- If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.
- This handout is for reference only. It may not include content identical to the PowerPoint. Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date

# New RECDs and a new ANSI standard: Revisiting RECD basics and applications

Susan Scollie, Ph.D.
Child Amplification Laboratory
Western University's
National Centre for Audiology

## Contributions

- From UWO:
  - Marlene Bagatto, Sheila Moodie, Shane Moodie, Paula Folkeard, Marianne Hawkins, Philip Narten, Richard Seewald
- From Audioscan:
  - Jim Jonkman, Jon Pietrobon, Bill Cole, John Pumford
- From the pediatric audiology community:
  - Eileen Rall & her many colleagues at CHOP, George Lindley, Pat Roush & her many colleagues at UNC, Ryan McCreery, Marc Brennan & their many colleagues at BTNRH

## Learning objectives:

Upon completion, each participant will be able to:

- Describe key changes in the definition of the Real Ear to Coupler Difference due to a new ANSI standard.
- Explain how the RECD varies when measured with foamtips versus earmolds.
- Understand a new protocol for correcting the RECD that is applied in new Audioscan software systems.

## Outline

1. Brief introduction to the new ANSI standard.
2. Evidence review: Why are there changes?
   - 5 under-the-hood RECD functions you might not have known about.
   - New software functions that pull all of this together.
3. Case examples.
4. Summary and resources for more information.

## Brief introduction to the new standard.

It's all about verification.

## Individuals vary in their ear canal acoustics. Hearing aids should be individualized to protect against big errors.

- We remove the error by doing *real ear measurement*.
  - Strong evidence exists to support this practice.
- Real ear measurement takes two forms:
  - Real ear verification: Place the probe tube, verify hearing aid output in the ear. Although historically done in REIG, current procedures recommend REAR instead, preferably on an SPLogram.
  - Coupler verification: Same thing, but in a coupler with predictions to the real ear. Developed for use with children, common practice in pediatrics, can be handy for adults.

## The ANSI Standard for REM (S3.46 1997) was the first to standardize REM terminology, such as "REAR".

- Was the RECD included in this standard?
  A. No, it was omitted entirely.
  B. Yes, it was defined in this standard.
  C. Yes, it was mentioned in the standard but in an appendix and not formally standardized.

## The new ANSI Standard for REM (S3.46 2013) is the first in North America to standardize the RECD.

- The only measurement that is defined as an "RECD" in this standard looks like this:
  - **FOAM TIP or EARMOLD** for the on ear response.
  - **HA1 coupler** for the coupler response.
  - The RECD is the difference between the two.
- Conceptually, this accounts for the acoustic properties of the ear cavity and is not designed to measure anything about earmolds. *(new concept, right?) This also means that verification would use the HA1 coupler + putty, unless we find another solution.*

## True or False?

- ANSI S3.46-2013 is a new standard dedicated to the Real Ear to Coupler Difference.

## True or False?

- ANSI S3.46-2013 is a new standard on the topic of "Measurement of Real-Ear Performance Characteristics of Hearing Aids", including real ear measures, test signals, and transforms such as the RECD.

## Evidence Review: Why the changes?

Five RECD functions "under the hood" that you may not have known about.

## RECD under the hood #1

The RECD gets used TWICE in many fittings.

- We personalize the assessment data from HL to dB SPL in the ear canal.
- We personalize the hearing aid fitting prediction from 2cc to dB SPL in the ear canal.

The "personalization" means that the individual's ear canal acoustics (and earmold) are represented in the fitting data.

## The RECD is used in two places:

HL Threshold **+ RECD** + RETSPL
= Real Ear SPL Threshold

Coupler SPL or gain **+ RECD** + MLE
= predicted Real Ear SPL or gain

SPLogram

For BTEs, this needs to account for earmold!

## I use "real" real ear. I don't use RECDs.

- Don't you?
- This is one of the major misconceptions in audiology. Let's do a sneak peek behind the scenes.

## If you do real ear verification, you may still be using the first one, behind the scenes:

HL Threshold **+ RECD** + RETSPL
= Real Ear SPL Threshold

Direct verification of the REAR does not use the RECD at all.

