Exposure to physical hazards

Exposure To Noise

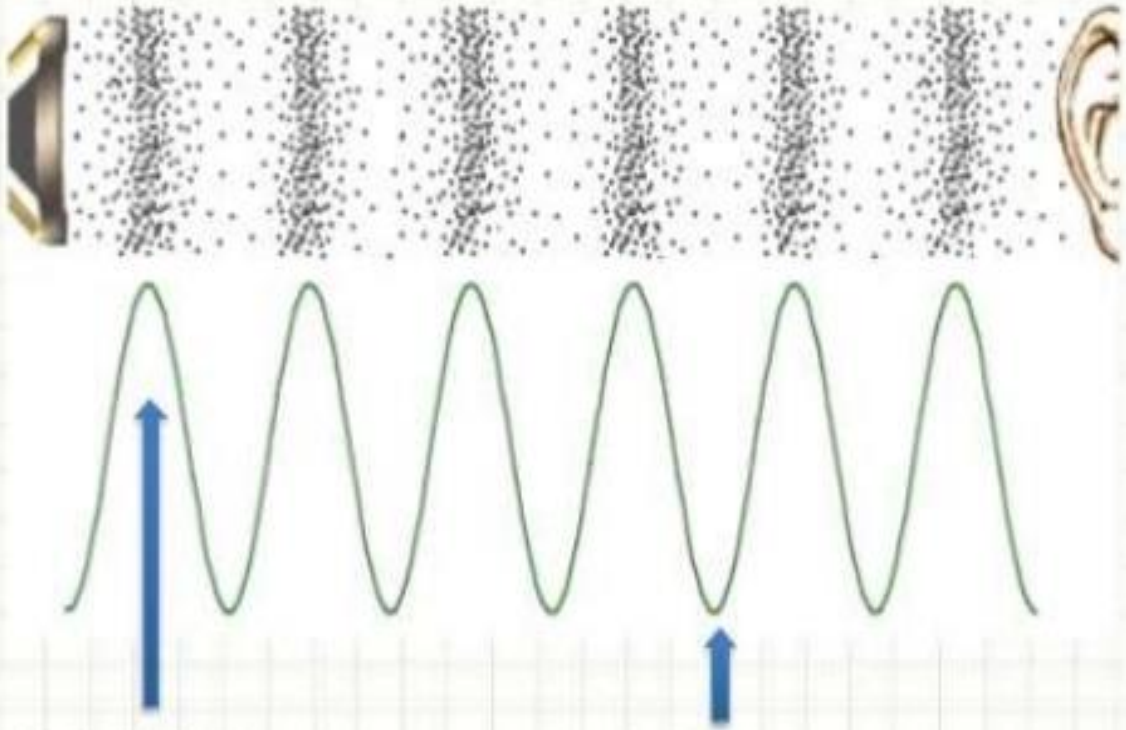
Noise:

Definition: Noise is any unwanted or undesirable sound.

- Auditory field lies between 20-20000 hertz (Hz) or cycles per second. If noise is below the lower level of normal hearing (below 20 Hz) it is called **infra sound** but if the noise above the upper limit of normal hearing (above 20 kHz) it is called **ultrasound.**
- Exposure to noise occurs in the following occupations:

1. - Weaving.
2. - Hammering of metals.
3. - Military exposure due to explosions and shooting.
4. - Building and construction.
5. - Aviation and submarines.

What does a sound wave look like?



General Class of Noise Exposure

There are three general classes into which occupational noise exposure may be grouped.

1. **Continuous noise:** Normally defined as broadband sound of approximately constant level to which an employee is exposed for a period of eight hours per day or 40 hours a week.

2. **Intermittent Noise:** This may be defined as exposure to a given broadband sound pressure level several times during a normal working day

3. **Impact (impulse) type Noise:** is a sharp burst of sound. A sophisticated instrumentation is necessary to determine the peak levels for this type of noise.

Effects of noise:

A) **Auditory effect:** hearing loss.

B) Non auditory effects:

The basis of these effects is grounded in the stress response to noise which lead to release of adrenocortical hormones and sympathomimetic mediators.

1- The heart rate increased and rise of blood pressure occurs.

2- The respiratory rate often increased.

3- Noise can affect the performance of psycho-motor tasks and decrease the work efficiency.

4- Deafness is associated with significantly higher rates of mental illness in the community .

5- Disturbance of sleep quality and quantity.

The severity of occupational deafness is related to:

1- The duration of exposure.

