

# Noise Control & Hearing Conservation

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## What is Noise???

- Unwanted Sound
  - Gunshots
  - Power Tools
  - Music
  - Air Craft
  - Nagging
- Noise causes Hearing Loss
- Noise interferes with Communication
- Noise can be Annoying



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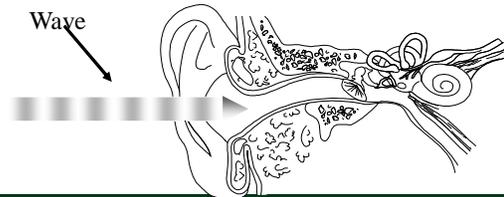
## Noise: Intensity and Frequency

- Pressure ~ Intensity (20 micropascal to 20 pascal)
- Frequency
  - human response [20 Hz to 20 KHz]
- Quality or perception of noise is a combination of loudness (pressure) and frequency.

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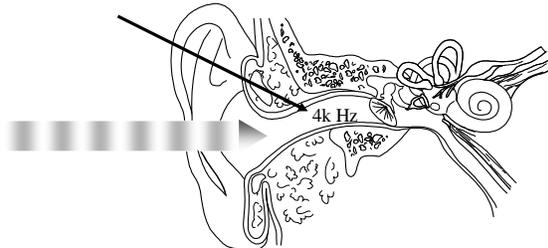
We hear when our ear perceives these disturbances in air.

Sound Wave



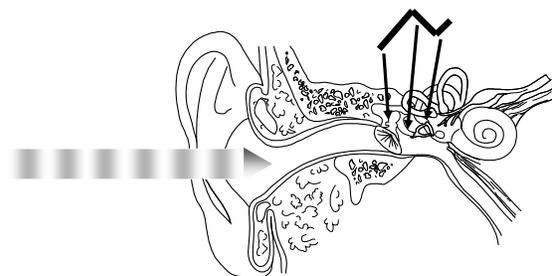
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Resonance at speech frequencies.

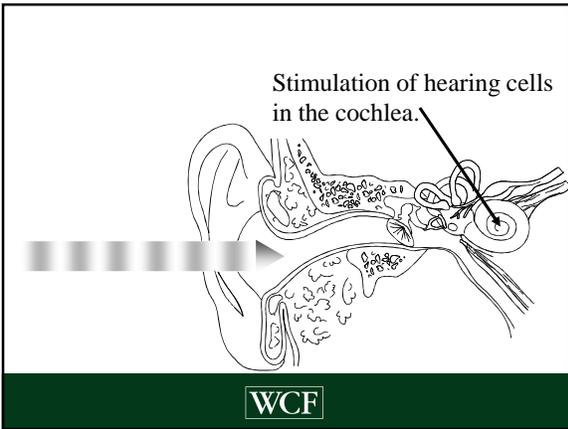


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Lever arm phenomena



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### How do we measure noise?

- The Decibel
- (Ten - Alexander G. Bell)

$$= 10 \log \frac{\text{Measured Level}}{\text{Reference Level}}$$

Reference level = level where we start to hear sound. ( $10^{-12}$  watts)

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### Is Noise Exposure Harmful?

- Causes Temporary Threshold Shift (TTS)
- May cause Permanent Threshold Shift (PTS)
- Types of Hearing Loss
  - Conductive
  - Sensori-neural
  - Mixed
  - Central
  - Psychogenic
- Most common industrial hearing loss = Sensori-neural.

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### Is Noise Exposure Harmful?

- Most common industrial hearing loss is Sensori-neural.
- It is PERMANENT!!

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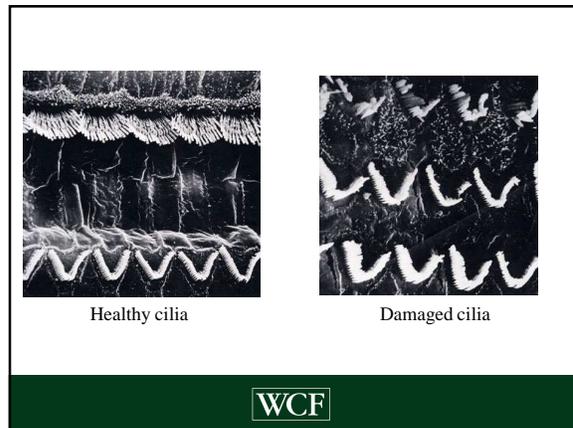
### Reduce the Hazard

Inverse Square Law:

$$I_1(d_1)^2 = I_2(d_2)^2$$

NOTE: Twice distance = 1/4 intensity

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## How do I protect myself?

