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Does the REUR Need to Be Subtracted for Non-occluding Fittings? What about Speechmap / SPL-o-gram Methods?

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Real-ear measurement (REM) is an invaluable tool for ensuring that hearing instruments are providing the appropriate gain/output for a client's hearing loss relative to prescriptive targets as supported by the research literature and numerous professional guidelines. In this regard, there are 2 primary verification philosophies: the real-ear insertion gain (REIG) approach and the more recent real-ear aided response (REAR) / SPL-o-gram approach, each with their own relative pros and cons (see Pumford, 2018). Non-occluding fittings present some unique challenges and considerations when conducting REM irrespective of the fitting approach. For clinicians who subscribe to the insertion gain method for verifying devices to prescriptive targets, confusion can arise regarding how to properly account for the real-ear unaided response (REUR) or real-ear unaided gain (REUG) given it is typically not impacted with open fittings. To address this concern, lets first clarify the terminology and calculation approach. As noted in Pumford (2018), insertion gain requires subtraction of the REUR (i.e., SPL across frequencies of the open ear canal for a given input signal) from the REAR (i.e., SPL across frequencies of an activated hearing aid in the ear canal for a given input signal). That is, REIG = REAR – REUR and is represented on REM systems as shown in Figure 1 below. As it relates to the topic at hand, we can then observe in Figure 2 below how the coupling selected as part of the fitting can impact the REUG, and hence lead to questions regarding whether modifications need to be made to the verification calculation.

While REIG calculations with non-occluding fittings may seem problematic, Mueller and Ricketts (2006) note it is still valid to subtract the REUR/G from the REAR despite the fact the external ear canal resonance is not impacted. That said, they note the required amount of hearing aid gain to achieve a given REIG target will vary depending on how much residual ear canal resonance is available to "help out" the REAR portion of the measurement. Consider that the REAR used during the REIG calculation will reflect both the unaided, vent-transmitted path and the aided, amplified path as shown in figure 3 below. For a given REIG target, the REAR component with more open fittings would generally require less amplifier gain than more occluding fittings due an increased presence of the residual ear canal resonance. Also consider insertion gain cannot be calculated without subtracting an REUR/G from the REAR and the REUR/G does not change regardless of the hearing aid coupling. All of this noted, Mueller and Ricketts state 'it is still okay with an open fitting to subtract the REUG from the REAG as this approach is interested in the gain the patient obtained, even if the patient still has their natural gain in place with the coupling in question'.

A related perspective to consider when conducting REM with non-occluding fittings is that we are ultimately concerned with the overall signal level delivered to the eardrum across frequencies. In this regard, the REAR / SPL-o-gram method for verifying devices shines as it reflects the

combined amplified and vent-transmitted sound paths and shows all relevant prescriptive and dynamic range variables on the measurement screen together (see Figure 4). Questions regarding which REUG to use and whether it should be modified are no longer relevant as the REAR / SPL-o-gram approach is solely interested in the overall SPL level required at the eardrum to meet REAR targets across frequencies for a particular input. While there are still open-specific REM considerations to keep in mind (i.e., sound field calibration – see Pumford 2018), REAR fitting targets and principles are consistent regardless of the earpiece being fitted. Regardless of your preference for insertion gain or REAR / SPL-o-gram verification approaches, both methods offer significant value with non-occluding fittings and help ensure that the clients we serve are provided with appropriately fitted hearing instruments.