SPLogram

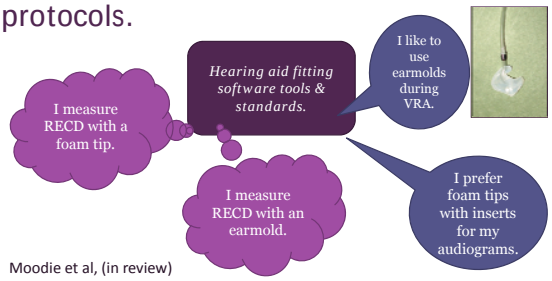
If you do coupler-based verification, you are using both of these, behind the scenes:

HL Threshold **+ RECD** + RETSPL
= Real Ear SPL Threshold

Coupler SPL or gain **+ RECD** + MLE
= predicted Real Ear SPL or gain

SPLogram

Recent practice surveys show that people do lots of different things with their RECDs and hearing aid fitting protocols.




Moodie et al, (in review)

## RECD under the hood #2

RECDs measured with foam tips and earmolds are not the same.

## Foamtips have 25 mm tubing. Earmold tubing is usually much longer. The earmold RECDs will often have a high frequency roll-off as a result.

- Here's a term for this: **"Coupling Type"**
- What if you need one type and only have the other type? Example: foamtip audiogram, but only earmold RECDs.
  - Age trends for both types are known (Bagatto et al 2002; 2005).
  - DSL5 will generate a predicted RECD for either type as needed. Sometimes the predicted RECD will be used instead of the measured one if the **coupling type** is not matched between RECD type and RECD usage.

## RECD under the hood #3

Although the new standard uses only the HA1 coupler, conversions between HA1 and HA2 are simple, well-understood, and are easily transformed by software.

## HA1 to HA2 transforms … let's be happy that one is under the hood.

- **Clinical impact:** When measuring the coupler portion of the RECD, the HA2 coupler can be used.
- **Clinical ease** advantages:
  - Fewer infection control issues because we avoid the need to putty earmolds onto the HA1.
  - Faster, more reliable connection to the coupler because a putty connection doesn't need to be constructed.
- **Standardization** advantages:
  - The standard HA1 RECD can be constructed & reported by software even though you didn't measure it that way.
- Here's a term for this: **"Coupler Type"**

## RECD under the hood #4

If you put together "Coupling Type" and "Coupler Type", you get four RECD combinations.

## Four subtypes of RECDs

| | | Coupler Type | |
|---|---|---|---|
| | | HA1 | HA2 |
| Coupling type | Foam tip | **Standard,** requires puttying of foamtip to coupler. | Nonstandard, no putty required. |
| | Earmold | **Standard**, requires puttying of earmold to coupler. | Nonstandard, no putty required. |

- We can and do measure for both coupling types.
- We prefer to measure on the HA2 – easier & cleaner.
- We need **software systems that label the RECD subtype**, so that the RECD can be corrected and used as needed.

## RECD under the hood #5

RECDs differ by coupling, coupler, and transducer type.

## Historically, RECDs have been validated for the use of predicting REAR from coupler responses.

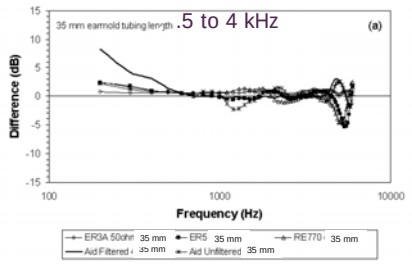
- Original method (Moodie et al., 1994)
  - Showed a single case illustrating agreement between REAG and predicted REAG
- Validation study (Seewald et al., 1999)
  - 95% CI was +/- 2.3 dB in 14 ears
- Replication study (Munro & Hatton, 2000)
  - Similar results
- All of these were done using ER3 insert phones and occluding earmolds for RECD measures.

