بسم الله الرحمن الرحیم

Occupational Noise Induced Hearing Loss (ONIHL)

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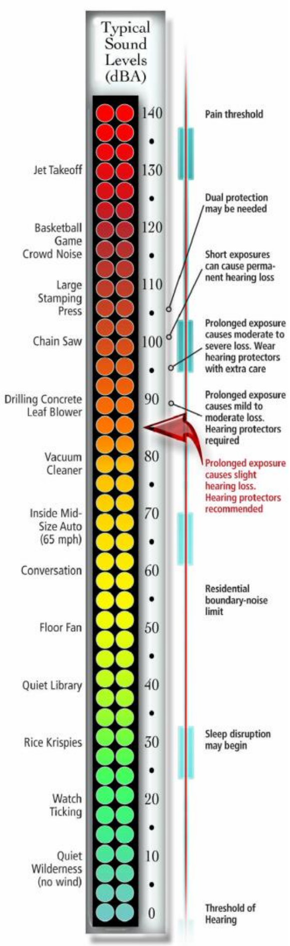
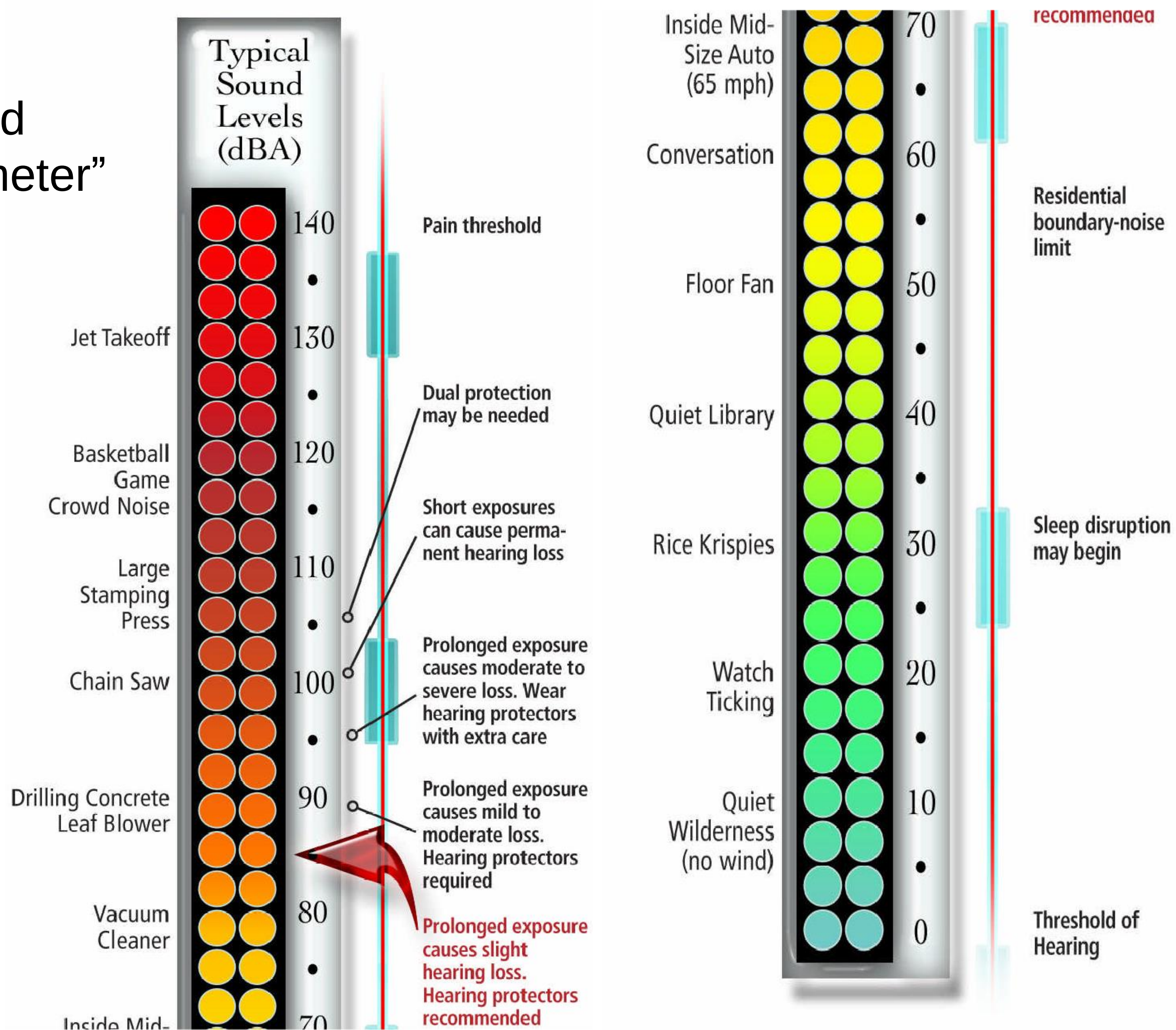
Over View[1]:

- Noise is the most pervasive hazardous agent in the workplaces.

- approximately 600 million workers are exposed to occupational noise worldwide.

Sound “thermometer”





Decibels

130 dBA	Threshold of pain
100 dBA	Short exposure can cause permanent hearing loss. Must shout to communicate at 1 foot distance
90 dBA	OSHA PEL. Prolonged exposure causes mild to moderate hearing loss.
85 dBA	ACGIH TLV. OSHA hearing conservation program required. Prolonged exposure causes slight hearing loss. Must shout to communicate at 3 foot distance.
60 dBA	Normal conversation
0 dBA	Threshold of hearing

Over View$_2$:

- According to NIOSH estimates:

  14% of the working population are employed in environments where the noise level exceeds 90 A- weighted decibels (dBA).

- in some manufacturing plants such as those producing textile mill products , lumber and wood products and food and kindred products this ratio exceeds 25%.

49% of Metal/NonMetal Miners Have Hearing Impairment* by Age 50 Compared with 9% of the General Population

90% 0f Coal Miners Have Hearing Impairment* by Age 51 Compared with 10% of the General Population

DID YOU KNOW……?

Noise-induced hearing loss

- is generally painless
- is progressive over time
- is permanent
- IS **PREVENTABLE**!!!

THE 4 Ps

According to OSHA regulations :

Prolong exposure to sounds louder than **85 dBA** is potentially injurious.

Table 10–1. Relative intensity of common noises.

Recreational noise	Noise level (dBA)
Normal conversation	50–60
Lawnmower	100
Motorcycle	110
Snowmobile	110
Firecrackers	150
Hunting weapons	160
Industry noise (average of many jobs)	
Printing and publishing	90
Truck transportation	90
Canning food products	100
Farm equipment	100
Textile mill	100
Lumber and wood products	100
Petroleum refining	110
Metal products	100
Mining, underground	110
Heavy equipment	110
Metal-tool operations	110
Military flight line	120

Regulations

Duration of Exposure (hrs/day)	Sound Level dB(A)		
	ACGIH	NIOSH	OSHA
16	82	82	85
8	85	85	90
4	88	88	95
2	91	91	100
1	94	94	105
1/2	97	97	110
1/4	100	100	115*
1/8	103	103	---
	***		**

* No exposure to continuous or intermittent noise in excess of 115 dB(A).
** Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.
*** No exposure to continuous, intermittent, or impact noise in excess of a peak C-weighted level of 140 dB.

HOW TO "LOOK" AT NOISE

INTENSITY COMPARISONS WITH NIOSH RECOMMENDED PERMISSIBLE EXPOSURE TIME

Note: For every 3dB the energy doubles.

85 dBA - 8 hour exposure limit

88 dBA - 4 hour exposure limit

91 dBA - 2 hour exposure limit

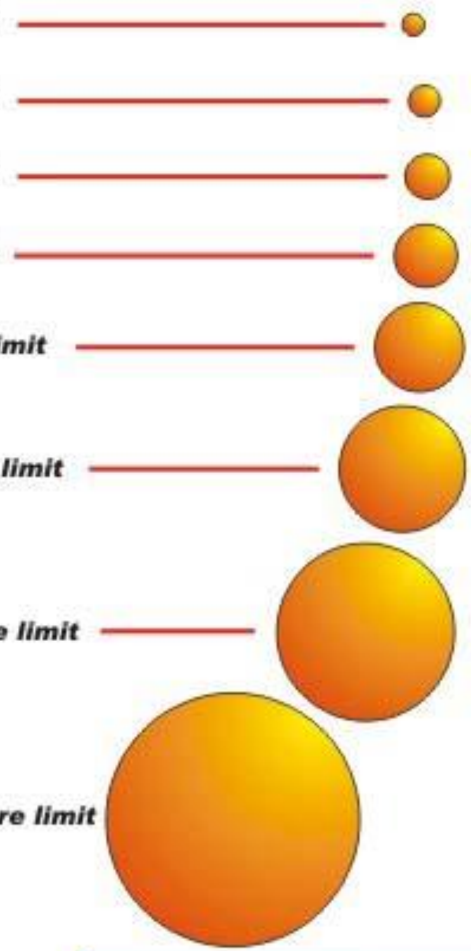
94 dBA - 1 hour exposure limit

97 dBA - 30 minute exposure limit

100 dBA - 15 minute exposure limit

103 dBA 7 1/2 minute exposure limit

106 dBA - 3 3/4 minute exposure limit



NOTE:

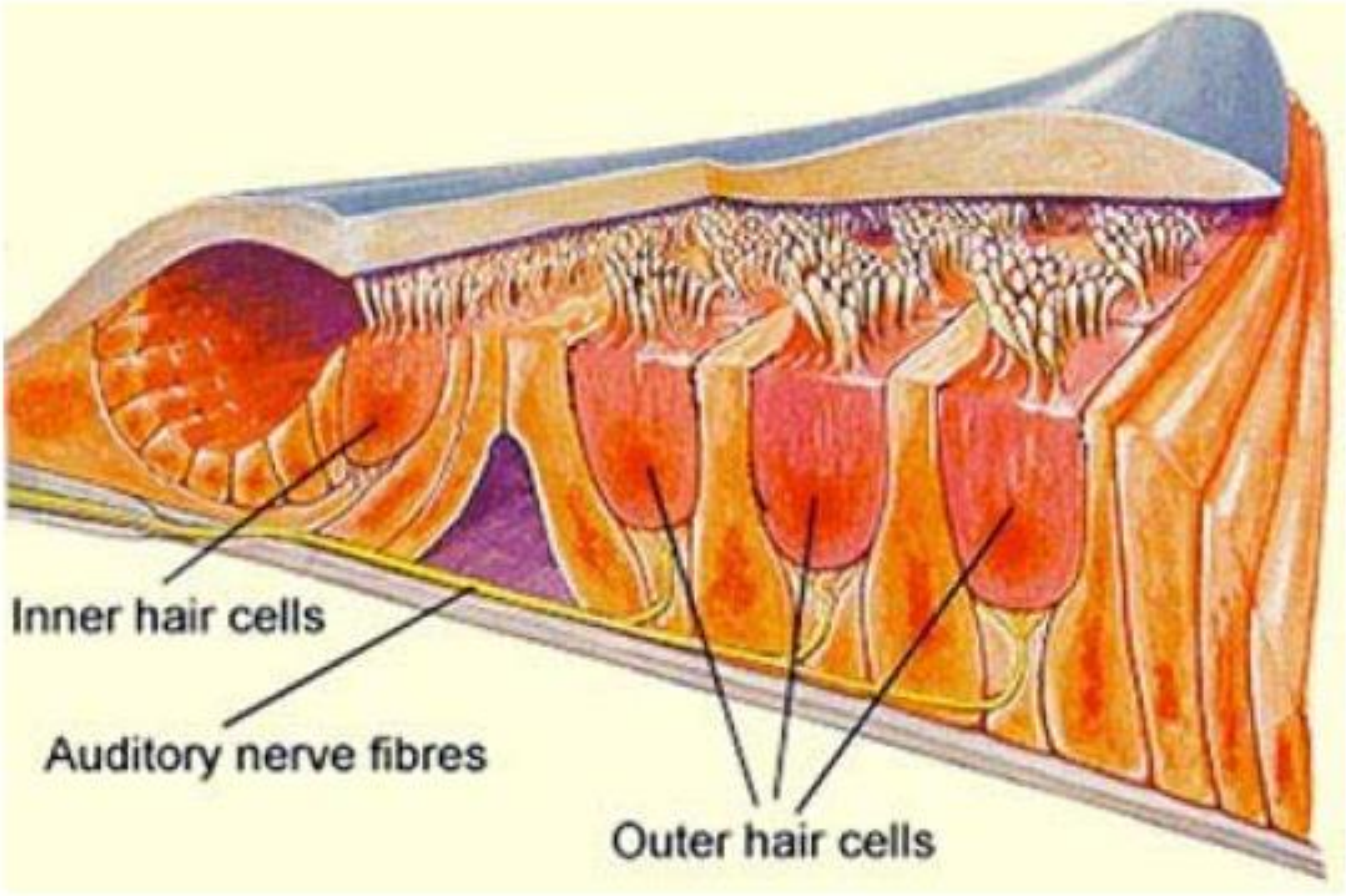
Noise Levels for the Following:

91dB - Orbital Sander

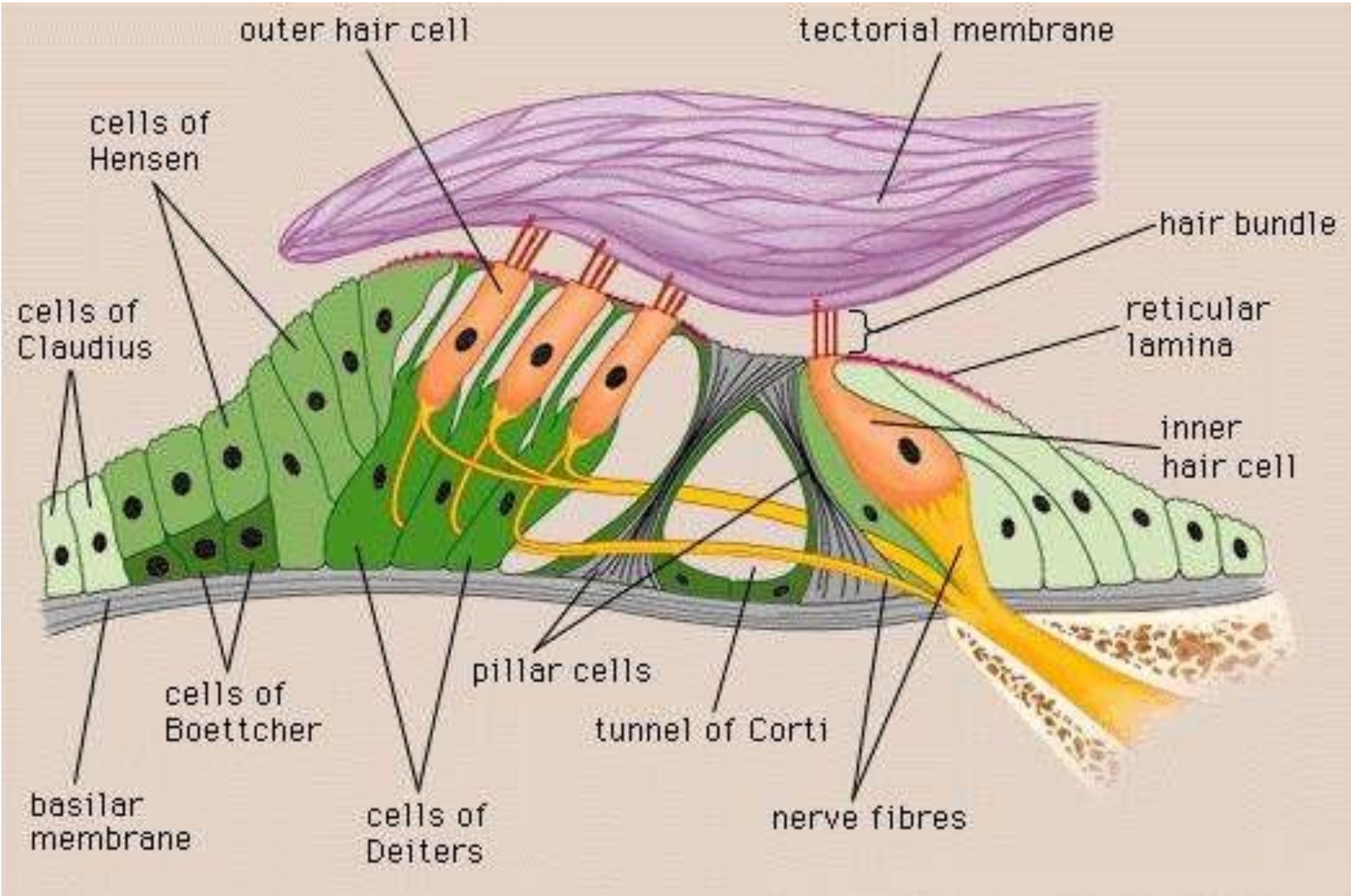
96 dB - Router

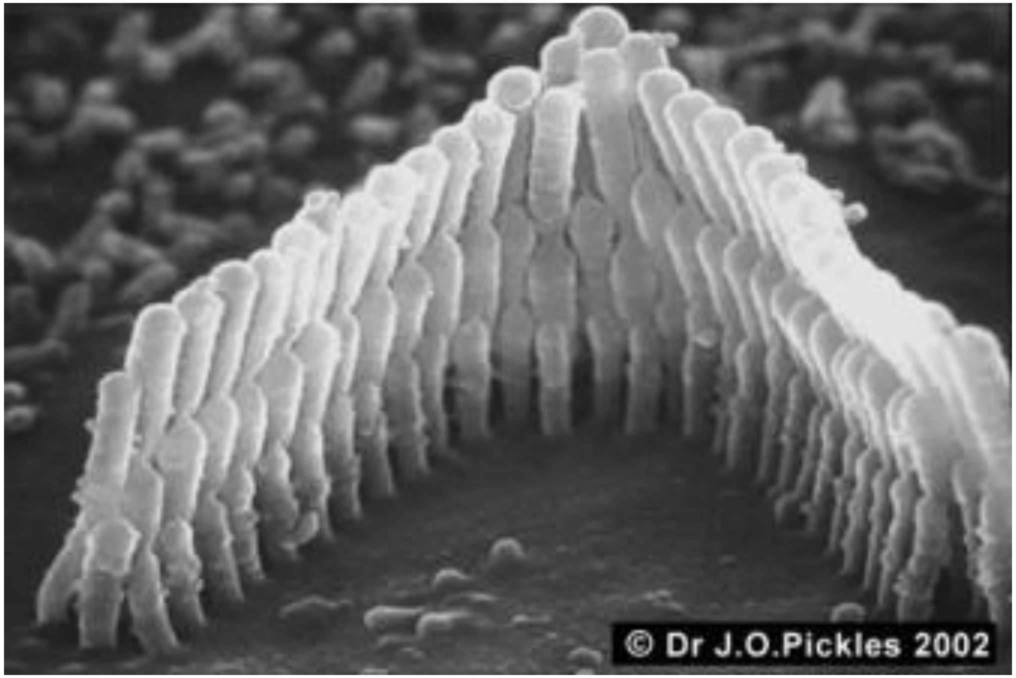
101 dB - Circular Saw

HAIR CELLS IN THE COCHLEA



Section of Basilar Membrane with Organ of Corti
(Courtesy of: Bacou Dalloz)


