Lecture 6

Earmolds and Earshells

- An earmold is an individually fabricated ear insert that channels the sound reproduced by a hearing aid receiver to the eardrum.

- Before making a decision on the earmold style and material, several considerations must be taken.

- The evaluation should include: severity and type of the patient's hearing loss, anatomical properties of the ear, patient's manual dexterity, allergic conditions, personal preferences, and difficulty with any previous hearing instrument fitting.

#1
#5X
#6
#1 MT
#2

- Earmolds are made in two basic styles: concha and canal. Each style has several sub-styles that differ mainly in cosmetics.

- **Concha earmolds** occupy the ear concha and canal, and can be made in the standard, shell, skeleton, or non-occluding configurations.

- The standard earmold fits in the entire concha.

- The *shell earmold* has the bowl shelled out for an enhanced cosmetic appeal.

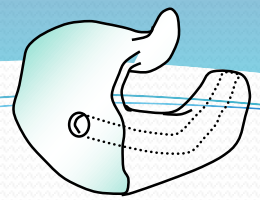
- In the *skeleton earmold* the concha is reduced even further to a ring, or 1/2-ring.

Canal style earmolds

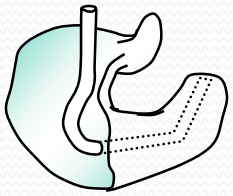
- ***Canal style*** *earmolds* include the half-shell, canal, and canal-lock configurations.
- The half-shell earmold occupies the cavum-concha.
- The canal earmold fits in the canal aperture.
- The canal-lock earmold possesses a small plastic tail (lock) extended to the ear concha.

Earmold styles

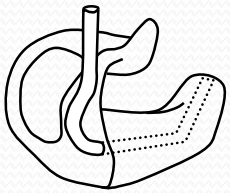
Earmold styles for BTE hearing aids.



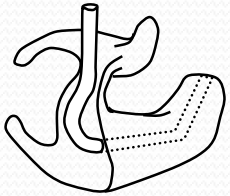
"Standard" mold



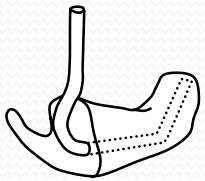
Carved shell



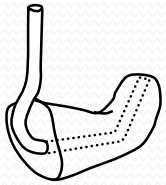
Skeleton



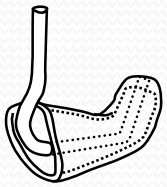
Semi-skeleton



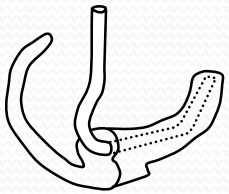
Canal lock



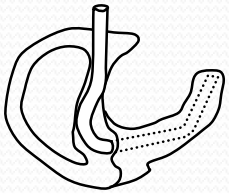
Canal



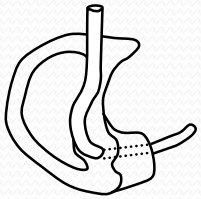
Hollow Canal



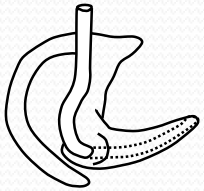
CROS - A



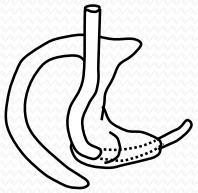
CROS - B



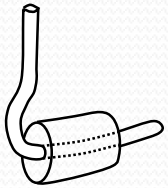
CROS - C



Janssen



Free Field



Sleeve

Source: Dillon (2001): *Hearing Aids*

Skeleton
(Acrylic, silicone)

Full Shell
(Acrylic, silicone,
soft silicone)

Half Shell
(Acrylic, silicone,
soft silicone)

Semi-Skeleton
(Acrylic, silicone)

Canal
(Acrylic, silicone,
soft silicone)

Canal Lock
(Acrylic, silicone)

CROS
(Acrylic, silicone)

Hollow Sleeve
(Acrylic)

Solid Sleeve
(Acrylic, silicone,
soft silicone)

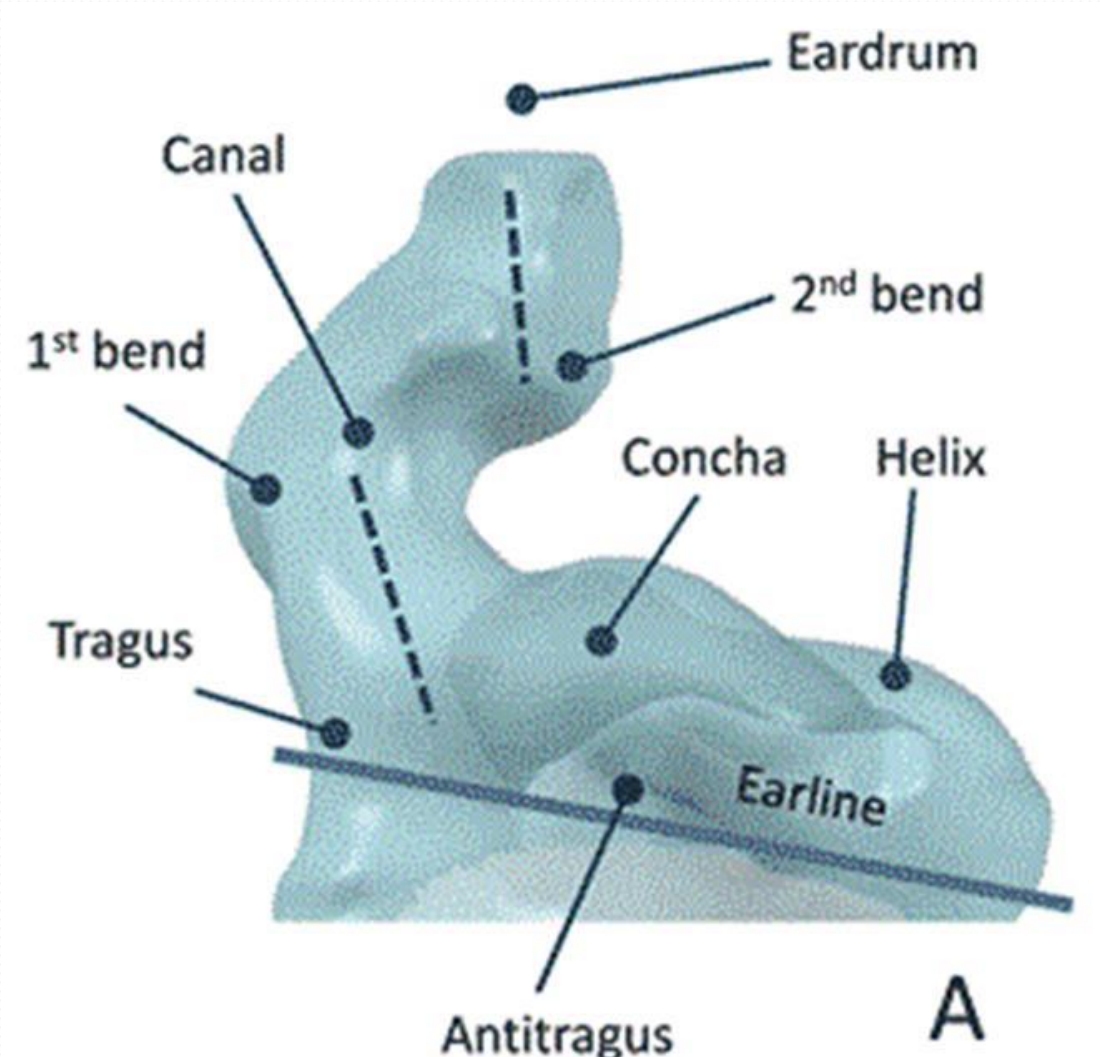
cShell
(Acrylic, silicone)

- Mandibular movements are a common culprit in making earmolds move laterally.
- Manufacturing the earmold from an open-mouth impression would eliminate the gap and provide a more secure fit.

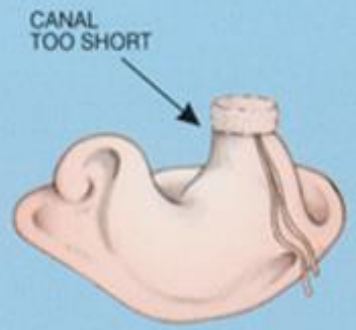
Earmold Characteristics

- Regardless of the earmold style or material, there are three requirements of a properly fitted earmold:
- **1) Acoustic seal.** The earmold needs to direct sound toward the eardrum without acoustic feedback.
- **2) Comfort.** The earmold should fit as comfortably as possible without causing irritation to the external ear.
- **3) Aesthetic appearance.** The earmold needs to be as inconspicuous as possible within the limits set by the acoustic requirements of the patient.

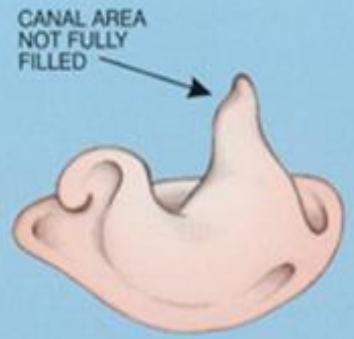
Prefect impression



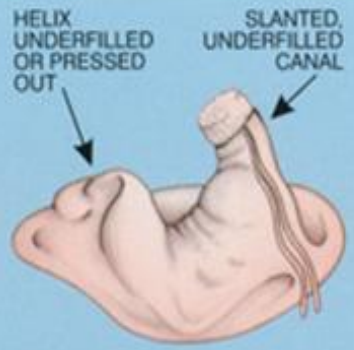
CORRECT
Canal, concha and helix adequately filled. Canal block left attached.



INCORRECT
Insufficient canal depth. Canal block not placed deeply enough in the ear.



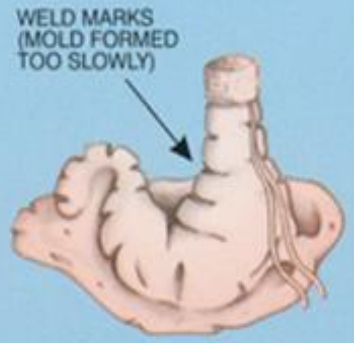
INCORRECT
Canal area not fully filled to canal block, or no block used.