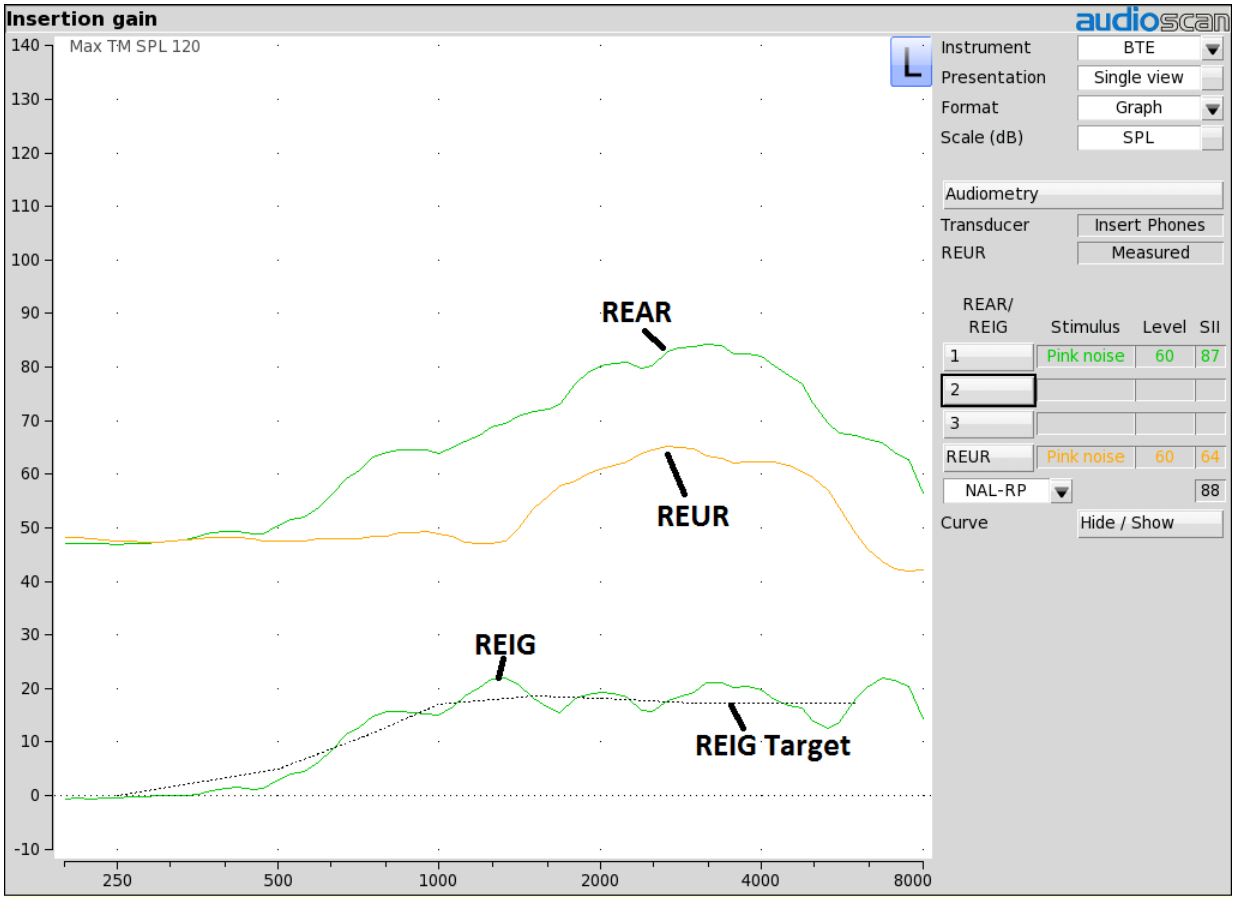


Figure 1. Example of a real-ear aided response (REAR) measurement, obtained with a 60 dB SPL pink noise signal. Also shown is the previously measured real-ear unaided response (REUR) measurement, along with the resulting real-ear insertion gain (REIG) values and the REIG target.

