OpenREM calibration

A leap forward in fitting accuracy

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"A hearing aid can be considered as a sound transmission system which is interposed in the path between the source of sound and the listener´s ear. As such, its performance can be judged by comparing the sound that reaches the ear first through the air path and then through the hearing aid"

"Methods for Measuring the Performance of Hearing Aids"
Romanow, 1942

As you can read above, the background for making probe microphone measurements (PMM) was described for the first time in 1942. Based on the Romanow statement, clinicians today use PMM to obtain quantitative, objective observations of the unamplified versus the amplified sound that "reaches the ear". Such comparisons are called real-ear insertion gain (REIG) measurements and are a part of the PMM process. Audiologists typically verify hearing instrument fitting using PMM. The Open Fitting is a clear trend today in hearing instrument fitting. The first fully open hearing aid was launched in 2003 and was made up by the *instrument body* (chipset, receiver, microphone, battery and housing), a *thin tube* and a ***dome*** inserted in the ear canal. The PMM process has since been challenged by the openness of the ear, which results in a leakage of sound. Indeed, this leakage reaches and pollutes the reference microphone input (see figure below). This pollution results in a miscalculation of the necessary output signal calibration. In consequence, PMM equipment today has to be able to monitor and control the sound reaching the ear without being influenced by the sounds coming out. In order to reach this goal, an adequate sound field equalization has to be performed. This paper will describe the technique of the OpenREM Calibration implemented in AURICAL FreeFit as well as its advantage for the user and the benefit for the hearing aid wearer.

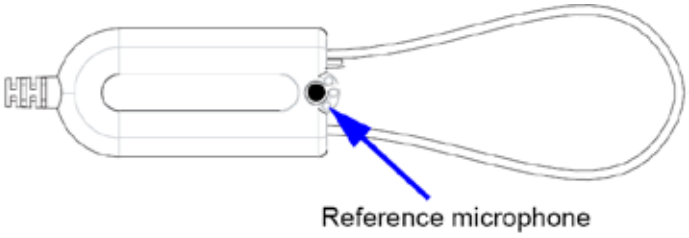

Figure 1: The reference microphone on the probe is located at the ear of the subject during measurements.

The Equalization question

When performed correctly, Real Ear Measurements (REMs) provide the most accurate assessment of the performance of the Hearing Aid (Valente *in* Audiology Treatment, 2007). Then the right equalization according to the right instruments is required to make sure we are fitting accurately. The question of how to make the right equalization was actually debated back in the 80´s when different probe-mic systems were introduced (MADSEN, 1986). There are different equalization methods available. The equalization actually depends on the calibration of the input signal. Two methods can be used for controlling the input signal level namely the **Substitution Method** and the **Modified Pressure Method.** Concerning the last one, we will see there are variations.

1. The Substitution Method

When the Substitution Method is selected, the calibration is performed without the subject in the room. In that case we have to place the microphone where the center of the subject´s head will be positioned. The calibration is stored and will be used as a reference for the rest of the measurement process. Thus the Substitution Method is by nature a **Stored Equalization Method**. However there are sources of errors associated with this method. Indeed, the absence of the subject makes the precision of this reference uncertain, and even if the subject is positioned in the exact same location of the calibration situation, any movement will decrease the measurement accuracy. Last but not least the head and body of the subject will influence the calibrated sound field (Fikret-Pasa & Revit, 1992; Hawkins & Mueller, 1992). This influence will be manifested as an increase of the mid- to high frequencies at the subject´s ear, resulting in the hearing aid compression behavior expected in that situation.

2. The Modified Pressure Method

When a reference microphone is employed during the measurement, as it usually is, it is termed the "**Modified Pressure Method**" (Mueller, 2006). We can furthermore distinguish two variants of this method:

2.1 The Modified Pressure method using Concurrent Equalization (MPCE)

This method does not require calibration or equalization prior to positioning the patient. The loudspeaker will adjust the signal level in order to continuously produce a constant sound pressure level at the subject´s ear. Meaning that if we move the subject during the measurement the loudspeaker will deliver a stronger or a softer sound. Also the MPCE takes into account the head and body effects (reflection and diffraction). This method has typically been recommended for PMMs (Dillon, 2001; Hawkins & Mueller, 1992; Larsby & Arlinger, 1988). Lantz et al. have pointed out differences in gain (REIG) when using the MPCE with Open Fittings mainly due to the pollution of the reference microphone by the sounds leaking out from the ear.