INCORRECT
Slanted underfilled canal due to improper placing of block in ear. Helix either underfilled or pressed out.

INCORRECT
Distorted due to insufficient curing time for impression, or too much liquid added to Audalin®.

INCORRECT
Concha missing

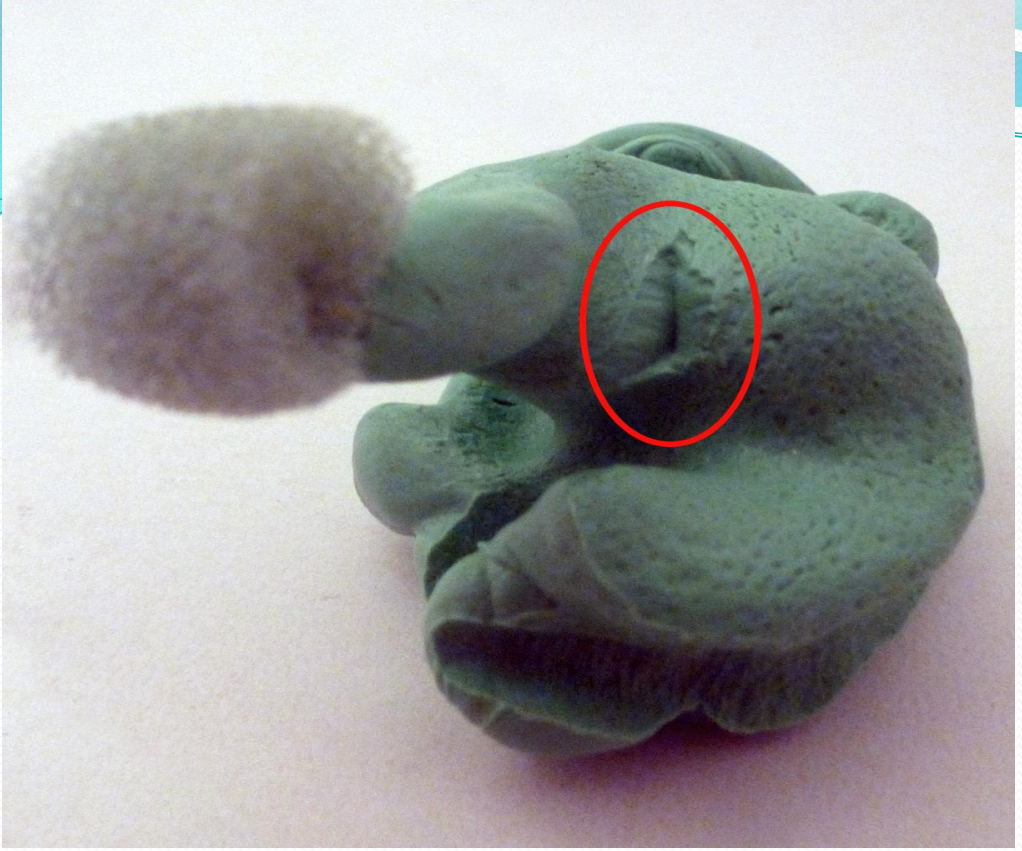


INCORRECT
Gaps or weld marks. Overall surface of impression not smooth.

INCORRECT
Mashed or bent due to improper handling or packaging. (Not usually a problem with the silicone-based materials unless the curing time was too short.)

INCORRECT
Underfilled tragus

INCORRECT
Helix missing



Glitter

Orange Glitter | Pink Glitter | Green Glitter | Blue Glitter | Yellow Glitter | Purple Glitter | Clear Glitter | Red Glitter

Opaque

White Opaque | Black Opaque | Green Opaque | Blue Opaque | Lilac Opaque | Red Opaque | Orange Opaque | Yellow Opaque

Translucent

Green Translucent | Blue Translucent | Purple Translucent | Pink Translucent

Matte

Clear Matte | Rose Matte | Beige Matte | Brown Matte

Earmold material options

- Another important consideration is the type of material used to make the earmold.
- In general, softer materials, such as silicon and vinyl, are used for hearing losses greater than 75 dB HL.
- The table outlines the three major earmold materials, along with their performance advantages.

Name	Characteristics	Advantages
Acrylic	Hard	Hard, durable Hypoallergenic Easy to modify in clinic More easily inserted Recommended for mild to severe hearing losses
Silicone	Semi-soft	Firm, semi-flexible Designed to provide added comfort over hard material May expand to reduce leaks Recommended for mild to profound hearing losses Recommended for pediatric patients Available in specialty colors and glitter options
Soft Silicone	Very-soft	Soft, flexible material with superior sealing properties Flexes to accommodate TMJ movement Recommended for severe to profound hearing losses Good choice for sports Recommended for pediatric patients

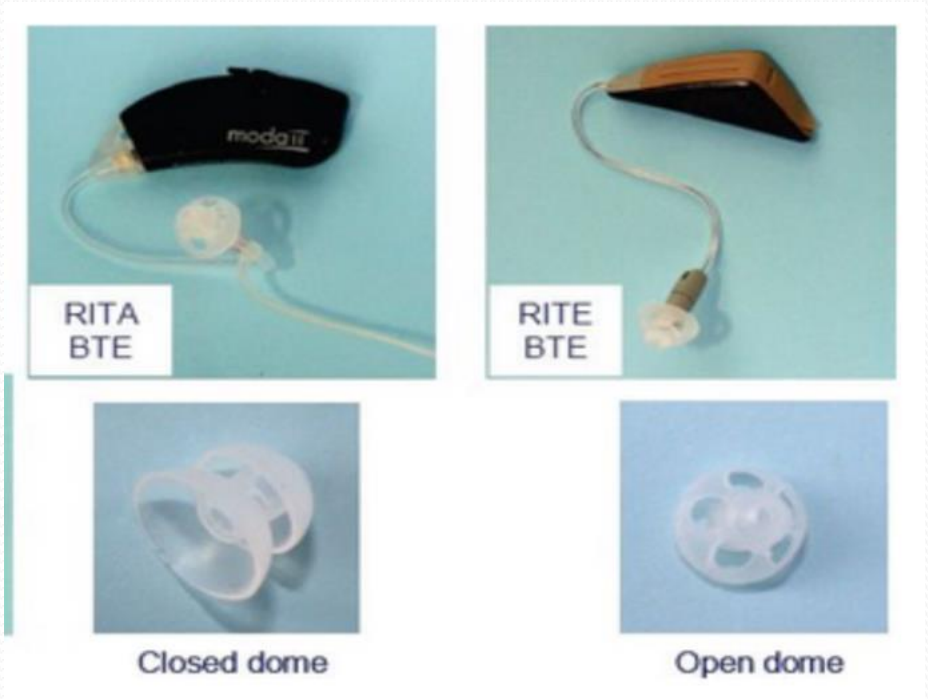
Pre-molded fittings

Consists of **dome-shaped canal fitting** + **thin sound tubing.**

Dome:

1.Open dome: holes in the flange

2.Closed dome: no holes



Closed Domes
Small
Medium
Large
Open Domes
Small
Medium
Large
Power Domes
9 mm
10 mm
11 mm
Tulip Dome

Advantages of pre-molded fittings

- 1.Very inconspicuous over-all appearance
- 2.Facilitate same-day fitting as no ear-impression needed

Mechanical Alterations to the acoustic parameters of a hearing aid:

- **Venting**
- An earmold vent, is a hole drilled completely through the earmold from the outer surface to the inner surface.

- All vents are designed to accomplish the same thing, which is to provide some reduction of amplified low frequency sound that is, allow low frequency sounds to leak out of the ear.

- That is, some of the low frequency sounds amplified by the hearing aid will not be transmitted through the middle ear into the inner ear.

- Instead, these amplified low frequency sounds in the ear canal will find that the acoustical path of least resistance is out through the vent hole and into the atmosphere, rather than through the middle ear.

- Venting also allows for some pressure relief. This problem is especially apparent when patients talk or chew.

Degree of hearing loss at 500 Hz (in dBHL)	Recommended vent diameter (solid mold)
<20 dB	open
20-29 dB	3-4 mm
30-39 dB	2-3 mm
40-49 dB	1-2 mm
50-60 dB	0.5-1 mm

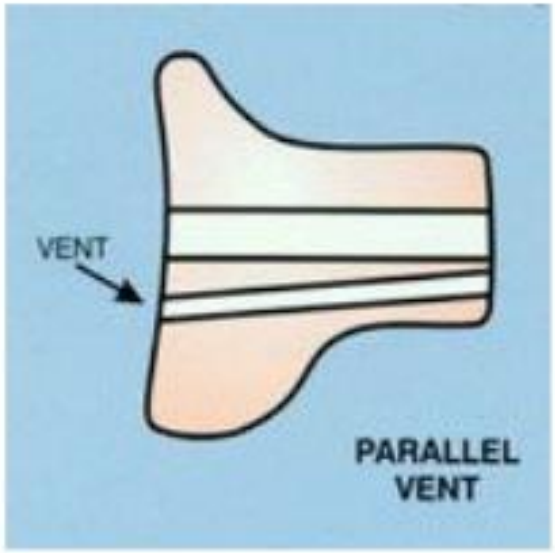
Recommended vent diameters (in mm) based on the hearing loss at 500 Hz (in dB HL). For an open-ear fitting, the hearing loss at 1000 Hz should not exceed 60-70 dB HL so that sufficient gain may be provided.