outer hair cell
tectorial membrane
cells of Hensen
hair bundle
cells of Claudius
reticular lamina
inner hair cell
pillar cells
cells of Boettcher
tunnel of Corti
basilar membrane
cells of Deiters
nerve fibres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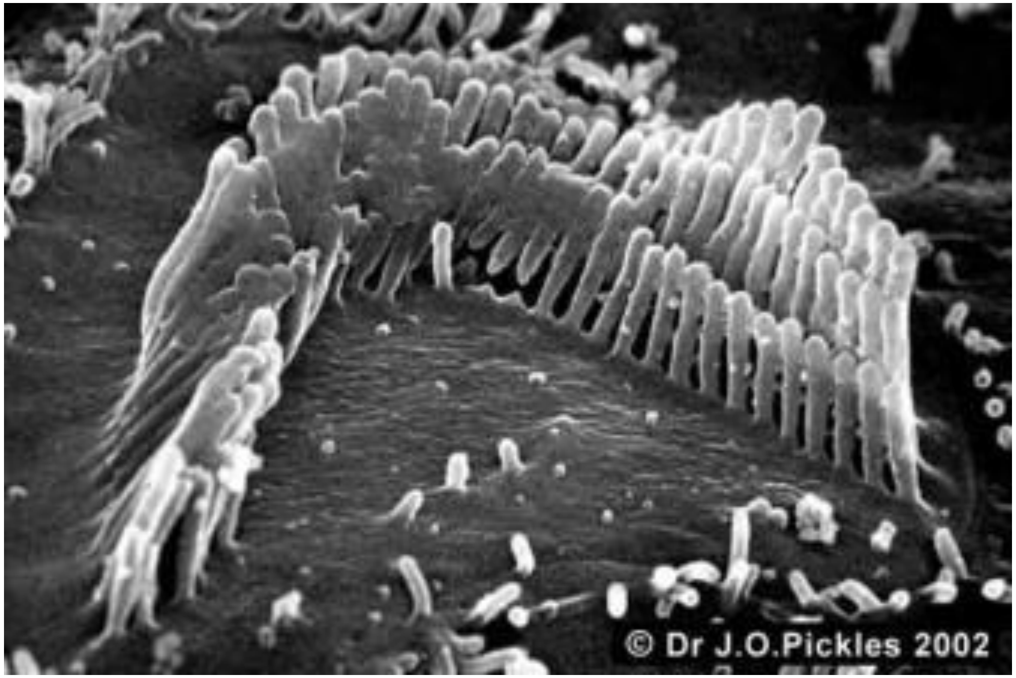
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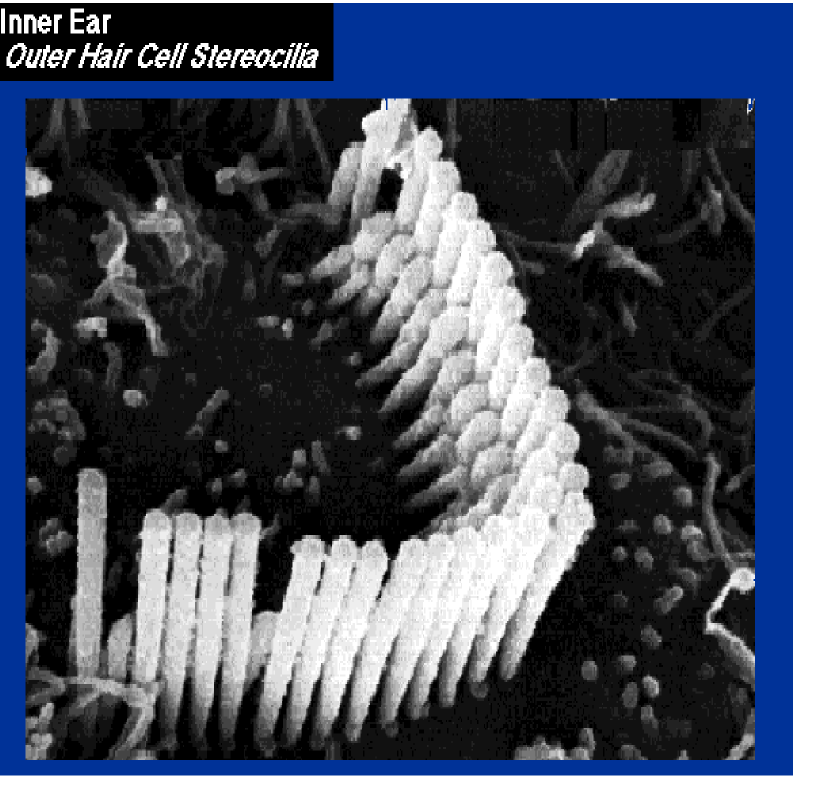
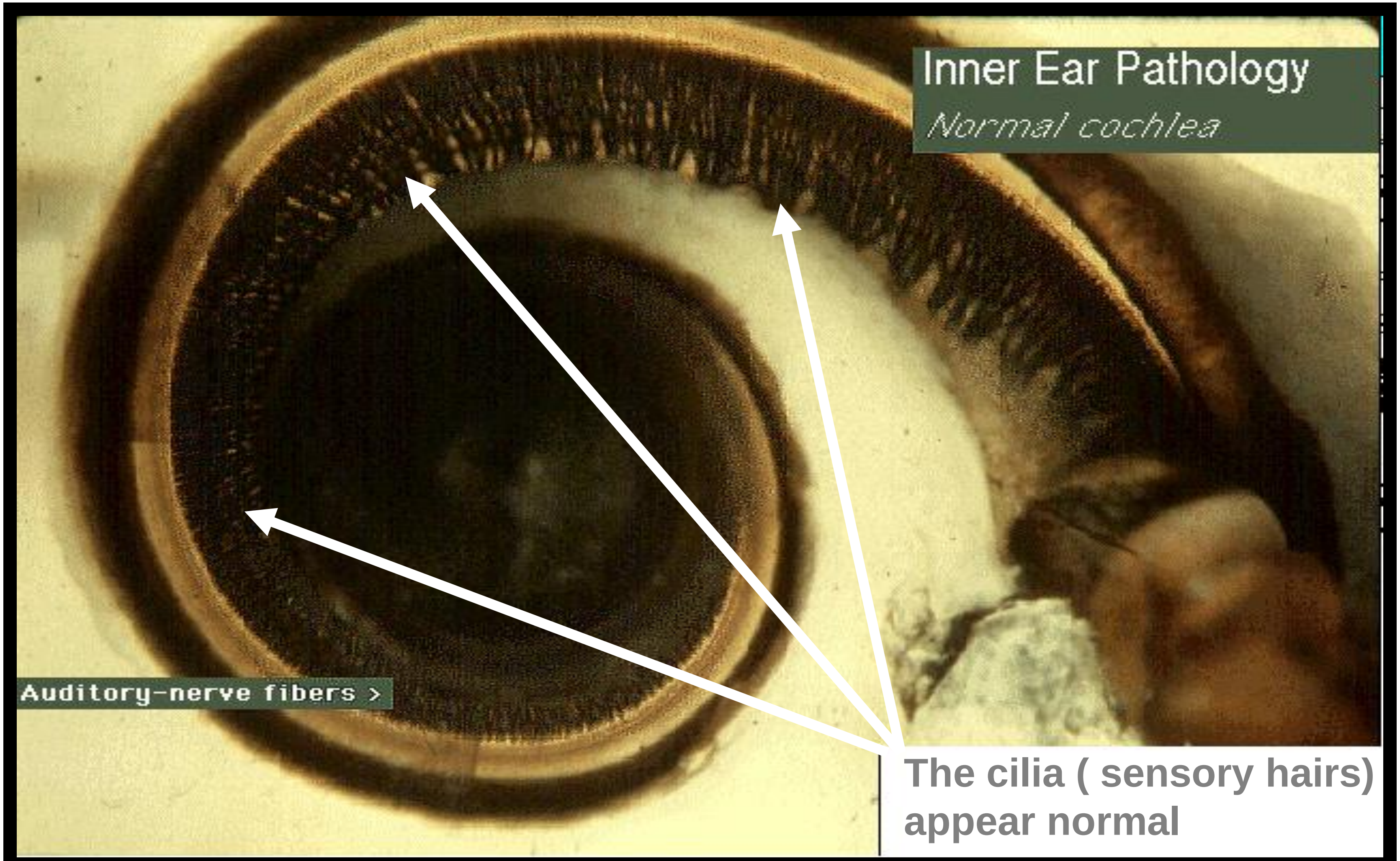
Biological Processes of Hearing

- Inside the cochlea, hair cells bend as waves pass by sending pulses via the auditory nerve to the brain.

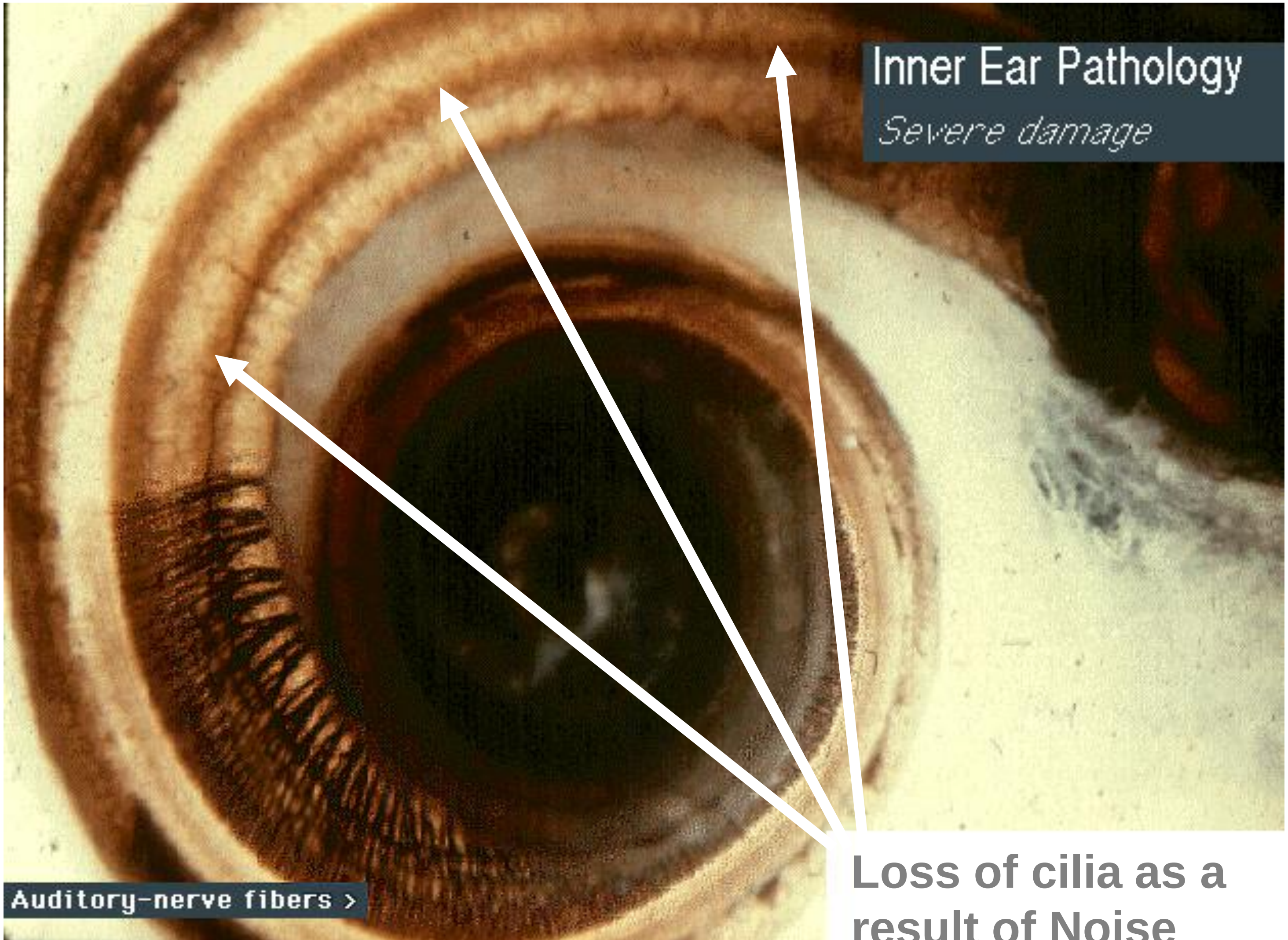
- Sound energy is converted from mechanical vibrations to fluid waves to electrical pulses.



Healthy Cochlea



Damaged Cochlea



Loss of cilia as a result of Noise

Acoustic Trauma

Acoustic trauma (AT) is a <u>sudden</u> change in hearing over a <u>short</u> period of time (i.e., several seconds) as a result of intense exposure to a single or series of impulsive noise events.

Noise-Induced Hearing Loss

Noise-induced hearing loss (NIHL) is a <u>gradual</u> change in hearing over a <u>long</u> period of time (i.e., several years) as a result of chronic exposure to continuous or intermittent noise.

✓**NOTE: Impulsive noise is considered <u>more</u> hazardous than continuous noise. Intermittent noise is <u>less</u> hazardous than continuous noise.**

Etiology of NIHL :

Trauma to the sensory epithelium of the cochlea.

- **Vascular**
- **Metabolic**
- **Chemical**

Initially changes are potentially reversible.

