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# Hearing Conservation



## FERMILAB

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 Fermilab      ES&H Section      *Hearing Conservation*

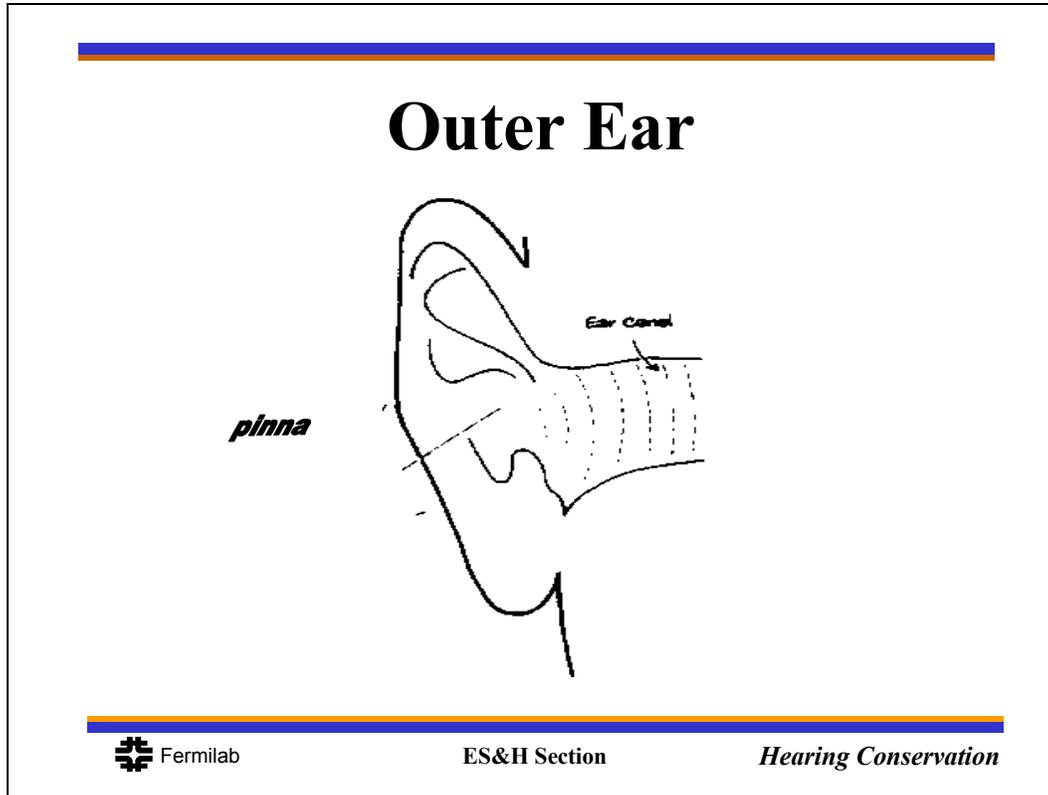
Introduce yourself and the section you represent - give a work history and mention your responsibilities at Fermilab.