Parallel vs. Diagonal Vents

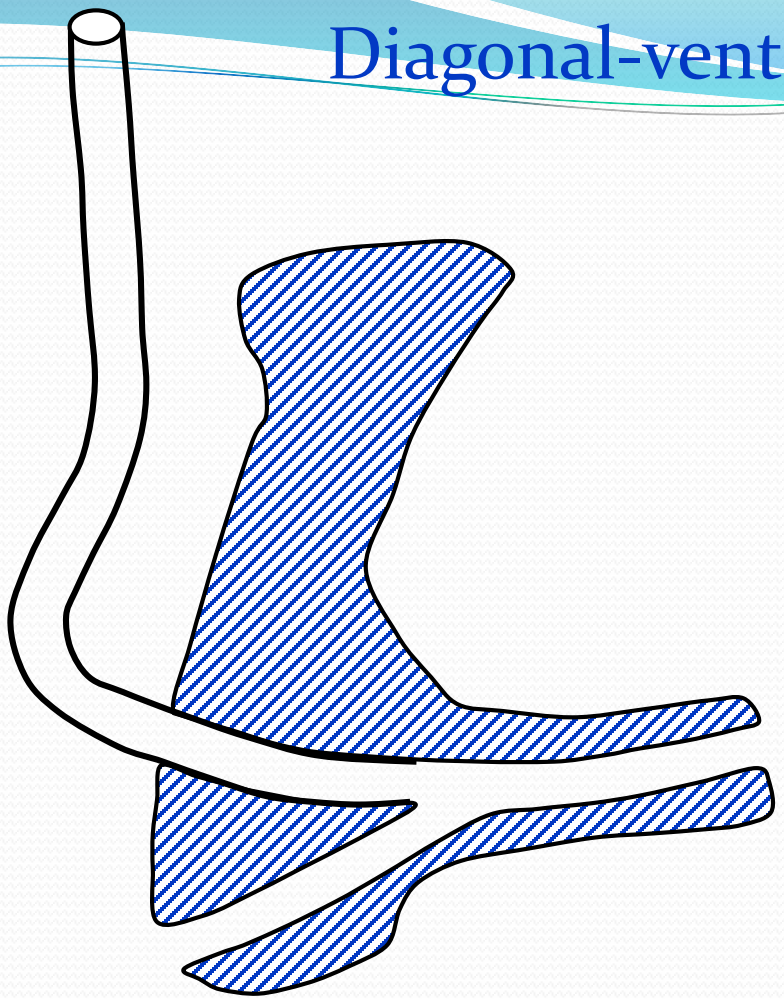
- There are two major types of vents found in a hearing aid shell or earmold: parallel, and diagonal.
- The most commonly used vent is the parallel type; however, there are instances when a professional may have to substitute a different style vent.
- It is easy to forget that the vent type can have a significant effect on the reduction in low frequency energy, as diagonal vents reduce low frequency energy more than parallel vents with the same internal diameter.

Venting

-Parallel vs. Y (diagonal) vents-



Diagonal-vent



Cross section of a diagonal vent in a BTE earmold.

Source: Dillon (2001): *Hearing Aids*

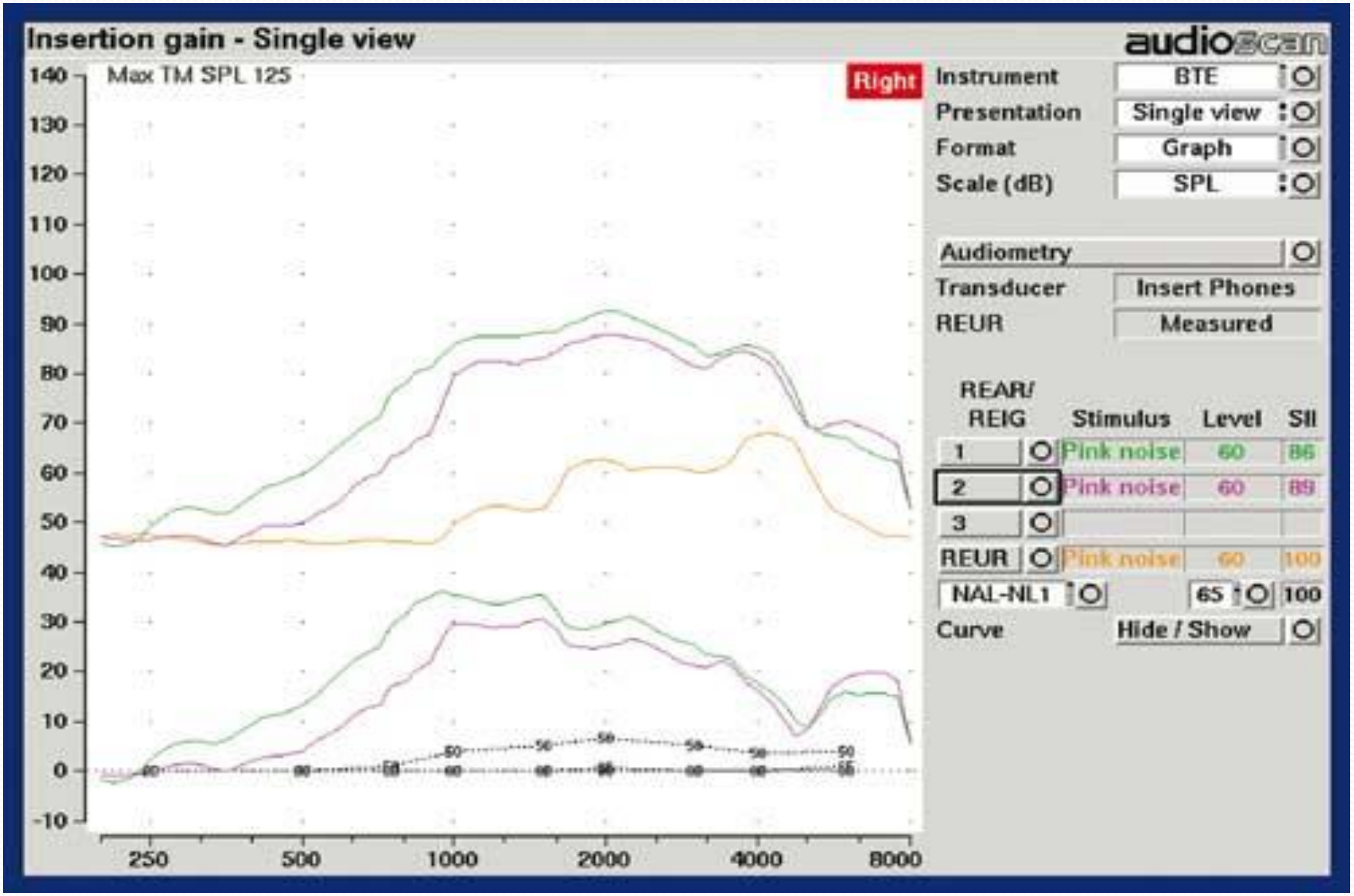
- This is illustrated in Figure 3, which compares the same hearing aid with identical acoustical settings.

- The only change is the style of vent. Notice in this particular example how gain is reduced through 3000 Hz with the use of a diagonal or side branch vent.

- **FIGURE 3.** The effects of vent style on gain and frequency response.

- The hearing aid, earmold style, and vent diameter were held constant and the vent type was changed.

- The green curves show aided gain for a parallel vent and the purple curves show the aided gain for the same product and earmold style using a diagonal vent. The orange curve is the REUR.


Insertion gain - Single view
audioscan
Max TM SPL 125
Right
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
250
500
1000
2000
4000
8000
Instrument
BTE
Presentation
Single view
Format
Graph
Scale (dB)
SPL
Audiometry
Transducer
Insert Phones
REUR
Measured
REAR/ REIG
Stimulus
Level
SII
1
Pink noise
60
86
2
Pink noise
60
89
3
REUR
Pink noise
60
100
NAL-NL1
65
100
Curve
Hide / Show

- Parallel vents are generally used, because not only do diagonal vents decrease low frequency gain like parallel vents, diagonal vents also decrease mid frequency (630-1600 Hz) gain by up to 10 dB.

- Therefore, unless you want to decrease mid frequency gain, parallel venting should be used.

Advantages and Disadvantages to Venting

There are at least 5 advantages to venting an earmold:

- 1) to reduce unnecessary low frequency gain and output from the ear canal/eardrum,
- 2) to allow unamplified sound to enter the ear canal,
- 3) to reduce the occlusion effect,
- 4) to relieve the feeling of pressure in the ear, and,
- 5) to reduce moisture build-up in the ear canal.

Disadvantages to venting an earmold:

- One disadvantage to venting is that the volume of the vent combines with the ear canal cavity to produce a Helmholtz resonator (increased gain in the 250-1000 Hz region), sometimes resulting in an echo or barrel effect when the patient speaks.

