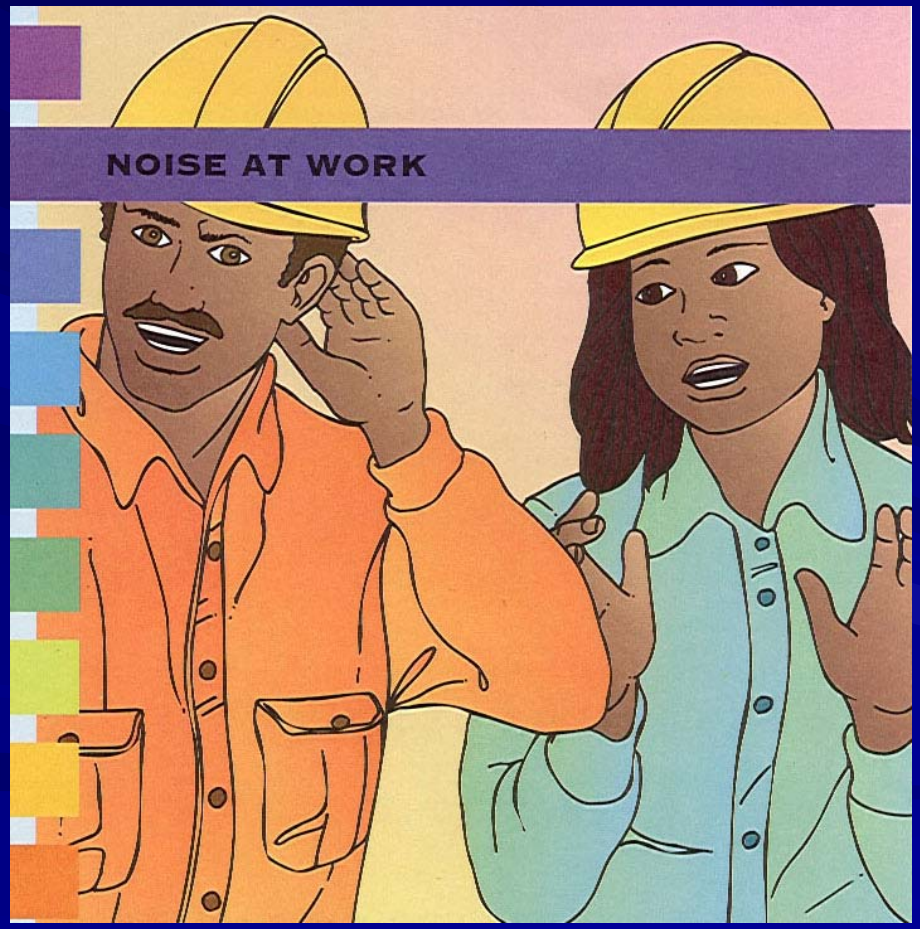
OCCUPATIONAL NOISE, HEARING CONSERVATION



Credit: ILO

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- **What is noise?**
  - Unwanted sound.
- **What is noise-induced hearing loss?**
  - Hearing damage caused by exposure to excessive noise.
  - Although damage is permanent, it may not be apparent until after it has already begun to occur.
  - Occupational hearing loss cannot be cured - but it can be prevented.

Credit: Phil Evans

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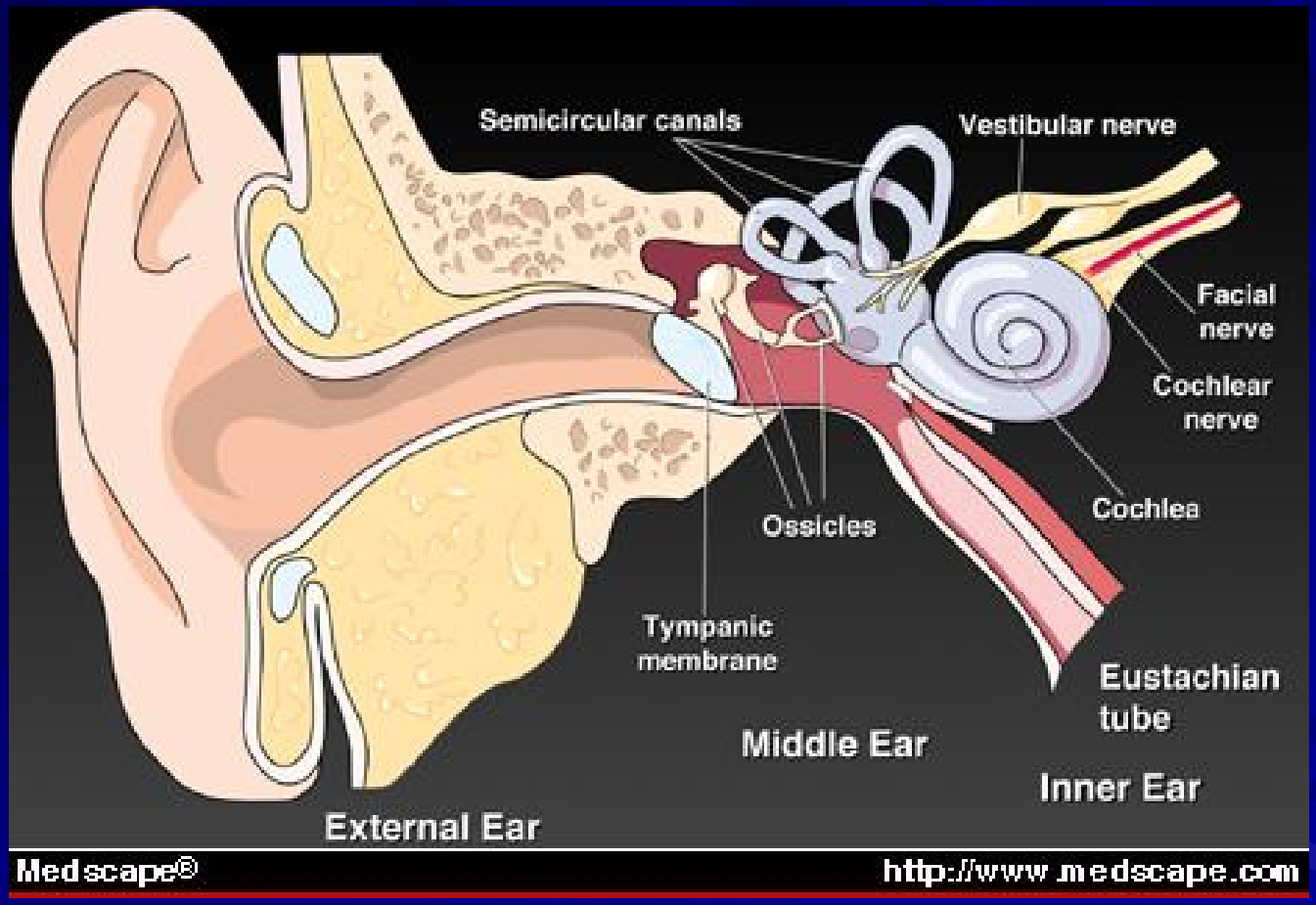
How does hearing work?



- The ear has 3 main parts - the outer, middle, and inner ear.

How does hearing work?

- Outer ear collects sound waves & directs them into external auditory canal.
- Sound waves strike eardrum, causing it to vibrate.
- Vibrations pass small bones of middle ear, which transmit them to sensory cells (hair cells) in the cochlea, the main sensory organ for hearing.
- The vibrations become nerve impulses & go directly to brain, which interprets the impulses as sound.
- When noise is too loud, it begins to kill nerve endings in inner ear. With greater exposure to loud noise, more nerve endings are destroyed. As number of nerve endings decreases, so does hearing. The damage is permanent - there is no way to restore life to dead nerve endings.

How do you know whether your hearing is damaged?

- Hearing loss is gradual and painless. It usually develops over several years - you might not even notice the loss during that time.
- Sometimes, overexposure to loud noise can trigger ringing or other sounds in your ears, called *tinnitus*. While tinnitus may be a symptom of damaged hearing, it can also be caused by infections, medications, and earwax.
- The only way to know for sure is to have a hearing exam by a certified audiometric technician, audiologist, otolaryngologist, or physician.

If you answer yes to any of these questions, *your hearing may be at risk:*

- *Do you frequently ask people to repeat sentences?*
- Do you feel your hearing is not as good as it was 10 years ago?
- *Have family members noticed a problem with your hearing?*
- Are you exposed to loud noise without hearing protection at work?
- *Do you have to speak above a normal conversational level in order to be heard at work?*
- Are you exposed to noise from firearms, motorcycles, snowmobiles, power tools, or loud music without hearing protection?