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# Objectives

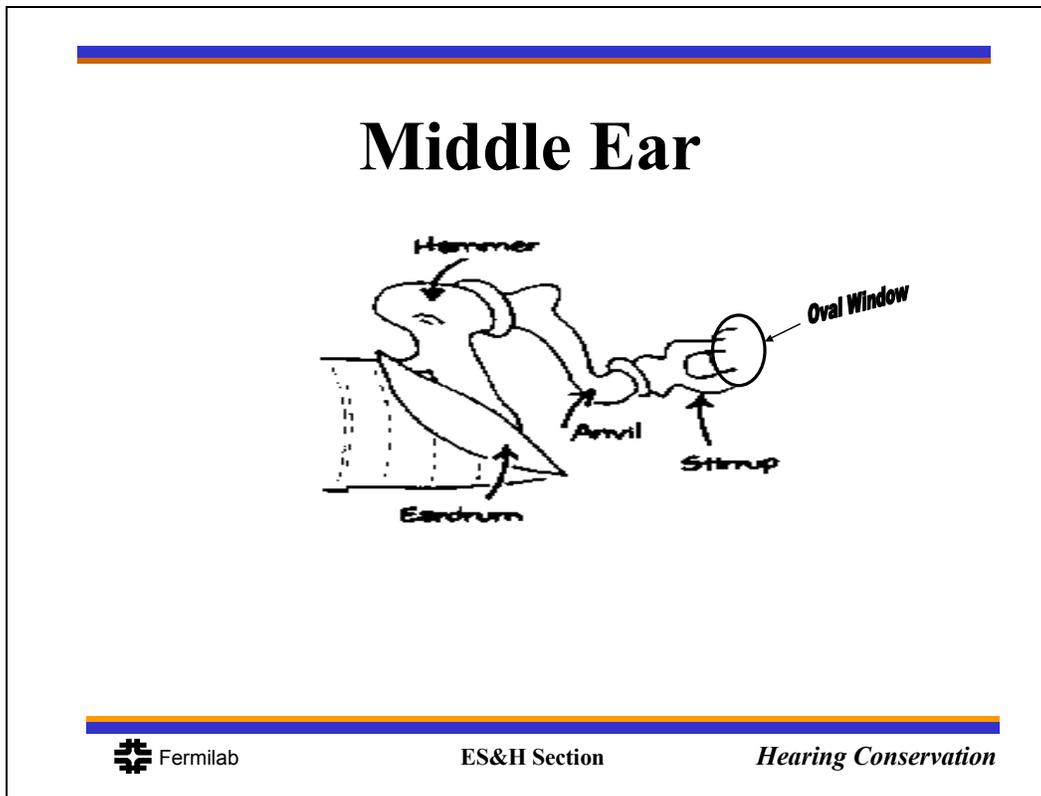
- Anatomy and Physiology of the Human Ear
- What is considered hazardous noise
- Sound level measurement
- How noise effects the ability to hear
- The Elements of Fermilab's Hearing Conservation Program
- Ways to protect your hearing
- Q & A

Review class objectives.



The Outer Ear is made up of a flesh and cartilage structure called the auricle or pinna. Ask someone from the class to explain what's the main function of the Pinna?

The main function of the Pinna is to funnel the sound waves into the ear canal and perhaps aid in the direction of where the sound is coming from.

