Ototoxicity

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Global Risk Advisors℠

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Progress in TLVs

- In many cases significant reductions since 1971
- 1990s introduced Inhalable
- PNOC is Inhalable along with many other compounds- Compliance ??
- Resin Acid Colophony “as low as possible”
- Ozone – TLV depends on Heavy , Moderate and light work
- Skin notation –
- STEL- Peak where no STEL
- Refined Petroleum Hydrocarbons – Appendix H RCP- D or E
- TLV basis – Res and dermal sensitivity
- NIC Ototoxicity and Surface limits

Recent History of Ototoxic References

- White Book – drugs- streptomycin -1970 or earlier
- EU European Agency for Safety and Health at Work - 2009

  Combined exposure to noise and ototoxic substances
- ACGIH NIC for Styrene
- NIOSH/ OSHA posted article on March 15 2018

OSHA's occupational noise exposure standard at 29 CFR 1910.95 only requires audiometric testing at the noise action level (i.e., an 85-decibel 8-hour time-weighted average). However, wearing hearing protection and using audiometric testing to detect early signs of hearing loss, even in workers exposed below the action level and ototoxic chemicals below the PEL, may prevent hearing loss from their synergistic effects.

2018 TLV NIC for Styrene

- TLV – TWA 2 ppm (OTO) Ototoxicant

- Styrene induced changes in cochleovestibular function and deficits in color vision and in high frequency hearing.

- Due to the likely correlation between the solvent induced neurological damage affecting hearing , color vision and central and peripheral nervous systems collectively.

- TLV – TWA has been 20 ppm since 1995

Ototoxicant Concentrations of Concern

- Styrene 2 ppm
- Xylene 25-40 ppm (100 ppm TLV)
- Toluene 25-70 ppm (20 ppm TLV)

Ototoxicants Act Through Blood Stream

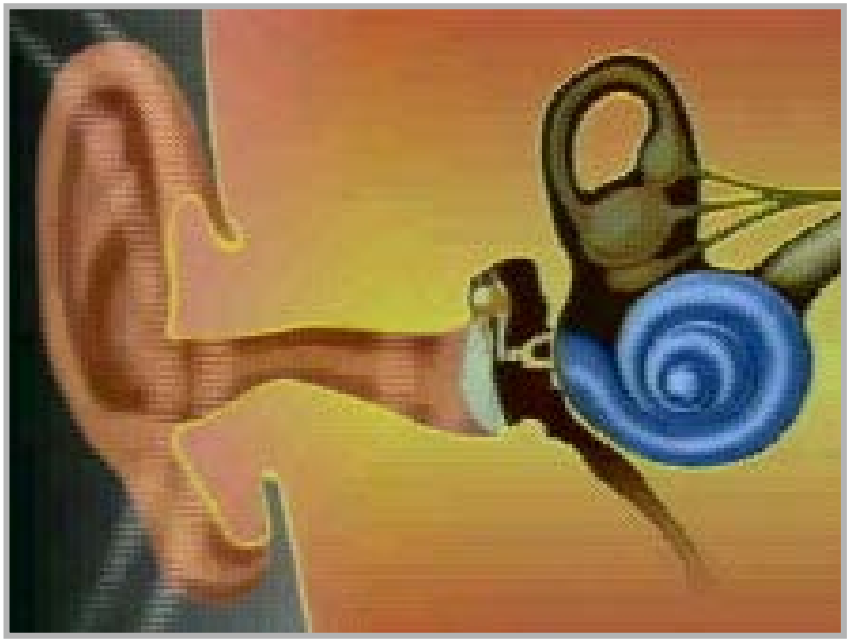
- Neurotoxicants are ototoxic when they damage the nerve fibers that interfere with hearing and balance.

- Cochleotoxicants mainly affect the cochlear hair cells, which are the sensory receptors, and can impair the ability to hear.

- Vestibulotoxicants affect the hair cells on the spatial orientation and balance organs.

How We Hear

- Sound waves cause the eardrum to vibrate
- Bones in middle ear transmit vibrations to cochlea
- Receptors (hair cells) in cochlea convert vibrations to electrical energy
- Brain interprets these electrical impulses as sound