## But sometimes the clinical RECD doesn't predict the real RECD with either the hearing aid or the insert phone.

- Munro & Salisbury (2002) measured RECDs with earmolds with both a custom-made RECD transducer and with ER3A insert phones.
  - They differed by 9 dB at 1.5 kHz.
  - This only happened with longer tubing lengths, which happened to be about the same as an adult earmold tubing length of >45mm.
- Munro & Toal (2005)
  - Looked at the implications for hearing aid fitting.
  - Findings varied with the type of hearing aid.

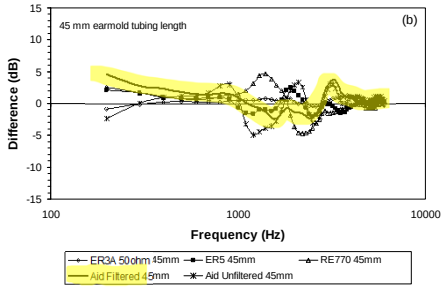
*In both of these studies, if the RECD was measured with a clinical transducer that had low impedance, there was more error.*

## The tranducer effects are less if earmold tubing is short.



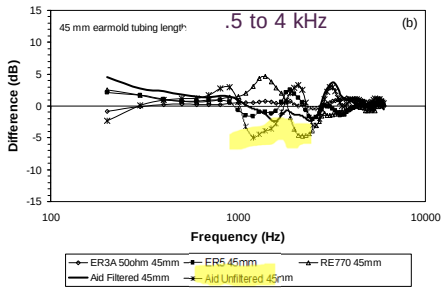

Bagatto et al. (2005)

## The transducer effects are less if the hearing aid has a filtered earhook.




Bagatto et al. (2005)

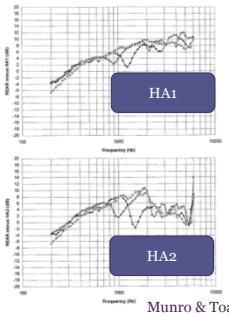
## The transducer effects are greater at frequencies where the HA2 earmold simulator and the actual earmold differ:




Bagatto et al. (2005)

## Therefore, the effects are also smaller if the HA1 coupler is used.

- RECDs measured with 3 different transducers:
  - A hearing aid
  - An ER3 insert
  - An RECD transducer.
- *This explains the RECD's standardization to the HA1 coupler, measured with a high-impedance transducer.*




Munro & Toal

## New software functions for the RECD.

Goal: to comply with the new standard, but also to support a wide range of clinical practice.

Note: Specific to Audioscan systems.

## 3 protocols that I teach in class:

(historical, and relies on "matching" for accuracy)

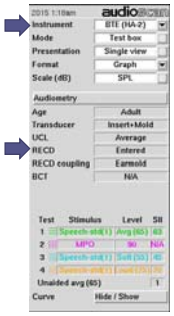
- Audiometry with insert phones + foam tip, measure RECD with foam tip, verify in the real ear
  - Good for adults, vented fittings, open fittings
  - Good for ITE/ITC/CIC
  - Can be modified for CROS fittings
- Audiometry with insert phones + earmolds, measure RECD with earmolds, verify BTE in the HA2 coupler
  - Good for babies & young children, likely little or no venting.
- Audiometry with insert phones + foam tip, RECD with foam tip, verify ITE/ITC/CIC/RIC in the HA1 coupler.
  - Note that this still assumes average adult MLE, and there may be venting, so perhaps real ear verification would be a better choice.

***But what about this "mis-matching" protocol?***

- Audiometry with insert phones + foam tip, measure RECD with earmolds, verify BTE in the HA2 coupler.

## New software systems allow you to label the RECD type. This supports new corrections that handle mismatches.

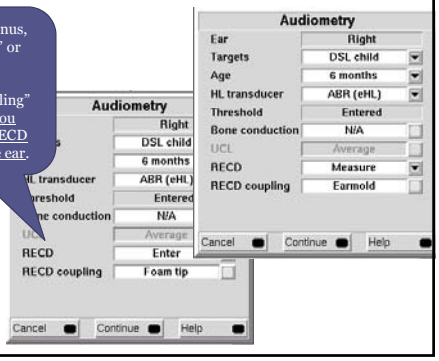
- A few small changes for you to do:
  - You will label what type of coupler-based fitting you are going to use:
    - HA2 or HA1?
  - You will label what type of RECD you are measuring:
    - With an earmold or a tip?
- If necessary, the software will convert between foamtip & earmold RECDs using a new correction procedure.
- Preliminary data suggests this may be more accurate than using age-predicted averages (Moodie et al., in review).