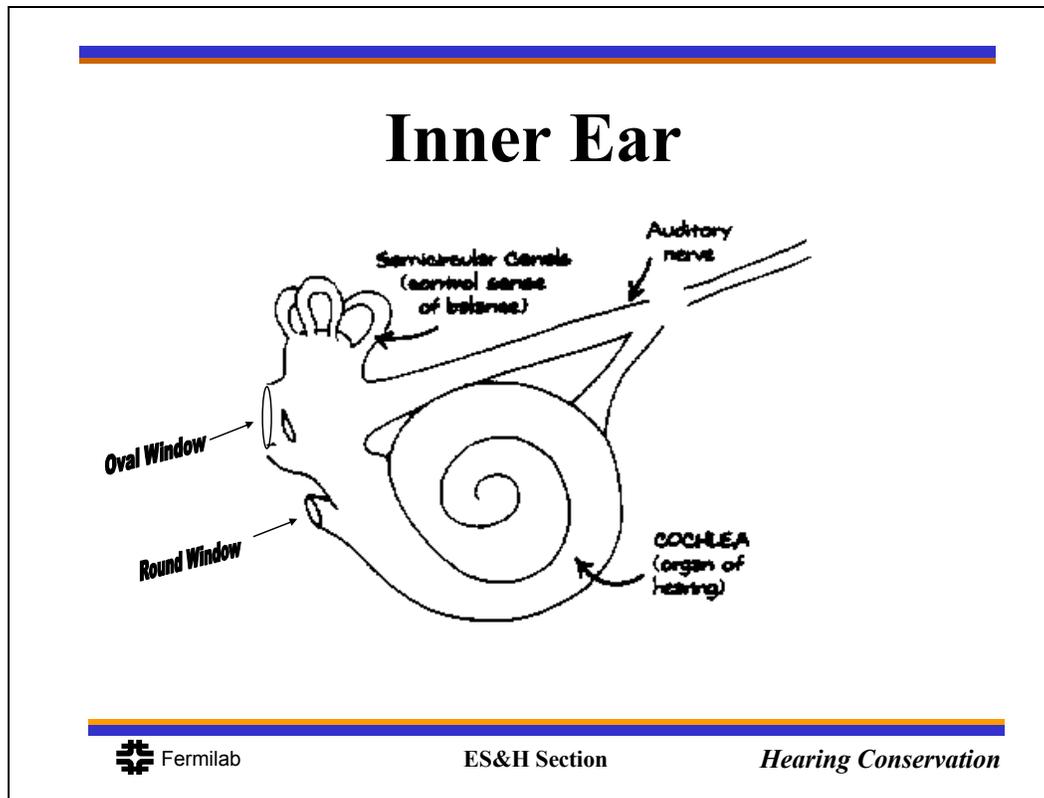


Sound waves travel down the ear canal and cause the eardrum (tympanic membrane) to vibrate. The vibrating eardrum, in turn, sets into motion the three smallest bones {auditory ossicles: hammer (malleus), anvil (incus), stirrup (stapes)} in the human body. The final bone in this small chain is called the stirrup and the stirrup is connected to the oval window.

Ask the class if anyone can tell you what's the purpose of the middle ear?

It has been estimated that the amplitude of sound waves is magnified twofold by the mechanical leverage of the ossicles and tenfold by the difference in area between the eardrum and the oval window of the inner ear, a twenty fold increase in all.

Fun Fact: Sound is transmitted through the system with remarkably little distortion and with such exquisite responsiveness that the faintest sounds we can hear cause the eardrum to oscillate by less than the diameter of a hydrogen molecule.



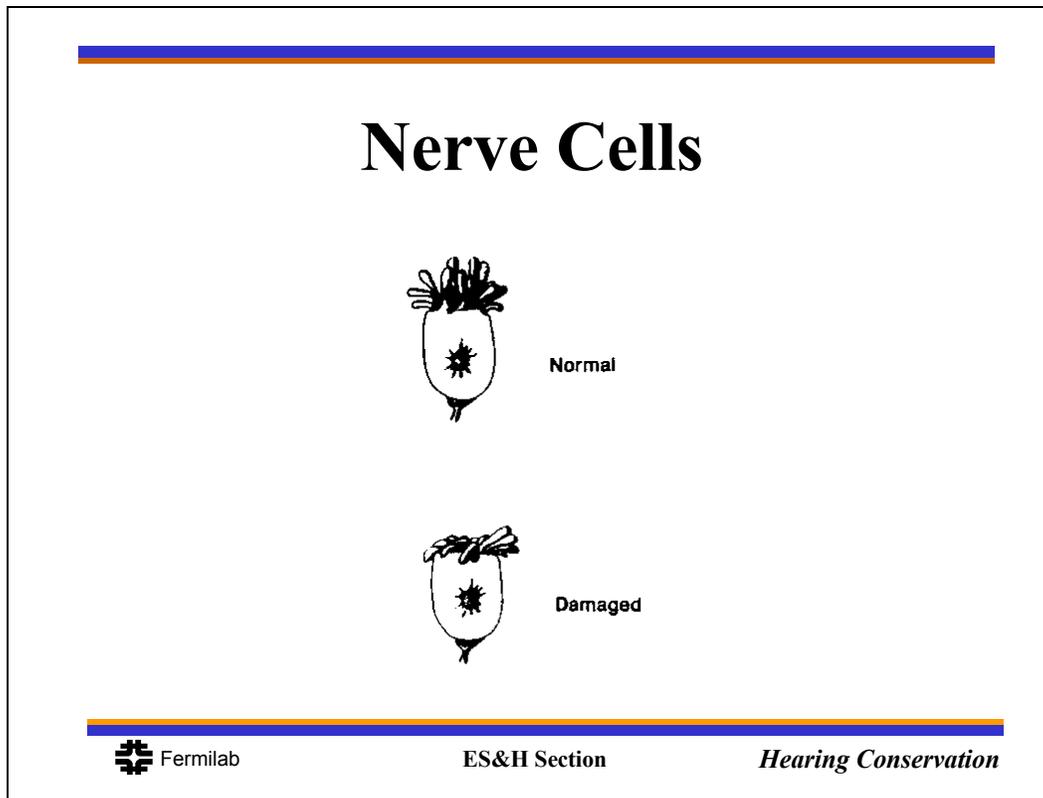
The Inner Ear includes the Cochlea (organ of hearing), the Auditory nerve and the Semicircular Canals (controls sense of balance).