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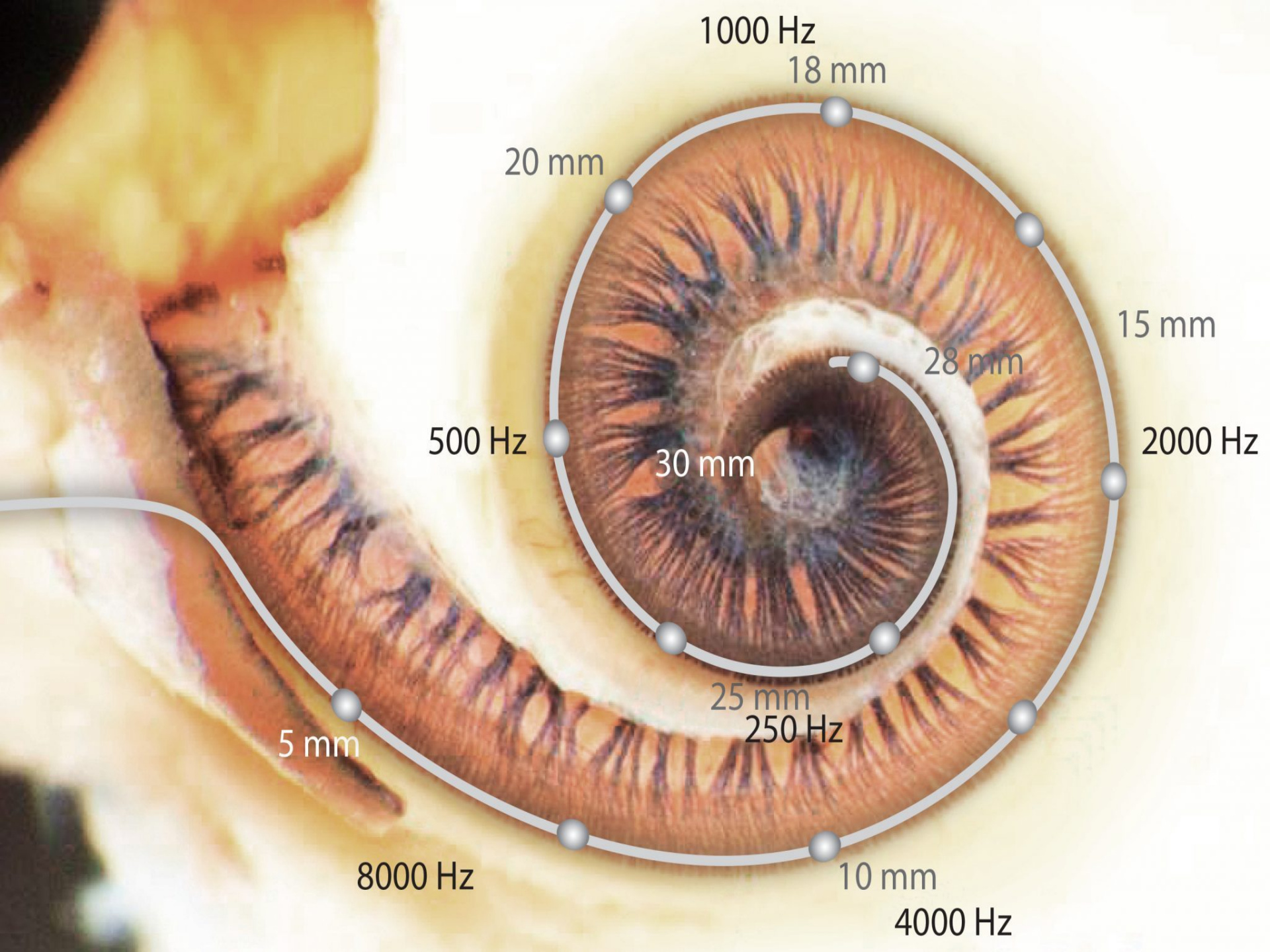
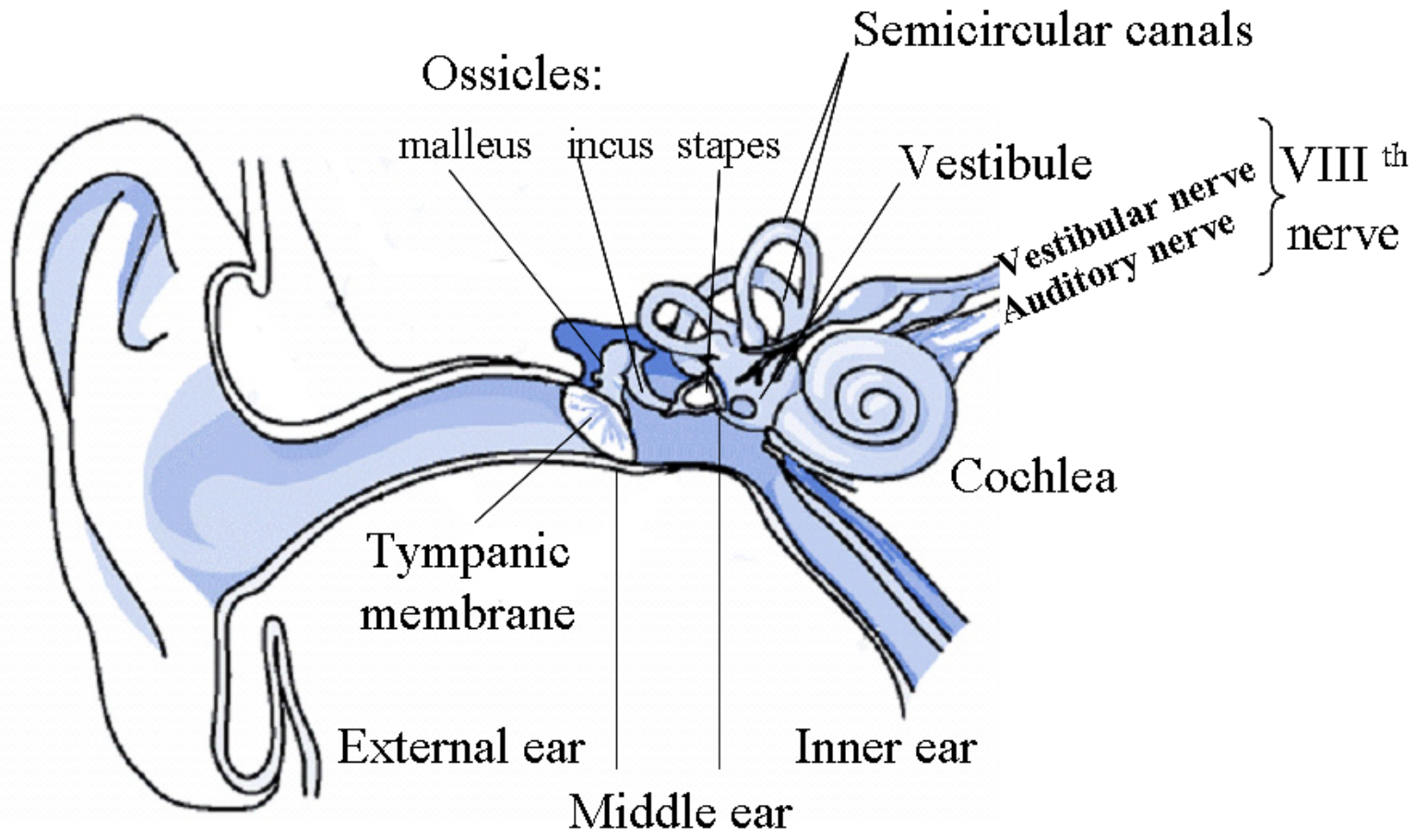

1000 Hz
18 mm
20 mm
15 mm
28 mm
500 Hz
2000 Hz
30 mm
25 mm
250 Hz
5 mm
8000 Hz
10 mm
4000 Hz

Schematic Section Of Human Ear



Label for Ototoxic compounds

New NIOSH/OSHA Guidance on Ototoxicity Posted

- "There is growing concern among occupational health and safety professionals that ototoxicant-induced hearing loss may go unrecognized since the measure for hearing loss does not indicate the cause," the document states.
- "For example, audiometric tests are powerful tools that show hearing impairments (i.e., threshold shifts); however, they do not differentiate between noise and ototoxic causes."
- Mar 20, 2018

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New NIOSH/OSHA Guidance on Ototoxicity Posted

A document posted by NIOSH on March 15 and credited both to NIOSH and OSHA offers guidance for preventing hearing loss that is caused by ototoxic chemicals and noise exposure. DHHS (NIOSH) Publication Number 2018-124 lists five examples of substance classes of ototoxic chemicals:

- Pharmaceuticals
- Solvents
- Asphyxiants
- Nitriles
- Metals and compounds

Substance Class	Ototoxic Chemicals
Pharmaceuticals ***Ototoxicity at therapeutic doses is limited**	Aminoglycosidic antibiotics (e.g. streptomycin, gentamycin) and some other antibiotics (e.g. tetracyclines), Loop diuretics* (e.g. furosemide, ethacrynic acid) Certain analgesics* and antipyretics* (salicylates, quinine, chloroquine) Certain antineoplastic agents (e.g. cisplatin, carboplatin, bleomycin)
Solvents	Carbon disulfide, n-hexane, toluene, p-xylene, ethylbenzene, n-propylbenzene, styrene and methylstyrene, trichloroethylene.
Asphyxiants	Carbon monoxide, hydrogen cyanide and its salts
Nitriles	3-Butenenitrile, cis-2-pentenenitrile, acrylonitrile, cis-crotononitrile, 3,3'-iminodipropionitrile.
Metals and Compounds	Mercury compounds, germanium dioxide, organic tin compounds, lead.