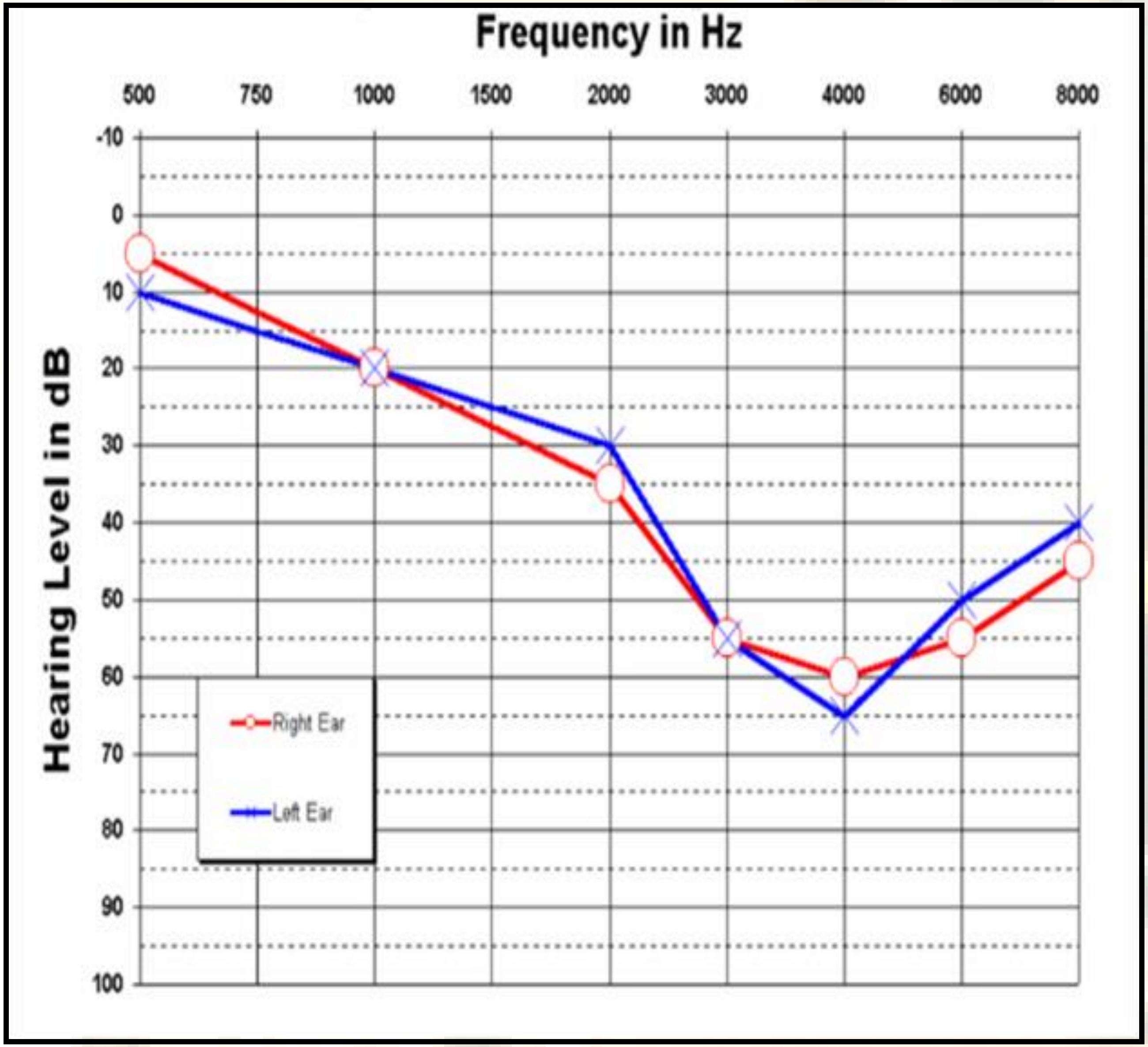
TTS $\xrightarrow{\text{time}}$ **PTS**

Recovery period = 12-24 hours

ONIHL Description:

- ONIHL is always a neurosensory loss.
- ONIHL is almost always bilateral.
- Hearing loss does not progress after noise exposure is discontinued.
- Loss is always greater at the frequencies 3000-6000 Hz than at 500-2000 Hz. Loss is usually greatest at 4000 Hz. The 4000-Hz notch

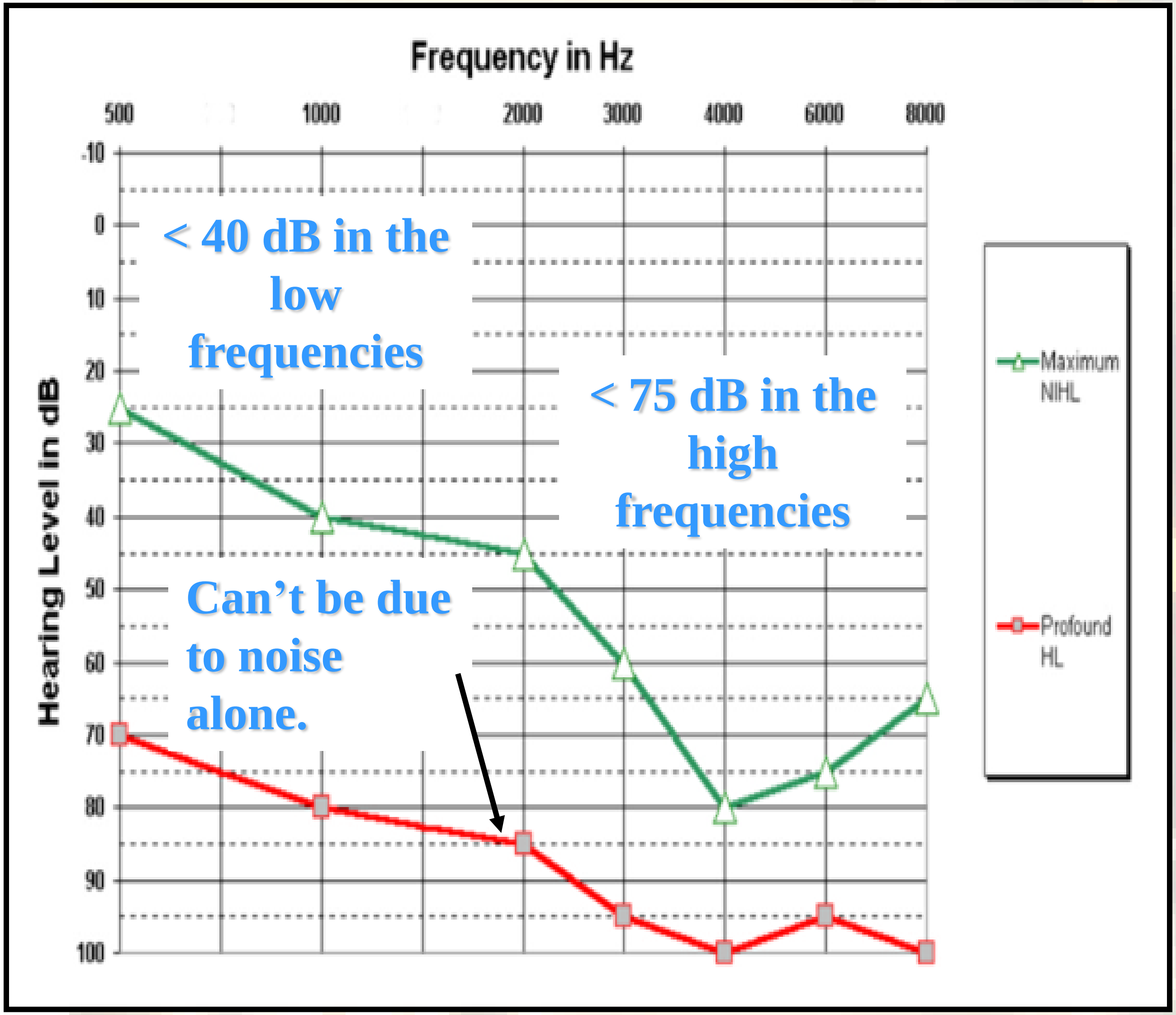
Bilateral & Symmetric



Most noise exposures affect both ears so the loss is bilateral with similar patterns on both sides.

✓ **Symmetrical hearing means few localization errors.**

Seldom Greater Than 75 dB



Noise exposure **alone** never produces more than a severe loss.

✓ You won't go "deaf" from noise exposure alone, but other causes are additive.

Clinical finding of NIHL :

- **Gradual deterioration in hearing:**
  - The first difficulty the patient usually notices is trouble understanding speech when a high level of ambient background noise is present.
  - As NIHL progresses, individuals may have difficulty understanding high-pitched voices (eg, women's, children's) even in quiet conversational situations.
- **Tinitus:**
  - Tinitus in absence of hearing loss is probably not related to noise exposure

Progression of NIHL

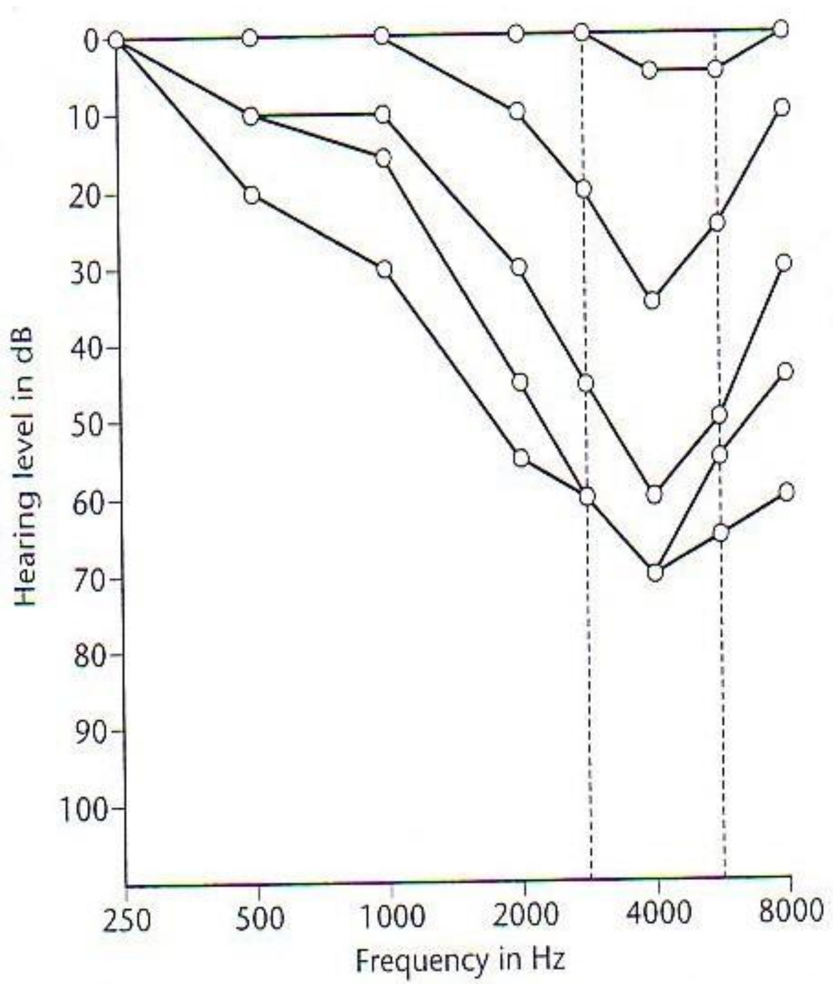


Figure 20.2.5: An audiogram showing the progression of noise-induced hearing loss, from a mild high-frequency impairment to a severe hearing impairment.

Physical Exam: The physical examination is not important in the evaluation of NIHL except to rule out other causes.

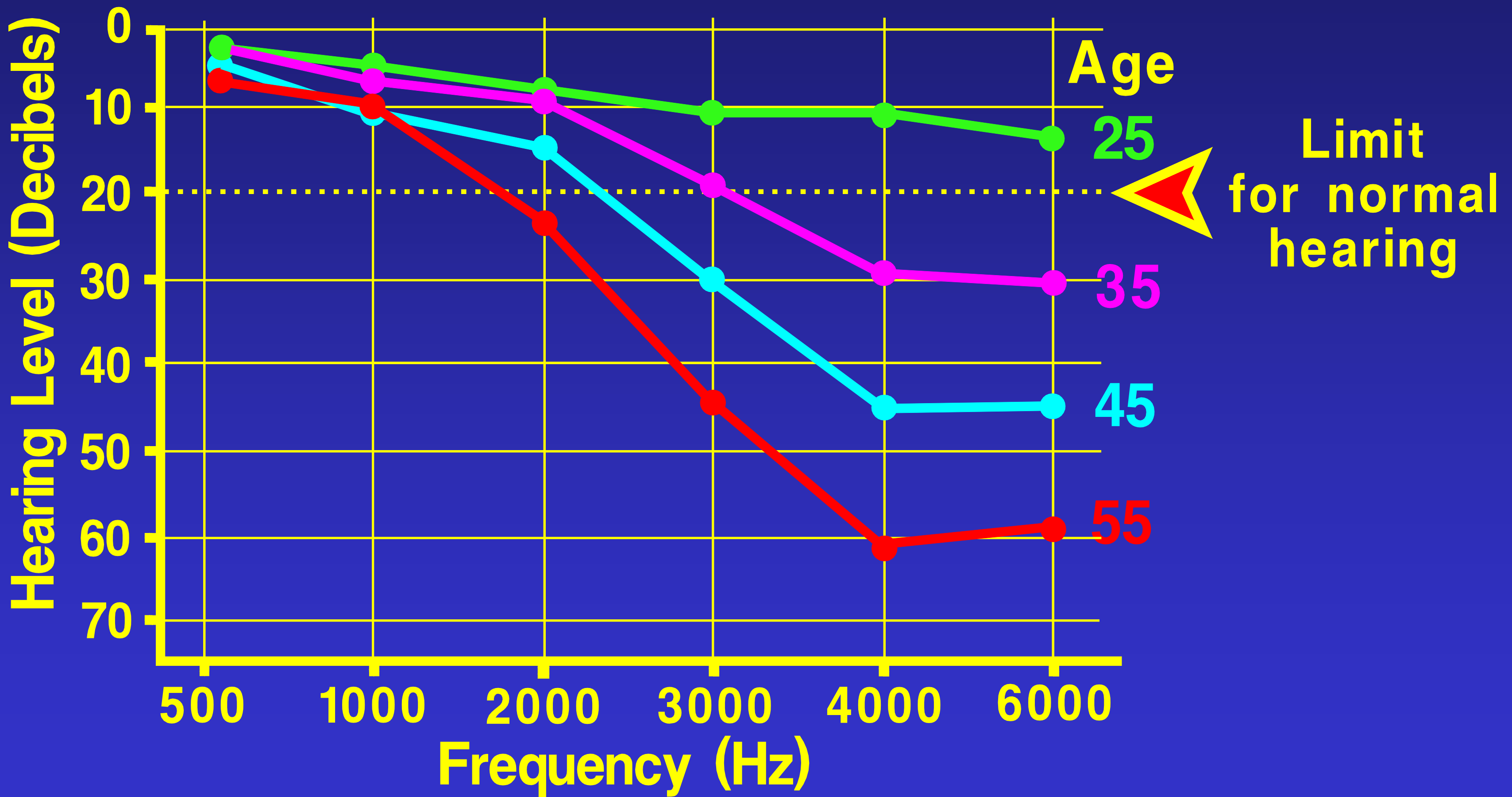
Lab Studies: No laboratory studies are appropriate in the evaluation of noise-induced hearing loss (NIHL).

Imaging Studies: No imaging studies are appropriate for the study of NIHL.

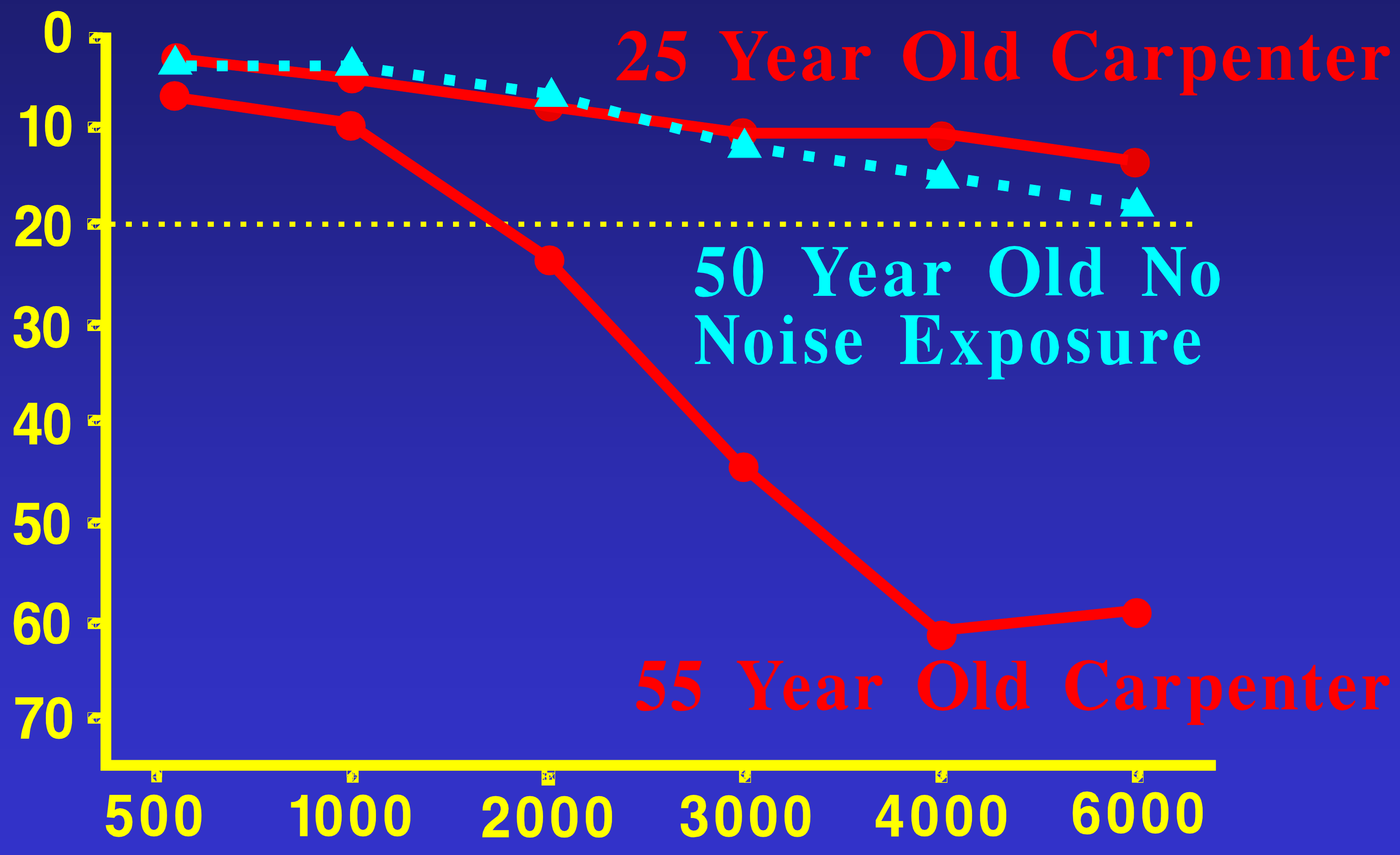
Other Tests: Audiometric testing is the only diagnostic evaluation relevant to diagnosis of NIHL.