2.2 The Modified Pressure method with Stored Equalization (MPSE)

This method is a kind of hybrid of the Substitution and the Modified Pressure methods. As stated above, the Substitution method is by nature a Stored Equalization method, and it is this criterion which is considered. At the 13th Danavox Symposium, Larsby & Arlinger (1988, p.46) stated: *"One risk of the Pressure Method is, however, that when an open fitting is made, amplified sound leaks out and may affect the reference microphone and thus the sound field from the speaker."* This risk has also been noted by Hawkins & Mueller (1992). The magnitude of the effect will depend on:

- how close the reference microphone is to the opening of the ear canal where the hearing aid is active
- the gain of the hearing aid and hence the amount of leakage
- and probably also the peak of the residual resonance

Recently the Modified Pressure with Stored Equalization method (MPSE) has been recommended for use when verifying open non-occluding hearing instruments (Lantz et al., 2007). The MPSE method does not use a reference microphone to adjust loudspeaker output *during* aided real-ear measurements and is therefore unaffected by sound leaks. This approach however changes the signal level at the client's ear as a result from unwanted movement of the client's head and torso during the verification process. Lantz et al. have described the difference in REIG when we use the MPCE or the MPSE as shown in the figure below.

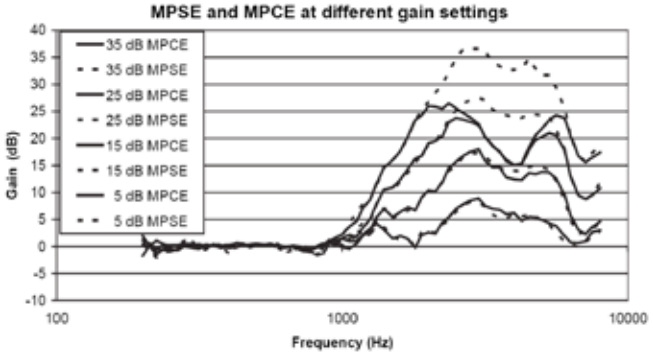

Figure 2: The REIG measured with MPSE and MPCE methods with four different gain settings in a single subject. The measuring error increases as a function of the digital feedback suppression benefit (from Lantz et al.).

The authors recommend the use of MPSE and not the substitution method. This will further increase the accuracy of insertion gain measurements. Paul Shaw (2010) suggests that the MPSE method does not introduce clinically significant errors in real-ear measurements when verifying hearing instrument fitting.

The Open Fitting Reality

Mueller and Picou (2010) note that real-ear probe microphone measures have been in the news often lately. For example, the July 2009 *Consumers Report* article on hearing aids referred to probe-mic measures as a "must have." In the September 2009 issue of *Audiology Today*, Catherine Palmer, PhD, suggested that not using probe-mic measures may indeed constitute an ethical violation. In April, 2010, Kochkin et al. noted that probe-mic measures impact customer satisfaction. But another trend in hearing instrument sales has appeared since 2003, in the rising popularity of Open Fitting.

The open fit hearing aid's popularity increased thanks to the digital features, effective feedback cancelation, cosmetics, instant fit and comfort. In parallel because of the post-war baby boomer effect and the global aged-population growth, the market was also ready for this type of hearing aid. Kochkin in 2008 (MarkeTrack VIII) has pointed out that more than half of all Behind-the-Ear instruments fitted, and 25% of all fittings, were open fittings.

The Open Fitting received considerable attention after the CROS (Contra Lateral Routing of Signal)-type hearing instrument was introduced (Harford & Barry, 1965). Then the IROS (Ipsi Lateral Routing of Signal) philosophy appeared concerning high frequency losses. The term IROS currently refers to a large vent. Dodds and Harford in 1968 then Green in 1969 have shared that Open Canal fittings could provide a useful high frequency amplification. But there was little further interest until the Libby Horn´s peak of popularity (Mueller et al., 1981). With the ReSound AIR in 2003 and the combination of the 5 necessary factors (Mueller et al., 1981) (listed below) supporting the product, open configuration has rapidly taken over a sizable market share.