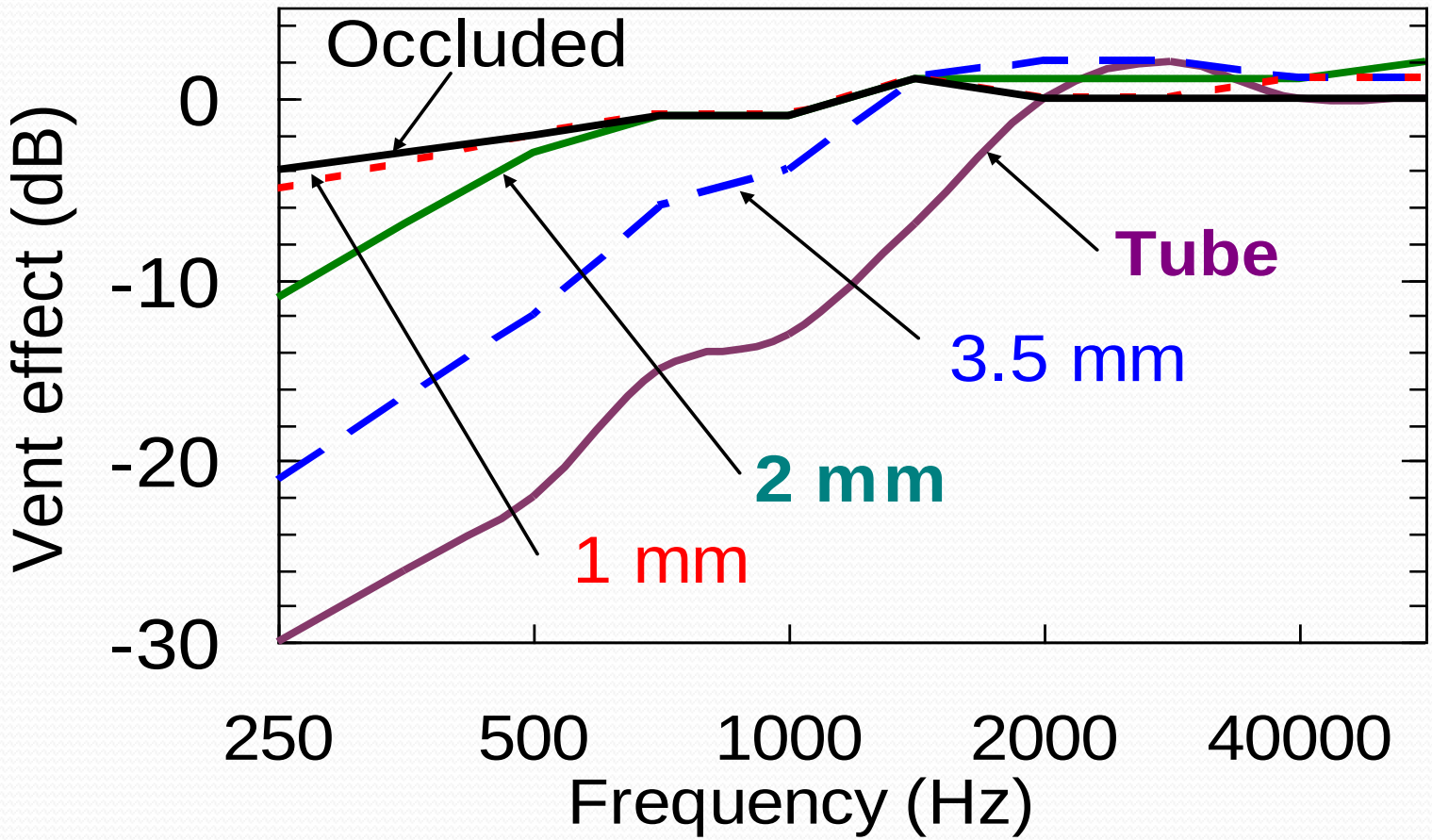
- Another disadvantage of venting is, of course, feedback. As vent size increases, the amount of acoustic leakage increases, and therefore the probability of feedback increases.

The Effect of Parallel Vent Diameter/Canal Length

- The rule of thumb is that as the parallel vent size increases (1 to 3mm), low frequency gain decreases (up to 30dB) at 500 Hz and below.

- As canal length increases (6 to 22 mm), the effect of venting is reduced. Thus, low frequency gain decreases are less (15 dB versus 30 dB) with long canals.

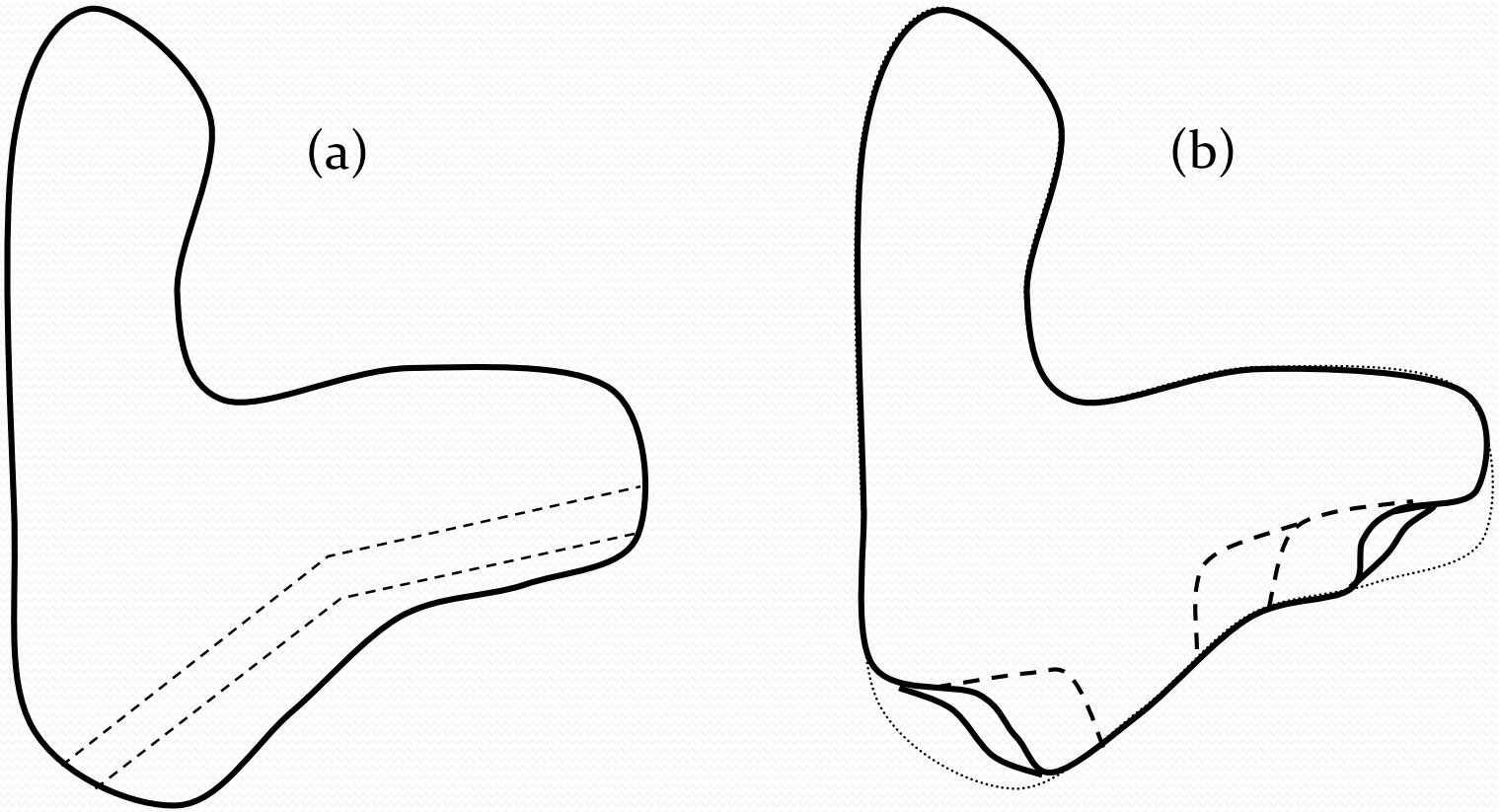
Low frequency vent-induced cuts



Effect of different sized vents on the frequency response of amplified sound, relative to the response with a tightly fitting earmold or earshell (Dillon, 1985).

Source: Dillon (2001): *Hearing Aids*

Shortening the vent



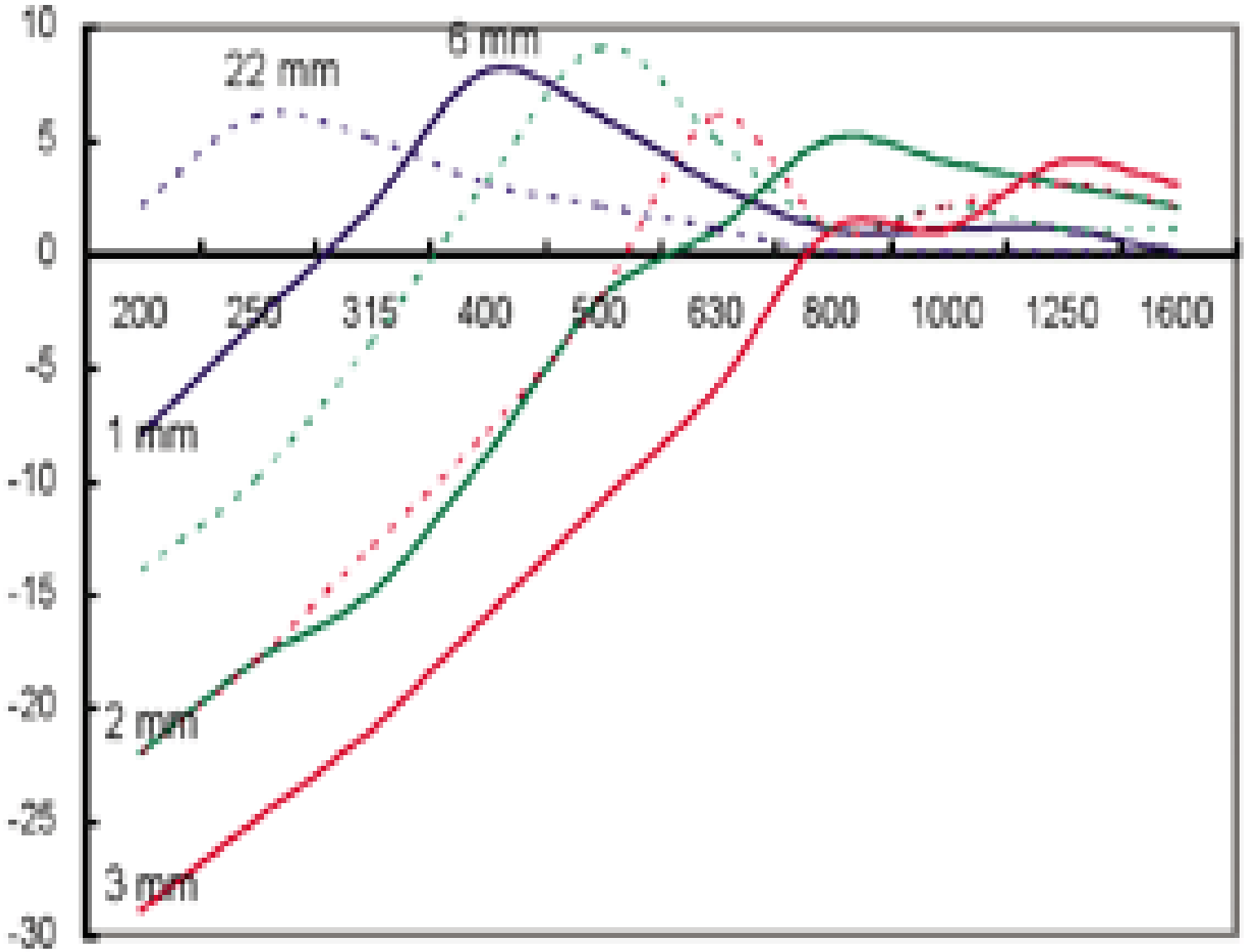
An unmodified vent (a) and a shortened vent (b). The dashed lines in (a) indicate the position of the vent. The dashed lines in (b) indicate potential further stages of shortening, and the dotted line indicates the original profile.