- **The speech reception threshold (SRT) should also be measured for each ear.**
- **Differences between the pure tone average (PTA) (ie, the number of dB of hearing loss at 500, 1000 and 2000 Hz averaged) and the SRT of more than 5-10 dB should bring into question the reliability of the test.**
- **Discrimination scored below 60% suggests an etiology other than NIHL**

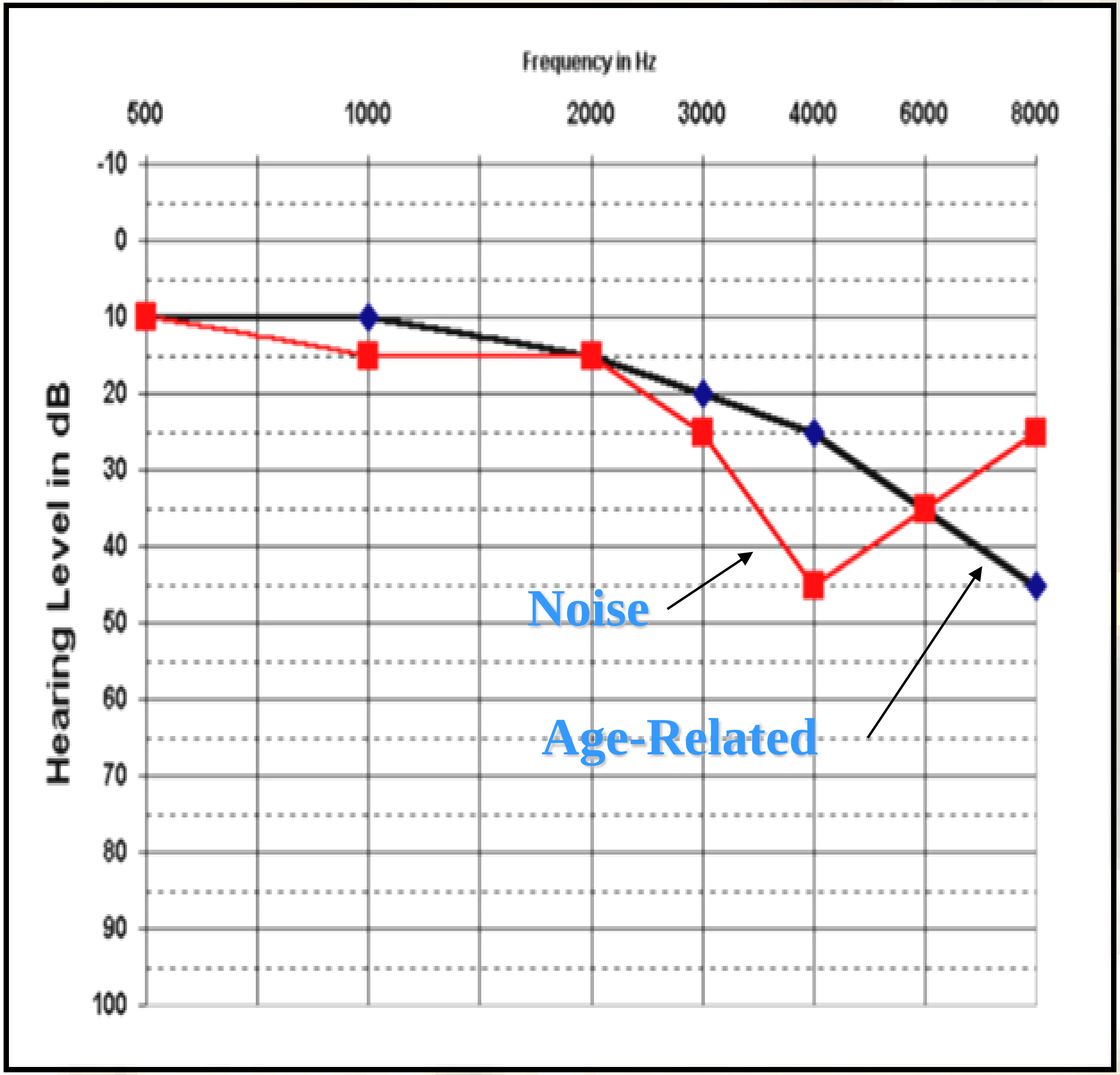
Hearing Loss Among Male Carpenters as a Function of Age



The Average 25 Year Old Carpenter Has 50 Year Old Ears!



4000 Hz Notch Pattern



Greatest damage occurs around 3-4k Hz with progressively more involvement in low frequencies.

Differential Diagnosis:

Government of South Australia

SafeWork SA

Safe Work 2006

OTHER HEALTH EFFECTS

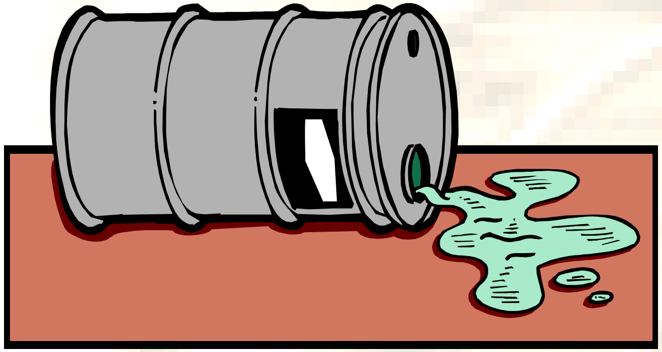
OTOTOXIC HEARING LOSS

- Some common industrial chemical substances can also cause hearing loss
- Such substances are called ototoxins

  Oto = ear, toxin = poison
- A wide variety of chemicals and medication may, alone or together with noise, result in hearing loss.
- Some substances may have an additive or synergistic effect (eg. toluene, ethyl benzene, styrene, carbon monoxide)
- Of the workplace chemicals three major classes have been identified:
  - Solvents *(eg. benzene, styrene, methyl ethyl ketone, toluene),*
  - heavy metals *(eg. arsenic, cadmium, mercury, lead),* and
  - chemical asphyxiants *(eg. carbon monoxide)*

Interacts with Ototoxic Agents

- Smoking
- Heavy metals
- Chemical Agents
  - paint solvents (toluene)
  - carbon disulfate (CS_2)
  - benzene (jet fuels)
  - carbon monoxide (CO)



Hearing conservation program (HCP)

HCP:

1- Noise monitoring

2- Engineering control

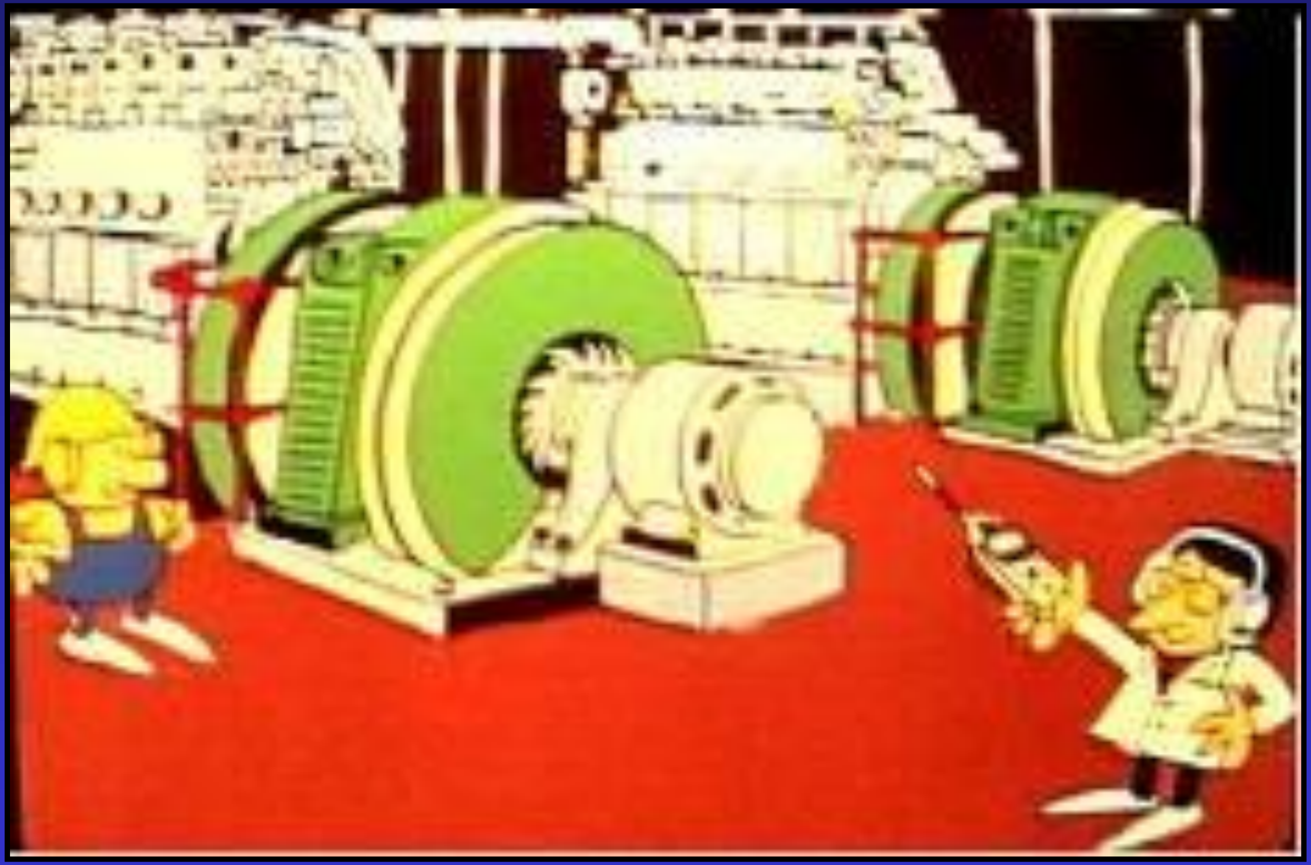
3- Administrative control

4- Worker education

5- Selection and use of hearing protection devises (HPDs)

6- Periodic audiometric evaluations

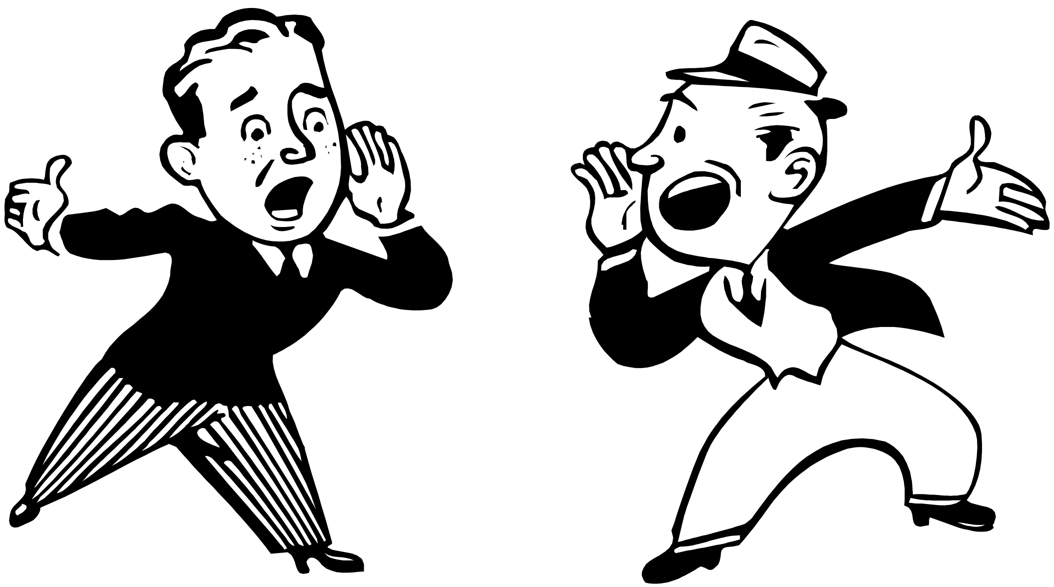
Noise monitoring:



Effects of Noise Exposure

When is Noise Too Loud?

- **If two people 3 feet apart must shout to be heard, the background noise is too loud (above 85 decibels).**



1 foot = 12 inch = 12 × 2.54 Cm =30.48Cm

30.48 × 3 = 91.44 Cm

Always request noise data for the worker's job category.

✓NOTE: When noise exposure data are not available, use this table to gauge the sound level.

Vocal Effort (at arms length)	Approximate Sound Level (A-weighted)	Maximum Duration (NIOSH)
Raised	75 dBA	---
Loud	80 dBA	24 hours
Very Loud	85 dBA	8 hours
Shouting	90 dBA	2½ hours
Shout @ 1ft	95 dBA	¾ hours
Impossible	100 dBA	¼ hour

Rosenstock:

- It is estimated that workers in an 85 dB environment will have to speak loudly.

- while those in 85–90 dB will have to shout to communicate at arm’s length.

- As the surrounding noise reaches 95 dB, communication only occurs with shouting, even if the workers stand next to each other.

Dosimeter Types

Noise Dosimeter

Analog Sound Level

Dosimeter Types

Digital Sound Level Meter

Digital Sound Level Meter

Evaluating Exposure

- Noise dosimeter
  - Direct-reading instrument
  - Worn by employees to determine TWA exposure
  - Display/download TWA noise levels
    - Often with datalogging
  - Must be calibrated to assure accuracy

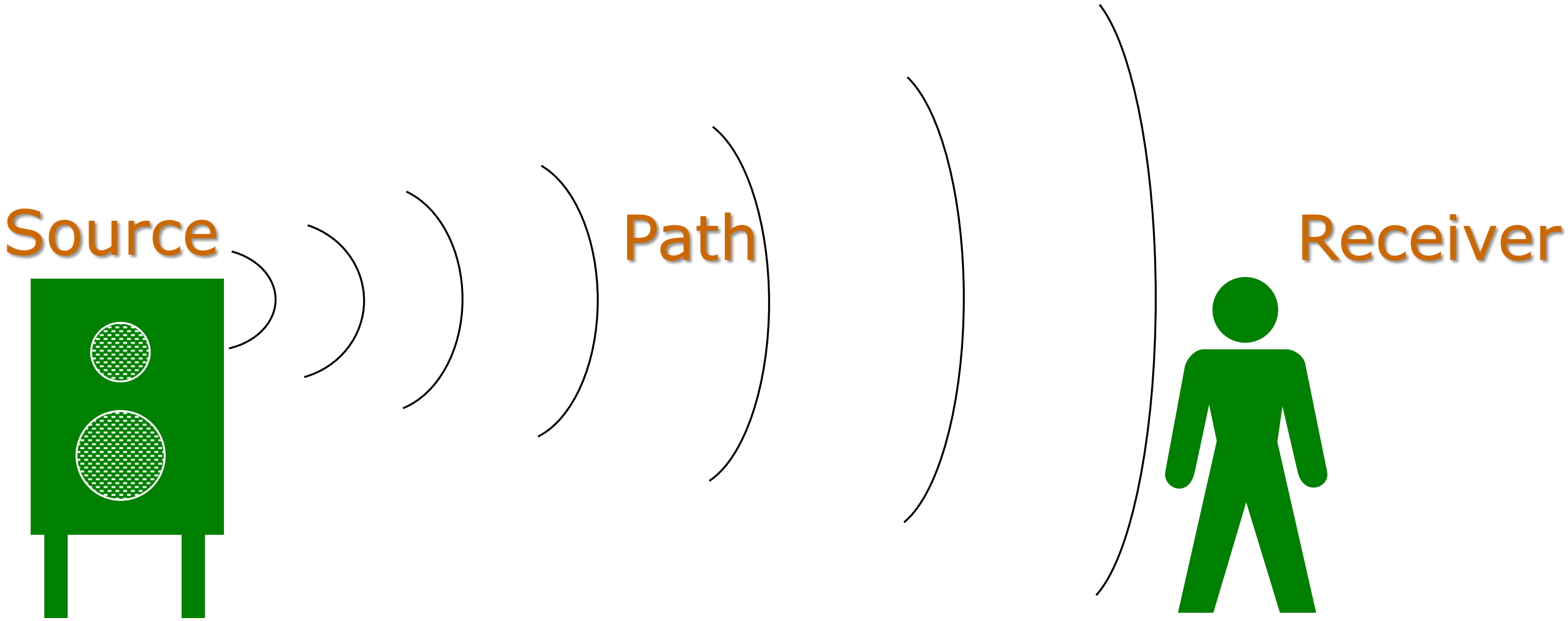
Engineering control:

Noise control options

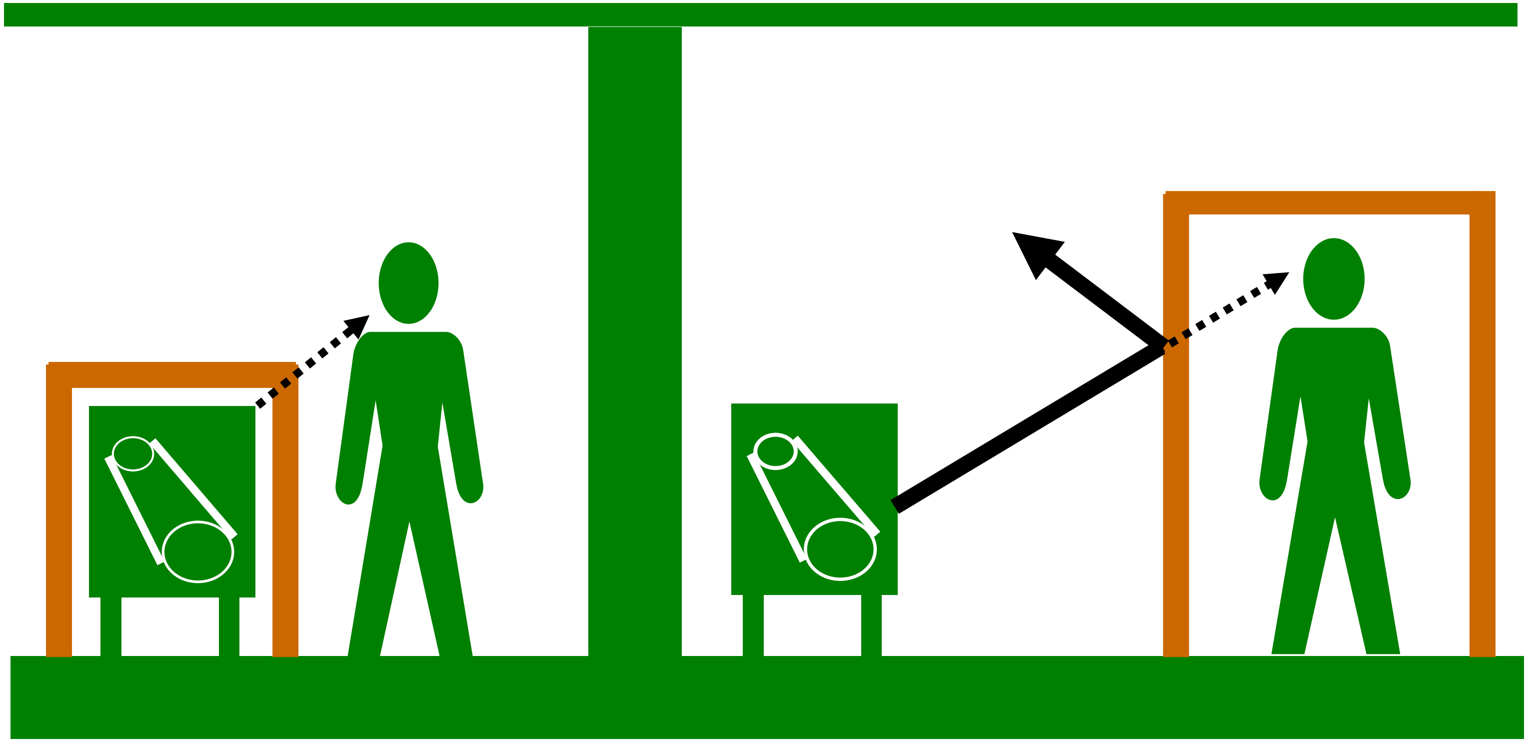
– Control at source

– Control the noise path

– Protect the receiver

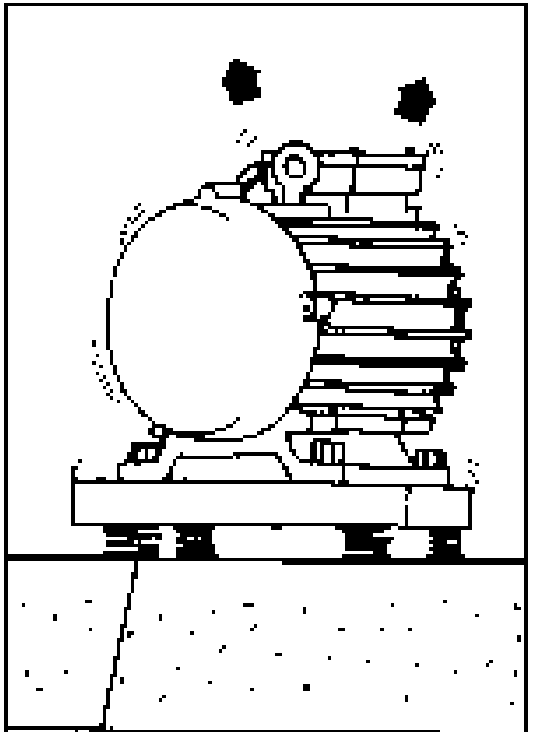


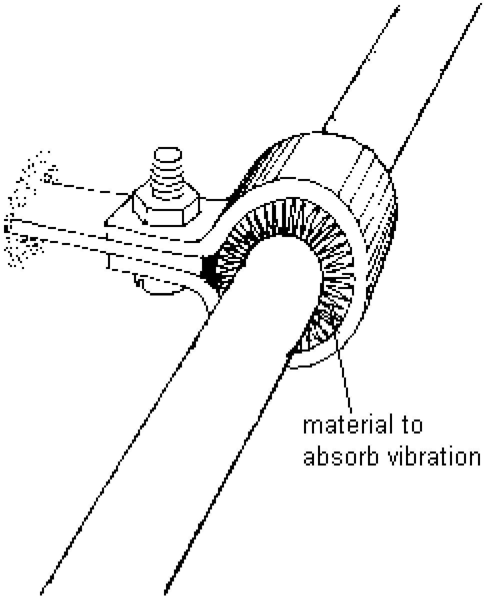
Thinking about enclosures

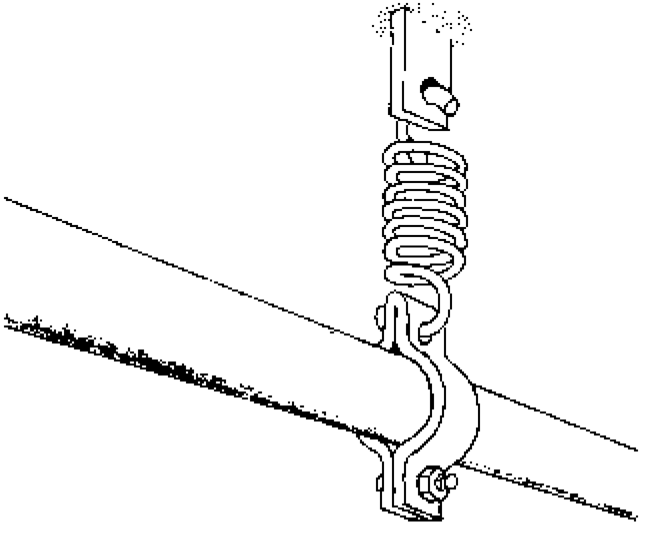


Controlling Noise

- Isolation of secondary surfaces

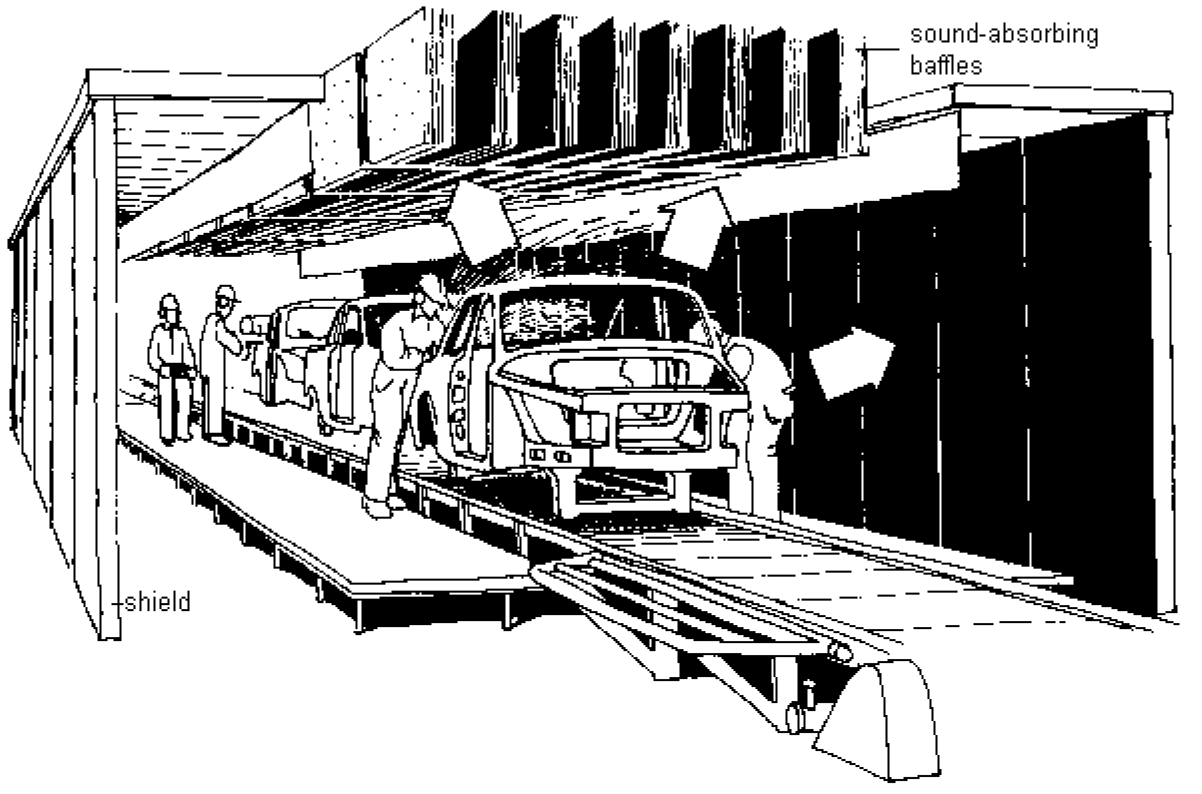






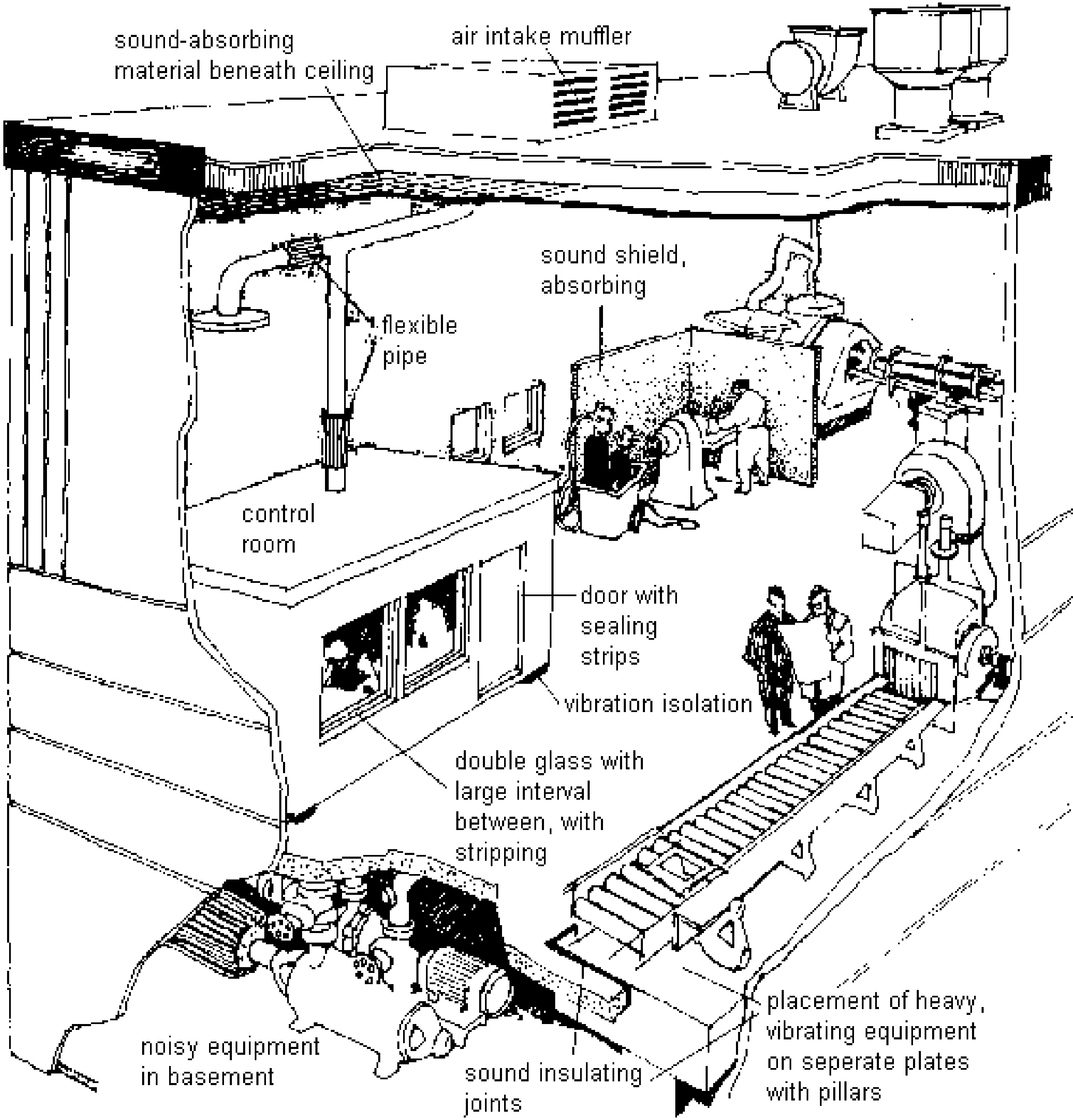
Controlling Noise

- Sound absorbing materials



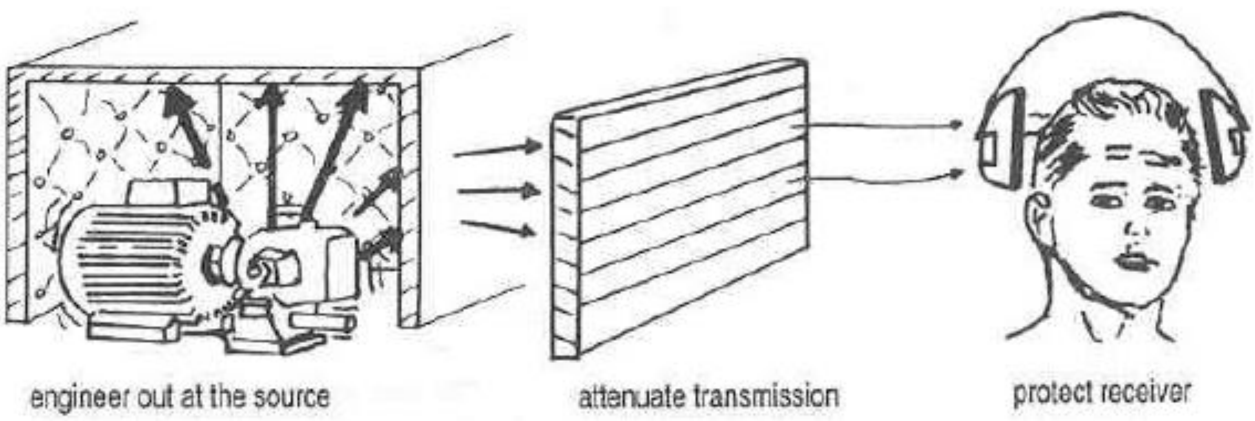
Controlling Noise

- Multiple methods



NOISE CONTROL PRINCIPLES

- Control at Source (engineer out)
- Control of transmission path and flanking paths
- Control at the receiver