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Physical properties of sound

- The effects of sound on a person depend on 3 physical characteristics of sound:
  - amplitude
  - frequency
  - duration.

Amplitude

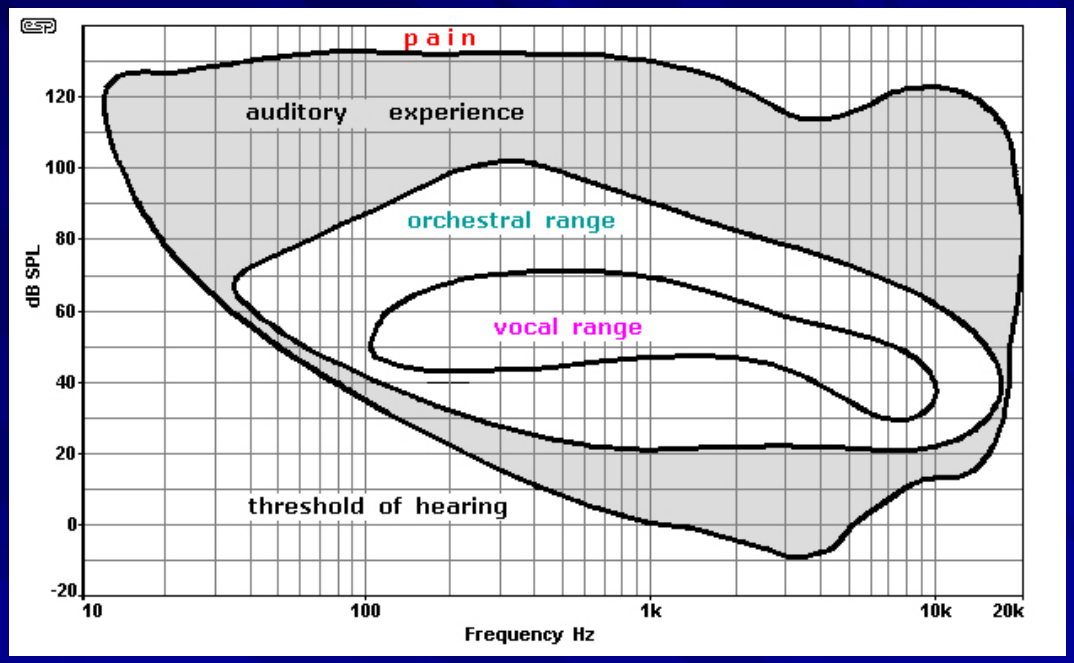
	DECIBEL - dB(A)	EQUIPMENT
Double protection recommended above 105 dB(A)	112	Pile driver
	110	Air arcing gouging
	108	Impact wrench
	107	Bulldozer - no muffle
	102-104	Air grinder
	102	Crane - uninsulated cab
	101-103	Bulldozer - no cab
	97	Chipping concrete
	96	Circular saw and hammering
	96	Jack hammer
	96	Quick-cut saw
	95	Masonry saw
	94	Compactor - no cab
Hearing protection recommended above 85 dB(A)	90	Crane - insulated cab
	87	Loader/backhoe - insulated cab
	86	Grinder
	85-90	Welding machine
	85	Bulldozer - insulated cab
	60-70	Speaking voice

Table 1: Some typical noise levels found on construction sites

- Sound pressure level (SPL), expressed in decibels (dB), is a measure of the amplitude of the pressure change that produces sound.
- Amplitude is perceived by the listener as loudness.

Frequency

- Expressed in Hz (Hertz), representing the number of cycles occurring in 1 second
- Determines the pitch perceived by the listener.



Credit: Elliott Sound Products

- Humans w/ normal hearing can hear frequency range of about 20 Hz - 20 kHz (kilohertz).
- Typical human speech ranges from 300 to 4,000 Hz.

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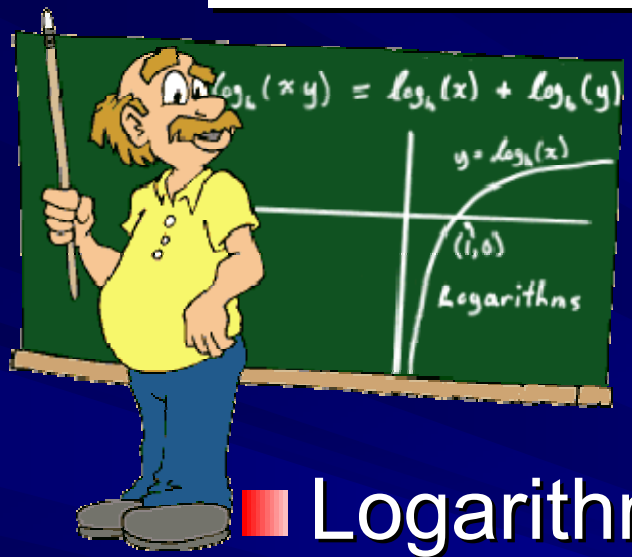
Duration

- Broadly classified as continuous or impulsive.
- All non-impulsive (i.e., continuous, varying, and intermittent) referred to as continuous type noise.
- Impact and impulse noises referred to as impulsive noise.
- Impulsive noise is distinguished from continuous type noise by a steep rise in the sound level to a high peak followed by a rapid decay.
- Workplace exposures are often a mixture of continuous type and impulsive sounds.

"They're playing our song."

Understanding decibels



- Logarithmic scale
- 3 dB increase = doubling of sound energy (loudness)
- 10 dB increase = 10X increase
- 20 dB increase = 100x increase
- 30 dB increase = 1,000x increase, etc.

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Sound Intensity	Sound Level in dBA
100 000 000 000 000	140
10 000 000 000 000	130
1 000 000 000 000	120
100 000 000 000	110
10 000 000 000	100
1 000 000 000	90
100 000 000	80
10 000 000	70
1 000 000	60
100 000	50
10 000	40
1 000	30
100	20
10	10
0	0

How are noise levels measured?

- **Area survey**
  - measurement of environmental noise levels using sound level meter
  - goal: ID work areas where worker exposures are of concern
  - can also approximate exposure levels by placing microphone within worker hearing zone

Sound level meter

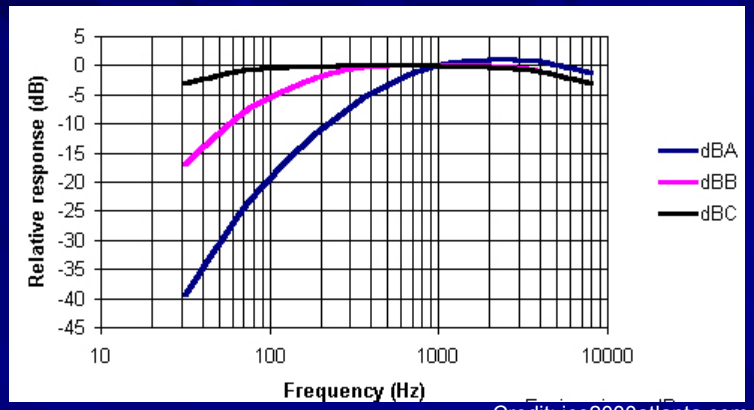
Calibration kit

How are noise levels measured?

Credit: www.envirotech-online.com

- **Dosimetry**
  - body-worn instrument (dosimeter) to monitor worker's exposure over course of work shift
  - dosimeter worn in pocket or on belt
  - microphone positioned on shoulder within hearing zone

Do you know your dBAs & dBCs?



Credit: ies2000atlanta.com

- Sound level meters and dosimeters can measure decibels in different frequency ranges, typically a dBA scale and a dBC scale.
- dBA scale reflects measurements that emphasize higher frequencies, approximating human hearing.
- dBC scale measures the lower frequencies, which we do not perceive as very loud. We may not hear the lower frequencies, but we can feel them.

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Conductive hearing loss

- Occurs when sound is not conducted efficiently through the outer ear canal to the eardrum and the tiny bones, or ossicles, of the middle ear.
- Usually involves a reduction in sound level, or the ability to hear faint sounds.
- Often can be medically or surgically corrected.
- Conditions that may cause conductive hearing loss include:
  - fluid in middle ear from colds, allergies (serous otitis media), poor eustachian tube function, ear infection (otitis media), perforated eardrum, benign tumors
  - impacted earwax (cerumen)
  - infection in ear canal (external otitis)
  - presence of a foreign body
  - absence or malformation of outer ear, ear canal, or middle ear

Conductive hearing loss

- Work-related conductive hearing loss is not common, but may occur as result of accidents involving:
  - An eardrum rupture or a break in the ossicular chain by a head blow
  - Explosions
  - A rapid pressure change in a decompression chamber.
  - Penetration of the eardrum by a sharp object or fragment.