Hearing Loss vs. Hearing Impairment

Hearing Loss

A neurological event in which, due to noise exposures, damages the nerve hairs within the cochlea, affecting hearing in the various frequencies. The audiogram shows hearing loss in each frequency. Not all hearing loss is occupational; i.e. age-related losses, medical losses, non-occupational losses, medicine and chemical losses, trauma, etc. Hearing losses reported in dBs.

Hearing Impairment

A state statutory calculation of a claimants hearing impairment, based on the audiometric testing results and the impairment formulas. Impairment percentages guide claims as to compensation if work-related. Hearing Impairment reported in percentages.

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Noise Induced Hearing Loss & Impairment

Two Basic Objectives:

1. To determine if claimant has hearing impairment and if so, to what degree;
2. If there is, impairment, is it work-related?

Tools Used:

1. Audiogram, preferably audiogram history
2. State Statutes for Hearing Impairment and Related Provisions:
3. Claimant Data: Work History – Job function – Products Manufactured - Noise exposure data – Medical information, if provided – Age Info. - Exposure period – Critical dates: i.e. date hired, claim filing date, date retired, audiometric test date, hobbies, medical considerations, etc.

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Noise Inducted Hearing Loss & Impairment

Issues Addressed:

1. Impairment Percentage
2. Calculation of Age-Adjusted Impairment from Presbycusis – note as to whether permitted in the claimants state
3. Calculation of the Whole Person Impairment (WPI), based on claimant's hearing impairment percentage
4. Apportionment – if there was hearing loss prior to their employment with the insured, can his losses/impairment be apportioned between employers. Need baseline audiogram

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Noise Inducted Hearing Loss & Impairment (cont'd)

Issues Addressed:

5. Statute of Limitation – Each state has their own SOL, which would bar the claim if applicable
6. Work-Relationship: Consider a). sufficiency of audiometric testing process, b). workplace noise exposure potential, including the use of hearing protection, c). audiometric hearing loss pattern
7. Opinion; End result, render an opinion on the claimant's hearing impairment and related legal issues and advise claims' representatives of the merits of the claim

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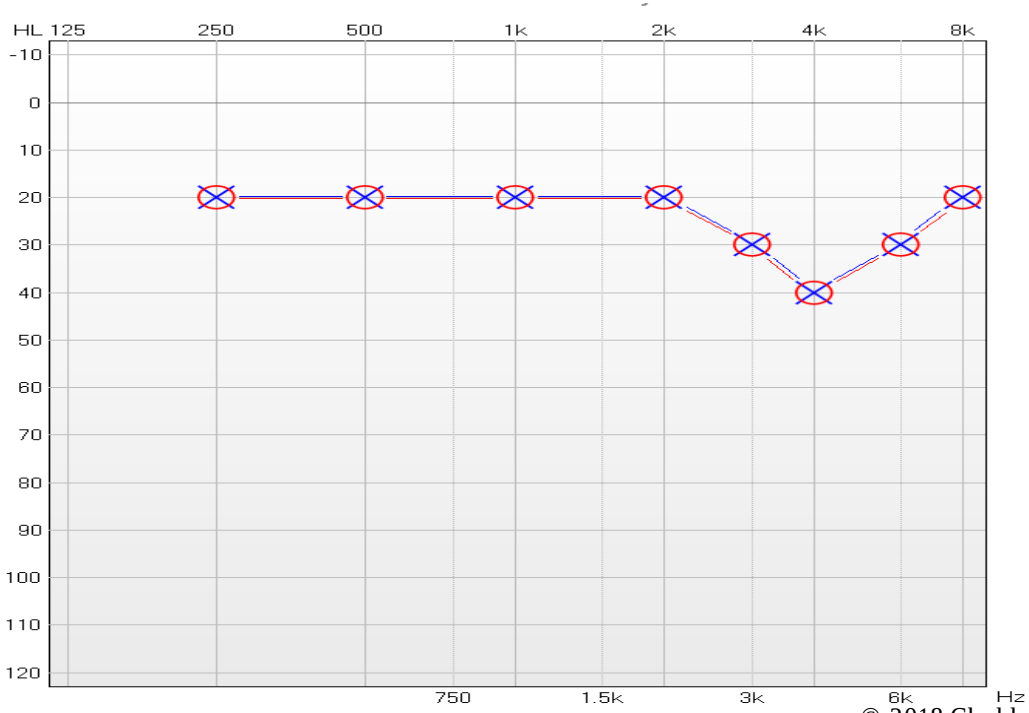
Noise Induced Hearing Loss

- A loud noise has caused damage to the hearing organ, the cochlea. This most commonly occurs at 4KHz. Therefore if a hearing loss is noise induced you would expect that
- The sounds have to be made louder before they are heard at 4KHz than at any other frequency. This leads to a dip in the graph as seen below and is referred to as the characteristic 4K notch.



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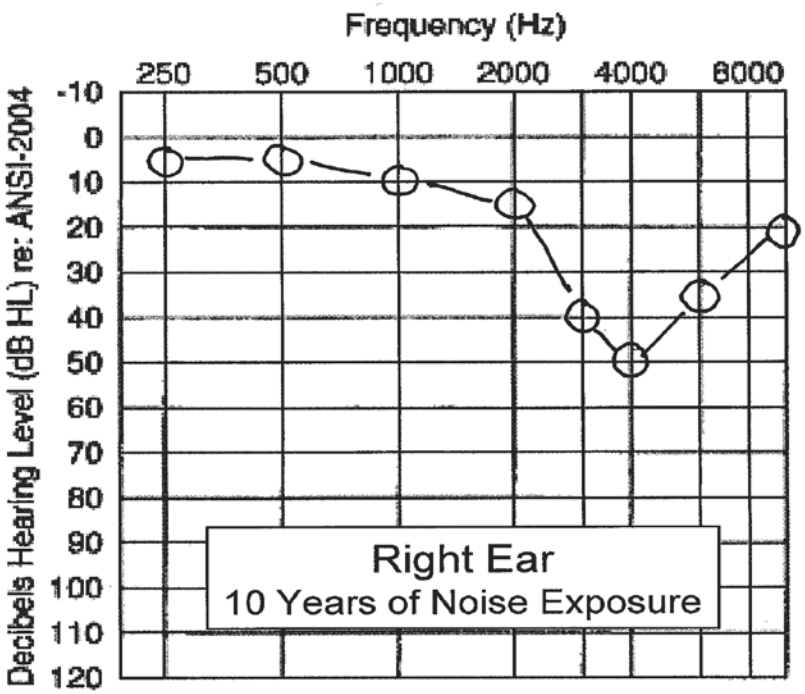
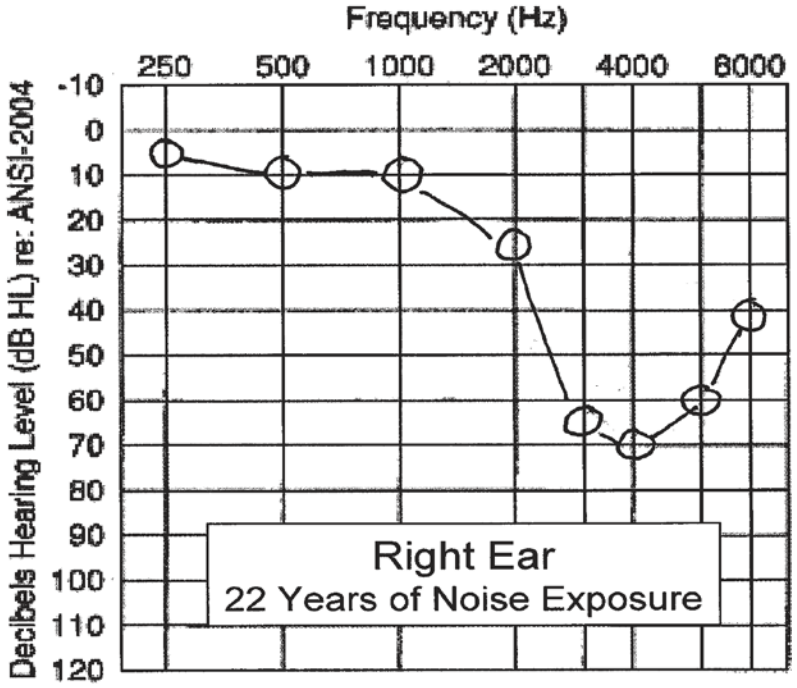
Noise Induced Hearing Loss Progression