CONTROL AT SOURCE

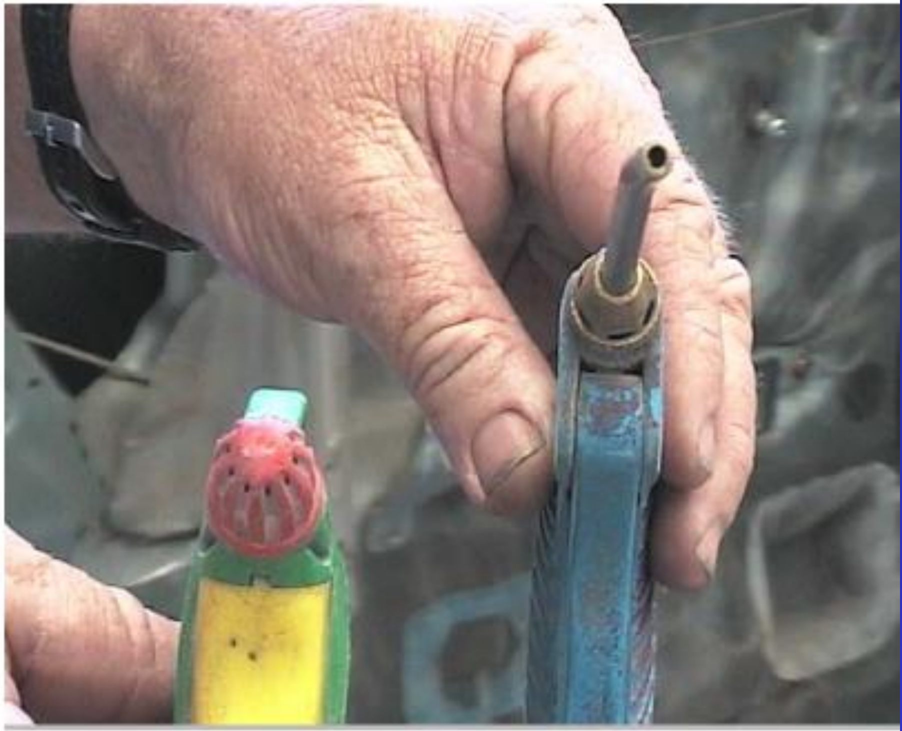
- **Eliminate activity/process creating noise**
  - Eliminate hard surface to hard surface contact in processes *(eg metal to concrete)*
- **Substitute activity creating noise**
  - Purchase quieter equipment
    - Electric forklifts instead of diesel/gas
  - Change to quieter processes
    - Screws instead of nailing
  - Change operating conditions
    - Reduce air velocity on fans
- **Maintenance**

CONTROL TRANSMISSION OF NOISE

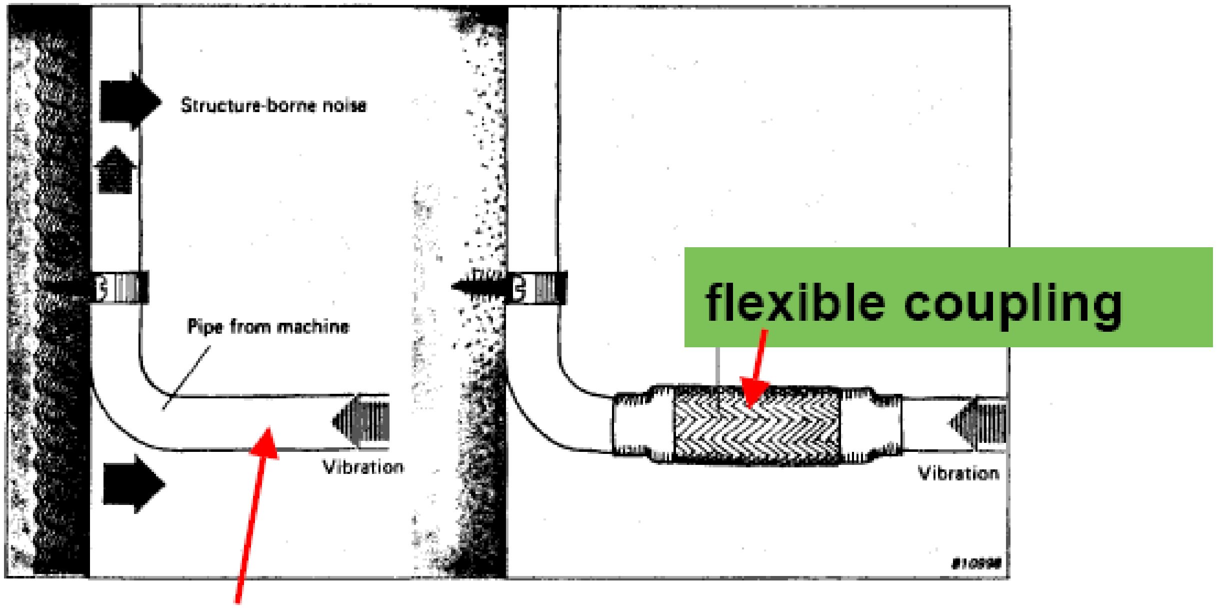
- Isolate sound using anti-vibration mountings
- Increase distance from source to receiver (*Note: if distance from source is doubled, SPL decreases by 6 dB*)
- Use sound absorbing surfaces
- Enclose sound sources
- Enclose person in soundproof cabin

NOISE CONTROL EXAMPLES

Replacing the nozzle of an air gun with one that has small openings around the central orifice introduces a secondary air flow and so reduces the noise generating turbulence of the main jet stream. A reduction of up to 7dB can be achieved



NOISE CONTROL EXAMPLES



The flow of fluid in the pipe causes vibration which may be heard in the room and may be transmitted through the structure of the building

Solution:

A flexible coupling in the pipe prevents vibration after the coupling and this eliminates or reduces vibrations travelling through the pipe and therefore reduces structure borne noise

NOISE CONTROL EXAMPLES

The 9" angle grinder, 108dB(A)

The 4" angle grinder, 102dB(A)

In terms of sound intensity the 4" angle grinder is 4 times quieter than the 9" angle grinder!!

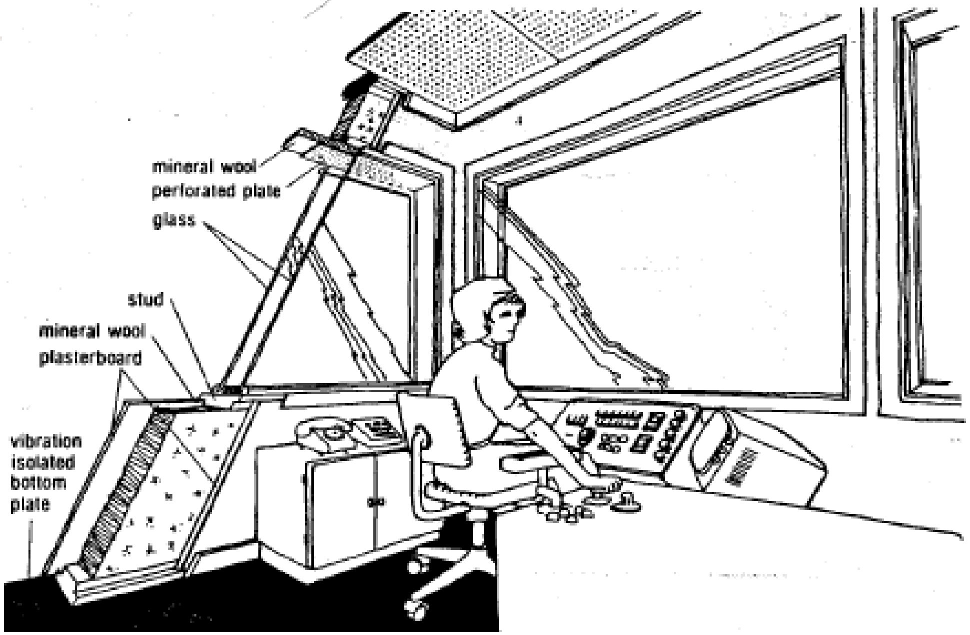
NOISE CONTROL EXAMPLES

TREATMENT OF NOISE RECEIVER

- Where the noise levels cannot be (adequately) reduced at the source, eg because of the nature of the machines or equipment, or the building structure.

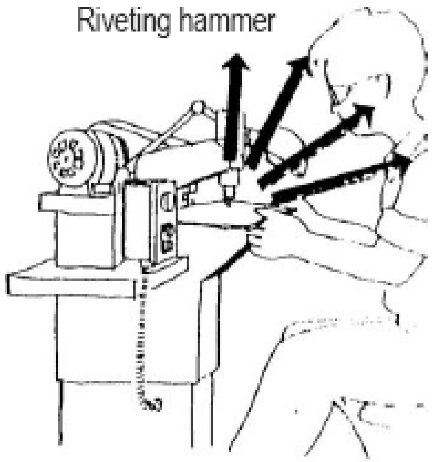
Solution:

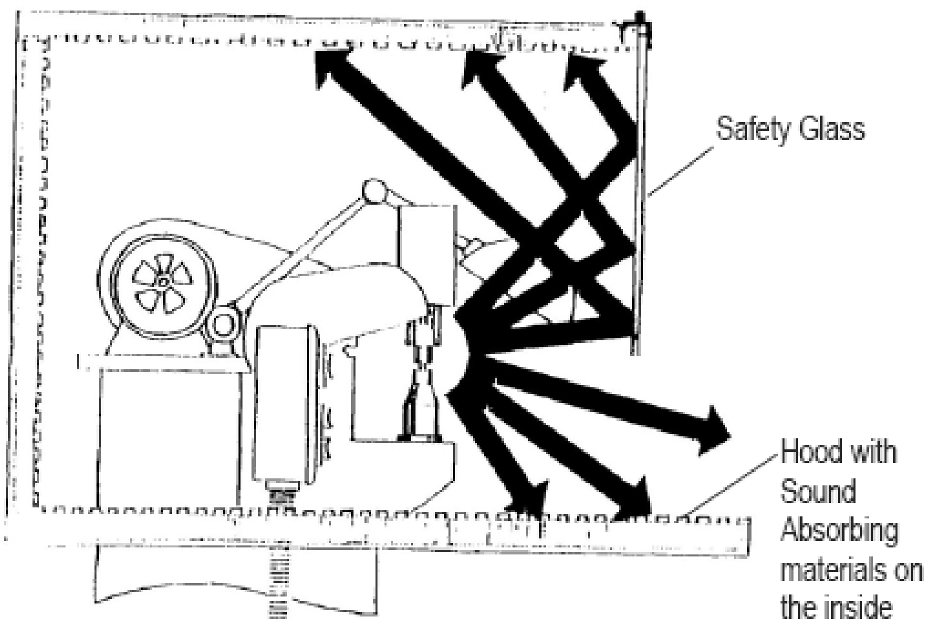
- A sound proof room around the machine or the worker



NOISE CONTROL EXAMPLES

High frequency sound is transported directly to the worker's ears from a high speed riveting machine





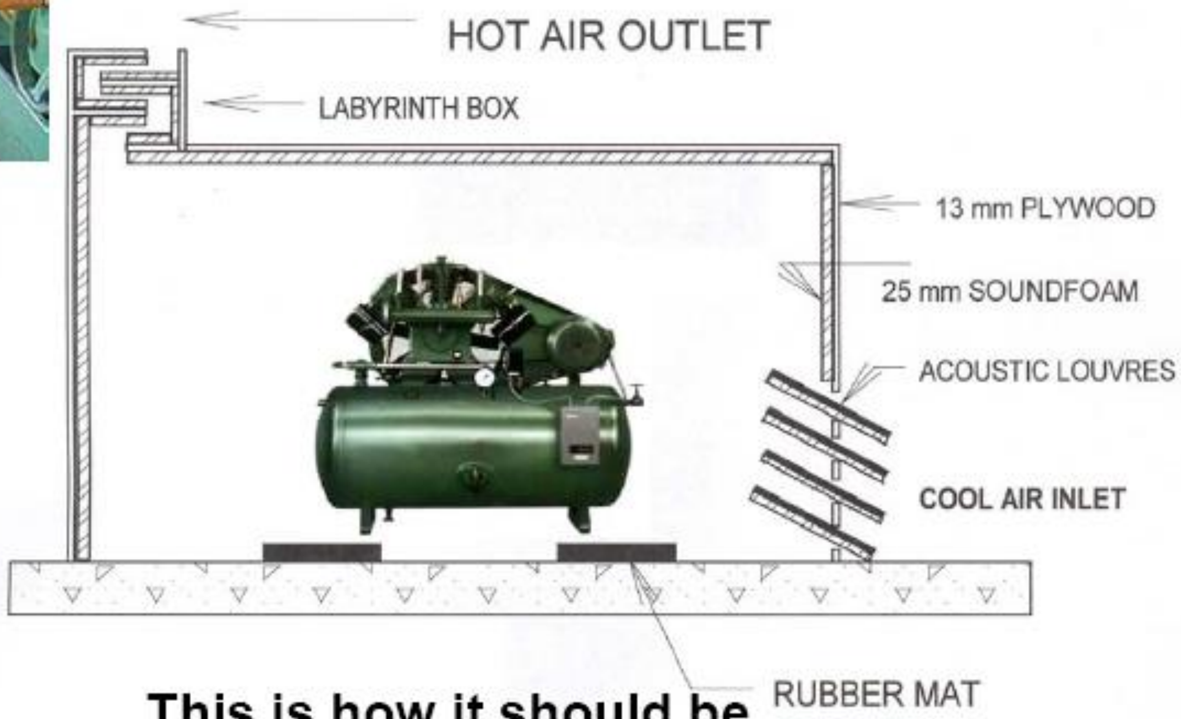
Solution:

A sound insulating hood is placed around the machine with a small opening for work pieces towards the bottom. Safety glass is placed in the upper part of the hood side facing the worker. The safety glass reflects the sound back onto the sound absorbent material of the hood.

NOISE CONTROL EXAMPLES

TREATMENT OF NOISE PATH

Does this look familiar?



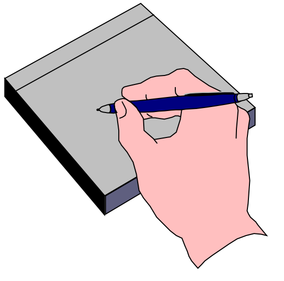
This is how it should be

Administrative control:

ADMINISTRATIVE CONTROLS

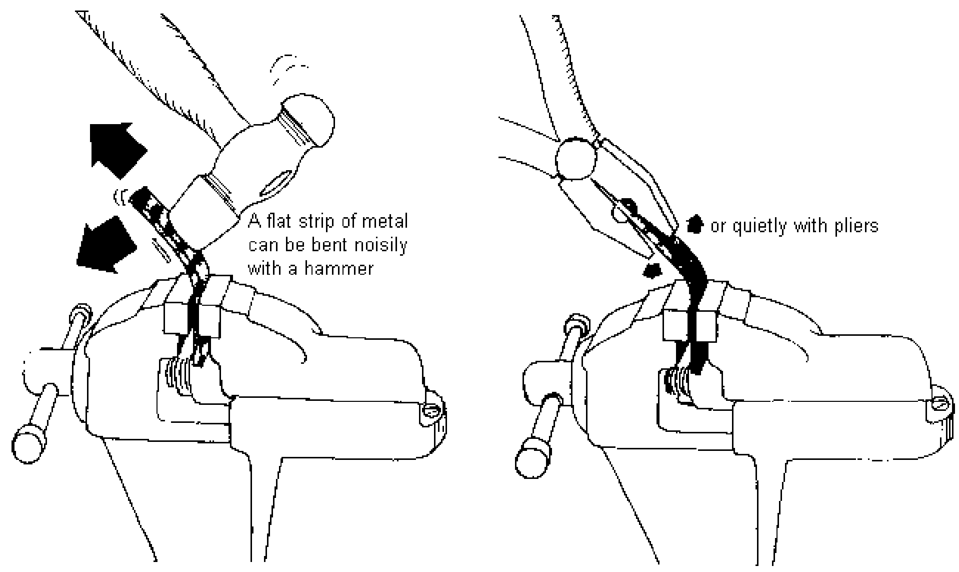
- Decreasing the exposure time

- Limiting the number of personnel exposed



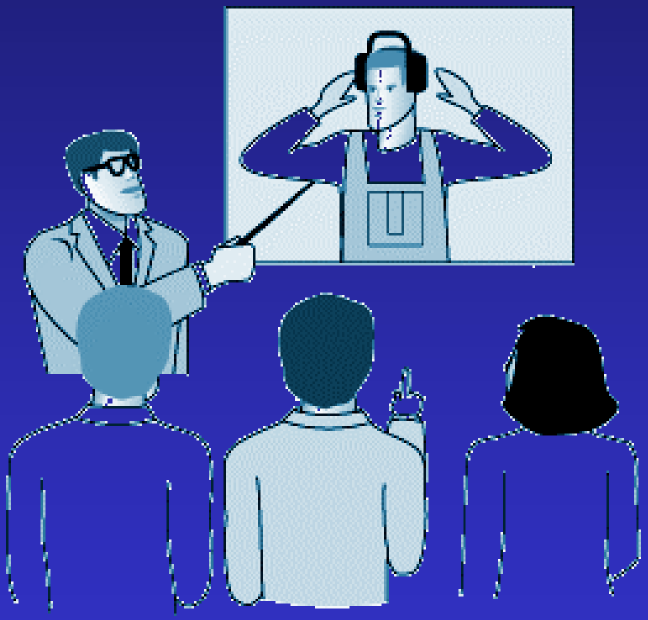
Controlling Noise

- Administrative controls (less desirable)
  - Restrict number of hours workers are allowed in noisy areas
  - Train workers to reduce noise



Employee Training & Motivation

- Training is required annually for all employees included in the Hearing Conservation Program.



