bernafon
Innovative Hearing Solutions

Where did my gain go?

Thin Tube Open Fit BTE Verification

Summary of presentation by C. Staples and S. Aiken

History of Thin Tubes:

Growth of new BTE market:

- First quarter of 2006 market: 42% BTE instruments
- Second quarter of 2006 market: 46% BTE hearing instruments
- 17% of hearing instruments sold were Thin Tube Open Fit BTE hearing instruments

Total number of Thin Tube Open Fit BTE hearing instruments available in Canada

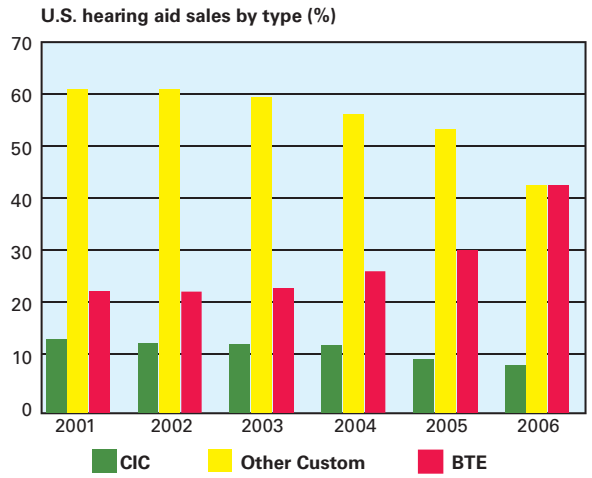
- 38 (as of October 1, 2006)
  - 12 designated Open Fit
  - 26 hybrid design

Reasons for the growth

- Minimal to no occlusion
- Cosmetically appealing
  - BTE is small
  - Thin Tube blends well with skin and hair
  - Fashionable designs
- Instant fits
  - Simplified process for Hearing Care Professional and customer

Concerns with Thin Tube Open Fit BTEs

- Limited fitting range
- Potential for feedback with increased hearing losses
- Uncertainty of extended fitting ranges



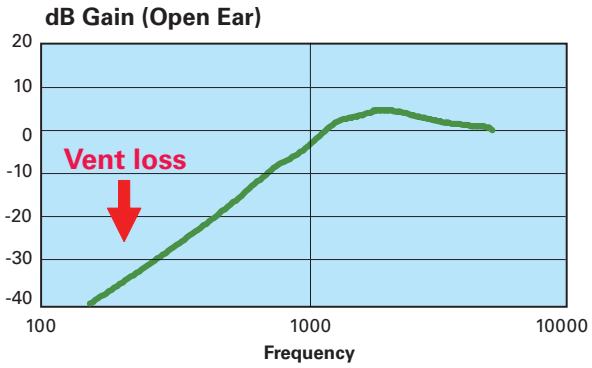
U.S. hearing and sales by type (total net units), indicating growth in BTE market share from 23% in 2001 to nearly 45% in the first quarter of 2006. Source: Hearing Industries Assn.

Acoustic effects of Open Fit Thin Tube BTEs

The vent-out effect

- The vent is a two-way street; sound travels in through the vent and travels out the vent as well. The larger the vent the greater the possibility for more sound to escape through the vent

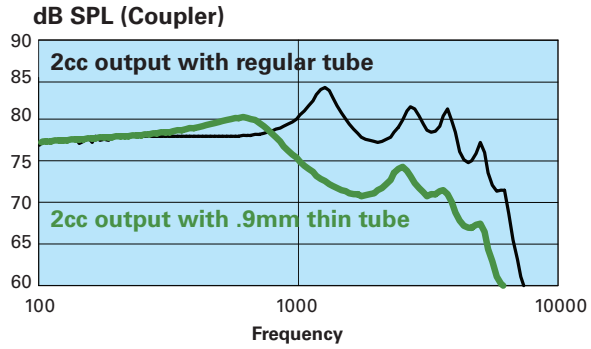
More gain is needed to account for vent loss (below 1000 Hz)



Thin Tube effect

- The thin tube (because of its smaller diameter) reduces the resonance peaks that would normally be present in standard tubing. This creates a situation where there is more electronic gain required by the hearing aid to meet the same output target

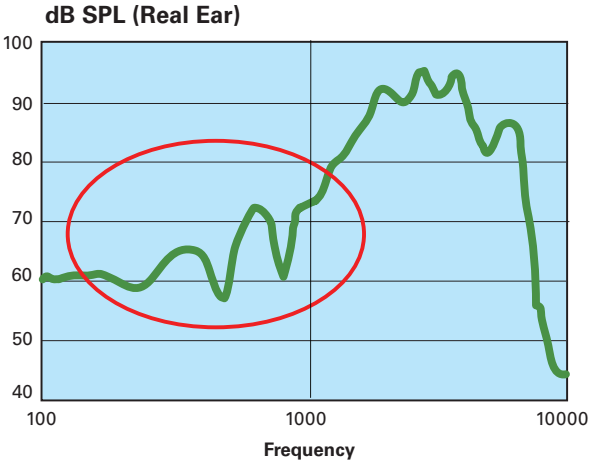
More gain is needed to reach the same output (above 1000 Hz)