The cochlea is snail-shaped bony tubular structure lined with a membrane containing thousands of feathery hair cells tuned to vibrate to different sound frequencies.

Vibrations of the stapedial footplate in and out of the oval window set into motion the fluids of the inner ear. As the basilar membrane is displaced, a shearing movement occurs on the tectorial surface that drags the hair cells attached to the nerve endings. This sets up electrical impulses that are appropriately coded and transmitted to the brain via the auditory (cochlear) nerve.

The nerve endings in the cochlea are sensitive to different frequencies. Those sensitive to high frequencies are located at the large base end of the cochlea near the oval and round windows. The nerve endings that respond to low frequencies are located at the small end of the cochlea.

Also within the inner ear is our balance mechanism, the vestibular system. The semicircular canals lie in planes at right angles to each other. The canals contain fluid that responds to movements and, over intricate nerve pathways to the brain, gives information about positions of the body.



This is a simple illustration of what the hair cells look like inside the human ear. Under normal conditions the hair cells stand up tall and vibrate back and forth with the movement of the fluid inside the cochlea. However, over time, especially when we refer to noise induced hearing loss, the hair cells ability to recover (stand-up) becomes diminished.

Let me give you an analogy. Take a nice field of grass. If one individual crosses the field, no problem. However, if a number of people walk across that same path in the grass over a long period of time the grass will eventual die back and you will be left with a bold dirt trail. The hair cells inside the inner ear behave much in the same way.

## Permissible Exposure Limits for “Continuous” Noise

T, Duration per Day (hours)	SPL Sound Pressure Level (dBA)
32	80
16	85
8	90
4	95
2	100
1	105
½	110
¼	115



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### What is considered hazardous noise?

Hazardous noise is defined by its loudness or sound pressure level. The sound pressure level of noise is measured in decibels. Noise measurements can further be defined by various weighting scales. The weighting scale used for occupational exposures to noise is the “A-weighted” scale. The “A-weighted” sound level measurement is used because it’s thought to provide the best representation of the injurious effects noise has on the human ear.

In the early 1970’s the Occupational Safety and Health Administration (OSHA) developed a standard for hazardous noise. The chart indicates that no employee shall be exposed to noise greater than 90 dBA for an 8-hour time-weighted average (TWA). Also note from the chart that for each 5 dB increase in the sound pressure level there is a halving of exposure time permitted. This is called the exchange rate.

Realizing that the standard was not as protective as first written, OSHA, in 1983, developed what is known as the Hearing Conservation Amendment. The amendment requires that employees with TWA noise exposures of greater than 85 dBA be required to enter into a Hearing Conservation Program that includes Annual Audiometric Testing, Access to hearing protection and training. If the TWA noise exposure is greater than 90 dBA employers are also required to implement engineering or administrative controls where practical, receive audiometric testing and training and hearing protection is required.