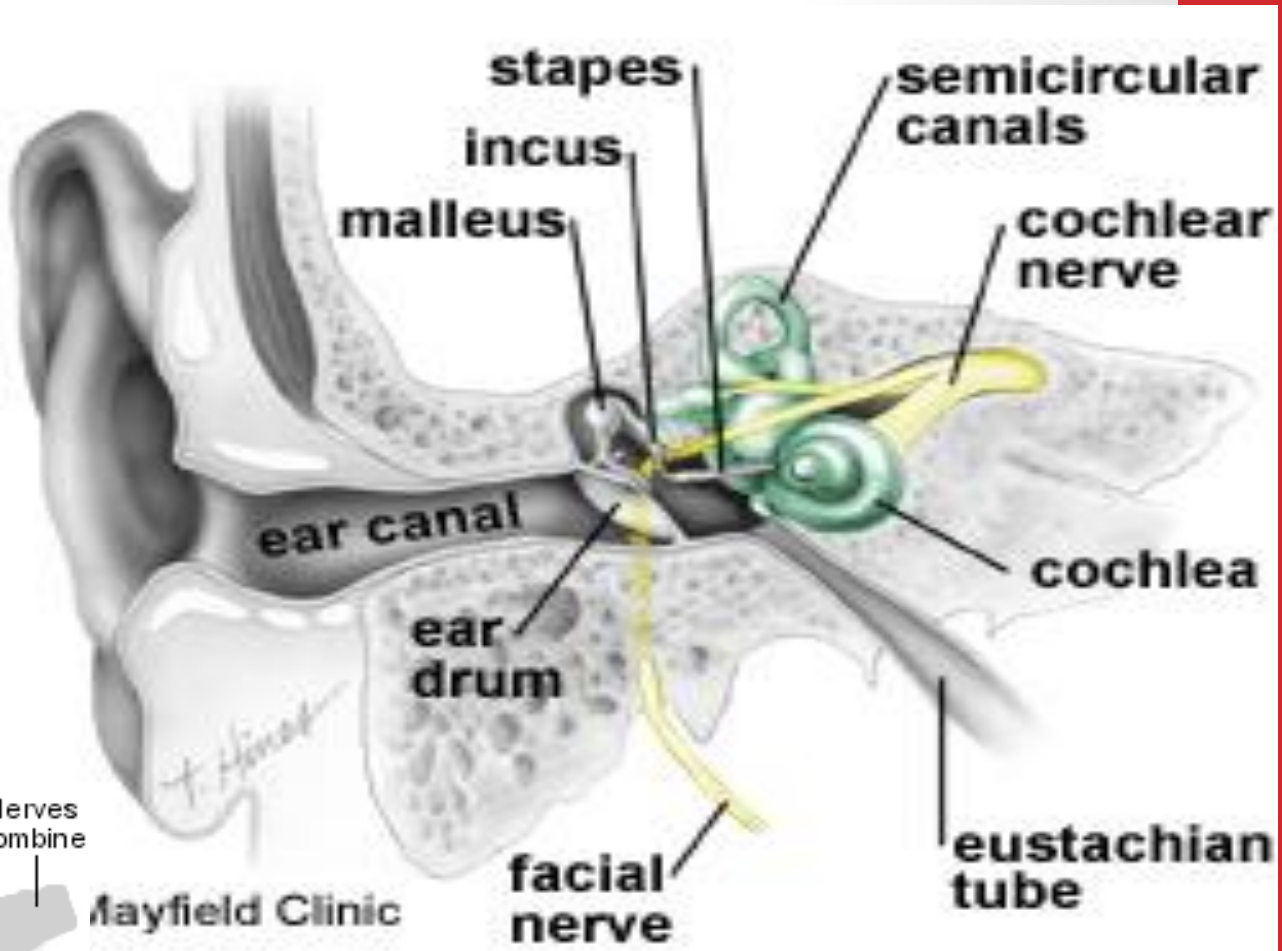
2- The intensity of the sound.

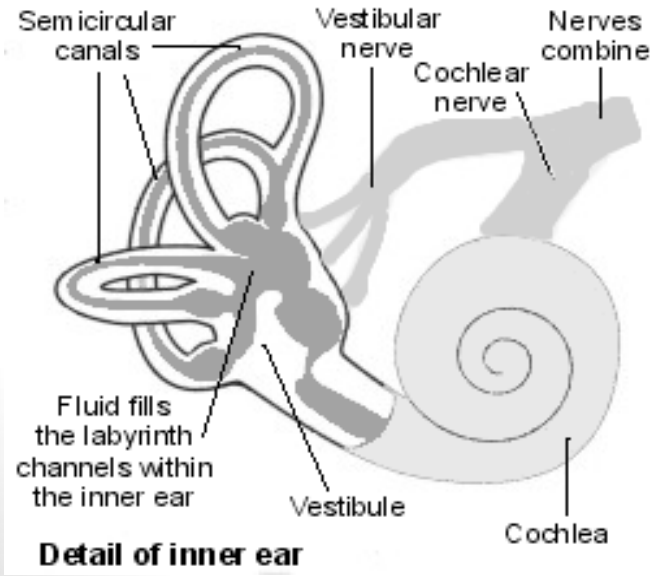
3- The frequency of sound waves.

4- The type of noise either continuous noise or impact noise which is more dangerous.

5- Personal susceptibility.

6- Individual age.





Detail of inner ear

Physiology and testing of hearing:

- Decibel scale is a logarithmic measurement of hearing which through standardization has defined normal hearing at 0 db.
- The human ear can detect sound **pressure variations** from the finest noise to powerful stimuli (roughly 0 – 120 dB).
- Frequency denotes **the number of waves passing a point in a second** and correlates subjectively with pitch.

- Human cochlea is capable of detecting and encoding sound waves across frequency range 20HZ – 20.000HZ.

- The most important range of human speech reception is between 500 – 3000 HZ and because isolated pure tone waves seldom occur in nature, the cochlea have the ability to analyze complex sound waves.

[A] NOISE INDUCED HEARING LOSS (NIHL)

1) May be acute secondary to loud impulse noise.

2) May be chronic due to long term repeated exposure to hazardous noise levels.

1-Acute Acoustic Trauma (AAT):

Noise level in the range of 140 – 160 dB in military service accounted for 45% of cases of AAT and about 1 in 4 have bilateral damage to both middle and inner ear.

- Signs and symptoms:

- Hearing loss, pain and tinnitus.