- After 12 years of noise exposure for a carpenter, note how the 4K notch has deepened and how losses in higher frequencies have increased. Losses in the speech frequencies have not been as impacted. His losses are greater than his impairment.





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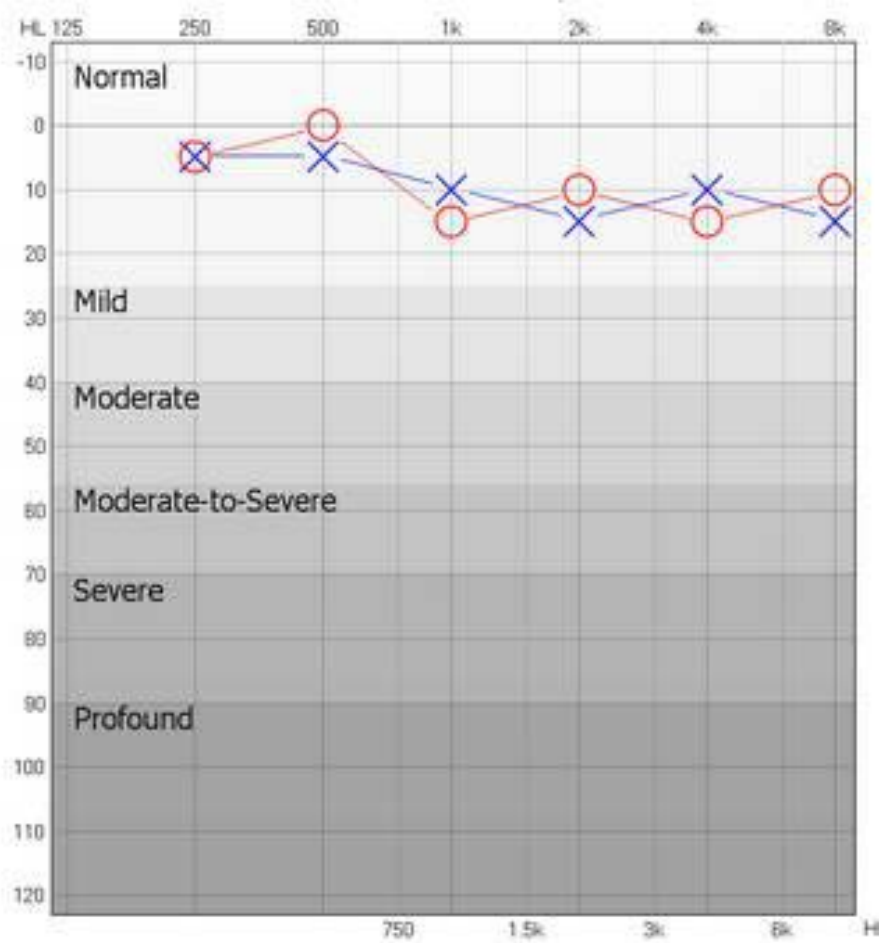
Normal Hearing: Frequency vs. Losses in dB



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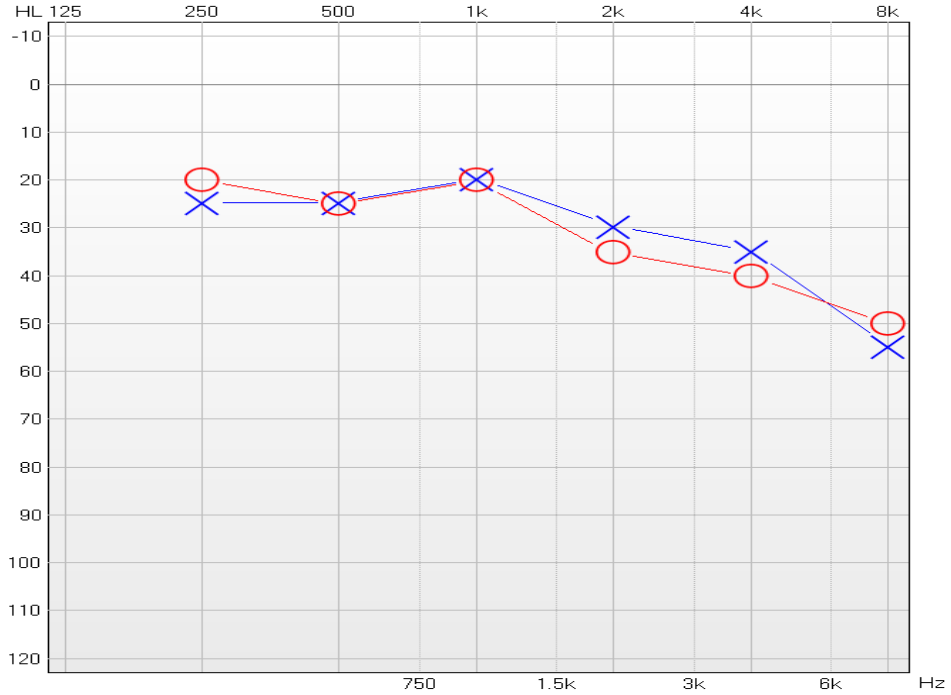
Symmetrical Hearing Loss

- Hearing loss is roughly the same in both ears. We consider a hearing loss to be symmetrical if the points for each ear occur within 10dB of each other. The red circles show the thresholds for the right ear, whilst the blue crosses show the thresholds for the left ear.
- When there is occupational hearing loss, it commonly occurs at equal rates and is termed Bilateral.