Note: Hearing Conservation FESHM Chapter 5061 requires that when sources of noise may expose personnel above an 8-hour time-weighted average of 85 dBA the area must be posted with a “Hearing Protection Required Sign”.

## Sound level measurement

- Sound level meter (SLM)
- Noise Dosimetry



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Sound level measurements are conducted with the aid of two different types of monitoring equipment.

The sound level meter (SLM) is a noise-monitoring device used to measure area sound pressure levels.

Noise Dosimeters are personal measuring devices that are worn by the employee around his waist and the microphone is clipped on the employee's shirt lapel as close to the ear as possible. The noise exposure is integrated over the sampling period and a TWA is automatically calculated.

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## Typical A Weighted Sound Levels

- **80**      **Vacuum Cleaner**
- **70**
- **60**      **Conversation at 1 m**
- **50**      **Urban Residence**
- **40**
- **30**      **Soft Whisper at 2 m / Rice Krispies**
- **20**      **North Rim of Grand Canyon**
- **10**
- **0**      **Threshold of Hearing (1000Hz)**

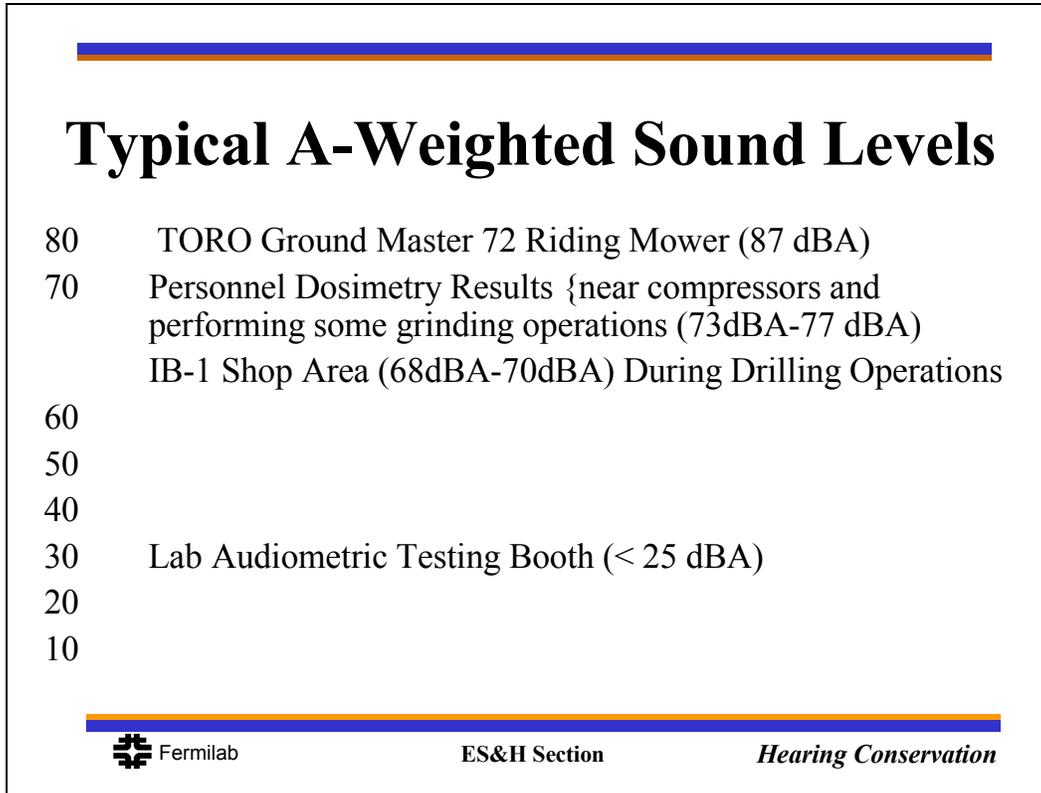
Lets take a look at some sound pressure levels of common noise sources.