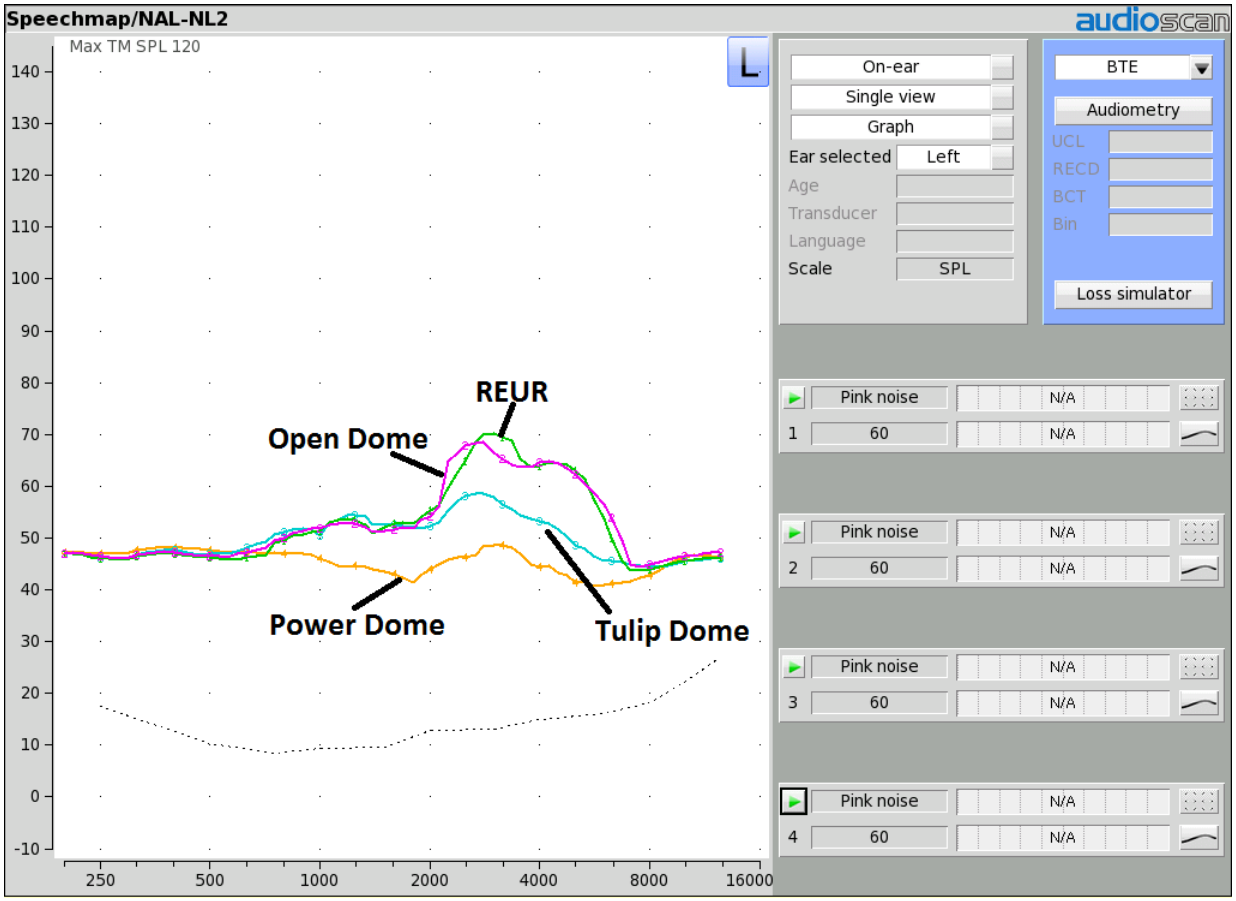


Figure 2. Example of real-ear occluded response (REOR) measurements (i.e., REM with hearing aid in place turned off) for various device venting conditions. Shown is the previously measured REUR, along with REOR measurements for an open dome, tulip/closed dome and a power/occluding dome. Note the reduction in the measured response relative to the REUR as the venting is gradually decreased and the ear canal becomes more occluded.