## Measuring & entering RECD

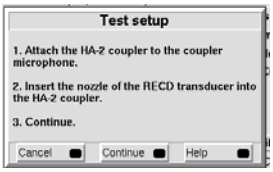
On these two menus, indicate "Enter" or "Measure".

The "RECD coupling" refers to how you attach(ed) the RECD transducer to the ear.

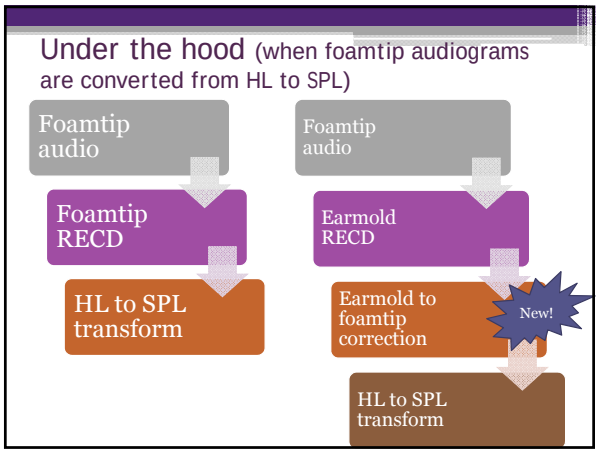


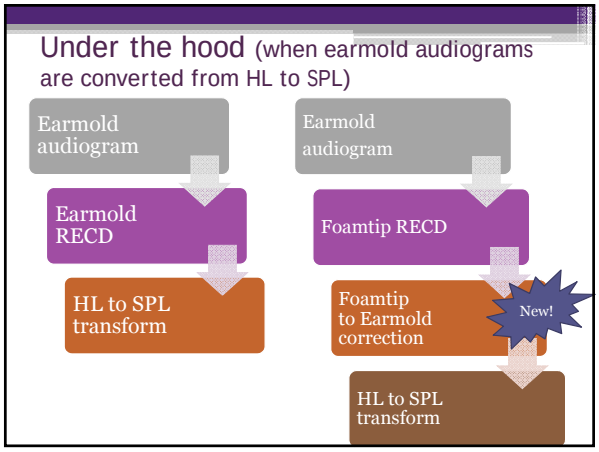

## Measuring the coupler portion of the RECD still uses the HA2 coupler.

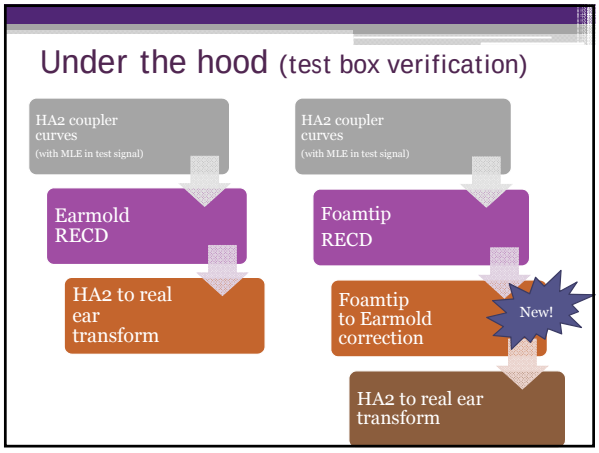
- Note: terminology change to "RECD Transducer Calibration" or "Xducer" for short.
- Values will be converted to HA1 later. This produces the "standard RECD" even if you didn't measure it that way.