Sensorineural hearing loss

- Occurs when there is damage to inner ear or to nerve pathways from the inner ear to the brain.
- Cannot be medically or surgically corrected. It is a permanent loss.
- Involves not only a reduction in sound level & ability to hear faint sounds, but also affects speech understanding & ability to hear clearly.
- Can be caused by diseases, birth injury, drugs that are toxic to the auditory system, & genetic syndromes.
- May also occur as result of **noise exposure**, viruses, head trauma, aging (presbycusis), & tumors.

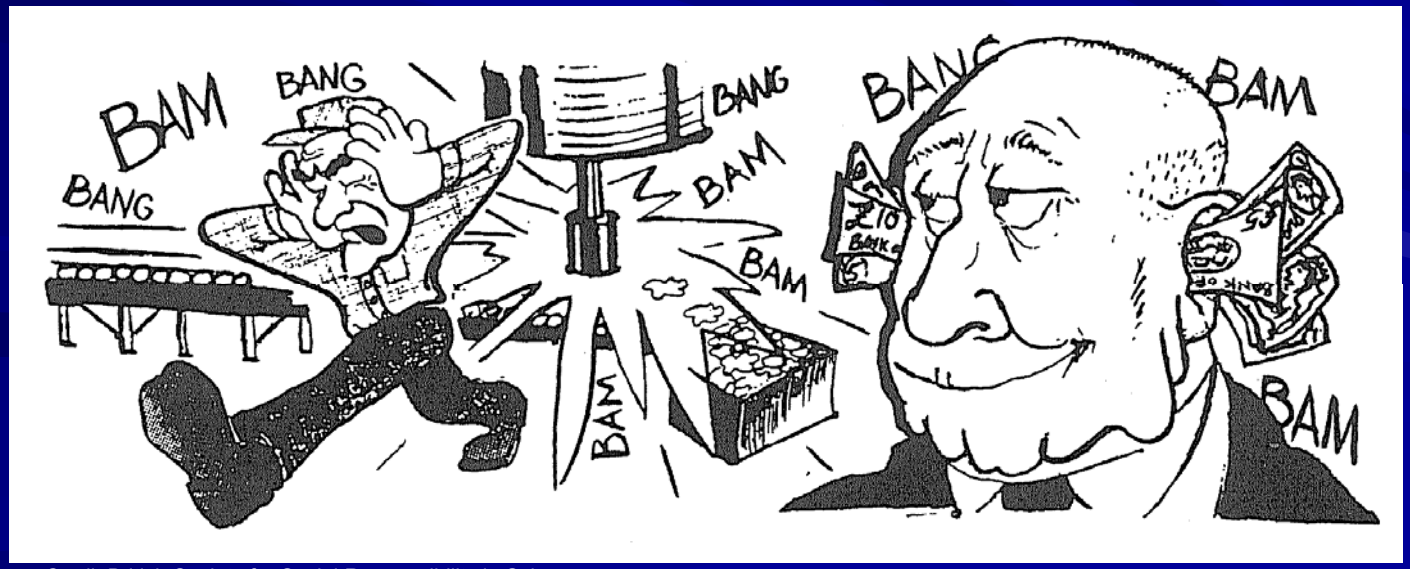
Health Impacts of Occupational Noise Exposure

HEALTH IMPACT	EVIDENCE	THRESHOLD (dBA)
hearing loss (adult)	sufficient	75
hearing loss (fetus)	sufficient	<85
hypertension	sufficient	55 - 116
annoyance (office)	sufficient	<55
annoyance (industry)	sufficient	<85
birth weight	plausible but limited	unknown
immune effects	plausible but limited	unknown
biochemical effects	plausible but limited	unknown
performance	plausible but limited	unknown

Credit: World Health Organization

Noise-induced hearing loss

- Begins to occur at 75 – 80 dB.
- OSHA/PESH noise PEL = 90 db 8-hour time weighted average (TWA).
- OSHA / PESH hearing conservation requirements triggered at 85 dB.



Credit:British Society for Social Responsibility in Science

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OSHA/PESH
Occupational Noise Standards

29 CFR 1910.95 – general industry
29 CFR 1926.52 - construction

- **protection against noise exposure**
  - permissible exposure limits (PELs)
  - “feasible” engineering or administrative controls
  - PPE (hearing protective devices [HPDs]) when exposed at/above 85 dB TWA

OSHA/PESH General Industry Occupational Noise Standard

- hearing conservation program
  - noise monitoring & employee notification
  - audiometric testing "available" when exposed at/above 85 dB TWA
  - annual training when exposed at/above 85 dB TWA
  - recordkeeping & employee access

OSHA/PESH Construction Occupational Noise Standard

- hearing conservation program
  - "Where the sound levels exceed the [PELs], a continuing, effective hearing conservation program shall be administered." 1926.52(d)(1)
  - *no criteria specified; performance standard*.

Credit: Advanced Safety & Health

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Proposed OSHA Enforcement Change

- Current policy:
  - OSHA issues citations for failure to use engineering & administrative controls only when they cost less than a hearing conservation program.
- Proposed change:
  - Issue citations requiring the use of engineering & administrative controls when such controls are feasible (*i.e., enforce according to the hierarchy of controls*).

OSHA/PESH noise PEL

When engineering or administrative controls are required

Hours of exposure	*Sound level (dBA)*
8.0	90
6.0	92
4.0	95
3.0	97
2.0	100
1.5	102
1.0	105
0.5	110
0.25 or less	115

This requirement applies to all exposed employees, including those with hearing impairments. Even employees who have been diagnosed with severe or profound deafness may have some residual hearing, which must be protected.

- **Note "exchange (doubling) rate" issue:**
  - **OSHA exchange rate = 5 dB**
  - **scientific exchange rate = 3 dB**

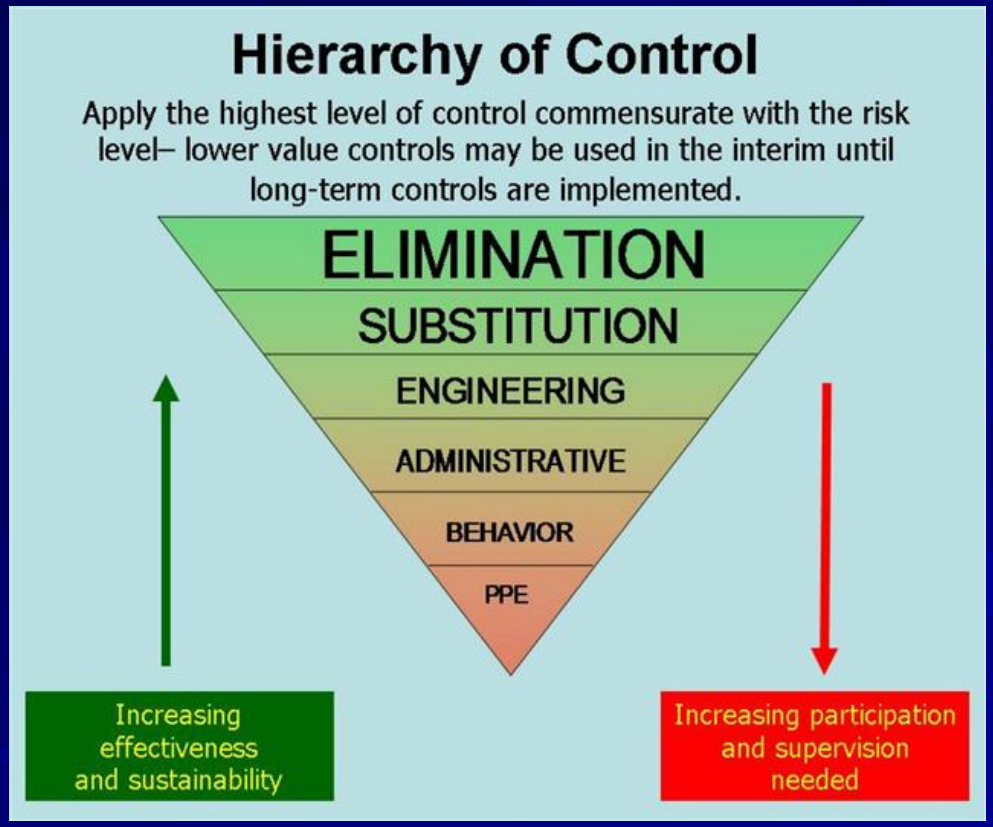
OSHA Definition: Impact or Impulse Noise

- Noises are considered continuous if the interval between occurrences of the maximum noise level is one second or less.
- Noises not meeting this definition are considered impact or impulse noises (loud momentary explosions of sound).
- Exposures to impact noise must not exceed 140 dB.

