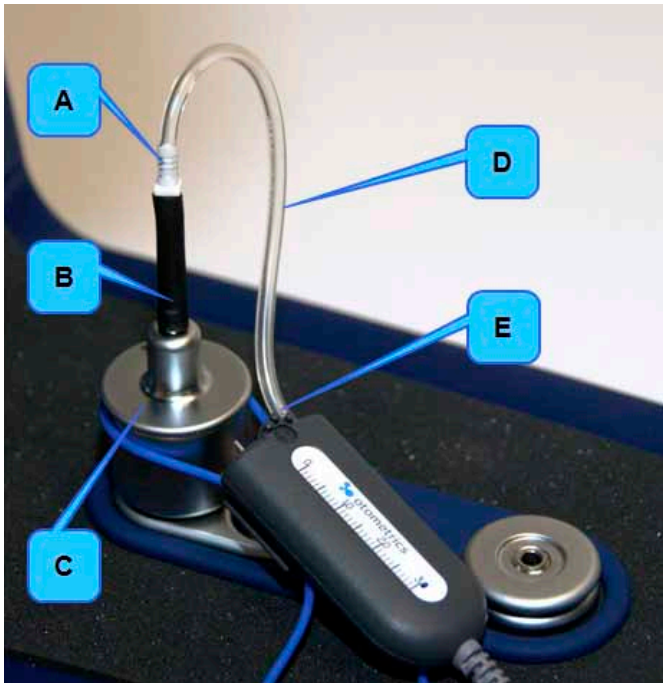
Measure coupler response:

NOTES:

1. You may skip this procedure if you have a previously performed coupler measurement stored in the probes.

2. Advanced users: For instructions on measuring RECD using the ITE (HA1) adapter please see the online help function within Otosuite.

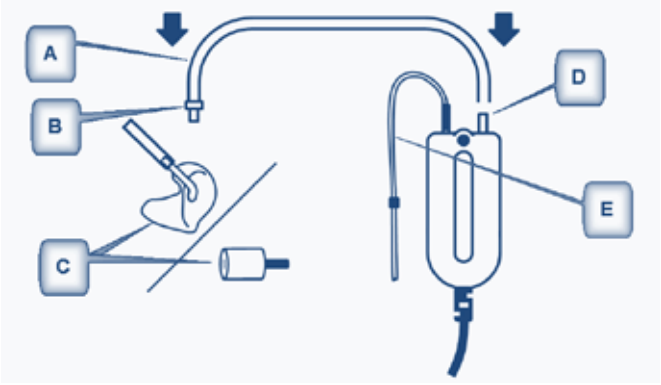
1. Open the RECD tab in PMM.
2. Indicate the type of coupler adapter you are using, and whether you are using an ear mold or foam insert tip.
3. Click Coupler Response... in the RECD Control Panel.
4. Attach the right RECD ear probe to the coupler in AURICAL HIT.
5. Click the Measure Right button.
6. Connect the left probe to the coupler in AURICAL HIT.
7. Click the Measure Left button.
8. Click OK.
9. Remove the probe from AURICAL HIT and remove the RECD coupling from the tubing of the BTE coupler



A. RECD coupling
B. BTE adapter tube
C. BTE (HA2) adapter
D. Transducer tubing
E. Transducer tube port

Then measure real ear response:

1. Attach the probes to the FreeFit.
2. Perform probe tube calibration. 
3. Connect the RECD coupling to the ear mold tubing (or foam insert tip).



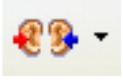
A. Transducer tubing
B. RECD coupling
C. Ear mold or foam insert tip
D. Transducer tube port
E. Probe tube

Place the probe tubes in the client's ears together with the ear molds or foam insert tips. Moodie et al. (1994) suggest that the probe tube should be placed at a standard insertion depth from the intertragal notch (for adult females, 28 mm; adult males, 31 mm; children 20-25 mm).

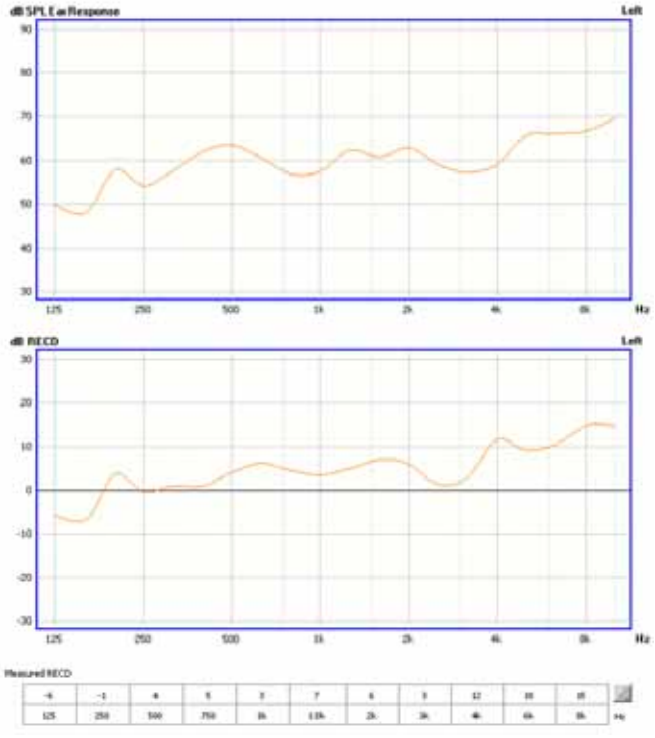
Note: This insertion depth means that the tip of the probe tube is likely to be within 5 to 6 mm of the tympanic membrane. Otosuite contains a user test designed to assist with proper probe tube placement via acoustical positioning procedures described in ANSI, 1997 and in ISO 12124:2001. A simplified method is through visualization and repositioning based on the REUG curve, monitoring particularly the frequency region above 4000 Hz.