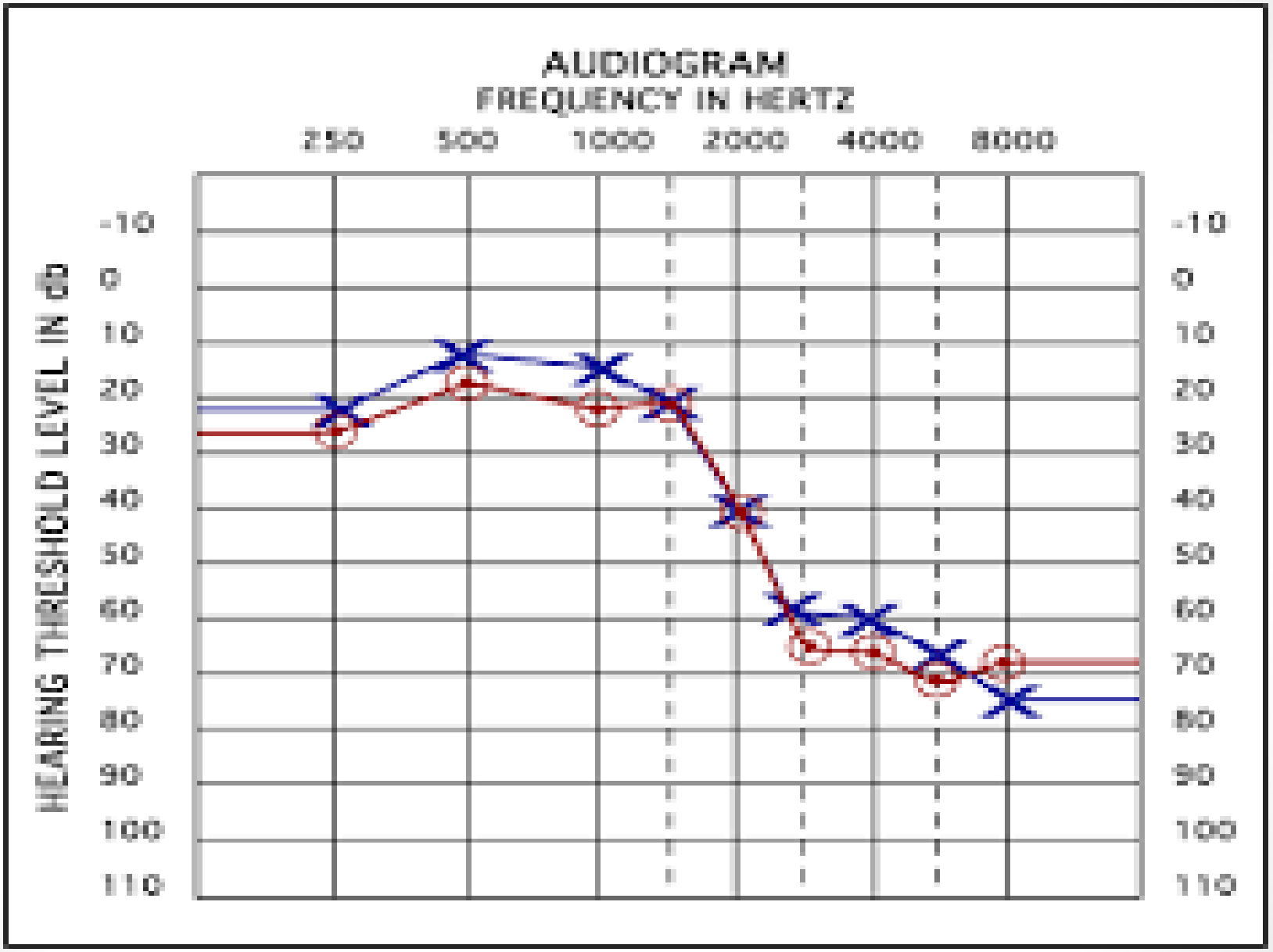
- Tinnitus may be the complaint and not the hearing loss.

On physical examination:

- The ear is usually normal unless the tympanic membrane is ruptured which occur in 30% of cases.
- Damage to the cochlea, vestibular system and ossicles of middle ear may also occur in 30% of cases.

Audiometric testing reflects:

- **Conductive hearing loss** 2ry to the rupture of the tympanic membrane, disruption of ossicles and mechanical damage to the oval window.
- **Sensorineural hearing loss** from cochlear hair cell disruption.
- Higher frequency pure tone hearing loss with frequencies between 4000 and 8000 HZ most affected.


AUDIOGRAM
FREQUENCY IN HERTZ
250
500
1000
2000
4000
8000
HEARING THRESHOLD LEVEL IN dB
-10
0
10
20
30
40
50
60
70
80
90
100
110

What is dB and frequency?

dB and frequency are terms to describe sound level and the number of cycles of a sound wave in one second

Frequency

The frequency of a sound is the number of cycles of a sound wave in one second. The unit of measurement is hertz (Hz). The frequency of a sound increases as the number of cycles per second increase.
Vibrations between 20 and 20,000 cycles per second are interpreted as sound by a normal healthy person. A high-pitched sound could be a piccolo flute or a bird singing. Low-pitched sounds could be thunder heard from far away or tones from a bass guitar.

DeciBel (dB)

The term dB (deciBel) and the dB scale are used world-wide for the **measurement of sound levels**. The deciBel scale is a logarithmic scale where a doubling of sound pressure corresponds to a 6 dB increase in level.

Here are some examples of different sound intensities as expressed in dB(HL):

180 dB: Rocket at take-off

140 dB: Jet engine at take-off

120 dB: Rock band

110 dB: Loud thunder

90 dB: City traffic

80 dB: Loud radio

60 dB: Ordinary conversation

30 dB: Soft whisper

0 dB: Softest sound a person can hear

Pure tone audiometry:

Threshold of hearing is expressed in dB with the normal range from 0-20 dB, at (250 – 500 – 1000 – 2000 – 3000 – 4000 – 8000HZ).

- When both bone and air conduction are decreased → this indicates Sensorineural hearing loss.
- When air conduction loss exceeds bone conduction loss (condition called air bone gap), this indicates conductive loss.

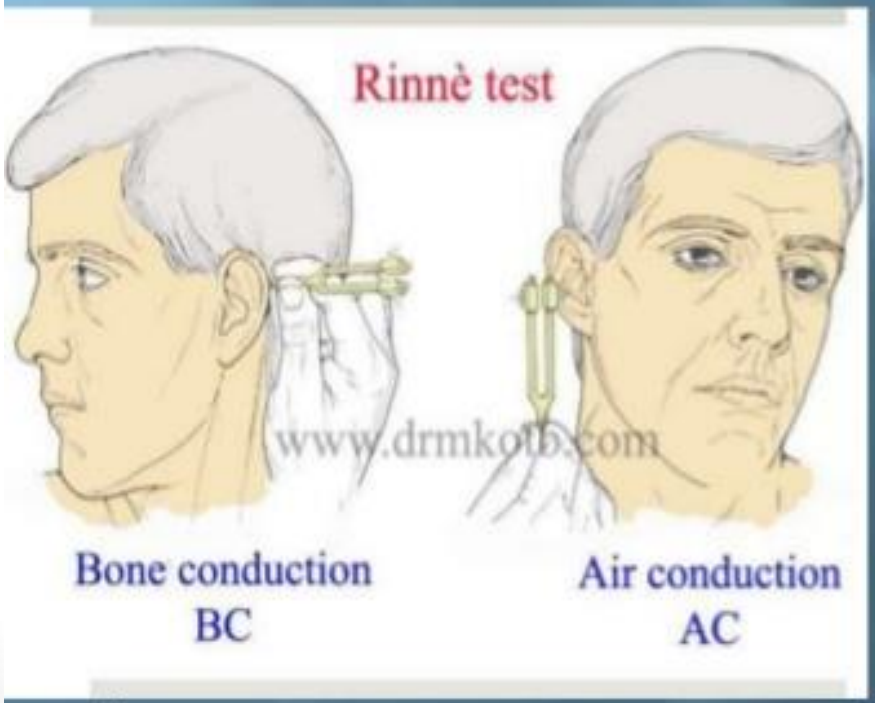
Tuning fork test:

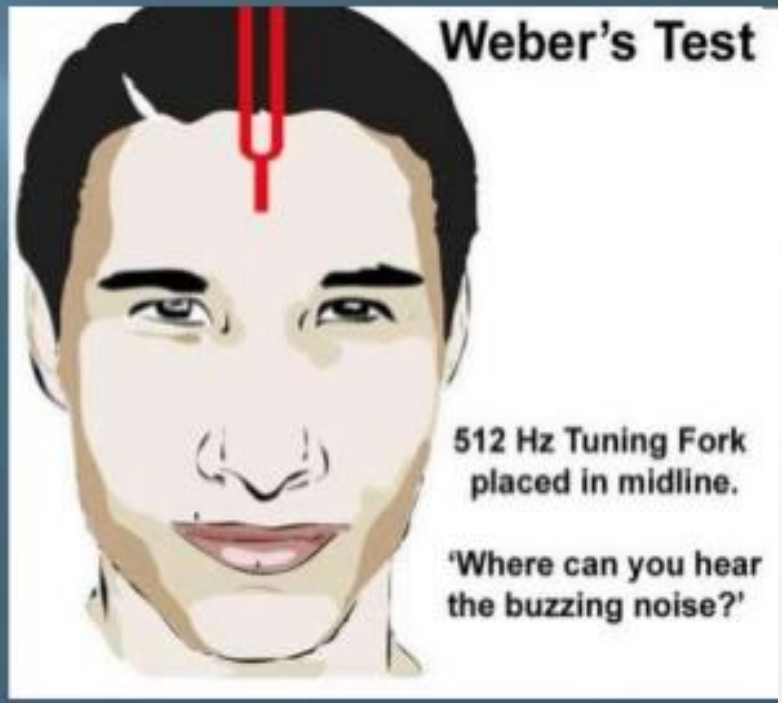
Using 512 HZ tuning fork since frequency below this level will elicit a tactile response.

- **Rinne' test:** Normally air conduction is better than bone conduction (the fork is put on the mastoid) if bone conduction is better than air conduction, this indicates conductive hearing loss.

- **Weber test** with the tuning fork over forehead or front of teeth, the sound lateralize toward the ear of conductive loss and away from a Sensorineural one.

Tuning Fork Test





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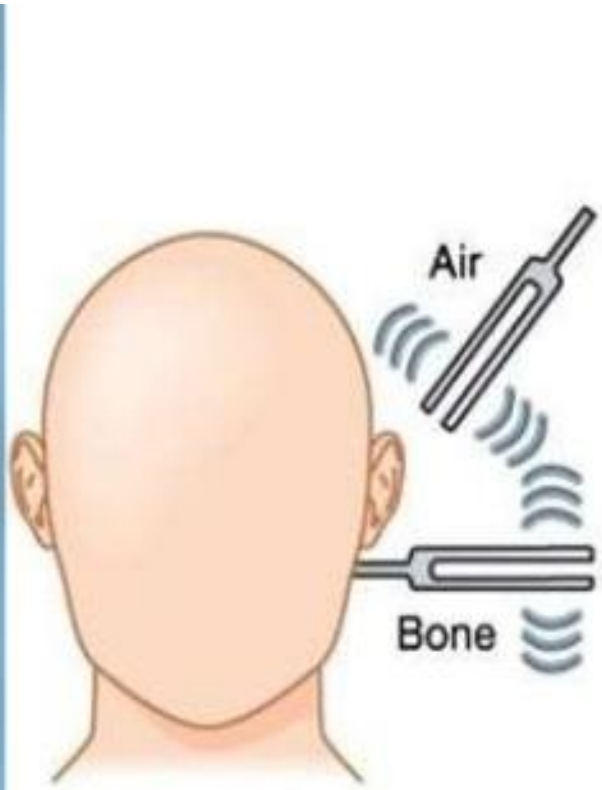
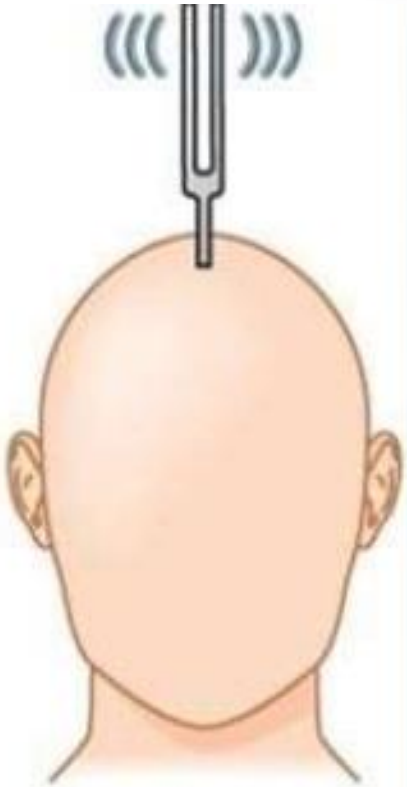


Rinne test



Weber test

Hearing loss	Rinne test (Conduction)	Weber test (Localization)
None	Air > bone	Midline
Sensorineural	Air > bone	Normal ear
Conductive	Bone > air	Affected ear

- The biological effect of impulse noise is different from continuous noise in that:

The inner ear in continuous noise is partially protected by the acoustic reflex triggered by noise > 90 dB, leading to contraction of the middle ear muscles (the stapedius and tensor tympani) and thus stiffen the conducting system and make it more resistant to sound entry.