Credit: Toolmonger

- Examples of situations or tools that may result in impact or impulse noises are powder-actuated nail guns, a punch press or drop hammers.

Applying the hierarchy of controls



Credit: Innovative Occupational Hygiene Solutions

- *A solution is likely to be safer & more effective when you:*
- understand **what is causing the noise**
- determine **how the noise is reaching the worker**
- identify **where to control the noise:**
  - at source
  - along sound path
  - at the worker.

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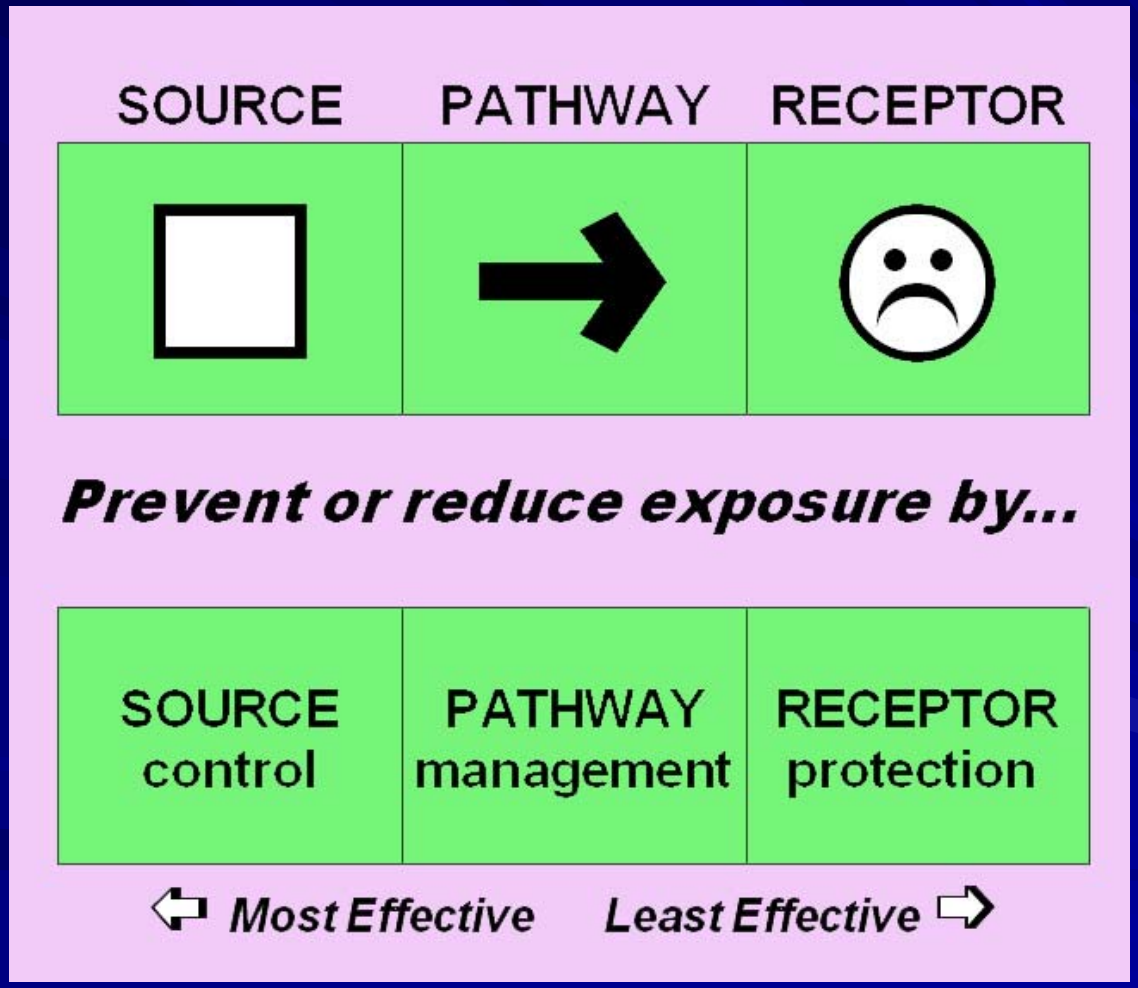
Alternate View: Hierarchy of Controls



Credit: NYCOSH

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Substitution

- "Buy quiet" purchase policy
- Power equipment & vehicle manufacturers have significantly reduced noise output of many of their products. Sometimes these noise controls are options.
- Some manufacturers have also developed retrofits for older equipment. Examples of built-in noise controls are insulated cabs on trucks and other large vehicles, & noise control in small engines.

Engineering controls

Credit: Behrens and Associates

- Reduce noise at source
  - examples: install muffler, improve maintenance
- Interrupt noise path
  - examples: erect acoustical enclosures & barriers

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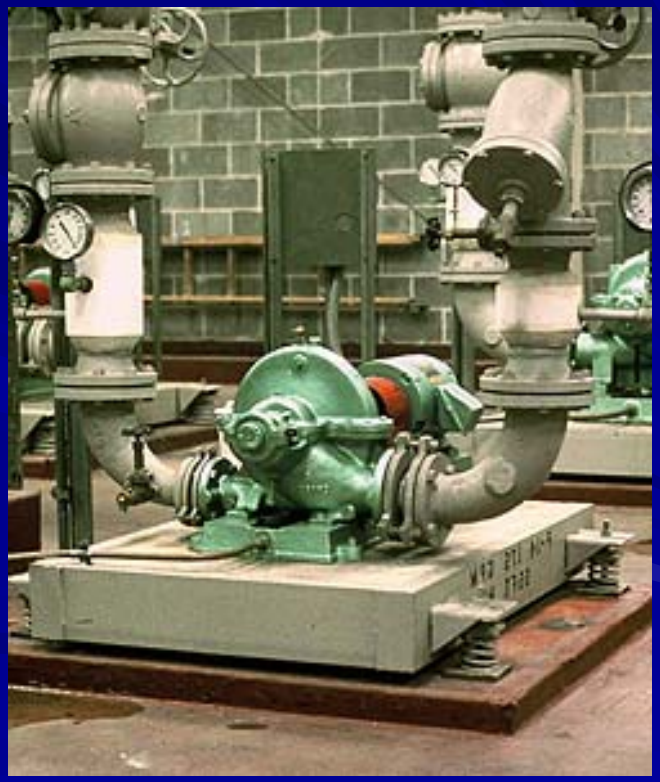
Engineering controls

- Reduce reverberation
  - examples: install sound-absorbing material
- Reduce structure-borne vibration
  - examples: install vibration mounts, provide proper lubrication