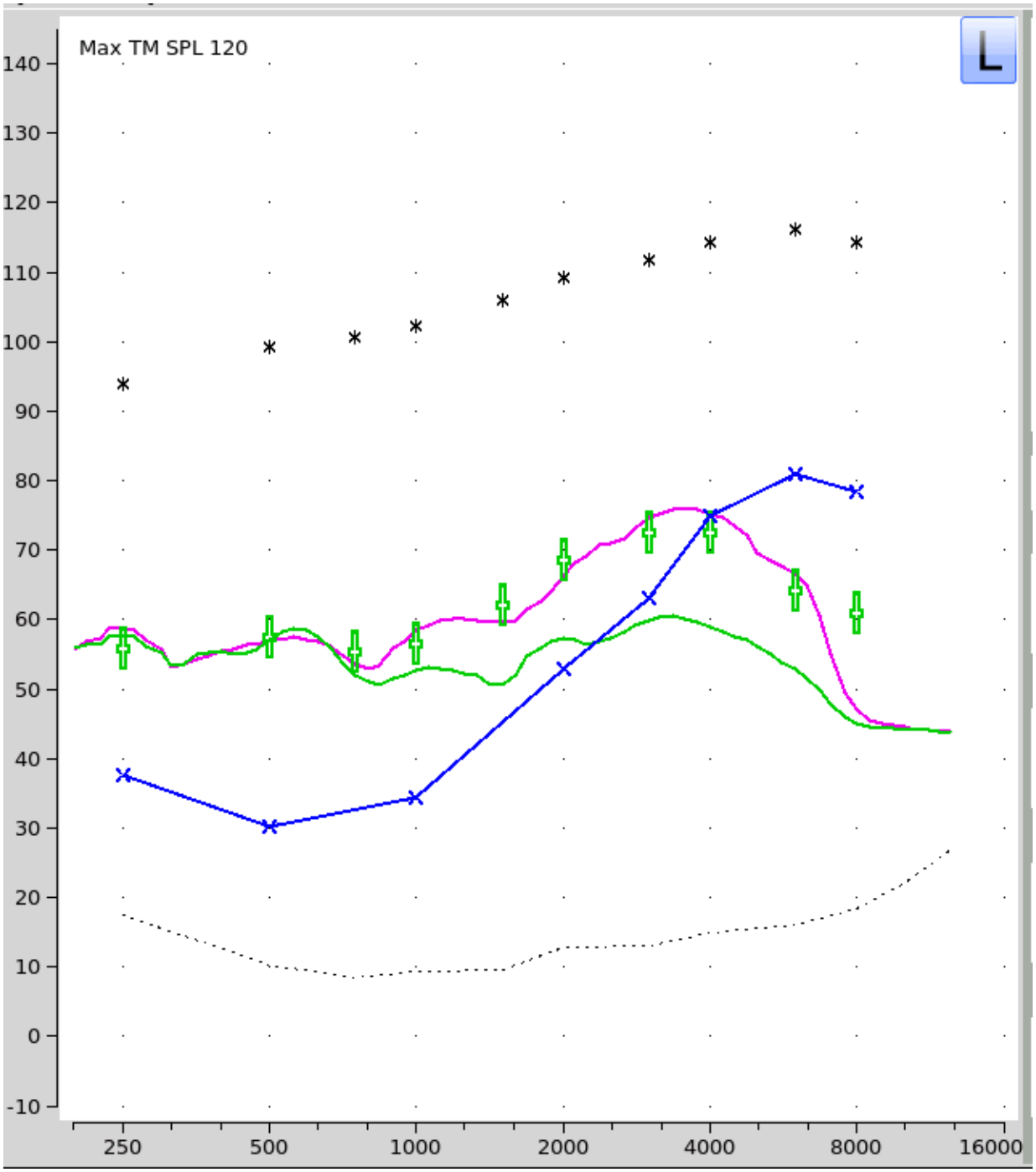


Figure 3. REM of an open fitting showing vent-transmitted signal (green curve) with hearing aid off (i.e., real-ear occluded response), and aid-transmitted signal (purple curve) with hearing aid on (i.e., real-ear aided response).