Amplified sound and vent-in interactions

- Open Fit BTEs provide a pleasing mix of natural and amplified sound; however at similar levels these sounds do not interact well
- Where the amplified sound is dominant (usually high frequencies) only the amplified sound is heard
- Where the vent-in sound is dominant (usually the low frequencies) only the vent-in sound is heard
- When the amplified sound and vent-in sound are at the similar levels, a conflict occurs. The combination of these two sounds at similar levels can lead to a doubling or complete cancellation of sound

More/less gain can be needed to account for phase interactions



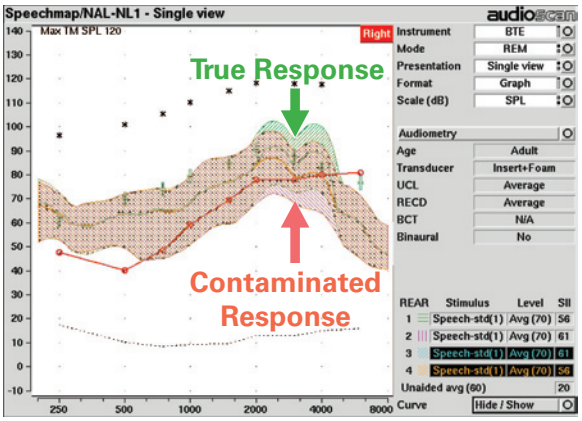
Doubling and cancelling occur at frequencies where the vent-in and amplified sounds interact at similar levels; a doubling is seen when in phase and a cancelling of sound is seen when out of phase.

Verification Recommendations

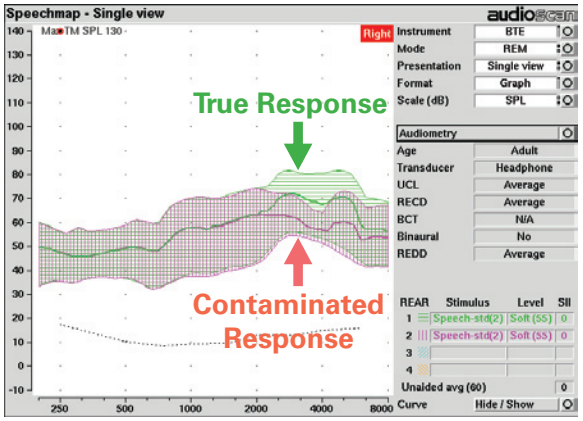
Reference microphone contamination

- Due to the large vent with Open Fit Thin Tube BTEs, sound can escape out of the canal and possibly contaminate the input to the reference microphone
  - If contamination occurs, the reference microphone measures an increase in sound volume and the hearing aid analyzer reduces the level of the test stimulus
    This might result in an underestimation of hearing aid output. The result of not taking this into account could lead to over amplification

Underestimation of output due to reference microphone contamination



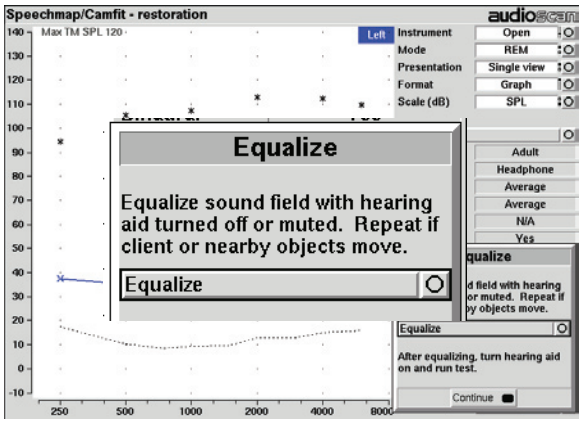
Speechmap screen shot from Audioscan Verifit®



Speechmap screen shot from Audioscan Verifit®

The solution

- The contamination of the reference microphone can be avoided by muting the hearing aid during the equalization process. Upon completion of the equalization process, turn the hearing microphone on and proceed with the hearing aid analysis. It is critical that the patient does not move during this process. Should the patient move restart the fitting/equalization process