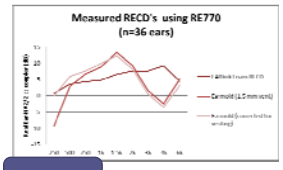

## Place probe tube as usual. You can use either foam tip or earmold.


Under the hood (when foamtip audiograms are converted from HL to SPL)
Foamtip audio
Foamtip RECD
HL to SPL transform
Foamtip audio
Earmold RECD
Earmold to foamtip correction
New!
HL to SPL transform

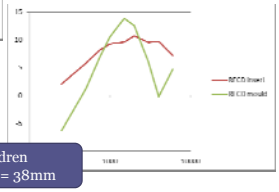

Under the hood (when earmold audiograms are converted from HL to SPL)
Earmold audiogram
Earmold RECD
HL to SPL transform
Earmold audiogram
Foamtip RECD
Foamtip to Earmold correction
New!
HL to SPL transform


Under the hood (test box verification)
HA2 coupler curves
(with MLE in test signal)
Earmold RECD
HA2 to real ear transform
HA2 coupler curves
(with MLE in test signal)
Foamtip RECD
Foamtip to Earmold correction
New!
HA2 to real ear transform

## Earmold to foam tip corrections
(Moodie et al, under review)



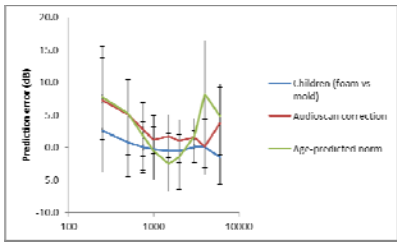

36 adults



36 children
Avg tubing = 38mm

## Earmold to foam tip corrections
(Moodie et al., under review)

- Predicting your own earmold RECD from your own foamtip RECD is more accurate than using the age-based average.




## 4 protocols: (updated)

***Best accuracy is likely still obtained with "matching" protocols:***

- Audiometry with insert phones + foam tip, measure RECD with foam tip, verify in the real ear
  - Good for adults, vented fittings, open fittings
  - Good for ITE/ITC/CIC. Can be modified for CROS fittings
- Audiometry with insert phones + earmolds, measure RECD with earmolds, verify BTE in the HA2 coupler
  - Good for babies & young children, likely little or no venting.
- Audiometry with insert phones + foam tip, RECD with foam tip, verify ITE/ITC/CIC in the HA1 coupler.
  - Note that this still assumes average adult MLE, and there may be venting, so perhaps real ear verification would be a better choice.

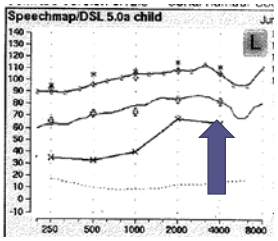
***Better accuracy than previously for "mis-matching" protocols:***

- Audiometry with insert phones + foamtip, measure RECD with earmolds, verify BTE in the coupler.

## If this is your protocol, here's what you need to know:

1. Audiometry with insert phones connected to foam tip.
2. Measure RECD with foamtip.
3. Verify BTE in the HA2 coupler.

- On transforms:
  - The RECD coupling type matches the audiogram coupling type. The HL to SPL transforms will use this RECD.
  - The RECD mismatches the coupling type for the hearing aid fitting. An earmold RECD will be predicted from the foamtip RECD.
- On verification:
  - You may see a notch in the high frequency region until you fine tune it out. This appears because the roll-off from earmold tubing is now represented.




## Updates may be needed:

| Year | Software versions | What you need to know: |
|---|---|---|
| ≤2014 | ≤3.10.56 | Commonly used for years, older RECD protocols. |
| 2014 | | New ANSI standard for RECD measurement. |
| | 3.10.56 – 3.10.70 | These first implementations required HA1 and putty. This has since been updated. |
| 2015 | **3.12.x 4.2.x** | **New RECD procedure. Support for HA2 or HA4 couplers and new foamtip to earmold conversions.** |

## What about the new Verifit (VF2)?

- There are two coupler sets: blue & silver
  - Blue are for ANSI testing ONLY
  - Silver is 0.4 cc, and is used for Speechmap
  - SPL in the silver > blue by ~ 20 dB. Do not fit to targets on the blue coupler.
- Worth watching: a video on coupler setups, which includes a non-putty option for the silver couplers:
- https://www.youtube.com/watch?v=vOAq39Tfb1Y

We labelled ours to help prevent user errors.