Source: Dillon (2001): *Hearing Aids*

So, what does this mean to you?

- If you want to decrease the low frequencies, you should order a short canal (6mm) and a large vent (3mm).

- Pressure equalization vents (.06-.8mm) on the other hand, no matter what the canal length is, generally only decrease gain up to 6 dB below 250 Hz.

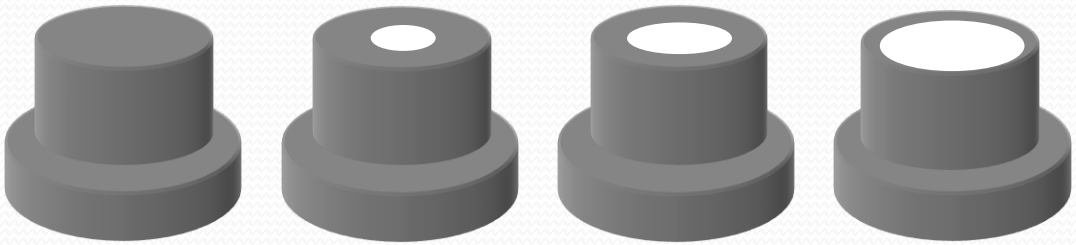

10
5
0
-5
-10
-15
-20
-25
-30
200
250
315
400
500
630
800
1000
1250
1600
22 mm
6 mm
1 mm
2 mm
3 mm

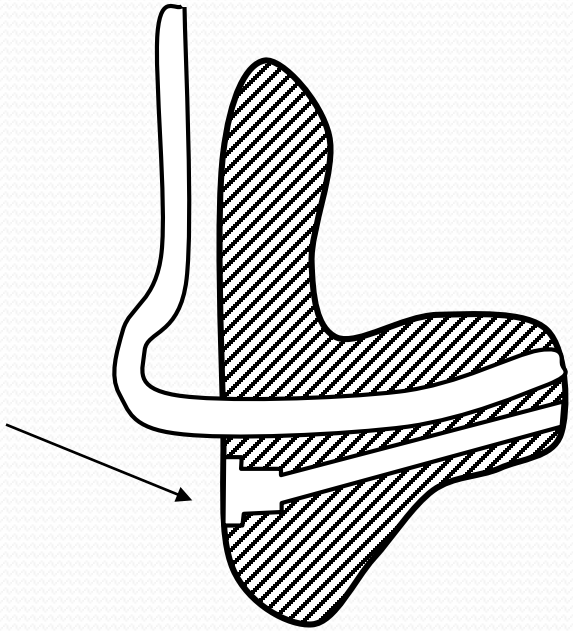
- *FIGURE . Effect of vent length on low frequency output for three vent diameters (1 mm in blue, 2 mm in green, and 3 mm in red). The solid line shows the result of a 6 mm-long vent, while the dotted line shows that of a 22 mm-long vent. A straight line at "0" would suggest no change to the output measured with an occluding earmold; data above "0" suggest a gain increase (from resonance) while that below "0" suggest gain reduction with the specific vent dimension (length and diameter).*

A Venting Selection Guide

- A rough guide for selecting the appropriate venting based on low frequency hearing loss.
- In general, if the hearing loss below 1000 Hz is 25 dB or less, an open mold (large vent 3.0 mm) is recommended.
- If the hearing loss is 30-45 dB in the low frequencies, an acoustic modifier or medium vent (2.0mm) is recommended.
- If the hearing loss is 50-60 dB in the low frequencies, a small vent (1.0 mm) or pressure vent (.06-.88 mm) is recommended.
- When the loss exceeds 60 dB, we usually do not put in a pressure vent, unless the patient is occluded or their voice bothers them.

Vent inserts





The inserts (larger than life-size) from a vent insert system, and the earmold and vent receptacle (approximately life-size) into which they fit. Positive Venting Valve (PVV) and Select-A-Vent (SAV) are two such systems commercially available.

Source: Dillon (2001): *Hearing Aids*

Tubing

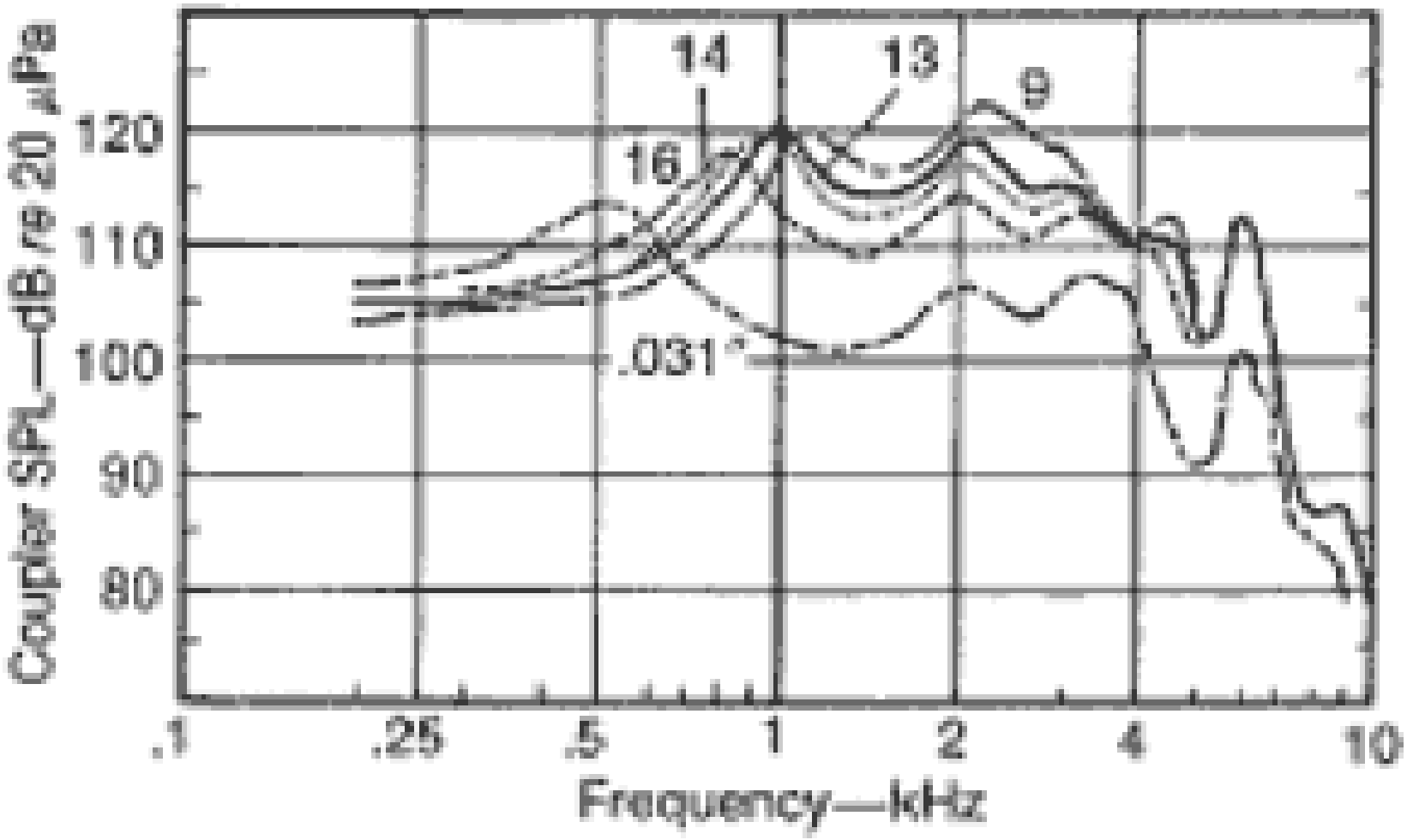
- Tubing length and internal diameter can have a pronounced effect on the frequency response of the hearing aid.
- Tubing diameters are standardized according to the internal diameter.
- The most common tubing is size 13

Tubing

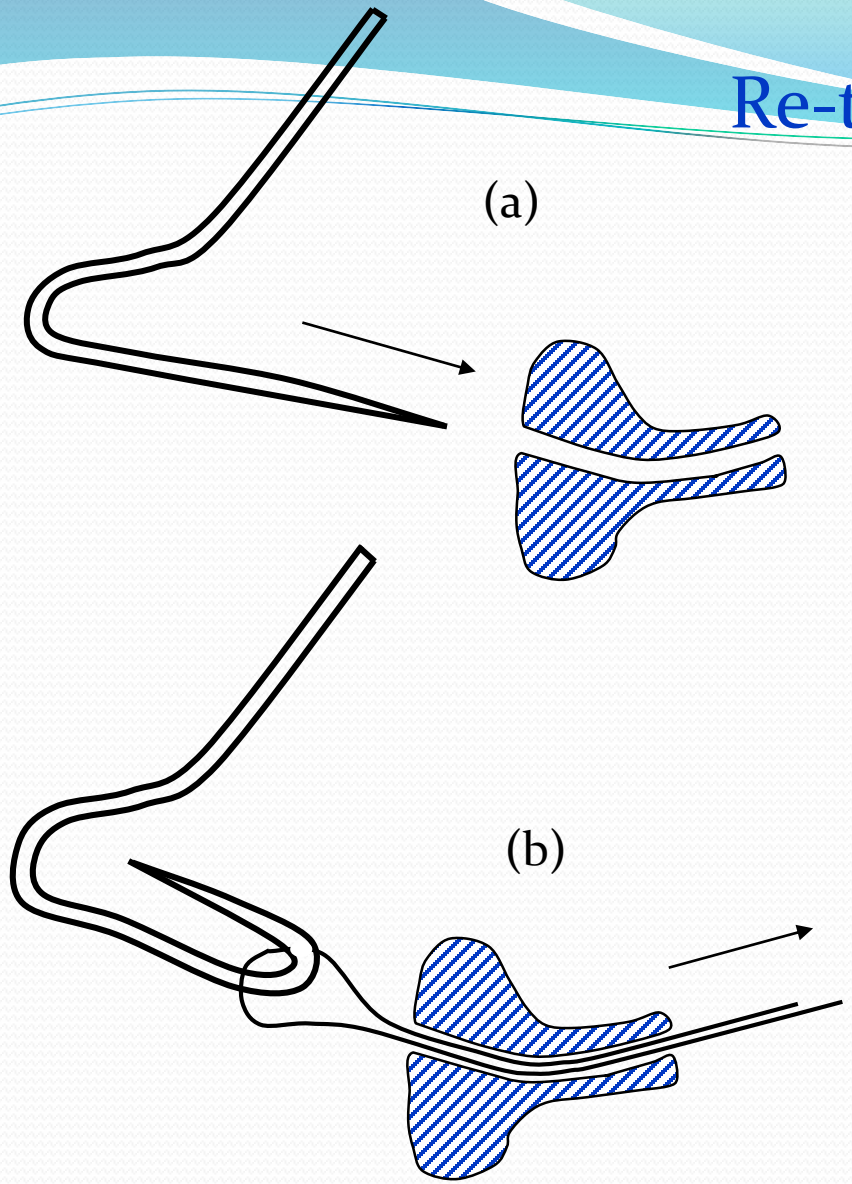
Tubing Size	Inside/Outside Diam
#12	2.16/3.18 mm
#13 standard	1.93/2.95 mm
#13 medium	1.93/3.10 mm
#13 thick	1.93/3.30 mm
#14	1.68/2.95 mm
#15	1.50/2.95 mm
Thin tube	0.90/1.40 mm