- Avoid exposure
- Utilize engineering controls
- Wear personal protective equipment

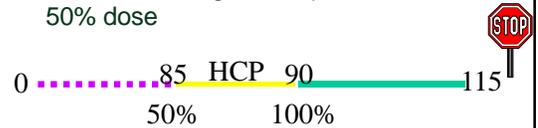


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## Hearing Conservation Program:

- Occupational Noise Exposure - 29 CFR 1910.95

☞ If employee noise exposure is > 85 dBA over an eight hour period, or > 50% dose



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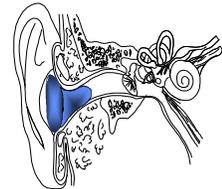
## OSHA Noise Standard

Duration (hours)	Decibel Level
16	85
12	87
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

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## Hearing Conservation Program

- 20 CFR 1910.95
  - Exposure Monitoring
  - Audiometric Testing
  - Hearing Protection
  - Employee Training
  - Recordkeeping



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## Typical Industrial Noise Levels

Source	Sound Level (dBA)
Turbo Jet	140
Threshold of Pain (Rock Concerts)	140
Steam Leak	130
Hydro-blasting	120
Steam Lance	110
Air Arcing	110
Compressor	100
Pneumatic Chipping	100
Diesel Truck	90
OSHA PEL 8 hour	90
Hearing Protection Req.	85
MIG Welding	85
Heavy Traffic	80
Stick Welding	80
TIG Welding	70
Control Rooms	60
Speaking Voice	60
Library	30
Whisper	20
Threshold of Hearing	0

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## Exposure Levels

- 8 hour exposure of 90 dBA
- Different levels of exposure within the 8 hour shift
  - $C1/T1 + C2/T2 + \dots =$
  - If that exceeds 1 then the employee is over
- Impulse or impact noise should not exceed 140 dBA (peak)

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## Exposure Monitoring

- Use calibrated instruments
- Repeat monitoring whenever a change:
  - Production
  - Process
  - Equipment or controls increase noise

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## Exposure Monitoring

Example Noise Dosimetry & Area Mapping

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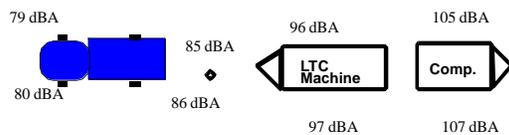


Figure 1

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## Employee Notification

- Notify exposed employees of monitoring results when they are at or above 8 hour TWA of 85 dBA

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## How often should I monitor?

- Change in operations or machinery
- Industry standard = every two years

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## Sound Math???

- Adding dB - note the difference in values:
  - if 0 to 1 dB, then add 3 dB to the higher #
  - if 2 to 3 dB, then add 2 dB to the higher #
  - if 4 to 7 dB, then add 1 dB to the higher #
  - if 8 dB or more, add 0 to the higher #
- If you double the distance between you and a noise source the sound level will decrease by ~ 6 dB.

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## OSHA Measurement Protocol:

- Type II Sound Level Meter/Dosimeter
- “A” Filter Weighting (dBA)
- Slow Response
- 5 dB Exchange Rate
- Threshold
  - 90 dBA for P.E.L. @ 100%
  - 80 dBA for H.C.A. @ 50%

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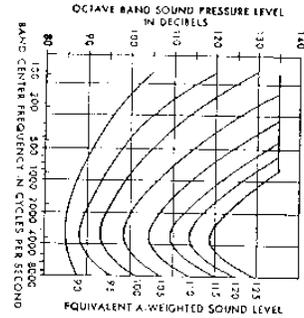
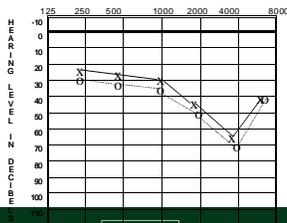


FIGURE G 9

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## Audiometric Testing

AUDIOLOGICAL RECORD  
 HEARING CLINIC  
 NAME Mike Lucas AGE 55 DATE 10/09/96  
 Audiometer Used H-98 Tested By Stewart Poore



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## Audiometric Testing

- No cost to employee
- Performed by:
  - Licensed or certified audiologist
  - Otolaryngologist
  - Other Physician
  - Technician certified by Council of Accreditation in Occup. Hearing Conservation

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## Baseline Audiogram

- Within 6 months of employee's first exposure at or above 85 dBA
- Exception:
  - Mobile van testing can be done within one year of employment if last six months of exposure are with PPE use.