## RECDs are measured using the new 0.4 cc coupler.

- These are called WRECDs for “wideband RECDs”
- Both the WRECD and standard 2cc HA1 RECD are shown on tables of values.
- A known transform converts RECD to/from WRECD when needed.

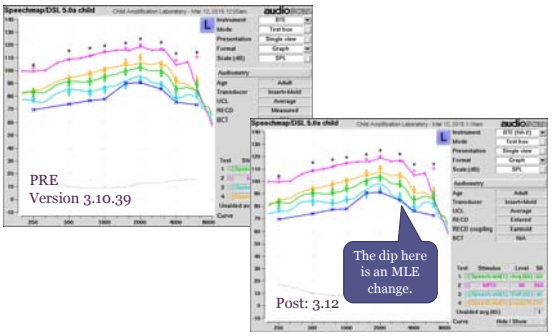

## BTE hearing aid verification uses a new coupler type:

- The HA4 coupler replaces the HA2


## Case Examples

1. Consistent verification results across software updates?

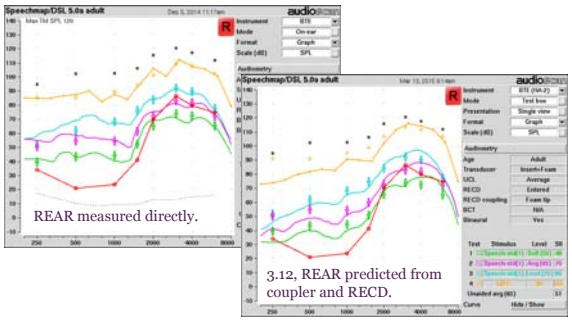
## Coupler verification pre- versus post new RECD standard:



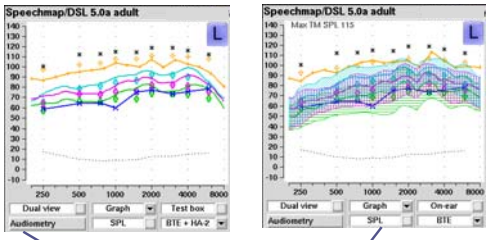

## Case Examples

2. Accurate prediction of on-ear output from test box verification for a BTE?

## REAR versus coupler-based verification with new standard (BTE):



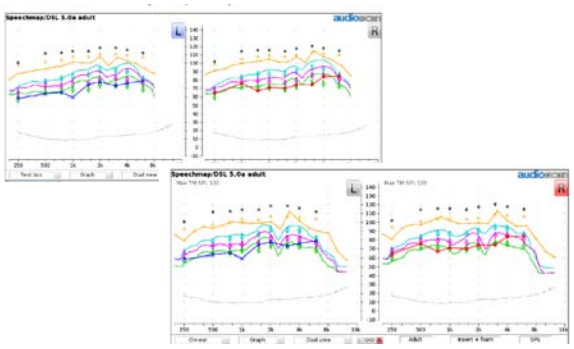
## Test Box (VF1) On-ear (VF1)




| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Test 3 | 74 | 79 | 83 | 89 | 93 | 96 | 93 | 99 | 86 |
| Test 3 | 66 | 82 | 89 | 88 | 94 | 97 | 98 | 97 | 89 |

Venting effects 1 to 5 dB agreement

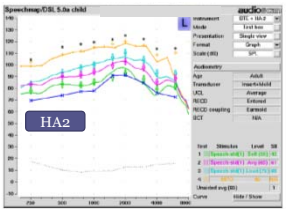
## Test Box (VF2) [same case] On ear (VF 2)