- Figure 4. provides a good example of how the gain above 1000 Hz is affected by the internal diameter of the tubing. In this example, five different internal diameters are compared in a Zwislocki coupler.

- The .031-inch (0.80 mm) internal diameter curve in Figure 4 closely approximates the internal diameter of a modern thin tube. Even though the reduction in gain resulting from tubing resonances can be compensated through software adjustments, if the proper correct factor is not properly verified, thin-tube fittings can result in inadequate mid and high frequency gain.


Coupler SPL—dB re 20 μPa
120
110
100
90
80
14
13
9
16
.031
.1
.25
.5
1
2
4
10
Frequency—kHz

Re-tubing



Insertion of tubing into an earmold by (a) pushing, or by (b) pulling with a loop of wire.

Source: Dillon (2001): *Hearing Aids*

Dampers

- As sound travels through the tubing, standing-wave resonances occur.
- These create peaks in the frequency response of the hearing aid, resulting in acoustic feedback or poor sound quality.
- To some extent, these peaks and valleys can be smoothed out electronically using the fitting software.

Dampers

- However, many manufacturers still rely on plastic or metal dampers placed in the earhook to smooth out the response.

- For example, in many high-gain BTEs, a 680, 1000 or 1500 ohm damper is used to smooth out the frequency response of the hearing aid.

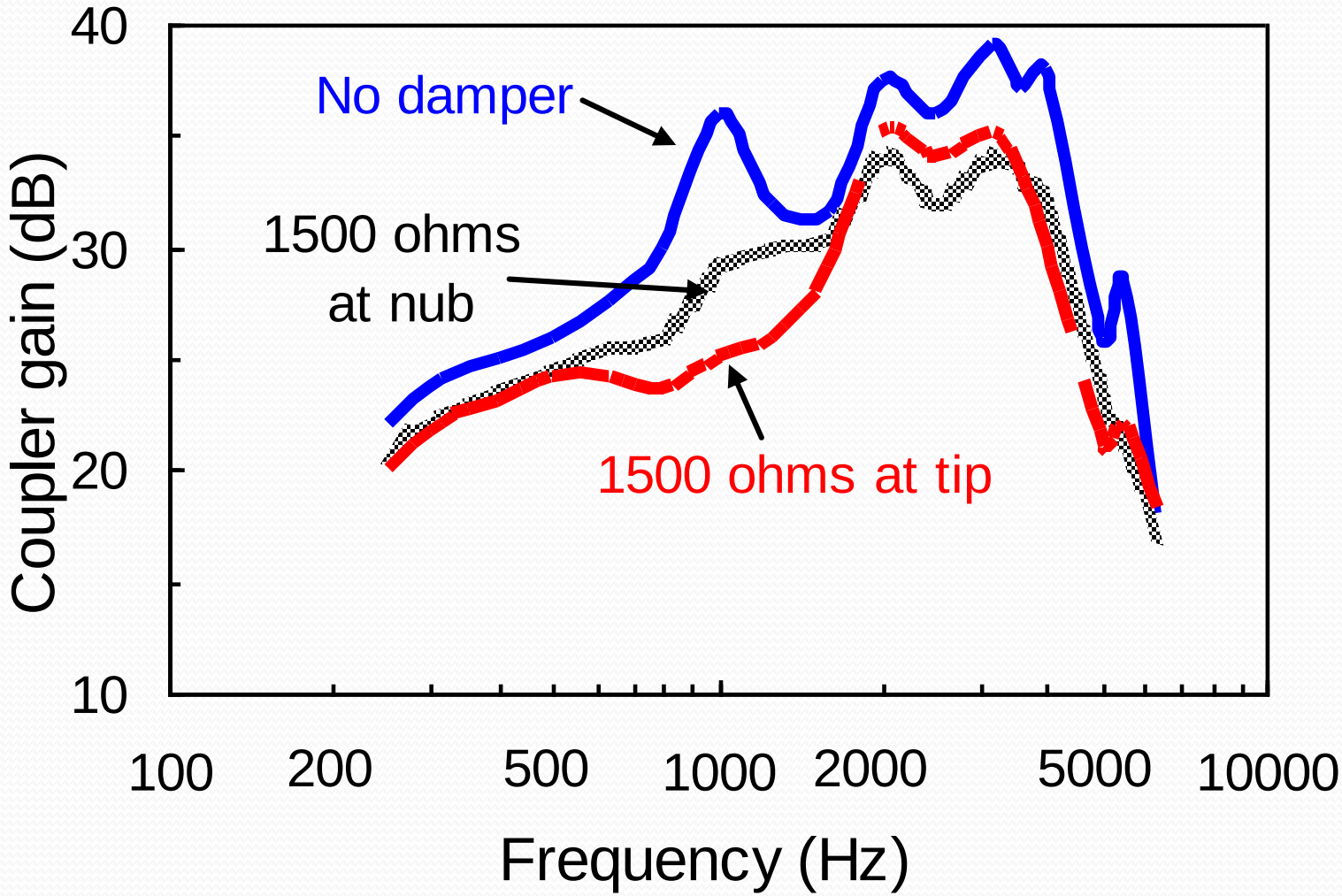
- The location of the damper also has a significant effect on the frequency response.

Dampers

- For the clinician, knowing the type and location of a damper is essential when replacing it, as the damper impacts sound quality.

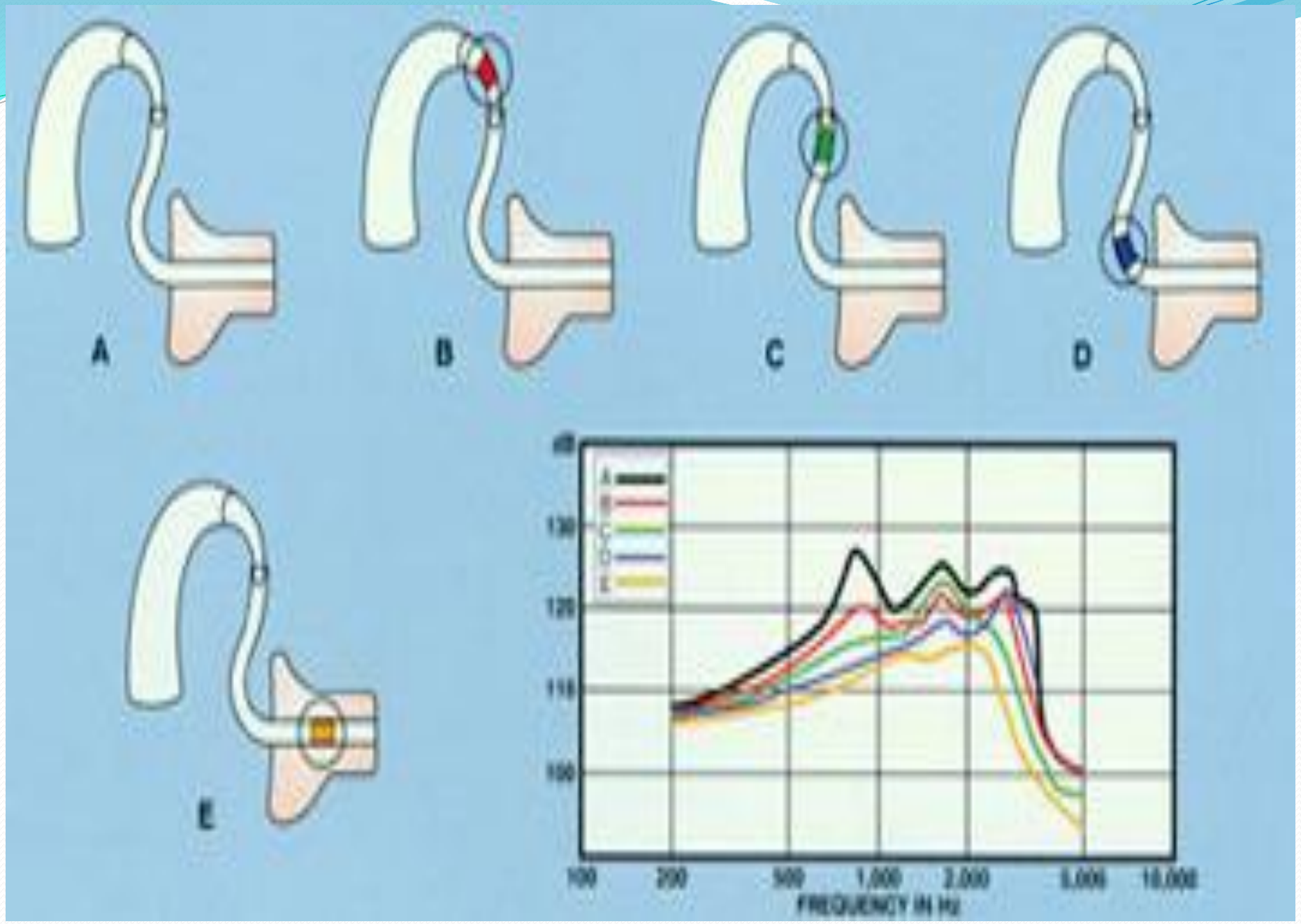
- Dampers, working in the mid-frequencies, primarily remove unwanted peaks in the response curve, and take several forms.