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## Baseline Audiogram

- Must have 14 hours w/o exposure prior to test
- Hearing protection can be used if 14 hours w/o exposure is not feasible

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## Annual Audiogram

- Done *at least* annually after the baseline for each employee exposed at or above 85 dBA for an 8 hour TWA.

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## Evaluating Audiograms

- Compare to baseline
- If STS, can re-test within 30 days.

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## Standard Threshold Shift (STS)

- Change in hearing threshold relative to the baseline an average of 10 dBA or more at 2000, 3000, and 4000 Hz in either ear.

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## Steps when an STS occurs

- HP MUST be used
- Re-fit HP, use greater attenuation
- Clinical evaluation (work related or medical)
- Employee referred to an otological exam if medically related
- Revised baseline set

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## Training Employees

- Annual training for **all** employees over 85 dBA 8 hour TWA
  - Effects of noise on hearing
  - Purpose of hearing protectors
  - Purpose of audiometric testing
  - Explain audiometric test procedures

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## Recordkeeping

- Noise exposure measurement = 2 years
- Audiometric tests = *duration of affected employee's employment*
- Audiometric Exam requirements:
  - Name & job classification
  - Date, Examiner's name
  - Calibration date of equipment
  - Employee's noise exposure assessment
  - Sound pressure levels of audiometric test room

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## Hearing Protection



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## Acceptance

- More apt to wear hearing protectors if employee:
  - Given major part in HC program.
  - Fully understand the need for protectors.
  - Given a choice of types and brands.
  - Convinced that the company is doing all it can to engineer out noise.

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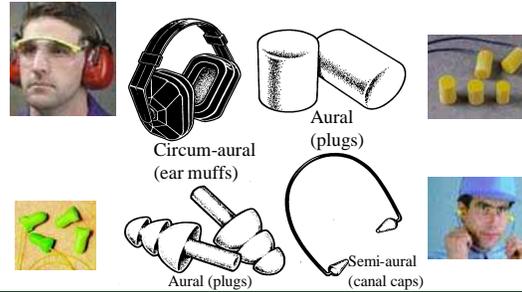
## Success of the Program Depends on . . .

- Upper management support
- Everyone from the CEO to the foremen should wear HP.

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## Types of Hearing Protection

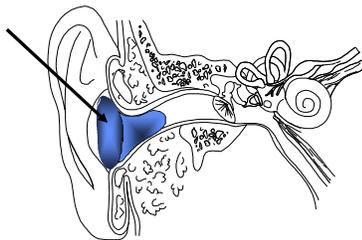
Required when noise exposure is above OSHA Action limit of 85dBA TWA



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## Types of Hearing Protection

Aural Inserts  
(Ear Plugs)



Est. NRR = 32 dB

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## Ear Plugs

- Properly fitted can be worn comfortably for hours.
  - “user-molded” or “formable” is most popular at present
    - Soft polymer foam or fiberglass
  - Other molded plugs
    - Silicone putty
    - Wax impregnated cotton varieties



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## Ear Plugs cont.

- **Pre-molded**
  - Vinyl
  - Silicone
    - Correct Sizing and fitting is critical for this type.
- **Custom molded**
  - Molded to fit individual employee's ear canal.
    - Comfortable.
    - Easier to insert correctly.
    - More expensive.



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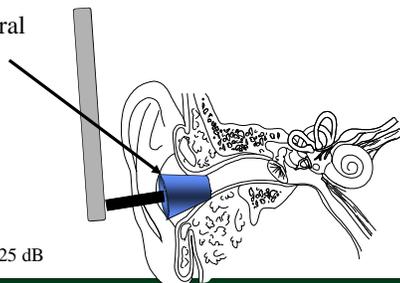
## Disadvantages of Ear Plugs

- Require proper fitting and insertion practices
- Can be difficult to monitor
- Easier for the worker to lose
- Interferes w/communication
- Dirty environments
- Attenuation is variable because of the above factors.

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## Types of Hearing Protection

Semi-aural Inserts



Est. NRR = 25 dB

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## Semi-Aural

- Sometimes referred to as **canal caps** or **banded ear plugs**.
  - Light weight headband.
    - Devices have pod-type tips which actually extend into the ear canal.
      - Intended for short duration.
      - On and off wearing.
      - Uncomfortable if worn for extended periods of time.
      - Not designed for high level noise
    - Cap type models (less attenuation)



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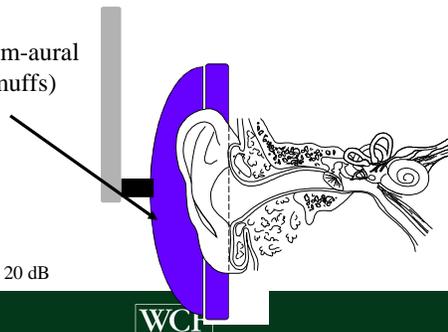
## Disadvantages of Semi-Aural

- Attenuation is relatively small by comparison
- Occlusion effect: Low pitched, hollow sound of one's own voice when the ear canal is covered at its entrance.