- But in case of impulse noise it is delayed in onset depending on sound intensity for **a period of 0.5 - 1.5 Ms**. High intensity impulse noise (explosions) penetrates the cochlea before the reflex has been neurally activated.
- Therefore impact noise > 140 dB may cause immediate and irreversible hearing loss.

Prognosis and complications of AAT:

- Progression of hearing loss appears not to extend beyond a year and even if the audiometer results return to normal, permanent damage have been found in the sensory cells.
- Complications include:

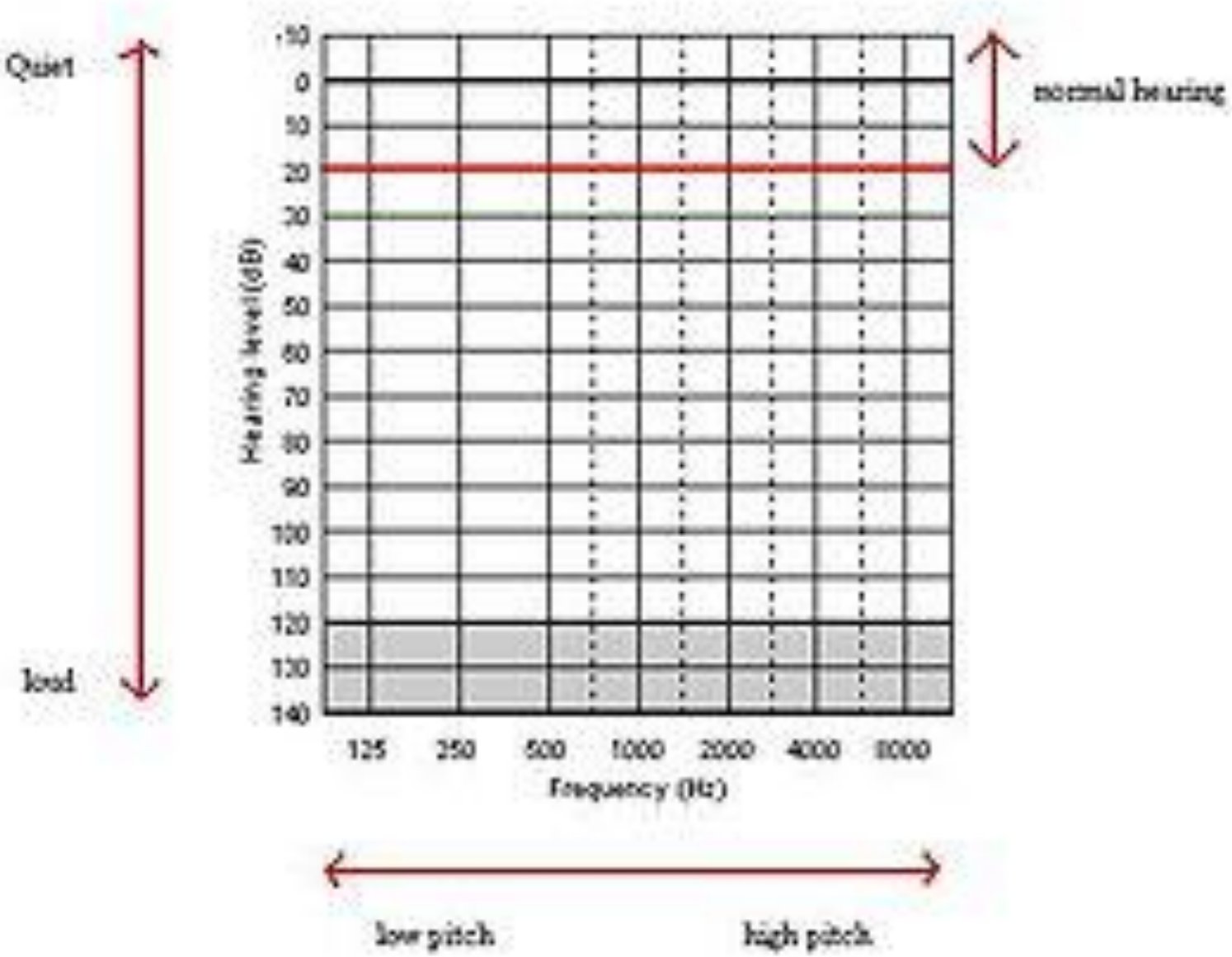
✓ Persistent perforation of tympanic membrane.

✓ Permanent hearing loss.

✓ **Cholesteatoma**.