Effects of dampers



Frequency response of a hearing aid with no damper, and with a 1500 ohm damper placed at each end of the earhook.

Source: Dillon (2001): *Hearing Aids*


A
B
C
D
E
dB
130
120
110
100
100
200
500
1,000
2,000
5,000
10,000
FREQUENCY IN Hz

Sound Bores and Horns

- Changes in sound bore diameter affect the high frequency response of the hearing aid.
- Increases in bore diameter alone, however, yield little or no change in the high frequency response.
- Figure 5 shows the aided and insertion gain differences for a standard, bell, and open sound bore, respectively.
- Notice how low frequency gain is affected due to changes in the venting characteristics relative to the sound bore, but high frequency gain is unaffected.

Sound Bores and Horns

- This is due to the fact that changes in the high frequency response can only be accomplished mechanically with a horn, and not with a larger sound bore within the earmold.

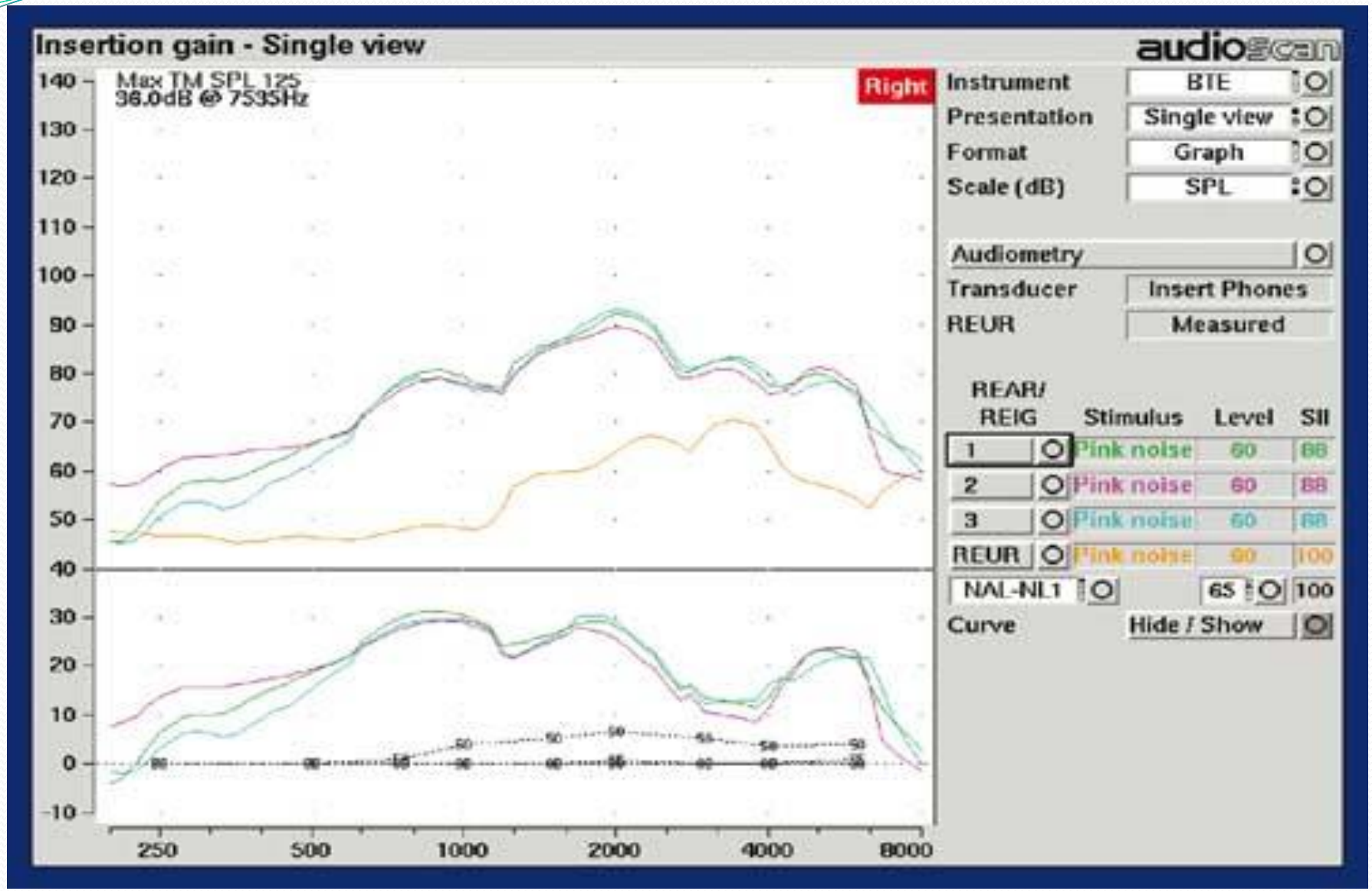
- Simply increasing the size of a sound bore has no appreciable effect on the hearing aid's response in the high frequencies.

Sound Bores and Horns

- **Next Figure.** The response curves for the same hearing aid using earmolds with three different sound bores.

- Note there is not a significant difference in the high frequencies.

- The differences seen in low frequency gain are due to changes in vent type for each of the earmolds.


Insertion gain - Single view
audioScan
Max TM SPL 125
36.0dB @ 7535Hz
Right
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
250
500
1000
2000
4000
8000
Instrument
BTE
Presentation
Single view
Format
Graph
Scale (dB)
SPL
Audiometry
Transducer
Insert Phones
REUR
Measured
REAR/ REIG
Stimulus
Level
SII
1
Pink noise
60
88
2
Pink noise
60
88
3
Pink noise
60
88
REUR
Pink noise
90
100
NAL-NL1
65
100
Curve
Hide / Show

- For an acoustic horn to work effectively, a gradual increase in internal diameter over a specific length is required. If the length is too long or too short, the increase in high frequency gain will not be attained.

- With a properly constructed horn, an increase in high frequency gain can be readily achieved without increasing the hearing aid's output.

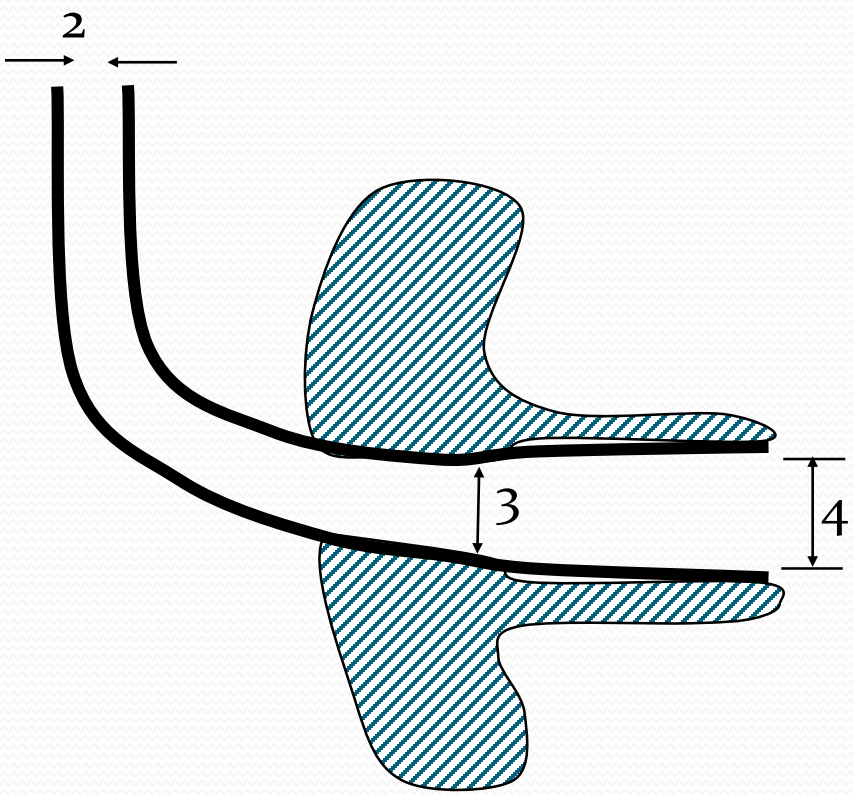
- The 3 mm or 4 mm Libby horn is a proven method for obtaining more high frequency gain mechanically rather than electronically.

- When using a Libby horn tube, it is important not to modify the length of the tubing, as shortening the length can render the horn ineffective.

- The mechanical action of a horn is governed by the length and taper of the horn.

- In simple terms, for any horn to be effective, the length of the horn must be at least 17 mm. With the proper length maintained, up to 12 dB of gain between 2 kHz and 5 kHz can be obtained.