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## Types of Hearing Protection

Circum-aural (ear muffs)



Est. NRR = 20 dB

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## Ear Muffs

- Often worn by air mechanics and baggage handlers.
- Not as widely used as ear plugs.



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## Ear Muffs cont.

- Plastic cups attached to a headband
  - Fit snugly, cushions filled with foam or liquid.
- Head bands are designed to be worn:
  - Over the head
  - Behind the head
  - Under the chin (hard hat or other safety equipment)
- Do not come in various sizes
  - Must be individually fitted

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## Ear Muffs cont.

- More attenuation than smaller volume devices (especially in low and mid frequencies).
- Small volume muffs can be useful.
  - Confined spaces.
  - Conditions allow lower level attenuation.



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## Disadvantages of Ear Muffs

- Headband pressure can become uncomfortable for extended wearing periods.
- Uncomfortable in hot weather.
- Difficult to wear with safety glasses.



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TYPE OF PROTECTOR	ADVANTAGE	DIS ADVANTAGE
Foam Plug eg. EAR® NRR = 29 QUIET® NRR = 26	Inexpensive, Good noise reduction rating	Small-hard to see if personnel are wearing them, get dirty, not a multiple use plug
Custom-molded	Reusable, good fit	Expensive, not "one size fits all", must maintain and clean them
Caps eg. EAR CARBOFLEX® NRR = 22	Reusable, handy, can see if personnel are wearing them	Not as good of noise reduction rating, not as comfortable
Muffs NRR = 22	Reusable, visible, handy	Warm/Uncomfortable, Lower noise reduction rating
Combination (muffs & plugs)	Increased NRR	Warm/Uncomfortable, Harder to apply

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## Noise Reduction Rating

- NRR = Noise Reduction Rating
  - manufacturer rating by laboratory procedure
- What is the compliance or actual NRR?
  - $(NRR - 7) =$  weighted for "A" Scale
  - reduce adjusted NRR for field plug fitting
    - Some suggest dividing the adjusted NRR by 2.

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### Field Attenuation

- Much lower NRR than in the laboratory.
- Why?
  - Lab protectors are sized carefully.
  - Inserted very tightly
  - Users have little training
  - Field protectors have aged
- **All of these factors indicate the need for vigilance.**



### Fitting and Insertion

- Inspect ear prior to fitting.
  - Infection
  - Small amounts of cerumen is normal. Excessive amounts, see a physician.
- Employees may not be able to wear hearing protection.
- Cannot work in noisy environments
  - Should not be penalized.



### Fitting and Insertion cont.

- Multi-sized plugs
  - Feel comfortable
  - Fit snugly
- Insert ear plug by:
  - Opposite hand grasps pinna and pulls gently up and back
  - Plug rolled into cylinder between thumb and finger (**with clean hands**)
  - Insert quickly and hold for 30 seconds.



### Fitting and Insertion cont.

- Pre-molded plug inserted correctly.
  - Should have some tension on stem when trying to remove.
  - Should be removed slowly.
    - Can cause pain or damage to eardrum if removed too quickly.



### Fitting and Insertion cont.

- Ear muffs fitted correctly.
  - Cushion should completely cover pinna.
  - Headband should rest on top of head.
  - Ear cups should be inspected for tight seal against head.
  - Temple bars on eye glasses should be as thin as possible.



### Hearing Protector Attenuation

- OSHA's Requirements
- PPE Evaluation
- Field Attenuation
- OSHA's Enforcement Memo
- The Right Amount of Attenuation
- Procedures for Checking Attenuation



## OSHA's Requirements

- Must attenuate most employees' exposure at least to a TWA of 90 dB.
  - Employee with threshold shift TWA of 85 dB.
- Attenuation should be evaluated **at least once per year** to ensure protection is sufficient.

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## OSHA's Enforcement Memo

- 1983 OSHA's Office of Health Compliance Assistance issued guidelines to its inspectors for enforcing the noise standard.
- Applied only to federal OSHA, but many states adopted it.
- Inspectors were instructed to do the following:
  - Not cite for failure to engineer out noise.
  - De-rate hearing protector by 50%.