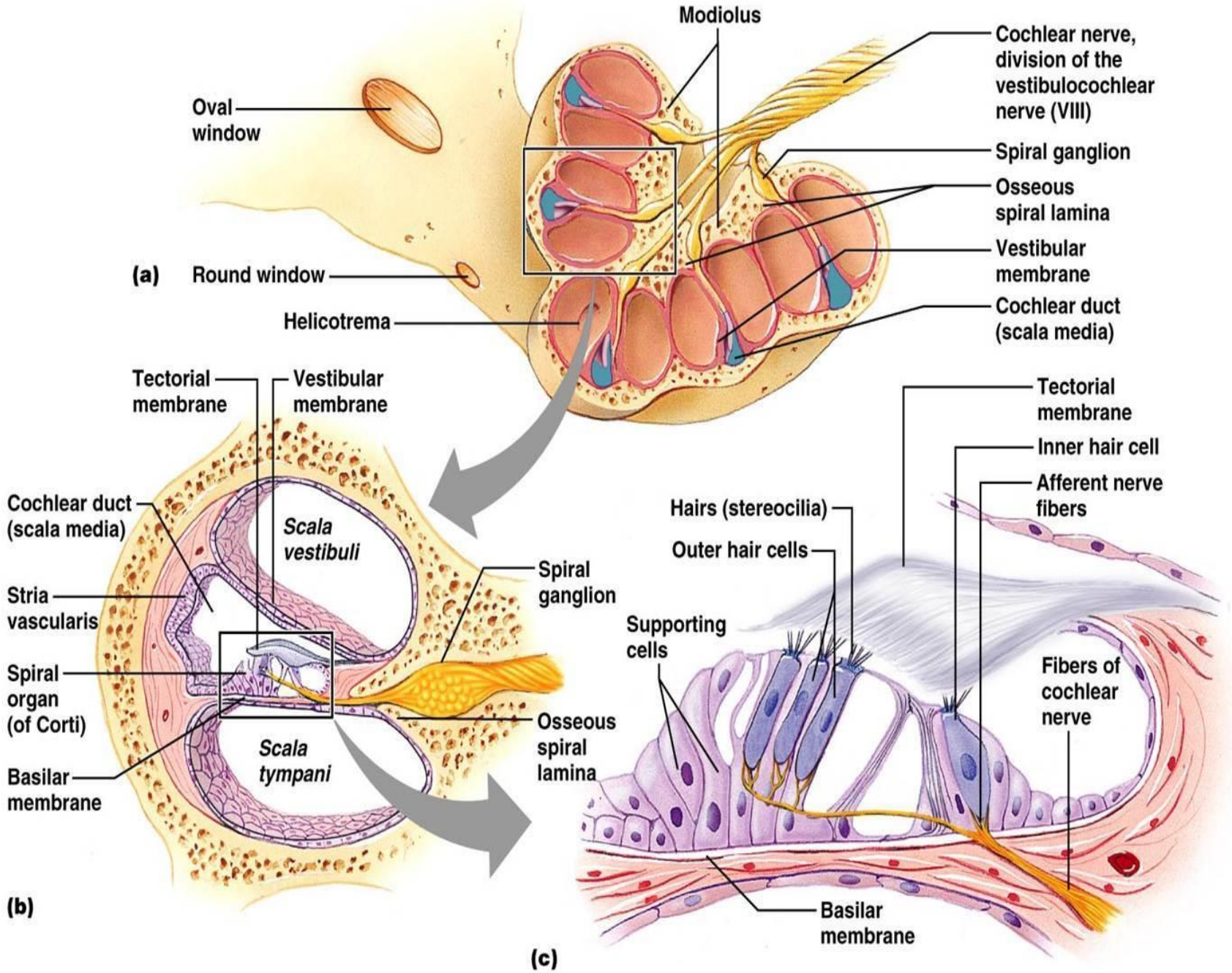
AUDIOGRAM


Left Ear ×
Right Ear ○
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
Normal Hearing
Mild Hearing Loss
Moderate Hearing Loss
Severe Hearing Loss
Profound Hearing Loss
Hearing Level in Decibels (dB)
125
250
500
1000
2000
4000
8000
Frequency in Hertz (Hz)


Quiet
loud
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Hearing level (dB)
normal hearing
125
250
500
1000
2000
4000
8000
Frequency (Hz)
low pitch
high pitch

2-Chronic noise induced hearing loss:

- Prolonged exposure to noise primarily damages the inner ear; especially the hair cells of the organ of corti, cochlear blood vessels, the striavascualris, the nerve endings associated with the hair cells are also damaged.
- Initially the basal turn of the cochlea are affected (the area responsible for perception of higher frequency sound).
- Eventually disruption of the medial and apical areas occurs as well.



Pathogenesis of NIHL:

repeated exposure to loud noise > 85 dB the following changes occur:

1. Cochlear cell bodies swell and ultimately hair cells are destroyed.
2. Capillary vasoconstriction in response to loud noise which causes disruption of blood supply to the basilar membrane and diminished O2 tension and local hypoxia in the cochlea.
3. Edema and swelling of the afferent nerve endings below the inner hair cells.
4. Eventually the organ of corti breaks down with separation of segment of sensory cells from the basilar membrane leading to elimination of the sensory structure and replacement by a single flat cell layer.
5. In fact these effects are due to **combination of mechanical, metabolic and vascular effects of the loud noise.**

❑Signs and symptoms:

1. People who suffer from Sensorineural hearing loss however don't usually recognize early changes on their ability to hear.
2. Early complaint of NIHL is difficulty in comprehending speech, especially in competing background noise which is usually of low frequency, **Since the maximum effect of NIHL occur in the high frequency sound perceived by basal turn of the cochlea (around 4000 HZ),** they hear vowel sound, better than consonant high pitched sound (e.g. of women and children) and thus women and children speech become less intelligible (the word fist may sound as fish).
3. NIHL is frequently accompanied by **vertigo and tinnitus** which become most bothersome in absent of ambient sound causing inability to sleep at night or concentrate in a quiet room.

- **Temporary threshold shift (TTS):**
  - Denotes slight and temporary decrease in hearing sensitivity due to reversible injury to the hair cells.

- **Permanent threshold shift (PTT):**
  - Permanent damage to the hair cell either due to brief exposure to high intensity sound or due to cumulative effect of long term exposure to noise.

Sensorineural NIHL

Temporary Threshold Shift 'TTS'

Short term exposure to noise

- Hearing returns when away from the noise

Permanent Threshold Shift 'PTS'

Exposure to a moderate or high level of noise over a long period of time

- Hearing loss is PERMANENT

- **Impairment:** any loss or abnormality of psychological, physiological or anatomical structure or function.

- **Disability:** any restriction or lack of ability to perform an activity in the manner or within the range considered normal for a human being. (resulting from an impairment)

- **Handicap:** a disadvantage for a given individual that limits or prevents the fulfillment of a role that is normal

- **Impairment** refers to a problem with a structure or organ of the body; **Disability** is a functional limitation with regard to a particular activity;
and **Handicap** refers to a disadvantage in filling a role in life relative to a peer group.