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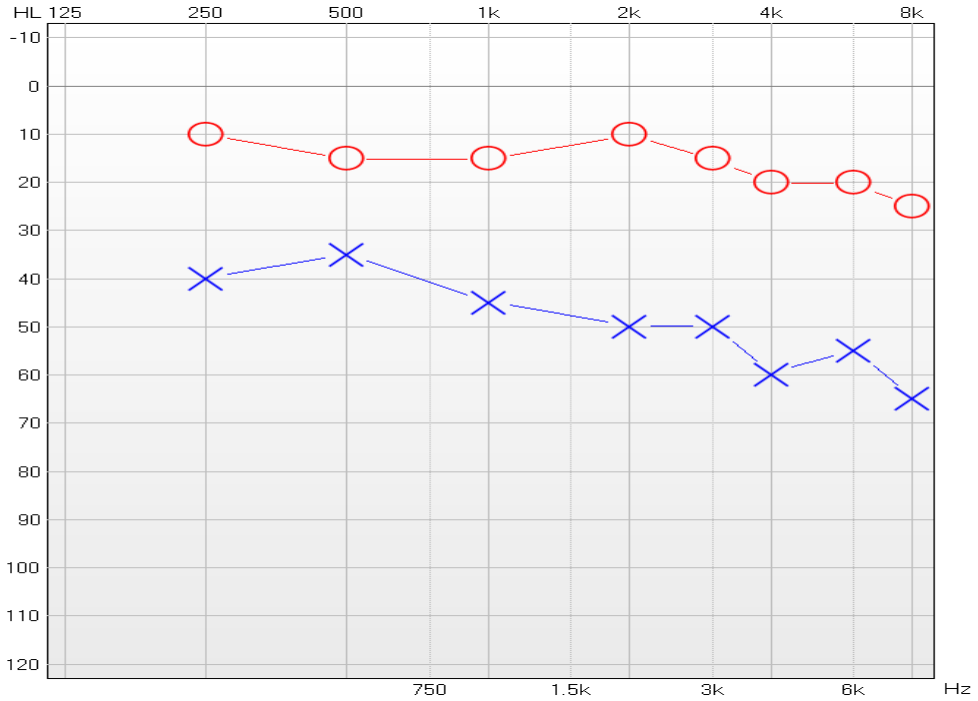
Asymmetrical Hearing Loss

- Hearing is different in each ear.
- On the audiogram below the right ear is mostly within normal limits, whilst the left ear has a mild to moderate hearing loss across the frequencies. This is also referred to as **unilateral hearing loss** and is inconsistent with occupational noise exposures.



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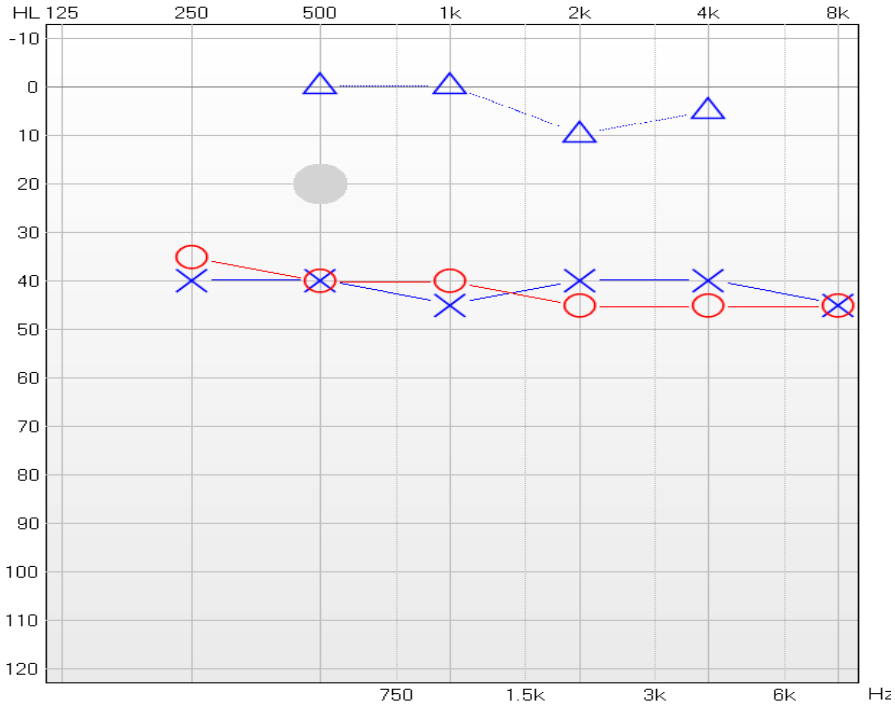
Bone Conduction and Conductive Hearing Loss

- Triangles on this audiogram indicate the **bone conduction thresholds**.
- Bone Conduction Testing required for this analysis.



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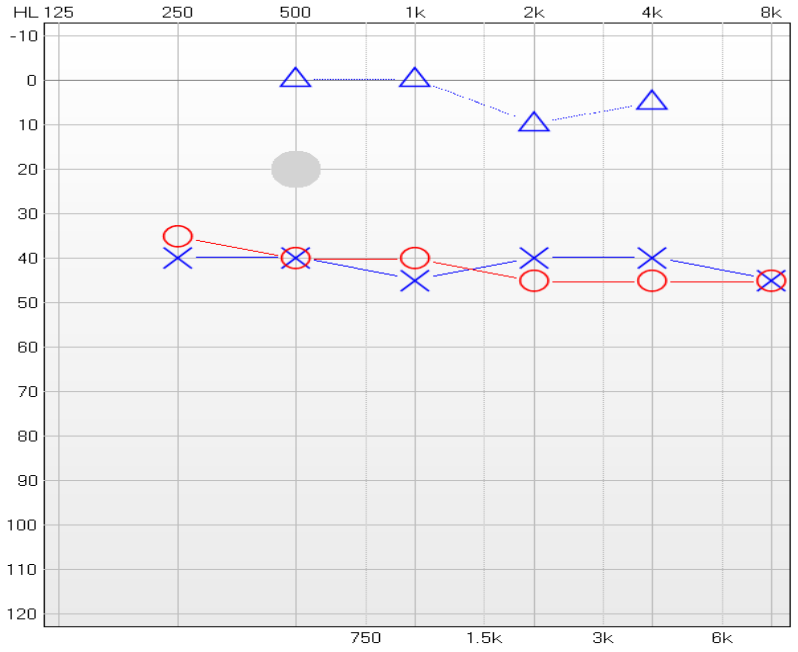
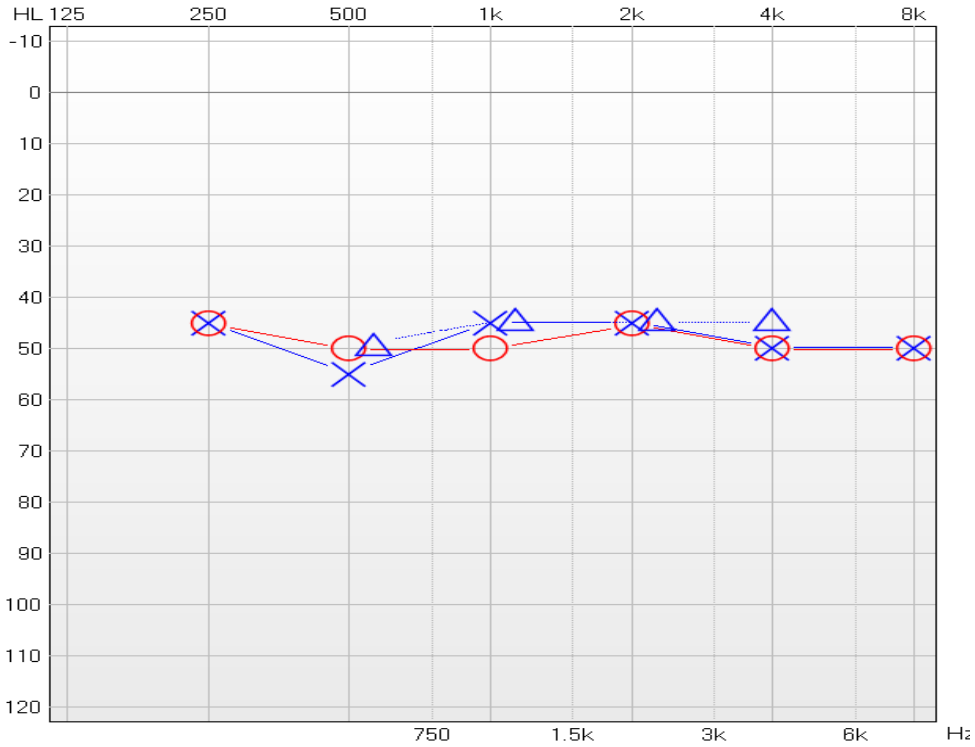
Bone Conduction and Conductive Hearing Loss