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## The Right Amount of Attenuation

- It is a delicate balance.
- Too much attenuation
  - Interferes with communication.
  - Causes feelings of isolation.
  - Protector may only be worn when supervisor is present.

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## Procedures for Checking Attenuation

- To date there is no standard method.
- 1 - audiometric test at the beginning and end of the shift. If the hearing threshold levels in certain workers show a drop on the second test, then protectors are not sufficient (or not worn correctly).
- 2- take an employee from work area and audiometric test with hearing protection in, then with it out. The difference is the attenuation.

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## Special Protectors

- Nonlinear Protectors
- Communication Headsets
- Double Protection



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## Nonlinear Protectors

- Also called level-dependent protectors.
- Provide different amounts of attenuation
- Intended to allow low and moderate levels of sound while attenuating high level sounds.
  - Enables the wearer to hear speech and warning sounds



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## Nonlinear Protectors cont.

- Two types
  - *Active*: Muffs use electronic circuitry to accomplish the nonlinearity.
    - Amplifies low to moderate sound levels; then at 85 or 90 dB the amplification ceases.
  - *Passive*: Ear plugs or muffs
    - Plugs attempt to attenuate high level sounds by means of small holes or valves (effectiveness is limited).
    - Muffs are more effective at attenuating low and mid frequencies as well as high frequencies at high sound levels (beneficial to speech communications).

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## Communication Headsets

- Often used when communication is a necessary part of the job.
- Receiver is built into ear muff, providing radio communication.
  - **Ordinary radio earphones provide little or no attenuation and are not recommended for use by personnel in a hearing conservation program.**

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## Double Protection

- Ear plugs worn in combination with muffs.
- Levels of about 105 dB are experienced over long periods of time.
- Attenuation rating is not doubled; increase of approximately 5-10 dB over individual use.
- May be very uncomfortable.

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## Use and Care of Hearing Protectors

- OSHA Requirements
- Fitting and Insertion
- Hygiene
- Replacement
- Wearing Protectors Away From Work

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## OSHA Requirements

- Employees must:
  - Be given choices
    - Minimum one plug and one muff (preferably three or more devices).
  - Be trained in fitting, care, use, purpose, advantages/disadvantages, and attenuation of various types.
- Employer is responsible to ensure hearing protection is used.

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## Hygiene

- Pre-molded ear plugs should be washed and ear muff cushions should be wiped off regularly.
- Foam plugs can also be washed and reused several times.

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## Replacement

- Muff cushions - check every six months.
- Headbands tend to loosen with age and should be replaced.
- Foam -fail to recover to original shape when removed from the ear.

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## Replacement cont.

- Pre-molded plugs may harden and should be checked every two to three months.
- Custom molded plugs will also harden and should be checked periodically.

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## Wearing Protectors Away From Work

- Encourage use for activities away from work.
- Take hearing protection home
  - This kind of generosity is in everyone's best interest.

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## Noise Control Methods

- Absorption Materials
- Transmission Loss Materials
- Damping Materials
- Vibration Isolators
- Material Selection

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## Absorption Materials

- Acoustical ceiling tile
- Glass fiber
- Foamed elastomers
  
- Flow resistance of the material is the most important characteristic
- *3dBA reduction in noise for each doubling in absorption.*

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## Transmission Loss Materials

- Energy is transmitted through materials
- Need the trans. loss in each octave band for proper application of materials

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## Damping Materials

- Reduce the resonance effects in solids
  - Machine panels
  - Belt guards
  - Panels
- Converts vibration energy into heat
- Materials used = homogeneous (sprayed on) and constrained layer (thin layer of damping mat. & backing with thin metal)

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## Vibration Isolators

- Material goes into transmission path with different wave-transmitting properties than the medium carrying the wave.
- Typically used with springs

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## Material Selection

- Environmental factors:
  - Moisture, water
  - Oil, grease, dirt
  - Temperature
  - Erosion by fluid flow

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## Material Selection

- Regulatory factors:
  - Lead containing materials
  - Disinfecting necessary
  - Fire protection concerns
  - Un-inspectable spaces (vermin hiding)
  - Secure anchoring required
- Ensure that the proper material is selected!!

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## Resources

- OSHA:  
<http://www.osha.gov/SLTC/noisehearingconservation/>
- NIOSH:  
<http://www.cdc.gov/niosh/topics/noise/>
- <http://www.hearingconservation.org>

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Thank You

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