Engineering controls

When engineering or administrative controls are required

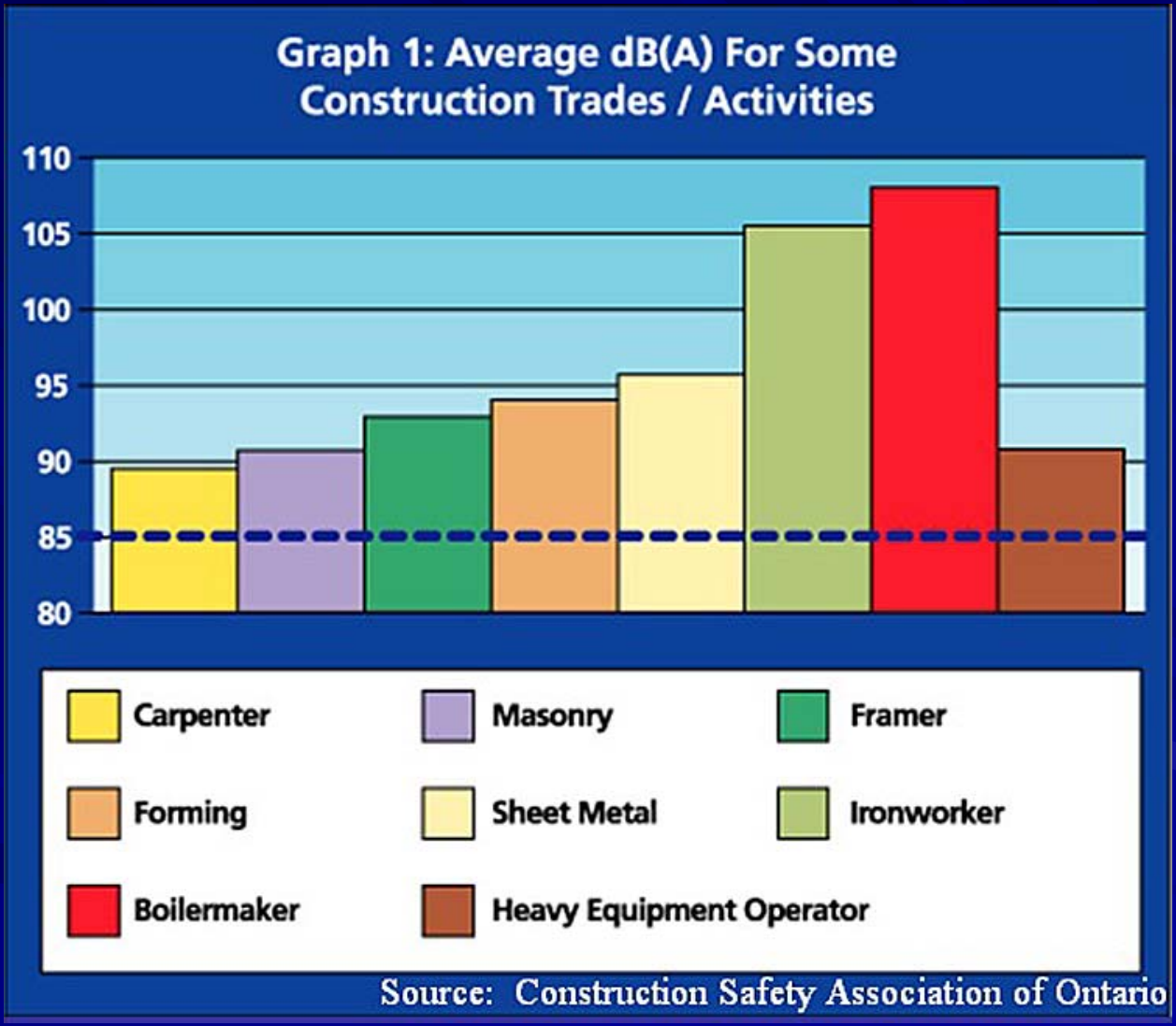
Distance	Decibel level at the source	Decibel level at the listener
5 feet	96	96
10 feet	96	90
20 feet	96	84

- **Increase distance.**
  - Noise sources can be isolated by locating them away from work areas. Sometimes just increasing the distance between the noise source and the worker in the same room will work.
  - Indoors, noise levels drop off by 2-6 decibels by doubling the distance between the source and the person. For example, a 90 decibel noise source at 5 feet will be 84-88 decibels at 10 feet.

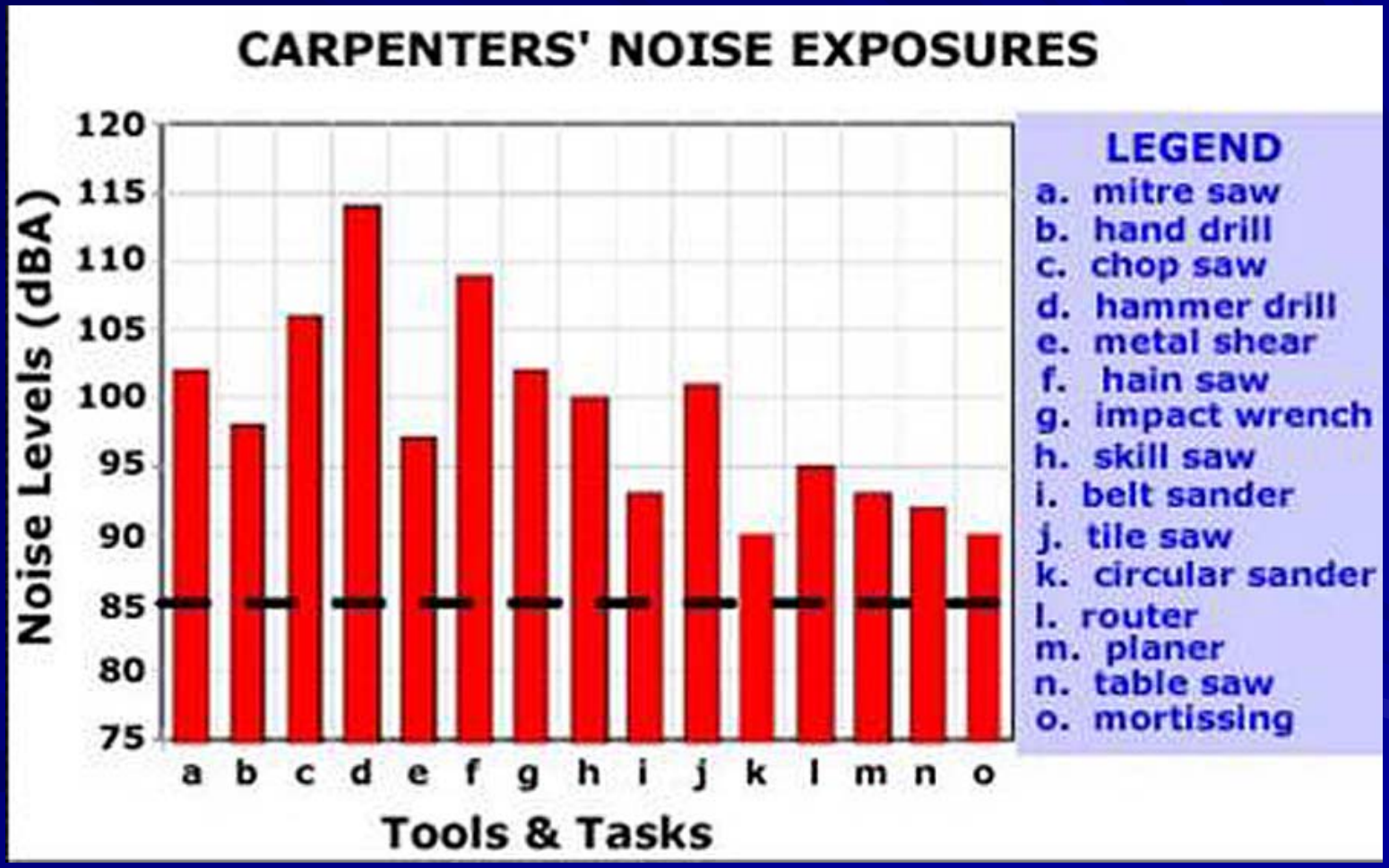
Administrative controls

- Change workers' activities to lower exposures
- Reduce time spent in noisy environments, rotate workers
- Shut down noisy equipment when not needed
- Implement work practice controls to emphasize safe practices
- Maintain equipment to run smoothly and quietly
- Use warning signs to ID noisy work areas

Noise in Construction



Noise in Construction



Credit: NIOSH

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Challenges in Controlling Construction Noise

Credit: OSHA

- Construction activities not always stationary or in one location.
- Construction activities affected by weather, wind, topography, & landscaping.
- Construction noise-producing equipment may move from location to location & can produce noise that varies in intensity throughout a work day.

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Construction Engineering Controls

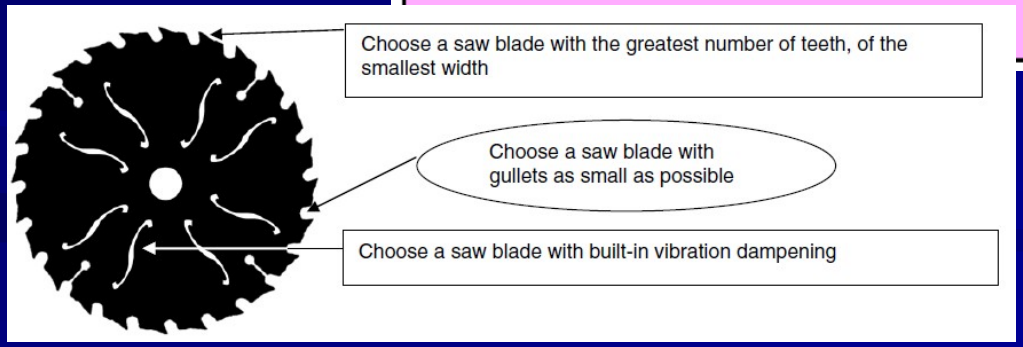
- substituting quieter, newer equipment
  - example: noise-reducing saw blades can cut noise levels in half when cutting masonry blocks
- substituting a quieter process
  - example boring can sometimes replace pile driving
- retro-fitting existing equipment with damping materials, mufflers, or enclosures
- erecting temporary barriers or enclosures
  - example: plywood with sound absorbing materials
- maintenance
  - example: basic maintenance can reduce noise levels by up to 50%