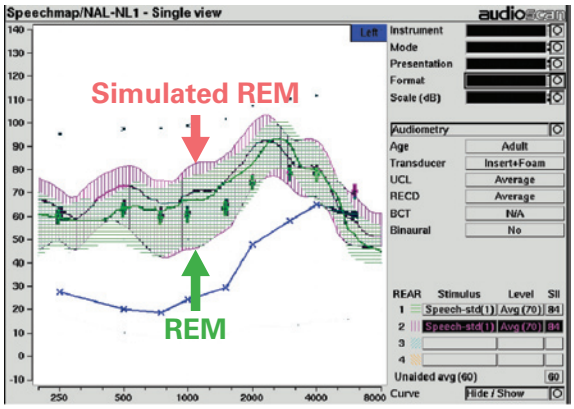


Speechmap screen shot from Audioscan Verifit®

Real Ear Verification

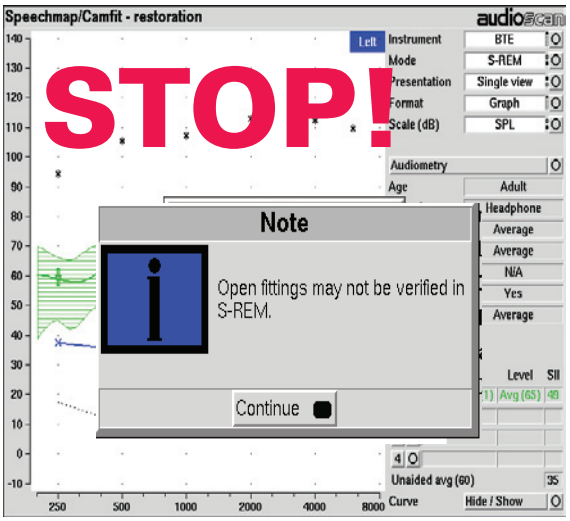
- Always verify Open Fit Thin Tube BTEs on the Real Ear
  - Coupler based measurements do not account for venting effects

Green = Real Ear Measurement (correct)
Purple = Simulated Real Ear Measurement with HA2 coupler (incorrect)



Speechmap screen shot from Audioscan Verifit®

- Simulated REM is not appropriate for Open Fit BTEs because the vent cannot be evaluated accurately
- Ensure adaptive feedback cancellation system is active and is not reducing gain to control for feedback



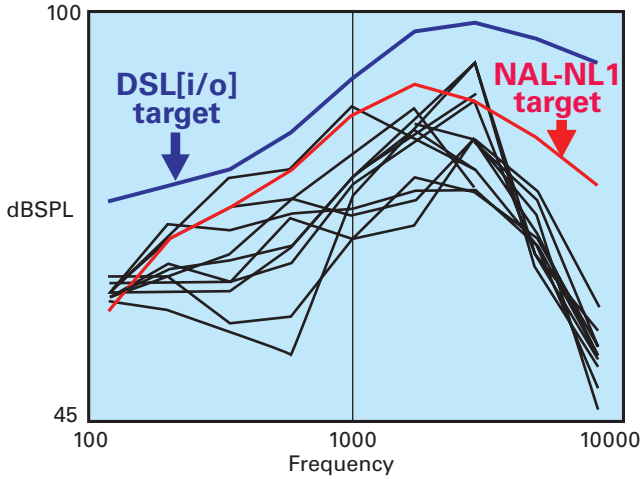
Speechmap screen shot from Audioscan Verifit®

Summary

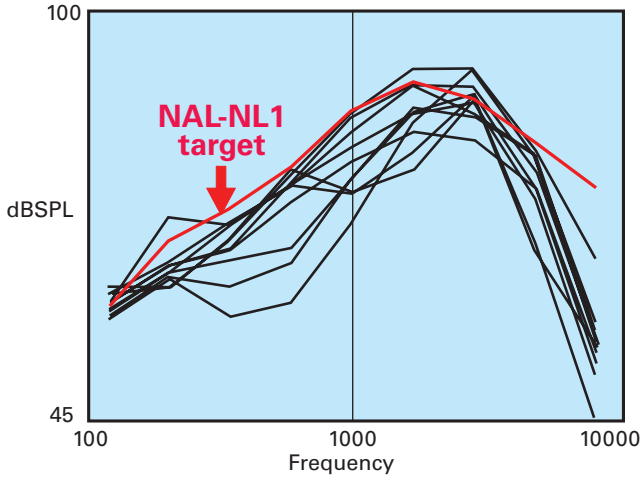
- Know what you are verifying
  - Since digital hearing aids delay the signal, amplified and vent-in sounds will likely be in-phase and out-of-phase at different frequencies. When the vent-in sound and amplified sound are approximately the same level, this creates a peaky REAR. If this is a problem, try minimizing or shifting the area of interaction by varying the hearing aid settings
  - **Check final REAR to ensure that response is appropriate**
  - **Preferred method of verification is Real Ear SPL with speech or speech-like stimulus**