1. Small BTE
2. Multichannel
3. Thin Tube (0,8 mm)
4. Ear tip (vent > 3 mm)
5. Effective feedback cancellation

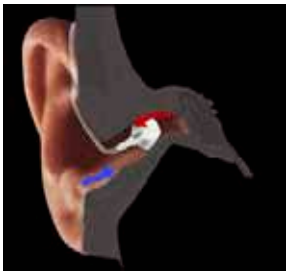

Figure 3: Illustration of the Open Fitting concept from ReSoundPulse.com.

In addition PMM can – and *should* – be used with Open Fit devices to assist with verification of initial instrument settings (Fabry, 2007).

AURICAL FreeFit is made for Open fittings

Otometrics was the first manufacturer to facilitate a practical implementation for accurate verification of Open fittings as part of AURICAL Plus. The approach using the modified pressure method with stored equalization (MPSE) was described by Lantz, et al. in 2007. Since then, this approach has become widely accepted as the correct way to verify open fittings. The AURICAL implementation made MPSE, also commonly known as OpenREM calibration, possible for constant level inputs. AURICAL FreeFit improved the method further to provide OpenREM calibration for all signal types. Additionally, the ergonomic workflow in OTOsuite supports the user in easily determining if their fitting is truly open or occluded and whether OpenREM calibration is required. This can be accomplished via overlays in either SPL or Gain view, depending on user preferences. This method is very easy; the user is very well guided as well as secured in his practice. The measurement displayed is very accurate. The absence of chirp calibration makes sure there´s no pollution around the reference microphone. Then during the measurement, the reference microphone is disabled.

Let´s see the different steps to make our Open Fitting PMM accurate.

1. OpenREM calibration is selected in Fitting Details (F10).

Figure 4: Fitting Details screen in the Aided Response section.

This disables the automatic calibration (chirp calibration) preceding each measurement.

2. Calibration must occur with the hearing instrument in the ear and **turned off** in order to avoid the reference microphone pollution described above. A counseling pop up window appears before the first measurement as below:

Figure 5: After you click on the OpenREM calibration button, the instructions above guide you

If REUR or REOR has been measured, Open REM calibration is not required since the signal calibration is stored from those unaided measurements, BUT its selection in the fittings details is required in order to **skip the chirp calibration** before each measurement.

If the patient or objects in the sound field move, the OpenREM Calibration must be repeated.

3. Should it be necessary OpenREM Calibration can be accessed at any point in time through either the icon on the toolbar or the button on the control panel, as seen below?

Figure 6: The Control Panel has an additional button on the top part called "OpenREM Calibration" easily accessible by the user.

The graph view area contains a reminder; "Please repeat calibration if the patient or objects in the sound field move."

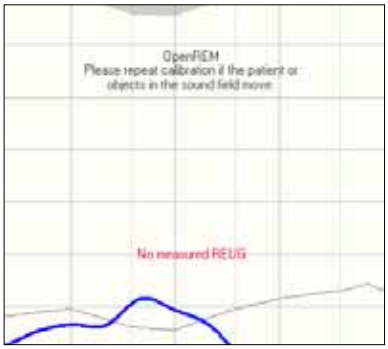

Figure 7: Clear yet discrete reminders are a part of what we've called the FitAssist environment.

Conclusion

The Open Fitting is very common today (25% of all fittings) and used for obvious benefits such as comfort, cosmetics, or even instant fit. PMM impacts customer satisfaction (Kochkin) and Consumers Report referred to PMM as a "must have" as well. In addition PMM can – and should be used with Open Fit devices (Fabry, 2007). But as described by Lantz and al. in 2007, the MPSE is very important to reach the necessary accuracy. Otometrics was the first manufacturer to implement the OpenREM calibration in AURICAL based on the statements described above. Today with AURICAL FreeFit, the dispensing professional is sure to make the most accurate probe-mic measurement with the open fitting condition. Because innovation makes the difference between leaders and followers, Otometrics is proud to provide the OpenREM calibration feature with AURICAL FreeFit.

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