→

Credit: Laborers' Health & Safety Fund of North America

Examples of Construction Equipment Engineering Noise Controls

EQUIPMENT	NOISE CONTROLS
portable air compressor	muffler, acoustic enclosures
stone saw cutting	noise control pad with water
pile driver	enclosure, muffler
circular saw blades	15° tooth angle, new tooth configuration, slotted saw blades, viscoelastic damping
pneumatic tools	muffler
bulldozer	cab-liner material, enclosure, sound adsorption in canopy, sealing of all openings



Credit: Laborers' Health & Safety Fund of North America

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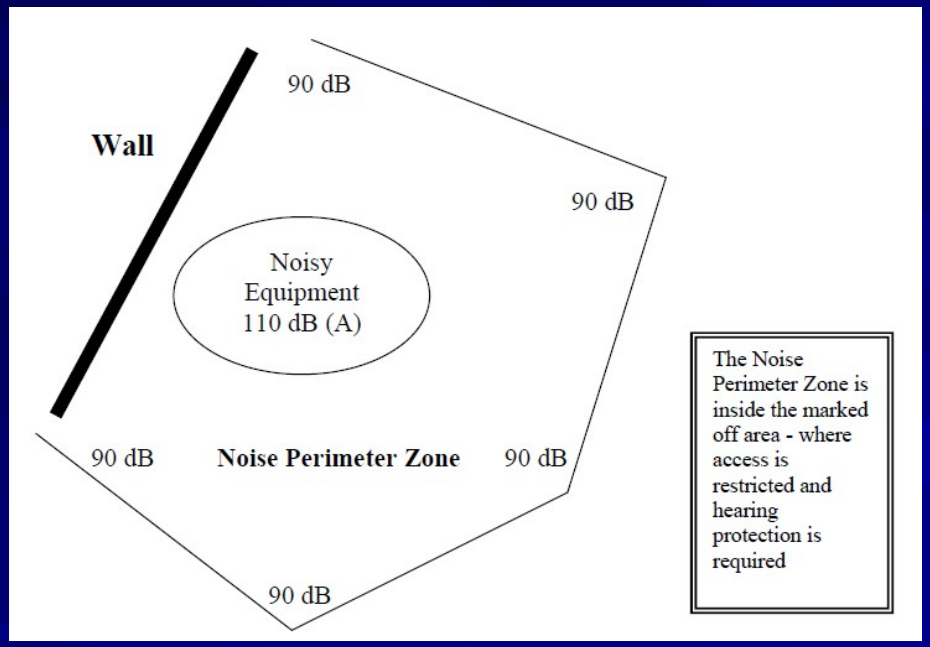
Administrative Controls to Reduce Construction Worker Noise Exposure



Credit: Laborers' Health & Safety Fund of North America

- moving workers away from the noise source
- establishing noise perimeter zones (NPZ)
- rotating workers who conduct noisy tasks
- shutting down noisy equipment when operation is not necessary

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PPE: hearing protective devices (HPDs)

- All HPDs are designed to reduce the intensity of noise that reaches the sensitive nerves in the inner ear.
- 3 types of hearing protectors
  - ear muffs
  - ear plugs
  - ear caps.
- Ear muffs and ear plugs offer about equal protection, ear caps are less protective.

When must HPDs be provided?

- "Employers shall make hearing protectors available to all employees exposed to an 8-hour time-weighted average of 85 dB or greater at no cost to the employees."
- "Employees shall …select their hearing protectors from a variety of suitable hearing protectors…"
- "The employer shall provide training and … ensure proper initial fitting…"

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Ear plugs

- made of foam, rubber or plastic
- 2 basic types
  - expandable foam
    - provide the greatest protection
  - pre-molded plastic
    - more comfortable for some people
- can be either one-size-fits-all or in sizes S, M, L
- more protection at 125 Hz than muffs
- inexpensive, lightweight, & maintenance-free
- reusable or single use/disposable.

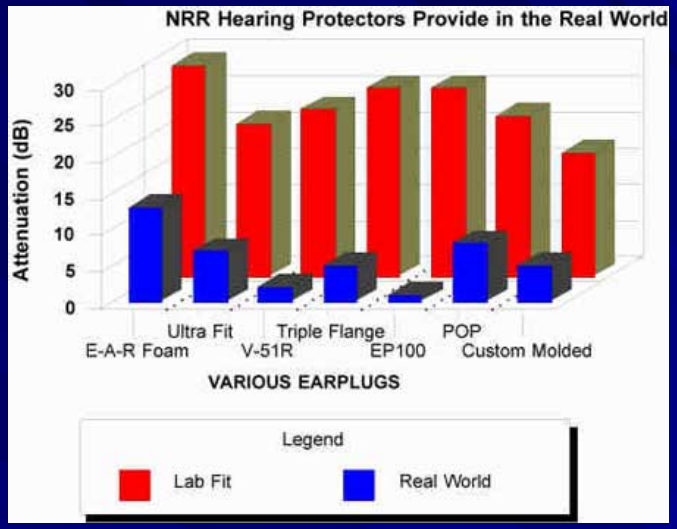
Ear muffs

- cover the entire ear
- have replaceable pads or cushions
- some high-tech styles filter out specific noise frequencies
- slightly better than plugs at reducing low frequency
- more protection at 500-8,000Hz than earplugs
- initially more expensive, but last much longer than most plugs
- can be uncomfortable in hot weather & don't seal well with glasses or heavy sideburns
- some designed to be worn with hard hats or goggles.

Ear caps (semi aural caps)

- like ear plugs except they do not insert into the ear canal, but only block it
- good for intermittent use or for people who find ear plugs uncomfortable
- will only reduce noise to the ear by about 10 decibels, so do not give adequate protection above 95 decibels.

HPD noise reduction ratings (NRR)



- Every HPD is assigned a NRR in dB.
- The NRR reflects testing done under ideal laboratory conditions.
- The NRR does not reflect real world performance & over-rates the amount of protection that an HPD can provide.
- There are a variety of methods for “de-rating” an assigned NRR in order to better reflect real world performance of an HPD.

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One method for de-rating the NRR

"All those in favour of moving the decimal point one place to the right?"

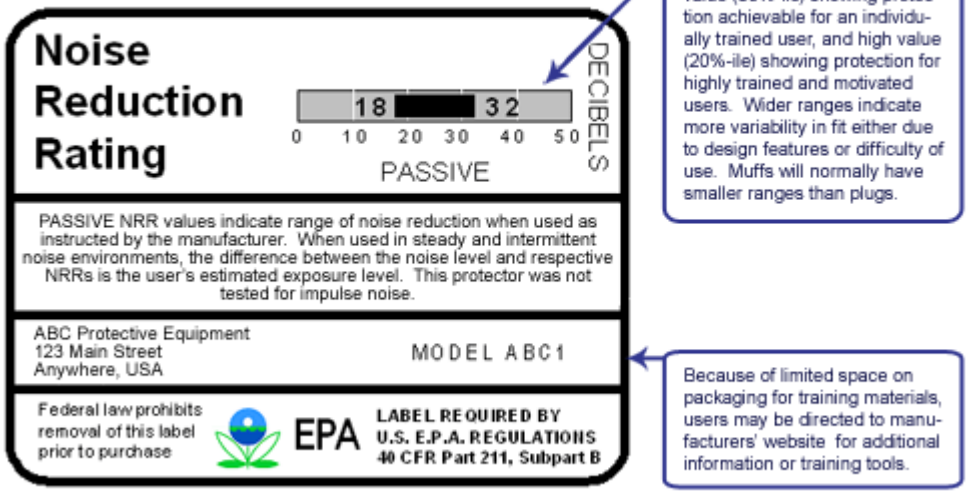
- NIOSH recommends derating the NRR by a multiplicative factor of:
  - 75% for earmuffs
  - 50% for slow-recovery foam earplugs & custom earplugs, and
  - 30% for all other earplugs. (NIOSH, 1998)

Another method for de-rating the NRR

Example: A hearing protector with an NRR value of 25	
1. Noise level to which the worker is exposed (averaged over eight hours).	95 decibels
2. NRR shown on the hearing protector label.	25 decibels
3. Subtract seven decibels from the NRR.	25-7 = 18
4. Subtract 18 decibels from 95 decibels.	95-18 = 77
This hearing protector may be able to reduce a worker's exposure from 95 decibels to 77 decibels.	