Protect Your Hearing Now **OR** **Wear this Later**





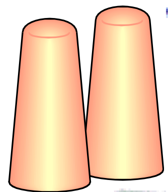
Your Children can whisper to you now.

Don't make them shout at you in the future

Don’t End up Like This.

Hearing Protection Devices (HPDs)

Ear Plugs



Hearing Protection

Types of Hearing Protection

earmuffs

- **There are three types of hearing protection – ear muffs, earplugs and ear caps.**
- **Ear muffs and earplugs provide about equal protection, ear caps somewhat less.**

earplugs

ear caps

Hearing Protection

Types of Hearing Protectors

- **All hearing protectors are designed to reduce the intensity (loudness) of noise to the inner ear.**
- **They work much better than wads of cotton or bits of cloth stuffed in the ear.**
- **All three types have advantages and disadvantages and people vary on which they prefer to use.**

Cotton doesn't work!!

Hearing Protection

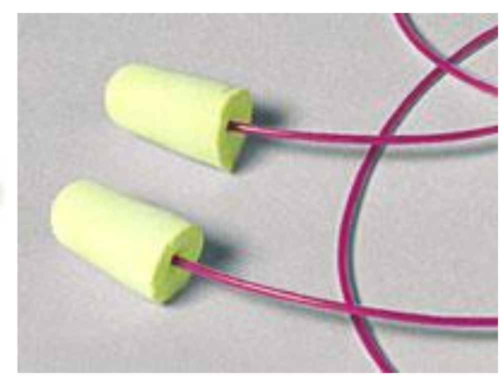
Hearing Protection – Ear Plugs

- **Earplugs are made of foam, rubber or plastic and are either one-size-fits-all or in sizes small, medium and large.**

- **Some are disposable, some are reusable.**

- **They are lightweight, and require no maintenance.**

- **They are inserted into the ear canal.**



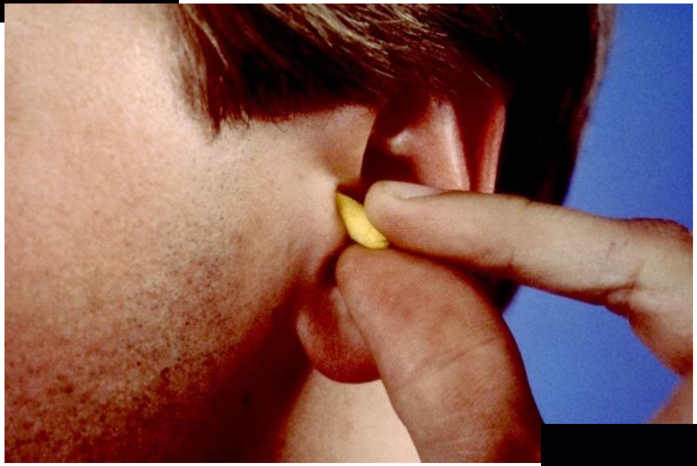
Hearing Protection

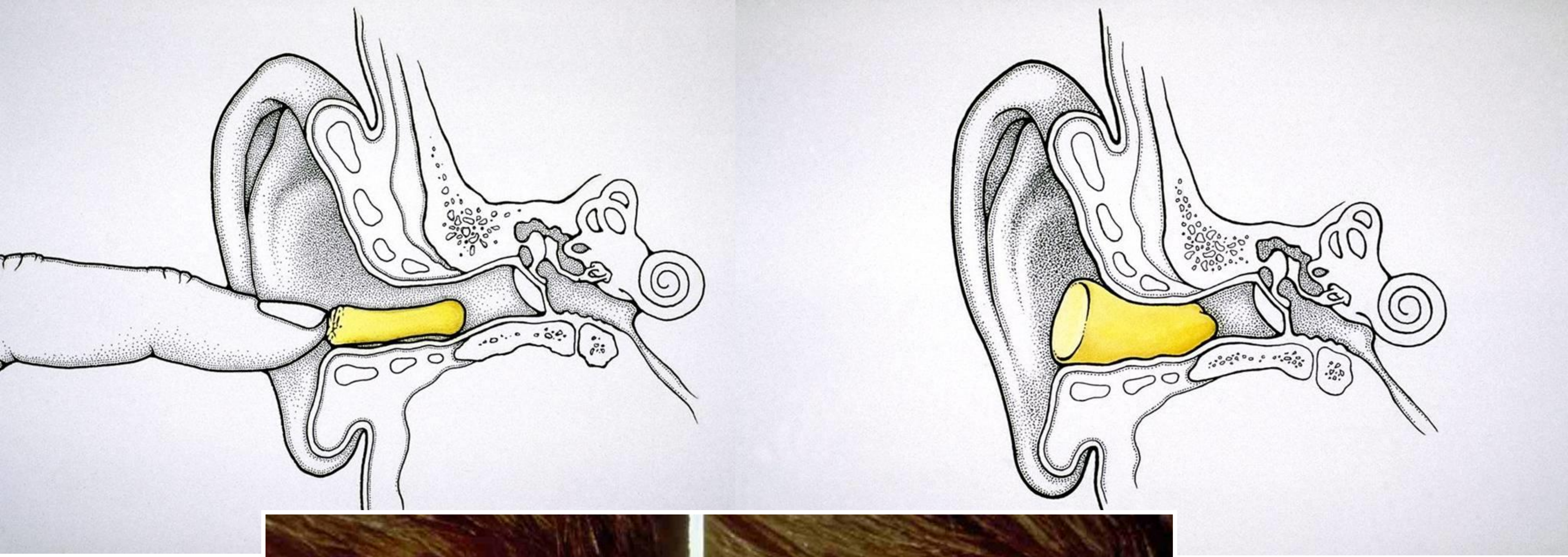
Ear Plug Comfort

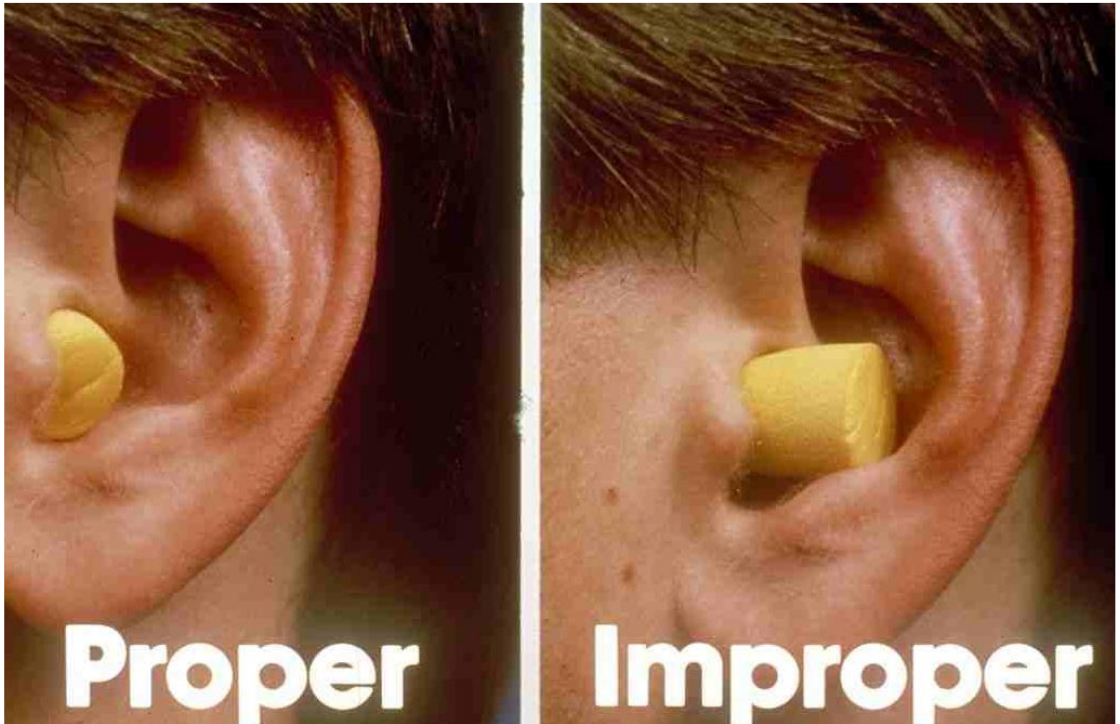
- **Some people may find ear plugs uncomfortable to wear for long periods at first.**
- **Ear plugs rarely cause infection or prolonged irritation of the ear canal.**
- **Most people can find a comfortable fit by trying several different sizes, types or brands.**
- **Custom-molded earplugs can be obtained for maximum comfort.**

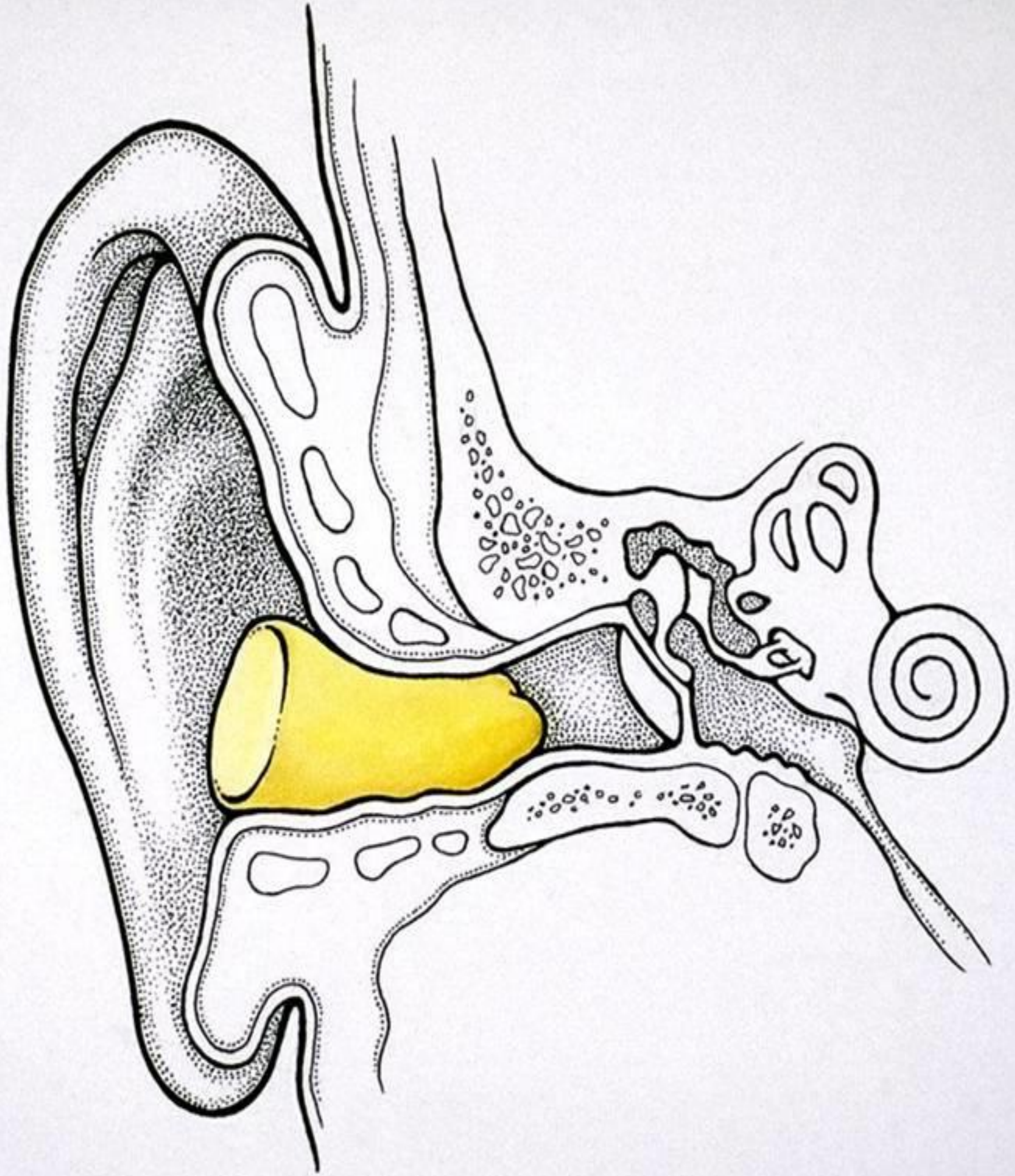
custom molded earplugs

CLEAN HANDS





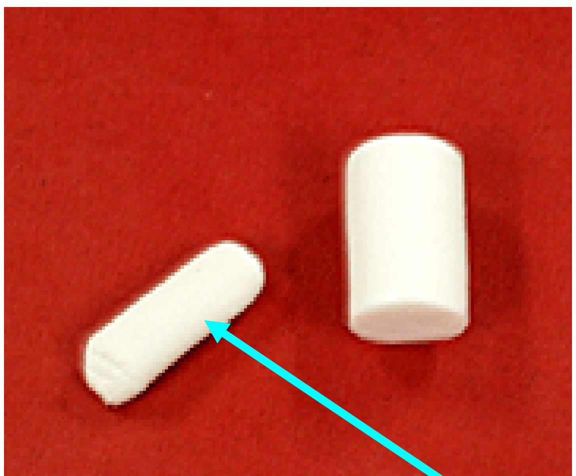

Proper
Improper



Hearing Protection

Inserting Foam Earplugs

Foam type earplugs are one-size-fits-all and must be inserted properly into the ear.



Roll earplug into small cylinder first, then insert in ear.

Hearing Protection

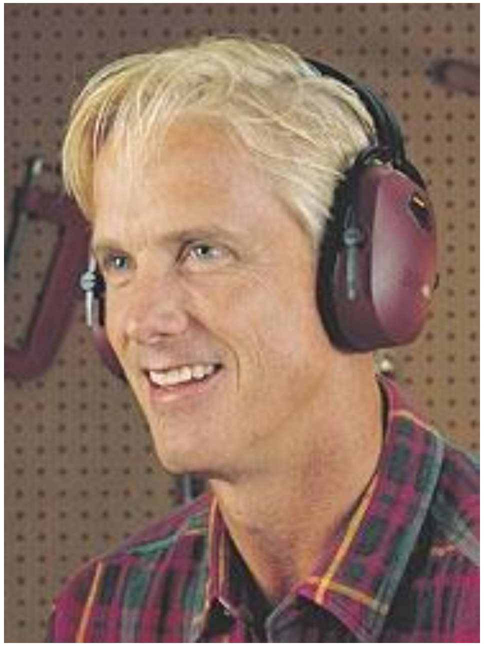
Inserting Foam Earplugs

Earplug incorrectly inserted

Earplug correctly inserted

Hearing Protection

Ear Muffs



- Ear muffs cover the whole ear and are preferred by some people.
- They have replaceable pads and some high-tech styles filter out specific noise pitches.
- They last longer than most plugs.