- To test: place a headband behind the ear, which stimulates the cochlear directly without going through the middle ear.
  - If there is a gap between the bone conduction thresholds, which are within normal limits, and the air conduction thresholds (tested using the headphones) it indicates there may be a problem in the middle ear (the area between the ear drum and cochlear).
  - This is called a conductive hearing loss and is rarely occupational in origin.



Sensorineural Hearing Loss

- When there is no difference between the air conduction and the bone conduction thresholds it indicates that the hearing loss is due to a problem in the cochlea. This is the most common type of hearing loss in adults and is known as a **sensorineural hearing loss**. This is almost always noise induced and may be occupationally in origin.



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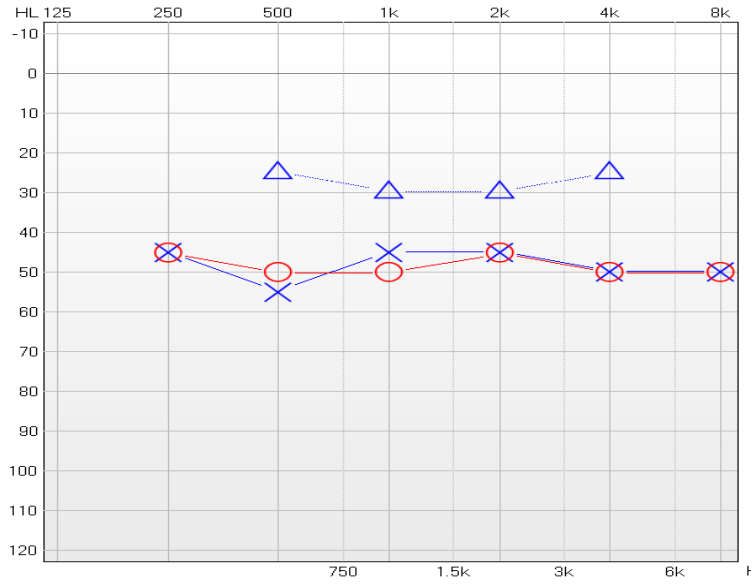
Mixed Hearing Loss

This audiogram shows a gap between the air conduction and the bone conduction thresholds, however the bone conduction thresholds still indicate a hearing loss as they are not within normal limits. This would suggest that there is a problem in both the cochlear and the middle ear, and is what is known as a **mixed hearing loss**. This could have a noise induced losses and conductive losses, partially occupational in origin.



Two Most Common Types of Hearing Loss Evaluated for ODIs

Sensorineural Loss

- Refers to a problem located in the inner ear or along the nerve pathway between the inner ear and the brain. This type of loss may be caused by aging, infection or other disease, noise exposure, or it may be related to a genetic disorder. Such a loss is usually permanent and not treatable by medical or surgical intervention. Noise induced and possibly occupationally related. (Bone Conduction Tests)

Conductive Loss

Refers to a decrease in sound caused by a problem in the outer or middle ear. Such a loss indicates normal inner ear activity. Possible causes of a conductive loss may be: wax in the ear canal, a perforation in the eardrum, or fluid in the middle ear. This type of loss is usually treatable with either medical or surgical intervention. Often seen when individual has annual test and does not ears cleaned and/or examined. Not occupationally related.

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Disorders of the Outer Ear

- Collapsing Ear Canal – Usually greatest loss in the higher frequencies
- Impacted Cerumen – Temporary Conductive Hearing Loss
- External Otitis – usually does not cause a hearing loss unless excessive swelling
- Tumors of External Ear Canal
- Perforated Tympanic Membrane

Disorders of the Middle Ear

Most show signs of a conductive hearing loss

- Otosclerosis – best understood mechanism is fixation of the stapes to the oval window
- Otitis Media – Usually loss of 20-30 db
- Negative middle ear pressure
- Cholesteatoma
- Tympanosclerosis
- Ossicular Disarticulation

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Disorders of the Inner Ear

Typically Sensorineural hearing loss

- Presbycusis – gradually sloping downward pattern
- Noise induced Hearing Loss (4 K notch)
- Otitis Interna
- Meniere's Disease
- Viral and Bacterial Infecitons
  - Syphilis
  - Rubella
  - Toxoplasmosis
  - Cytomegalovirus
  - Herpes Simplex Virus

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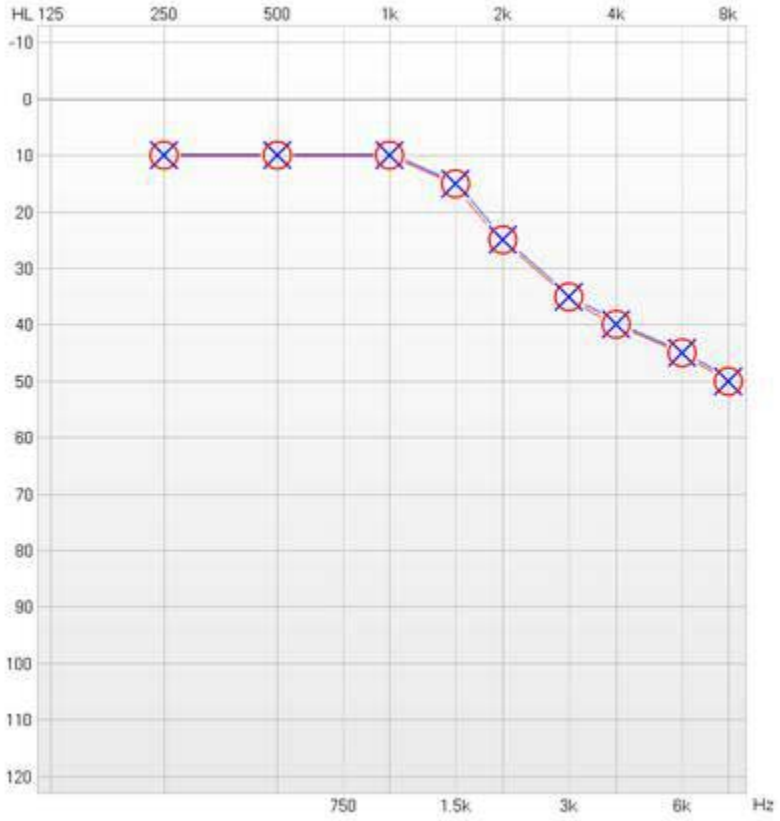
Presbycusis