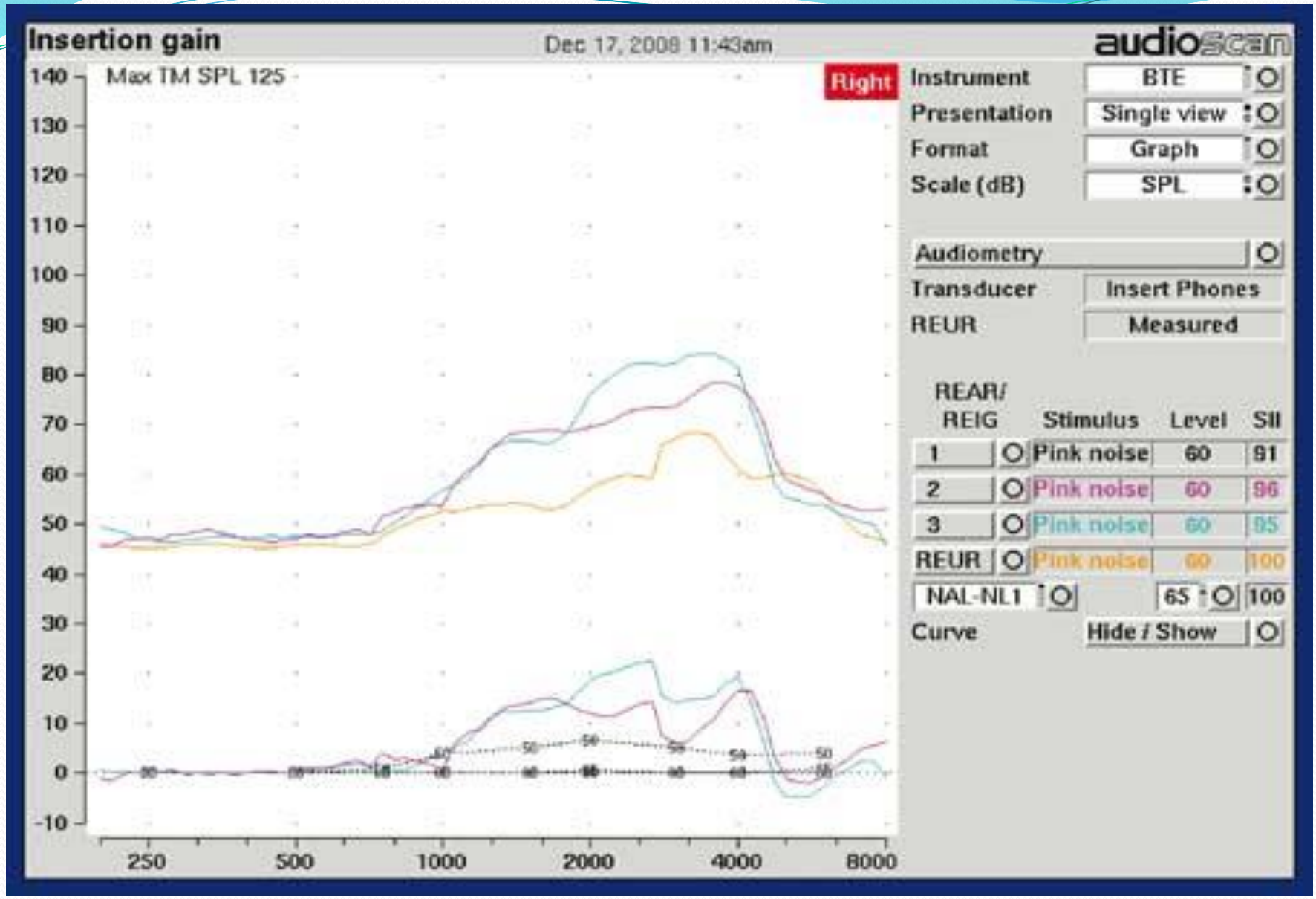
Libby horn insertion



A Libby 4 mm horn fully inserted into the earmold. Diameters are in mm.

Source: Dillon (2001): *Hearing Aids*

- **Next Figure.** The difference in high frequency gain between an earmold with standard tubing and sound bore (purple curve)
- compared to 4 mm Libby horn (blue curve).
- The REUR is the orange curve.


Insertion gain
Dec 17, 2008 11:43am
audioScan
Max TM SPL 125
Right
140
130
120
110
100
90
80
70
60
50
40
30
20
10
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-10
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2000
4000
8000
Instrument
BTE
Presentation
Single view
Format
Graph
Scale (dB)
SPL
Audiometry
Transducer
Insert Phones
REUR
Measured
REAR/ REIG
Stimulus
Level
SII
1
Pink noise
60
91
2
Pink noise
60
96
3
Pink noise
60
95
REUR
Pink noise
60
100
NAL-NL1
65
100
Curve
Hide / Show

Acoustic modifications

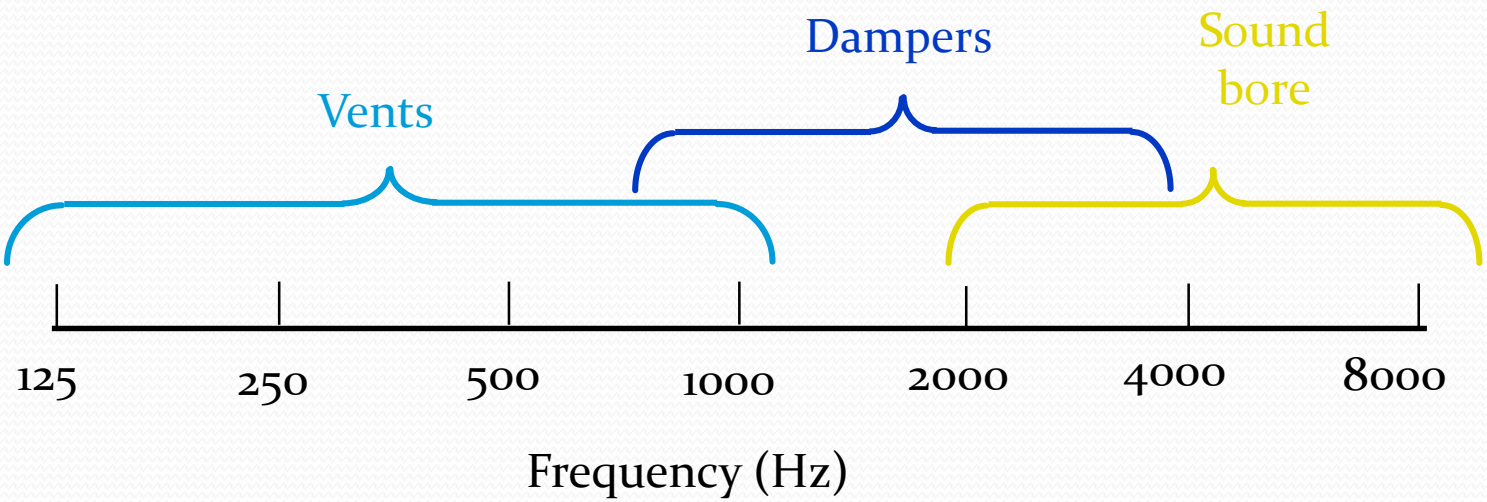

Figure 7 Frequency regions affected by each of the components of the hearing aid coupling system.

Source: Dillon (2001): *Hearing Aids*

Getting used to the earmolds

- *At first it may feel strange to the patient having the earmold in place in the ear. It will take some time for the patient to get used to the new feeling.*

- The earmold is not, however, always perfect, so it is not unusual for the earmold to require several adjustments before fitting and functioning properly.

Some of the problems that may occur include:

- 1. Unpleasant sound blockage - also known as the '**occlusion effect**'

- The occlusion effect is a phenomenon that has been described by some hearing aid users, newer ones in particular, of their own voice sounding a bit "funny" when they talk.

- Sometimes people feel like they're talking in a barrel, that what they're hearing is echoes of their own voice, or that their voice sounds "hollow" or "booming".

- Whatever adjectives people use to describe their perceptions of their own voice while talking, it is almost invariably negative. They just don't like the way their own voice sounds.

- And it is not just their voice that can be disturbing. People who have a large occlusion effect may also feel a sense of pressure or blockage in the ear when an earmold is inserted.

- Chewing one's food may sound noisy or unpleasant.

- It is disturbing enough so that if the occlusion effect is not solved or made acceptable in a reasonable time frame, some people will reject hearing aids.

- For them, the benefits they receive with hearing aid amplification are overshadowed by the problems the occlusion effect causes.

- An occlusion effect occurs when some object (like an unvented earmold) completely fills the outer portion of the ear canal.

- What this does is trap the bone-conducted sound vibrations of a person's own voice in the space between the tip of the earmold and the eardrum.

- Ordinarily, when people talk (or chew) these vibrations escape through an open ear canal and the person is unaware of their existence.

- But when the ear canal is blocked by an earmold, the vibrations are reflected back toward the eardrum and increases the loudness perception of their own voice.

- Compared to a completely open ear canal, the occlusion effect may boost the low frequency (usually below 500 Hz) sound pressure in the ear canal by 20 dB or more.

- The way to reduce or remove the occlusion effect is to not completely block the ear canal with an earmold.
- This permits the bone-conduction sound generated in the ear canal to escape the ear the way it is supposed to.
- When someone is wearing hearing aids, the only way to do this is to create a vent in the earmold.
- The amount of sound that escapes, and thus the magnitude of the occlusion effect, depends upon the size of the vent.
- The larger the vent, the more the occlusion effect can be reduced.

- The smallest vent is termed a "pressure" vent.
- By allowing air to enter the ear canal, a "pressure" vent will alleviate the feeling of fullness in the ear that can occur when an ear is completely blocked by an earmold.
- It does this by equalizing the atmospheric air pressure to that occurring in the ear canal.
- While a pressure vent will not influence the pattern of amplification, it will help a hearing aid user be more comfortable when wearing the aid.

- Pressure vents are very common in hearing aids, except for the smallest completely-in-the canal (CIC) hearing aids.

- These aids are so full of electronics that they have no spare space left to accommodate a vent.

- The people who seem most susceptible to the occlusion effect are those with relatively good hearing at the lower frequencies.

- <u>2. Acoustic feedback</u>

- Acoustic feedback is a kind of whistling sound that occurs when amplified sound escapes from any part of the hearing aid and re-enters the hearing aid microphone.

- It is a phenomenon that occurs when the earmold does not fit tightly enough. This can make it difficult to make the vents that are needed to overcome sound blockage.

- <u>3. Cerumen (earwax) build-up</u>
  The ear mould can also cause a build-up of cerumen (earwax) - especially when wearing tight earmolds. Cerumen can reduce sound transmission and thereby making it difficult to hear.

- <u>4. Allergic reactions</u>
  Lastly, the materials used to produce the ear mould can cause allergic reactions. In such cases other hypoallergenic materials must be sought.