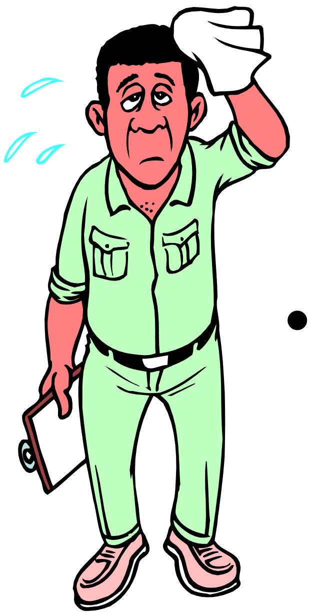
Hearing Protection

Attached Earmuffs

- **Some muffs are attached to hardhats or goggles.**
- **Some high-tech muffs can filter out certain frequencies or have radios inside for communication in high noise areas.**

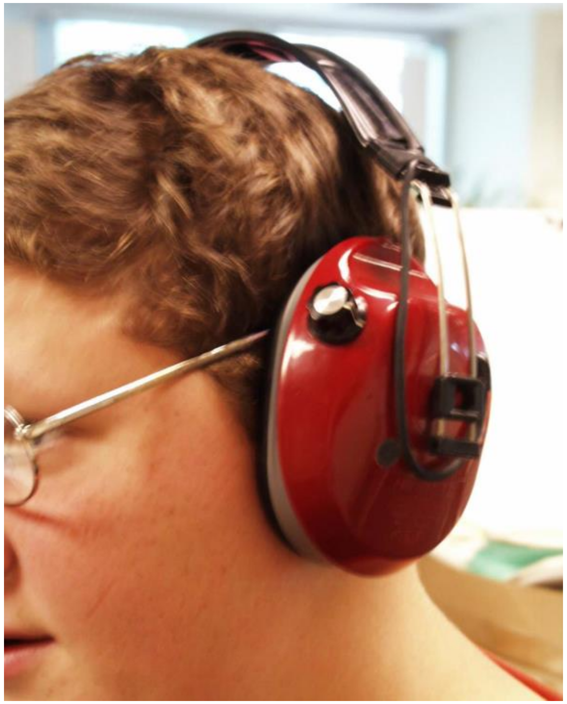
Hearing Protection

Ear Muff Comfort & Glasses



- **Muffs can be uncomfortable in hot weather.**

- **Muffs don't seal well for someone with glasses or heavy sideburns.**



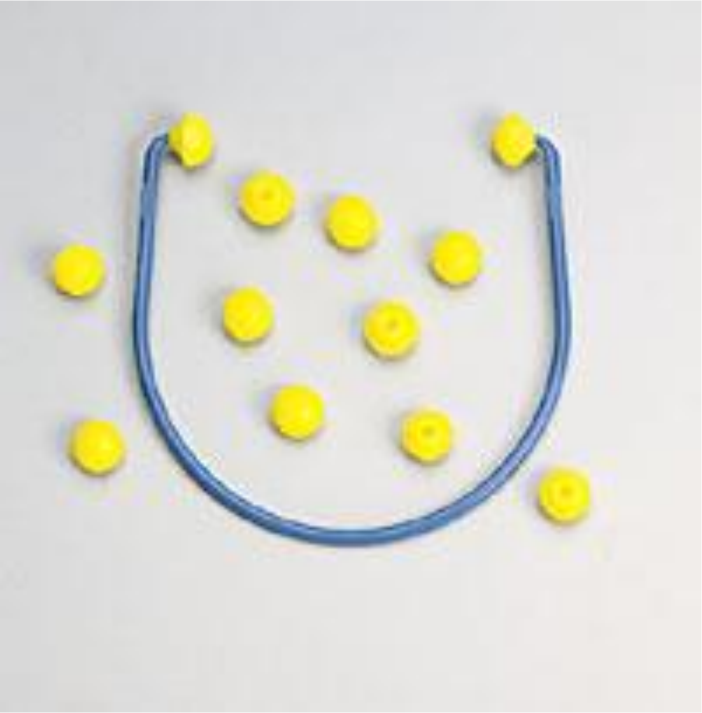
Hearing Protection

Ear Caps

- **Ear caps are like earplugs, except they do not go into the ear canal, they only block it.**

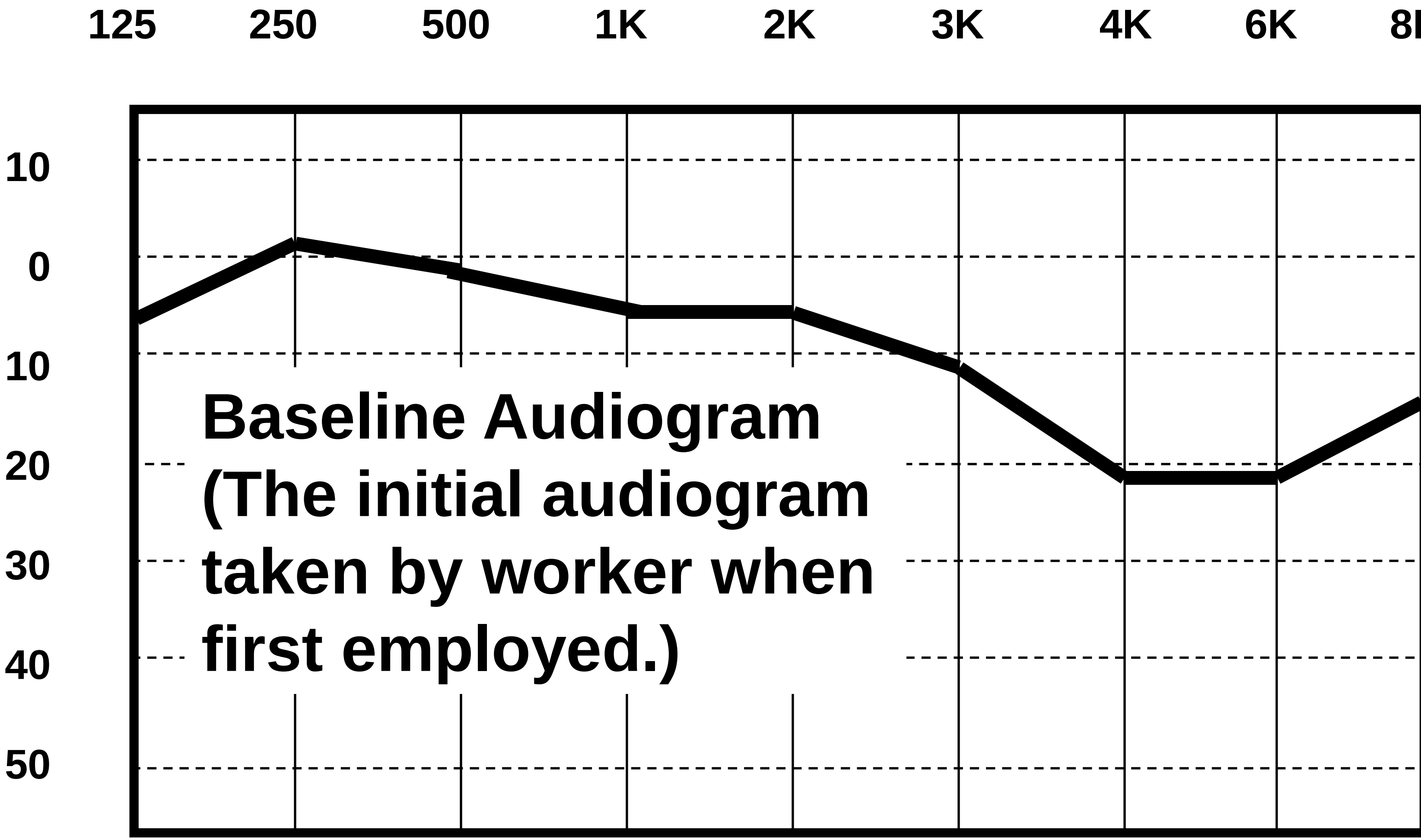
- **They are good for occasional use or for people who find earplugs uncomfortable.**

- **They are not as protective as earplugs or muffs.**

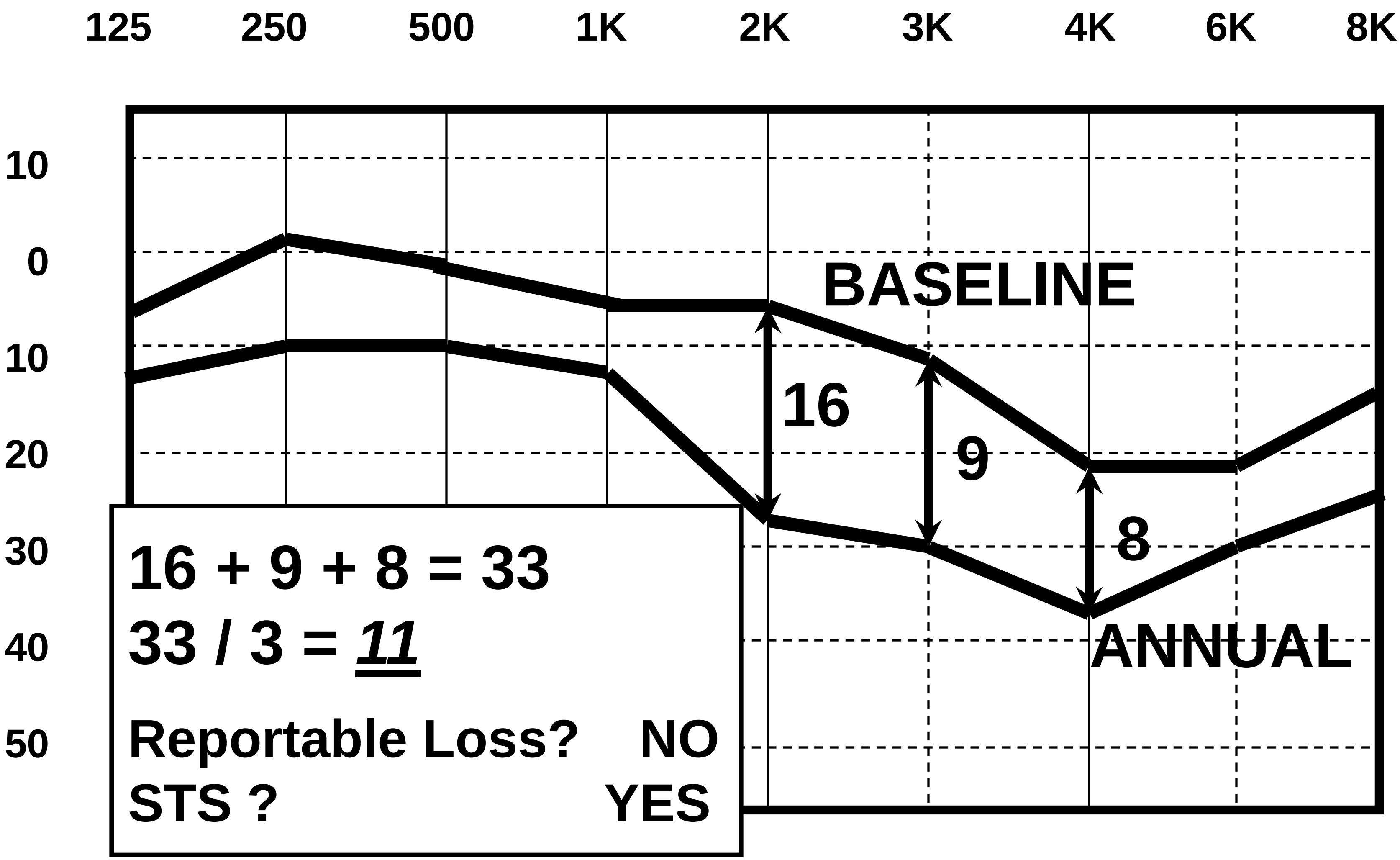


Enforcement

Example Baseline Audiogram



Annual Audiogram (Showing STS)



Audiogram Comparison for Mr. I. Ben Listnen

Right Ear	500	1000	2000	3000	4000	6000
9/10/82	10	5	15	10	20	15
9/16/98	15	20	35	25	45	35
		difference =	20	15	25	

Average = (20 + 15 + 25) / 3 = 60/3 = 20 dB

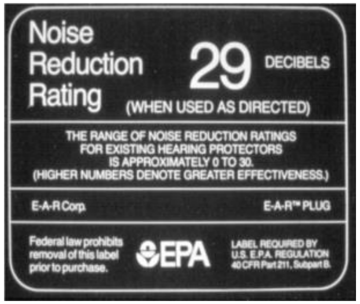
Standard Threshold Shift ?

Hearing Protection

Noise Reduction of Hearing Protection

- **The "noise reduction rating" or "NRR" of hearing protection is measured in decibels.**

- **The NRR is found on the earmuff or earplug package. The higher the number, the greater the protection.**



Hearing Protection Devices (HPDs)

- Noise Reduction Rating (NRR)
  - HPD's have an NRR that is used to determine how effectively HPD's reduce employee exposure by subtracting the NRR from the employees exposure.
  - However, the NRR does not accurately reflect attenuation and a safety factor of 7 must be used.
  - OSHA 50% Derating.

$$\text{Employee TWA (dBA)} - (\text{NRR} - 7\text{dB})/2$$

Hearing Protection Devices

Example :

NRR=21

(21-7)/2= 7 dBA

Protection=97 (90+7) dBA (8h TWA)

(per the legal OSHA 90 dBA PEL)

- A combination of ear muffs and earplugs or other HPD provides greater protection than either device alone.

NIOSH NRR Calculation

http://www.cdc.gov/niosh/98-126f.html

- **Earmuffs - Subtract 25% from the mfr's NRR**
- **Formable earplugs - Subtract 50% from the mfr’s NRR**
- **All other earplugs - Subtract 70% from the mfr’s NRR**

- **Formula**

  Noise level = dBA – (derated NRR – 7)

Dual Protection

- Using plugs and muffs simultaneously
- Actual attenuation depends on many factors
- Reduction is not near what you would expect

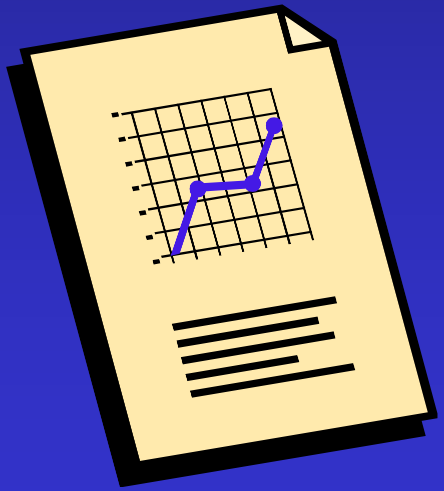
- NRR calculation:
  – Take the higher NRR and add 5 to the field adjusted NRR

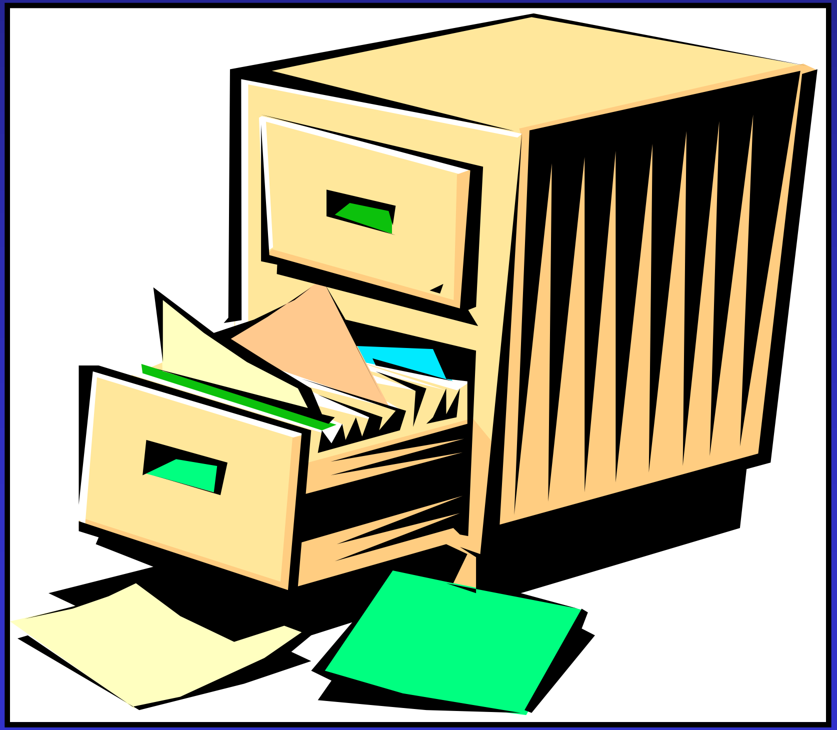
Dual Protection

As a practical matter, double protection is inadequate when TWA noise exposure exceed 105 dBA

Periodic audiometric evaluations

Record Keeping





Medicolegal Issue

Hearing Impairment:

AAO-HNS method:

Unilateral (monaural loss):

1- Average HTL at 500,1000,2000 and 3000 Hz = X

2- **monaural loss = [** $(X - 25) \times 1.5$] = Y

Bilateral (binaural loss or Hearing handicap):

$$\boxed{\frac{[(\text{better ear}) \times 5\ ] + [(\text{poorer ear})]}{6}}$$

Example 1:

Frequency	250	500	1000	2000	3000	4000	6000	8000
Right Ear (dB)	40	40	45	55	70	80	90	70
Left Ear (dB)	35	45	60	70	85	95	100	85

Right ear: $\frac{40 + 45 + 55 + 70}{4} = 52.5 - 25 = 27.5 \times 1.5 = 41.25$

Left ear: " " " " " $= 60$

Binaural Impairment: $\frac{[(41.25) \times 5] + (60)}{6} = 44.37\ \%$

Example 2:

	Hertz (Hz)						
	500	1000	2000	3000	4000	6000	8000
Right ear (dB)	25	35	35	45	50	60	45
Left ear (dB)	25	35	40	50	60	70	50

1. Unilateral impairment:
(Average dB at 500, 1000, 2000, 3000 Hz) – 25 dB (low fence) × 1.5% = Percentage of unilateral impairment
   Right ear = (25 + 35 + 35 + 45 ÷ 4) – 25 × 1.5% = 15%
   Left ear = (25 + 35 + 40 + 50 ÷ 4) – 25 × 1.5% = 18.8%
2. Bilateral impairment:
(Percentage of unilateral impairment in better ear x 5) + (Percentage of unilateral impairment in poorer ear) ÷ 6 = Percentage of bilateral impairment
   (15 × 5) + (18.8%) ÷ 6 = 15.6%

Table 20.2.2 Sample audiogram and calculation of impairment (AAO-79 method)