- **Presbycusis** is an age related hearing loss. It usually affects the high frequencies more than the low frequencies. The general pattern is likely to be similar for all presbycusis hearing losses. A right hand sloping hearing loss with the left and right ear usually deteriorating at equal rates.



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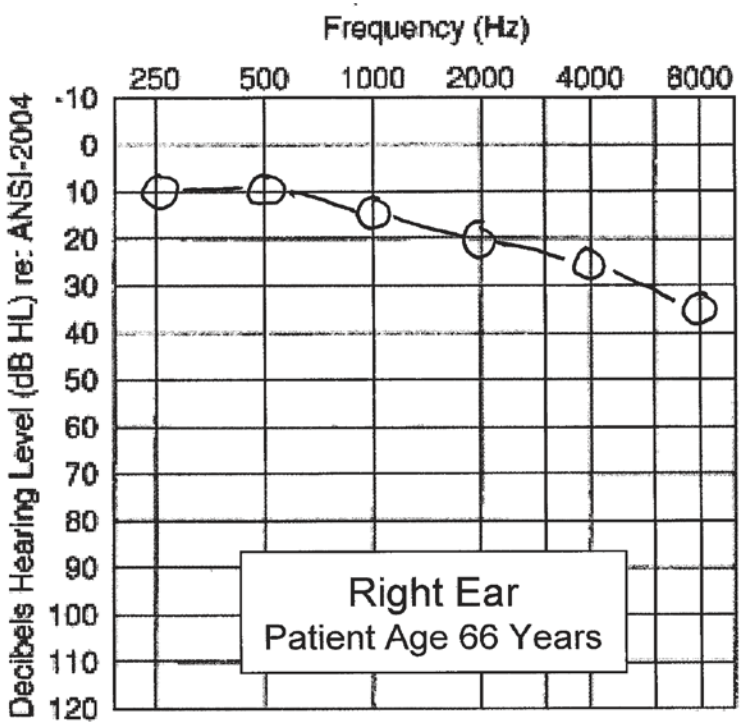
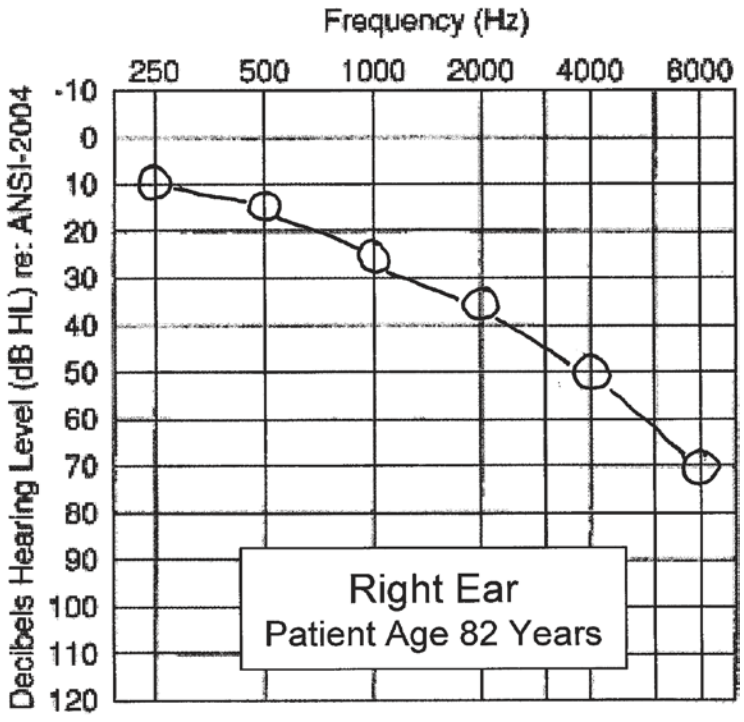
Presbycusis Ages 66 & 82





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Tinnitus

- American Tinnitus Association (www.ata.org)
  - Not a disease in and of itself, by a symptom of some other underlying health condition
    - Tinnitus is the perception of sound when no actual external noise is present. While it is commonly referred to as “ringing in the ears,” tinnitus can manifest many different perceptions of sound, including buzzing, hissing, whistling, swooshing, and clicking. In some rare cases, tinnitus patients report hearing music. Tinnitus can be both an acute (temporary) condition or a chronic (ongoing) health malady.
    - Caused by hearing loss, trauma, temporomandibular joint disorder, obstruction in the middle ear, sinus pressure and Barometric Trauma, Traumatic Brain Injury, Ototoxic drugs, etc.

Handicap Equations

Formula	Frequencies (Hz)	Low Fence (dB)	High Fence (dB)	Better Ear Ratio
AAO 1979	500, 1000, 2000, 3000	25	92	5 : 1
AAOO 1959	500, 1000, 2000	25	92	5 : 1
NIOSH-FECA 1972	1000, 2000, 3000	25	92	5 : 1
British Society of Audiology	500, 1000, 2000, 4000	25	92	5 : 1
Wisconsin (CHABA)	1000, 2000, 3000	25	92	4 : 1
Oregon	500, 1000, 2000, 4000, 6000	25	92	5 : 1
Ireland	500, 1000, 2000, 4000	20	100	4 : 1

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Hearing Loss Statutes

TABLE 18.1
Hearing loss statutes in the United States and Canada.