Thin Tube Verification Study

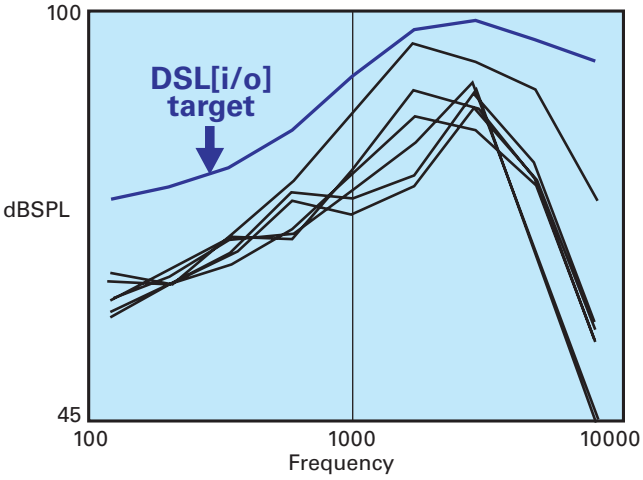
- Method
  - 14 Hearing Aids from 9 manufacturers
  - Set Client Experience level to maximum
  - Set to manufacturer recommended target, and NAL-NL1, DSL [i/o] if available
  - Feedback Manager ran if recommended by manufacturer
  - Verified on the Audioscan Verifit® System
  - Real Ear Verification completed as suggested in Verifit "Help" menu
  - REM calculated using Standard Speech sentence #1 at input levels of 55 and 70dB SPL
  - Estimated Speech Intelligibility Index (SII) was collected for each input level and converted to a predicted percent intelligibility for Connected Speech Test



Manufacturer Recommended First Fit compared to NAL-NL1 and /DSL[i/o] target



NAL-NL1 First Fit compared to NAL-NL1 target



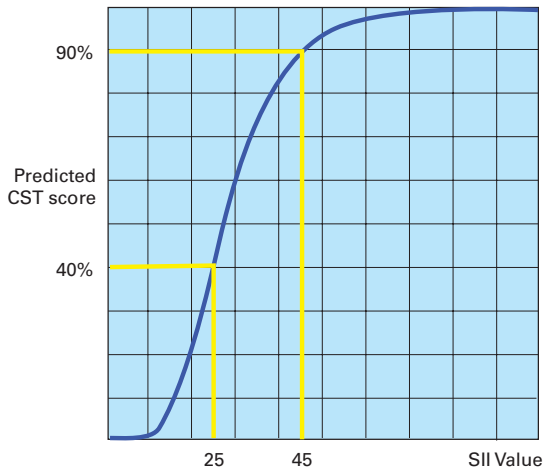
DSL[i/o] First Fit compared to DSL[i/o] target

Scores for Connected Speech Test vs SII

- **Key Messages**
  - Speech Intelligibilty Index converted to a predicted percent intelligibility for Connect Speech test

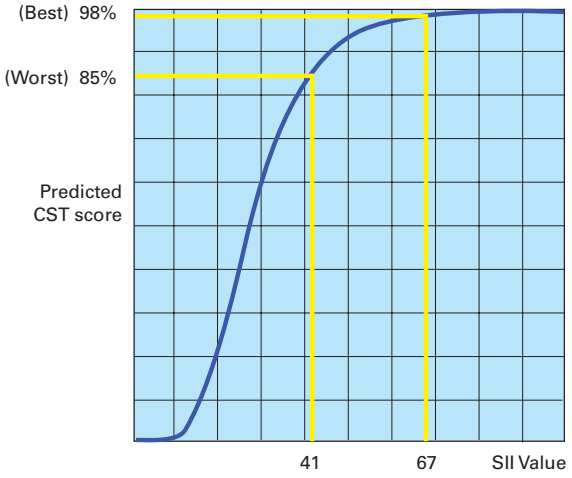
Significant decrease in predicted intelligibility when SII is reduced from 45 to 25

Relationship between SII and CST



- **CST/SII Score for Loud Speech (70 dB)**
  - 98% was the predicted score of the best Thin Tube Open Fit BTE performer
  - 85% was the predicted score of the worst Thin Tube Open Fit BTE performer
  - All Thin Tube Open Fit BTEs performed quite well with Loud Speech

Range of SII/CST values with 70 dB speech input



- **CST/SII Score for Soft Speech (55 dB)**
  - 88% was the predicted score of the best Thin Tube Open Fit BTE performer
  - The 88% score for Soft Speech was better than the worst performer for Loud Speech
  - 8% was the predicted score of the worst Thin Tube Open Fit BTE performer

Ironically, the hearing aid with a predicted score of 8% costs three times more than the best Open Fit BTE performer

Range of SII/CST values with 55 dB speech input