Determination of hearing impairment:

- In evaluating hearing impaired person pure tone audiometric testing is important. During the test, tone levels are increased in volume until the person recognizes the sound. The dB reading at this time is recorded and represent hearing threshold at that frequency. **Threshold levels above 25dB are abnormal.**
- **Hearing handicaps** are usually noticed when the threshold hearing level in important speech frequencies (**500 – 3000 HZ) average > 25dB.**
- **Hearing impairment** is considered when either of the following 2 factors are present:

- 40 dB loss in both ears at either 1000 or 2000 HZ.
- 40dB loss in one ear at both 1000 & 2000 HZ frequencies.

- **Hearing conservation programs (HCP)**

- They are required where workers are exposed to levels > 85dB.
- The fundamentals of the HCP include:

1. - Noise level assessment.
2. - Noise control measures.
3. - Audiometric monitoring.
4. - Hearing protection devices.
5. - Education and training.

1) Noise level assessment and noise control measures:

- Ambient noise levels are assessed by sound level meter or noise dosimeter.
- TWA8 dBA is the permissible daily exposure to noise which is 90 dBA with an exchange rate of 5 dB for every doubling or halving of the exposure time (e.g. workers would be permitted only 4 hour exposure to noise at 95 dB and 2 hours only at 100 dB).

Noise Measuring Equipment

Sound Level Meters (SLM)

Continuous on-mobile sources

Determine loudness (dB) of noise at any given moment

Personal Dosimeters

Mobile/variable noise sources

Worn by employees

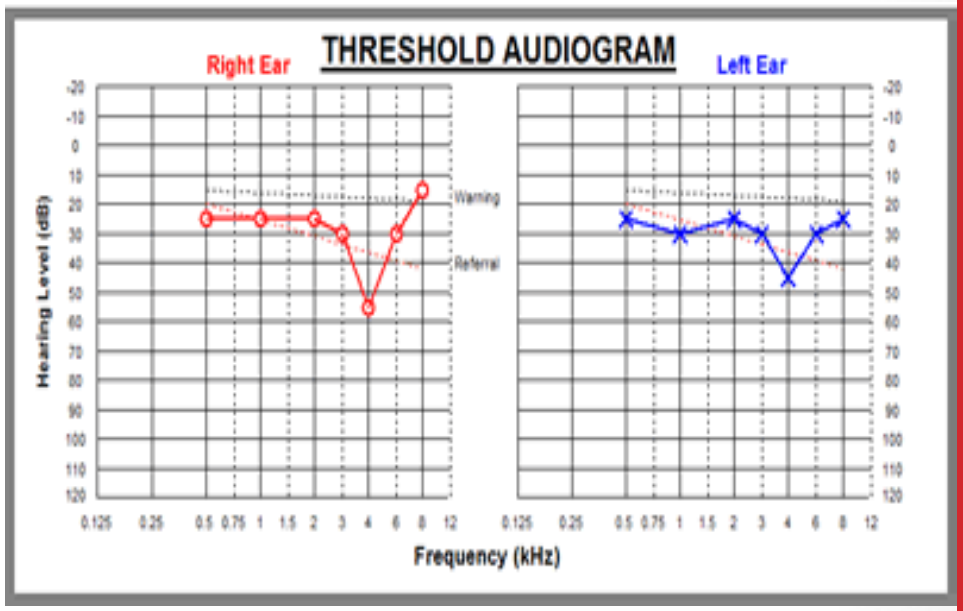
Measures the average loudness in an 8 hour work shift "8hr. TWA" (Time Weighted Average)

OSHA requires hearing protection for workers depending on dB level & exposure time

Noise Level	Exposure Limit
90 dBA	8.0 hours
92 dBA	6.0 hours
95 dBA	4.0 hours
97 dBA	3.0 hours
100 dbA	2.0 hours
102 dBA	1.5 hours
105 dBA	1.0 hours
110 dBA	30 minutes
115 dBA	15 minutes

Table 1. OSHA's Permissible Noise Exposure Limits.

- In work setting where noise exposure is **> 90 dB**, engineering controls (such as machinery design, enclosures and noise control products such as sound absorbents should be attempted). Also administrative procedures such as rotating worker and mandatory use of hearing protective devices are needed.