Jurisdiction	1. Is occupational hearing loss compensable?	2. Is minimum noise exposure required for filing?	3. Schedule in weeks (one ear).	4. Schedule in weeks (both ears).	5. Maximum compensation (one ear).	6. Maximum compensation (both ears).	7. Hearing impairment formula.	8. Waiting period.	9. Is deduction made for presbycusis?	10. Is award made for tinnitus?	11. Provision for hearing aid?	12. Credit for improvement with hearing aid?	13. Is hearing loss prior to employment considered in compensation claim?	14. Statute of limitations for hearing-loss claim.	15. Penalty for not wearing hearing protection devices?	16. Self-assessment of hearing impairment considered in rating/award?	Comments
Alabama	Yes	No	53	163	$11,660	$35,860	ME	No	No	Yes-I	Yes	No	Yes	2 yrs.	Yes-D	Poss	
Alaska	Yes	No	*	*	*	*	AAO-79	No	No	Yes-I	Yes	No*	No*	2 yrs.	No	No	**3-6:** awards based on temporary disability and permanent partial impairment according to AMA guidelines; **12:** unless hearing aid enables worker to return to work; **13:** as long as there has been substantial aggravation at work.
Arizona	Yes	No	86	260	$23,100	$69,300	ME	No	No	Yes-I	Yes	No	Yes	1 yr.	No	No	
Arkansas	Yes	No	42	158	$11,296	$42,502	AAO-79	No	Poss	No	Poss	No	Yes	Yes*	No	No	**14:** statute of limitations and other hearing loss issues currently before Board of Appeals.
California	Yes	No	50*	311*	$8,040*	$58,863*	AAO-79	No	No	Yes	Yes	Yes	Yes	1 yr.	Yes-P	Yes	**3-6:** awards modified by age and occupation at time of injury.
Colorado	Yes	No	35	139	$5,250	$20,850	AAO-79	No	Yes	Yes	Yes	No	Yes	Yes	Yes-P	No	
Connecticut	Yes	No	35	104	*	*	ME*	3 days	Poss	Poss	Poss	Poss	Poss	1 yr.	Yes-P	Poss	**5-6:** no maximum reported—award is number of weeks scheduled benefit at claimant's compensation rate; **7:** case law has supported AAO-79.
Delaware	Yes	No	75	175	$30,833	$71,944	ME	No	No	No	Yes	Yes	No	2 yrs.	No	No	
District of Columbia	Yes	No	39	150	$34,880	$134,170	AAO-79	6 mo.	Poss	Poss	Poss	Poss	Poss	1 yr.	Poss	Poss	
Florida	Yes	No	18	105	$8,892	$51,870	AAO-79	No	No	Yes-I	Yes	No	Yes	2 yrs.	Yes-P	No	
Georgia	Yes*	Yes*	NA	150	NA	NR	AAOO-59	6 mos.	NR	No	NR	NR	Yes	NR	Yes-D	NR	**1:** no awards granted for monaural hearing loss unless pre-existing deafness in other ear; **2:** 90 dBA for 90 days.
Hawaii	Yes	Yes	52	200	$26,416	$101,600	AAOO-59	No	No	Yes	Yes	No	No	2 yrs.	No	No	

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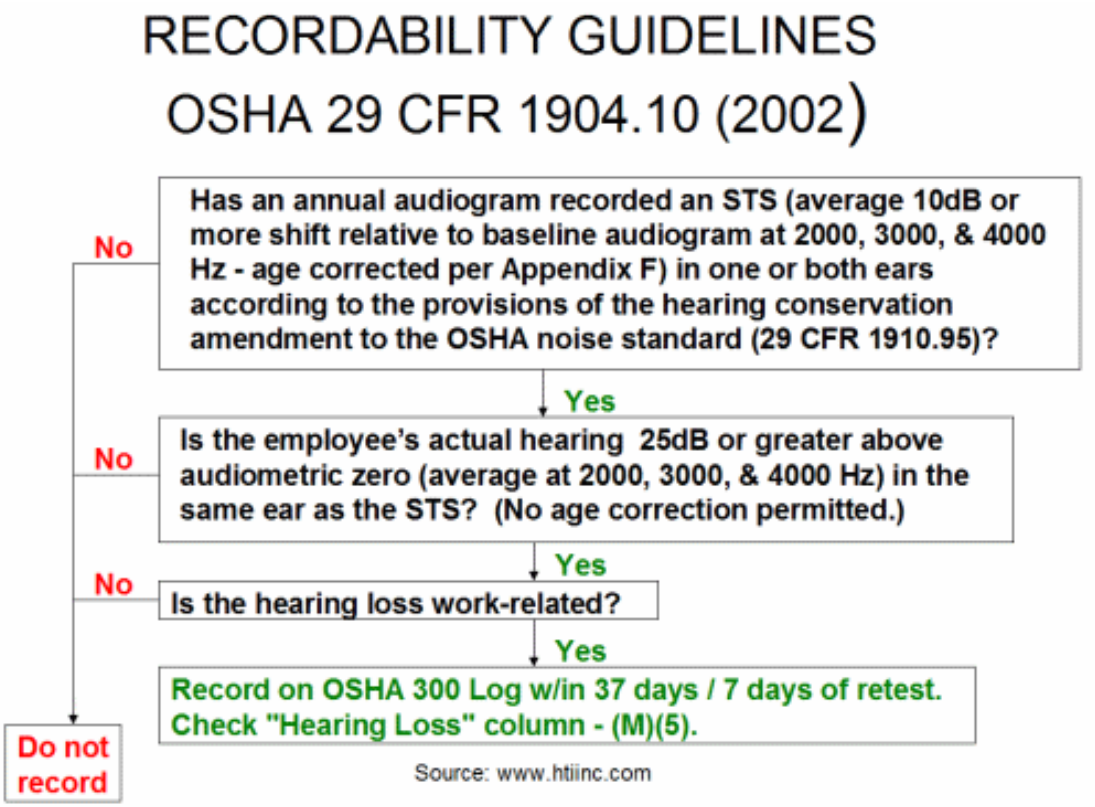
OSHA Regulations and Recordability

Significant Threshold Shift & OSHA Recordability



Determination of work-relationship must be from medical professional. For ODIs, we assess and advise as to that probability.

STS Calculation Example

An STS is calculated by comparing the annual audiogram to the baseline audiogram at 2,000, 3,000 and 4,000 Hz. If an average difference of 10dB or more has occurred at these frequencies, an STS has occurred.

Example 1:

Frequency Hz	Annual Audiogram	Baseline Audiogram	Annual - Baseline
2,000	5 dB	10 db	5 – 10 dB = -5 dB
3,000	20 dB	15 db	20 – 15 dB = 5 dB
4,000	30 dB	15 db	30 – 15 dB = 15 dB

The average change is equal to $\frac{-5 + 5 + 15}{3} = \frac{15}{3}$ = 5 dB. Therefore, an **STS has not occurred.**

Example 2:

Frequency Hz	Annual Audiogram	Baseline Audiogram	Annual - Baseline
2,000	10 dB	0 dB	10 – 0 = 10 dB
3,000	20 dB	5 dB	20 – 5 = 15 dB
4,000	25 dB	5 dB	25 – 5 = 20 dB

The average change is equal to $\frac{10 + 15 + 20}{3} = \frac{45}{3}$ = 15 dB. Therefore, an **STS has occurred.**

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Summary

- Hearing loss can occur from other sources besides Noise levels above 85 dba
- Use of TLV vs OSHA might allow for earlier intervention if needed
- Examination of the list of Ototoxic compounds and determine airborne concentrations would be good practice to reduce non noise hearing loss
- Consideration of implementing HCP with noise levels <85dB if ototoxic compounds detected at target concentrations
- Hazcomm training should include information on Ototoxic and medical causes of hearing loss
- Medical Questionnaires when performing audiometric testing should include list of medicines and other recreational chemicals known to be ototoxic