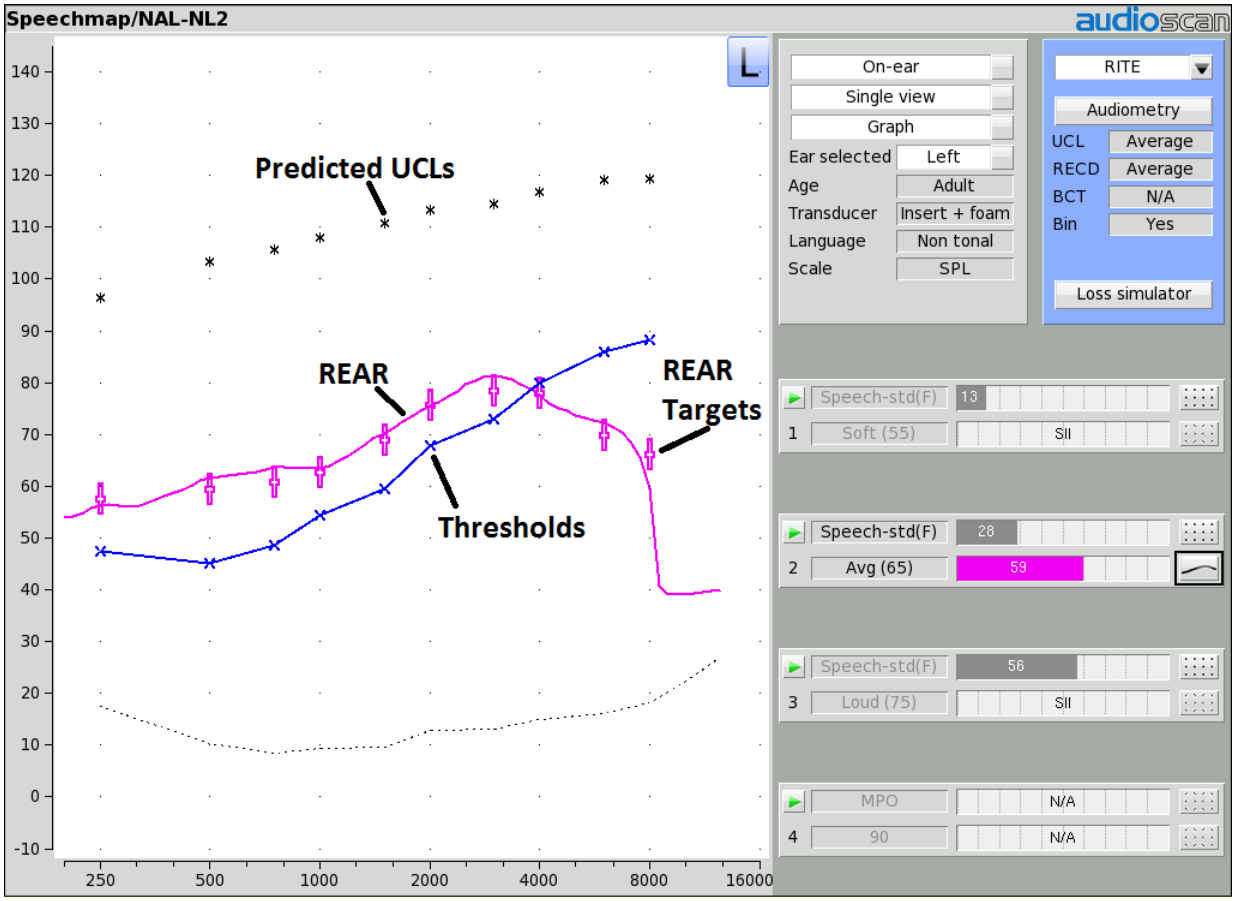


Figure 4. Example of a real-ear aided response (REAR) measurement on a SPL-o-gram or Speechmap® screen, obtained with an average speech input level. Also shown are the REAR targets generated by the prescriptive formula for that particular input level (+'s), the patient's thresholds (X's) and the predicted UCLs for the patient (*'s).

References

1. Mueller, H. G., & Ricketts, T. A. (2006). Open-canal fittings. Ten take-home tips. The Hearing Journal, 59(11), 24.26,28-32,34,36-39. https://doi.org/10.1097/01.HJ.0000286216.61469.eb

2. Pumford, J. (2018). Considerations in real-ear measurement: Points to Ponder. Canadian audiologist. 5(3). Retrieved from https://www.canadianaudiologist.ca/issue/volume-5-issue-3-2018/real-earmeasurement-feature/