NRR labels will be redesigned

The New NRR Label may look like this



For electronic products, two bars will likely be presented, one showing the performance for the device in its passive mode (turned off) and the other when energized (turned on). The off-mode NRR would be useful for example, if the device is worn and the batteries fail.

OSHA/PESH Hearing Conservation Program 29 CFR 1910.95 (c) – (o)

- Written program
- Noise monitoring, with employee observation
- Employee notification
- Audiometric testing
- Hearing protectors
- Training
- Access to information
- Recordkeeping

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Why audiometric testing?

- Hearing tests are the only way to tell for sure whether a hearing conservation program is working.
- Because occupational hearing loss occurs gradually, we often do not notice a change in hearing ability until a relatively large loss has occurred.
- Comparing annual hearing tests tells us early on if workers are developing mild hearing losses.
- We can then do something to prevent further losses.
- For example, we can evaluate and improve engineering controls, refit hearing protective devices, or retrain workers, so that no one suffers additional hearing loss.

Noise monitoring

- Employers must monitor noise exposure levels in a way that accurately identifies employees exposed to noise at/above 85 dB TWA.
- The exposure measurement must include all continuous, intermittent, and impulsive noise within an 80 dB to 130 dB range and must be taken during a typical work situation.
- Employers must repeat monitoring whenever changes in production, process, or controls increase noise exposure.
- Employees are entitled to observe monitoring procedures and must receive notification of the results of exposure monitoring.

When should audiograms be conducted?

Credit: Noisebrain

- Per OSHA / PESH requirements:
  - within 6 months of employee's exposure at/above 85 dB TWA
  - annually as long as the worker is exposed at/above 85 dB TWA.
- Per professional recommendations:
  - pre-employment
  - prior to initial assignment in a "hearing hazardous" work area
  - at the time of reassignment out of a "hearing hazardous" job
  - at termination of employment.

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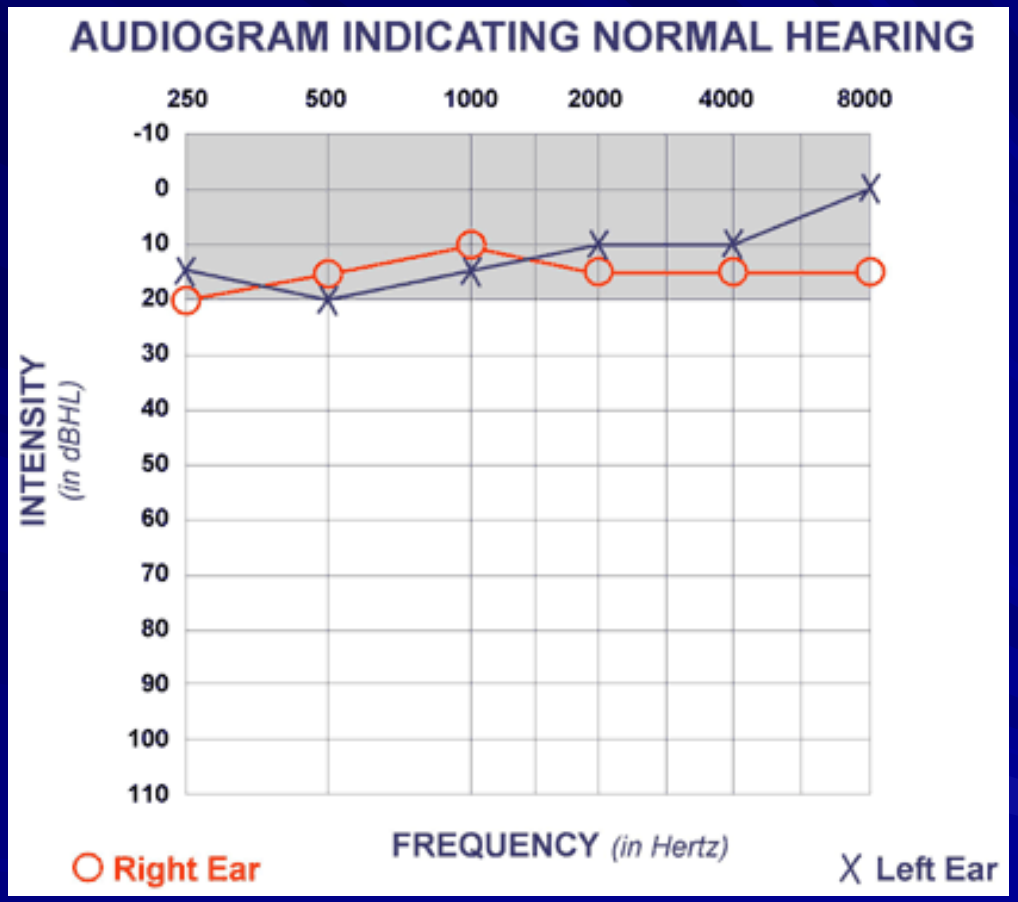
What does a normal audiogram look like?



Credit: www.hearingprofessionals.co.nz

- Responses will fall between 0 and 25 dB at all frequencies.

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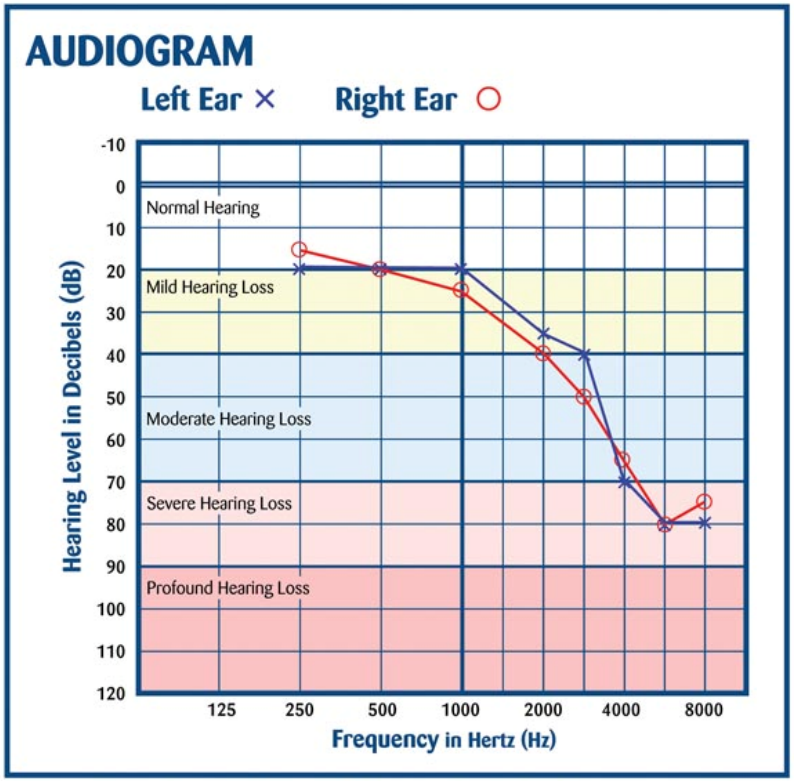
What does an age-related hearing loss audiogram look like?



* An example presbyacusis (sloping high-frequency hearing loss) synonymous with the ageing process.

Credit: HearingLife

- Typically, losses are seen at the higher frequencies between 6000 and 8000 Hz.

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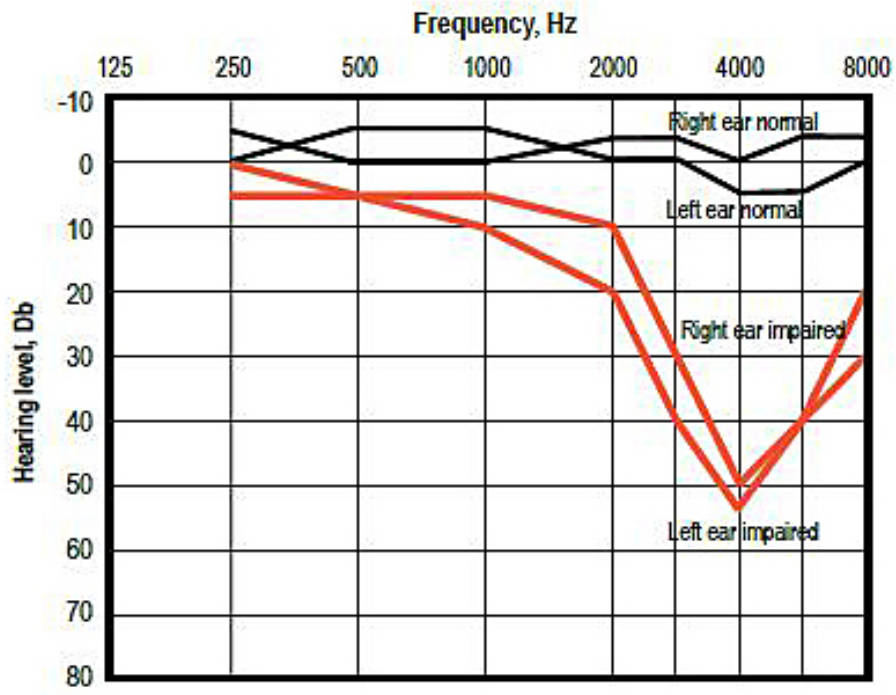
What does a noise-induced hearing loss audiogram look like?