a. Insert the probe tube less than half way into the ear canal while presenting a 65 dB pink noise signal.
b. A notch in the gain curve above 4000 Hz is likely to be observed.
c. Gently insert the probe tube deeper while keeping an eye on the notch which is moving towards higher frequencies.
d. The probe tube is located correctly as soon as the notch is no longer pulling the gain curve down (-5 dB) in the high-frequencies.
e. Once the measurement is stabilized move the probe tube marker into position or attach the probe tube to the probe tube support.

4. Select ear to measure.



5. In the control panel, click Ear Response (or briefly press the power button on the FreeFit).

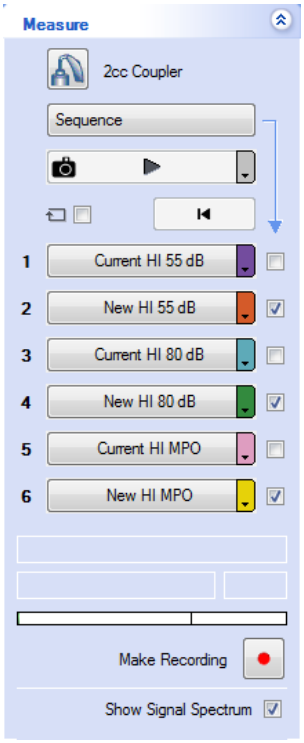


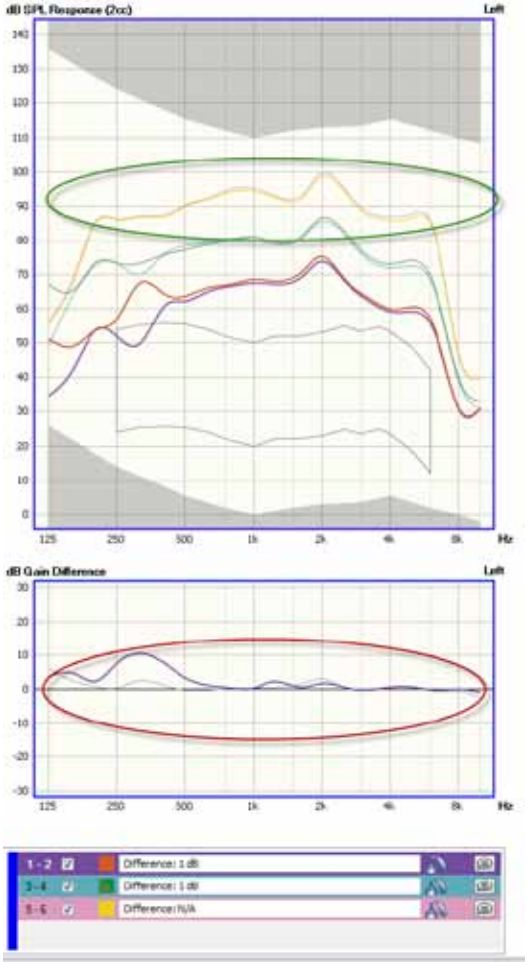
Hearing Instrument (HI) transition

The HI Transition procedure is carried out as a 2cc measure in the FreeStyle test modality.

Procedure

- Open OTOsuite, navigate to PMM and select "HI Transition" from the User/Special Test selection.
- Attach the "current" HI to the coupler using the appropriate coupler adapter.
- Click the Sequence button to measure the "current" HI at 1 (55) dB, 3 (80 dB) and 5 (MPO).
- Now attach the new HI to the coupler and prepare it for programming.
- Select "HI Transition New" from the User/Special Test selection.
- Click the Sequence button to measure buttons 2 (55 dB), 4 (80 dB) and 6 (MPO) and make adjustments to the HI until the measurements between the current and new HI match as closely as possible.





The comparison of measurements is made by viewing the dB Gain Difference curves (55 and 80 dB measurements – red oval) and the dB SPL Response (MPO – green oval).

Alternatively, a customized user test can be designed to make overall gain adjustments to the hearing instrument choosing levels based on the gain handles in the fitting software or the compression thresholds applied by the validated fitting prescription used.

Once the new hearing instrument is programmed according to the above instructions to provide the closest 'match' to the previous device, it can be put onto the client's ear for additional fine tuning.

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