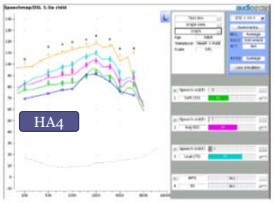
## Case Examples

3. Agreement in verification between systems (VF1 vs. VF2)?

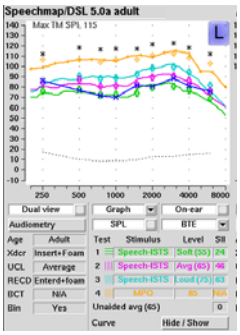
VF1 (BTE, 3.12)
Test Box



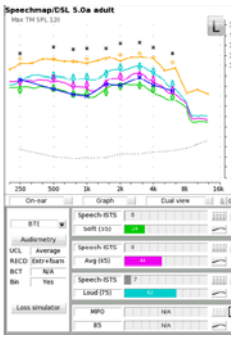

VF2 (BTE, 4.2)
Test Box



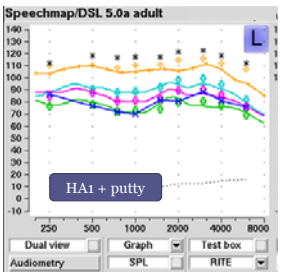

VF1 (RITE, on ear)



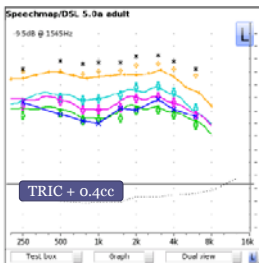

VF2 (RITE, on ear)




VF1 (RITE, Test Box)




VF2 (RITE, Test Box)



## A bit of fine print on between-system agreement.

- If your aid is directional or partly directional:
  - VF1: orient the aid with the line of directionality oriented at the front speaker. (Same as instructions for directional test)
  - VF2: orient the aid as shown in Help menu.
  - This matching helps to avoid between-system differences that are due to the directionality in the aid interacting with different directional orientations between systems.
- Avoid using blue putty on a silicon mold. Test retest and measurement validity will be poor. Use the HA4 instead.
- If comparing back to previous versions on VF1, know that Audioscan is using slightly updated MLEs. These result in a few minor differences at some frequencies.
- Vent effects are still best measured on-ear, not in test box. This is not new.

The case studies presented here are extracted from a current study that is ongoing. Group data are required and planned to evaluate these corrections.

## To note:

- Evaluated mainly on earmolds of 31 mm and longer.
  - Current Audioscan "help" recommends entering everything as "foamtip" for earmolds less than 35 mm so that this correction get disabled for babies.
- Evaluations with BTE, ITE and RIC are currently in progress. Our BTE fittings have "clinically typical venting", and are fitted to adults.
- As always: further work is necessary… ☺

## We're done!

- Summary:
  - Studies have continued to evolve our knowledge about real ear measurement. Much of this knowledge has been incorporated into the new standard.
  - Clinical practice continues to need flexibility, and many clinicians use many protocols.
- Changes for you to make in clinic:
  - If you use Audioscan, check your software version and update if necessary.
  - Any system that fully labels RECDs by coupling type and coupler type is already making either age-based or foam-to-earmold corrections. Measuring the RECD with correct labelling is your best contribution to accuracy.

## Selected References


- American National Standards Institute (2013). S3.46-2013, Methods of Measurement of Real-Ear Performance Characteristics of Hearing Aids.
- Bagatto, M, Moodie, S, Scollie, S, Seewald, R, Moodie, K, Pumford, J, Liu, KPR (2005). Clinical protocols for hearing instrument fitting in the Desired Sensation Level method. Trends in Amplification, 9(4): 199-226.
- Moodie KS, Seewald RC, Sinclair ST. (1994) Procedure for predicting real-ear hearing aid performance in young children. *Am J Audiol* 3:23-31.
- Moodie S, Rall E, Eiten L, Lindley G, Gordey D, Davidson L, Bagatto M, Scollie S (in revision). Applying the AAA Pediatric Amplification Guidelines: Survey of current practice. *J Am Acad Audiol.*
- Munro KJ, Toal S. (2005) Measuring the RECD transfer function with an insert earphone and a hearing instrument: are they the same? *Ear Hear* 26: 27-34.