Example of an audiogram showing normal and impaired hearing

- Frequently shows a notch at 4000 Hz with better hearing at 8000 Hz.

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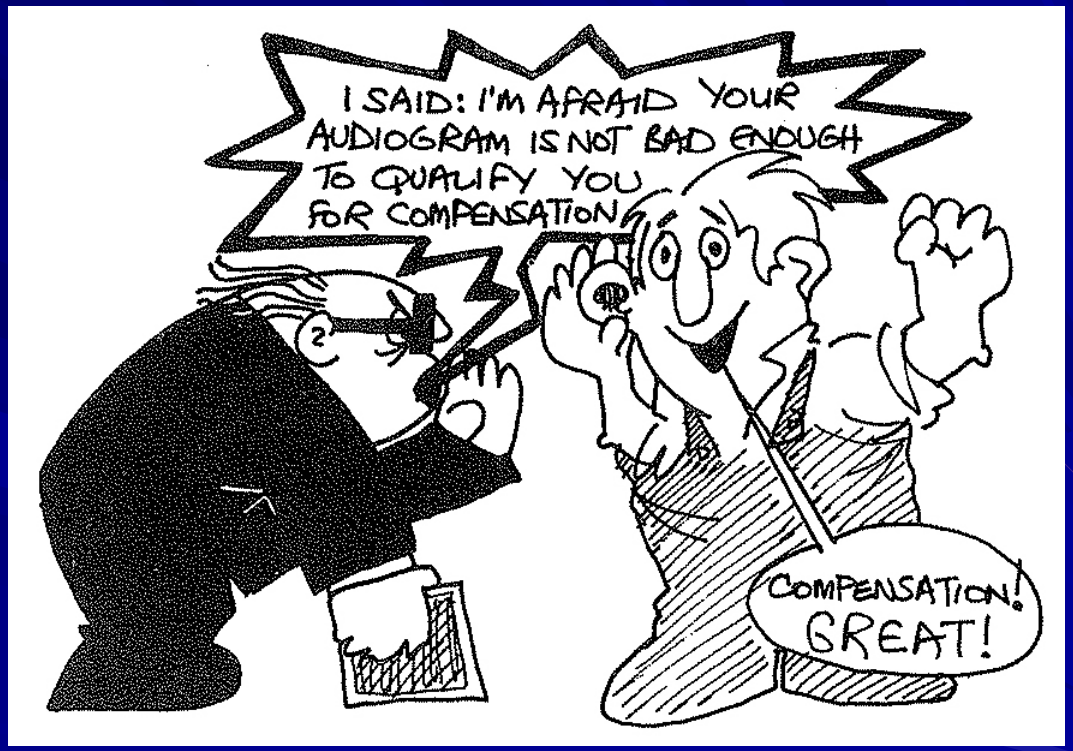
What happens if your audiogram shows a hearing loss?

- If technician sees a Standard Threshold Shift (10 dB or greater change at 2000, 3000, or 4000 Hz in either ear) when compared to your baseline audiogram, employer may obtain a retest within 30 days and consider the results of the retest as the annual audiogram.
- The employee must be informed of the STS in writing within 21 days.



Credit: British Society for Social Responsibility in Science

What training is required?

- Employer must train all employees exposed at/above 85 dB TWA.
- Training must be annual.
- Training must cover:
  - the effects of noise on hearing
  - the purpose of HPDs & their advantages, disadvantages, and attenuation (noise reduction capabilities)
  - instruction on selection, fitting, use, & care of HPDs
  - the purpose of audiometric testing & an explanation of the test procedures.

Recordkeeping

- Noise exposure measurement records shall be retained for [at least] 2 years.
- Audiometric test records shall be retained for the duration of the affected employee's employment.

NYC Noise Code

- Unreasonable noise =
  - sound other than impulsive sound >6 dBA above ambient sound level between 10 PM & 7 AM measured anywhere within receiving property
  - sound other than impulsive sound >9 dBA above ambient sound level between 7 AM & 10 PM measured anywhere within receiving property
  - impulsive sound >14 dBA above ambient sound level between 7 AM & 10 PM measured anywhere within receiving property

NYC Noise Code

Credit: Deaf Blog

- Every construction site must have noise mitigation plan on location. Plan must include noise mitigation training for all supervisors & workers.
- Construction may occur between 7 AM & 6 PM on weekdays.
- Alterations or repairs to existing owner-occupied dwellings may occur on weekends between 10 AM & 4 PM (if not within 300 feet of a house of worship).
- Work may take place after hours & on weekends only if authorized by NYC DOB & NYC DOT. Emergency work necessary for public safety, or work that cannot be performed during normal work hours, may take place after hours or on weekends.

Noise Code & Construction Equipment

- Specific equipment regulated:
  - air compressors, pile drivers, sledgehammers, bulldozers, pneumatic hammers, steam shovels, derricks, cranes, steam or electric hoists, off-road construction vehicles other than trucks, pumps, pneumatic tools, blasting, power tools, tunneling machines, construction devices with internal combustion engines, construction devices that emit impulsive sound or that create vibration, etc.
- NYC noise code prescribes how to reduce noise output from each type of construction equipment.
  - example: jackhammers must be equipped with noise-reducing mufflers &/or have portable street barriers in place to reduce the sound impact on neighboring residences & businesses.

Questions for you, your co-workers, and your union

- What are the noisiest tasks you perform or the noisiest areas you work in?
- How long are you exposed? How often?
- What are the sources & pathways of the noise?
- Is your exposure legal? Why or why not?
- Is your exposure safe? Why or why not?
- What can be done to eliminate or reduce exposure?
- What does your employer do if a worker's audiogram shows STS hearing loss?
- What do you think should happen if a worker's audiogram shows hearing loss?
- What should the union do about these issues?

NYCOSH
New York Committee for Occupational Safety & Health

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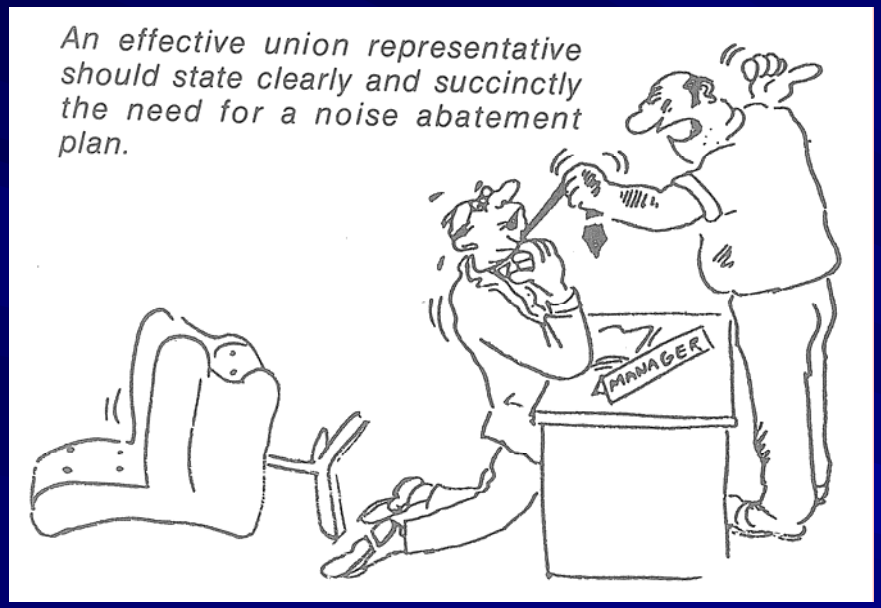

Credit: Phil Evans

NYCOSH thanks:

American Speech Language Hearing Association
Electronic Library of Construction Occupational Safety & Health (eICOSH)
Hunter College Center for Occupational & Environmental Health
Laborers' Health & Safety Fund of North America
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World Health Organization

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NYCOSH is a union shop.