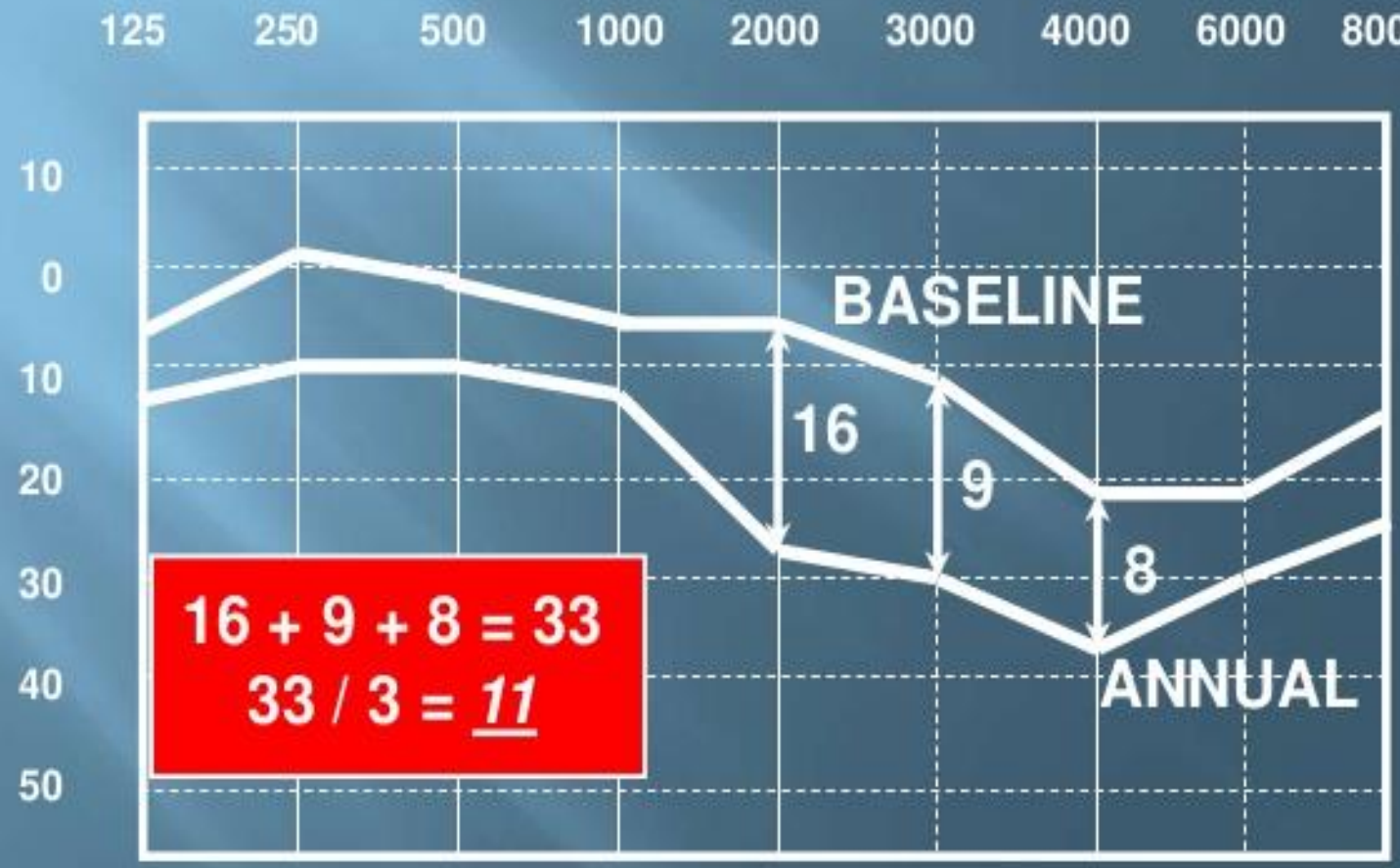
2)Audiometric Monitoring:-

- Periodic audiometric monitoring is a notable example of an effective screening test that reduces the risk of occupational illness because workers with early occupational loss evidenced by audiometry don't complain of hearing difficulties.

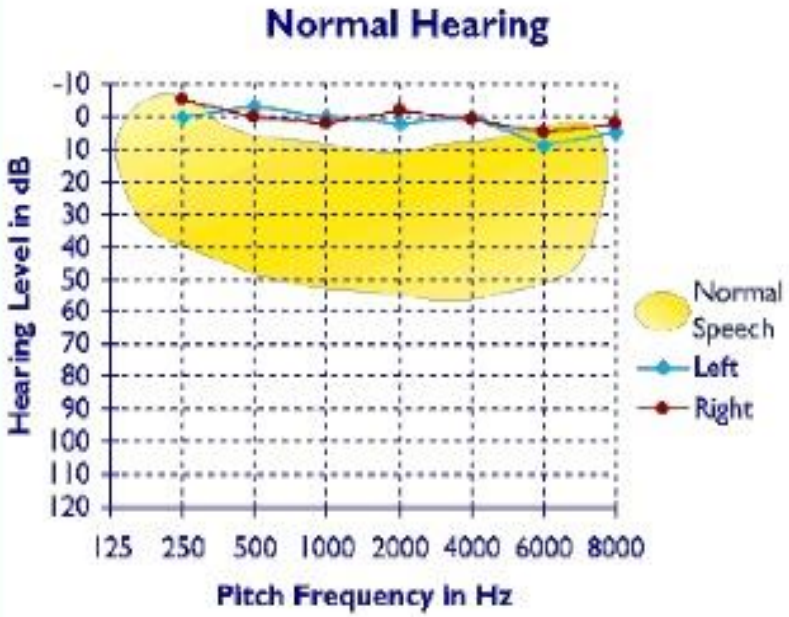
- To determine whether an employee has experienced any recordable hearing loss.
- The hearing loss is referred to in the OSHA standard as: **Standard Threshold Shift (STS).**

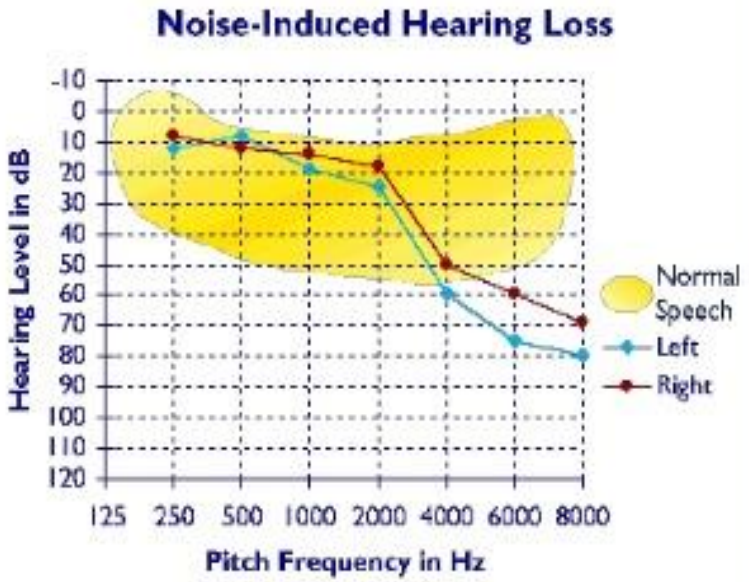
OSHA defines STS as " A change in hearing threshold relative to the baseline audiogram of an average of **10 dB** or more at **2000, 3000, and 4000 Hz** in either ear.

Annual Audiogram (Showing STS)



Normal Vs NIHL Audiometric testing





- **3) Hearing protective device:**

- There are 3 types: insert, semi-insert, muffs

- Most devices provide 15-30 dB attenuation to noise. When insert plugs are combined with ear muffs an addition of 15-30 dB protection is added.

- The noise reduction rating under actual working condition is usually lower (25% - 75%) of that assessed by the manufacturer.

- **4) Education & training programs:**

Is for both mangers & employees (especially those with risk factors) should include nature & consequences of NIHL and of importance of proper use of hearing protection & participation on audiometric monitoring.

Semi insert ear plugs

insert plugs

ear muffs