## Typical A Weighted Sound Levels

- 140      **Threshold of Pain**
- 130
- 120      **Jet Takeoff at 100 m**
- 110      **Rock Concert**
- 100      **Jackhammer at 15 m**
- 90      **Drilling Concrete**
- 85      **Heavy Truck at 15 m**



You're probably thinking, what are the noise sources at FERMILAB



Here are some of the common noise sources at FERMILAB.

Since you are all enrolled into Fermilab's Hearing conservation program, each year you are required to receive audiometric testing. The OSHA standard outlines the requirements for audiometric testing booths. The testing booth is subjected to maximum background sound pressure levels of 25 dBA for all frequencies you will be tested on.

## Typical A-Weighted Sound Levels

140	Threshold of Pain
130	
120	
110	Testing of Fire Alarm System in FCC
100	MRRF - F0 Compressor Room CHL Nitrogen Plant
90	TORO Grounds Master 322-D Riding Mower TORO TV5004 Master Push Mower CUB                                      Lab D Compressor Room CDF A/C units                      CHL Chiller Room



As you can see the high noise areas at Fermilab are those areas with large industrial machinery (I.e., compressor rooms, pump rooms, CHL and CUB).

<b>Time Weighted Average Exposure (dBA)</b>	<b>Employee Population Experiencing Hearing Loss (%)</b>
<b>&lt; 80</b>	<b>0</b>
<b>80</b>	<b>5</b>
<b>85</b>	<b>10</b>
<b>90</b>	<b>20</b>
<b>100</b>	<b>~100</b>
<b>&gt;100</b>	<b>100</b>

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Why the concern for occupational noise? Take a look at this table for a minute or two and give me some of your own observations with the current OSHA standards in mind.

Noise exposures at the current OSHA standard of 90 dBA TWA over a working lifetime (30-40 years) will still result in approximately 20% of the employees experiencing some amount of hearing loss.

At 85 dBA TWA exposures over a working lifetime, 10% of the employees will experience some amount of hearing loss.

## Effects of Hearing Loss

- Everybody Mumbling
- Communication with people
- Tinnitus



There are two important characteristics of normal hearing-the ability to hear sounds as loud as they truly are, and the ability to hear sounds with complete clarity.

Characteristic speech sounds can be related to the two principal kinds of speech- vowels and consonants. The vowel sounds-located in the lower frequencies-are the more powerful speech sounds. In contrast, the consonant sounds-located in the higher frequencies-are the keys to distinguishing one word from another, especially if the words sound alike. This type of hearing loss may actually result in further isolation from people (from less communication) because “everybody’s mumbling”. The individual simply finds it too exhausting or stressful to talk to others.

### Tinnitus (head noises)

Head noises are hissing, ringing, whistling, whizzing, roaring, booming sounds but the kind most frequently described by patients is “like steam coming out of a kettle’ or ‘foghorn,” or ‘bells. “The patient with tinnitus usually works at peace in noisy surroundings which drown out his head noises, and the condition may be most annoying at night when the room is quiet. Some sufferers of tinnitus resort to using background noise (fan) at night just to fall asleep.

## The 4 P's of Hearing Loss

- **Progressive**
- **Painless**
- **Permanent**
- **Preventable**



Here are the four (4) P's of hearing loss:

**Progressive** – usually not an instantaneous event. While it's true that hearing loss can result from a traumatic event like an explosion, which can rupture the eardrum or dislodge the ossicles chain, noise induced hearing loss is primarily progressive in nature.

**Painless** – again, aside from the traumatic event or occupations with extremely high noise exposure potentials, most occupational noise exposures are painless.

**Permanent**- there's a lot of amazing research in this area, but the bottom line is that once permanent hearing loss occurs, you can never fully regain the quality of hearing that you were born with.

**Preventable** – we know the hazard and how to protect ourselves, so it's up to each of us to take the appropriate steps to minimize our exposures and save our the hearing we have left. And remember, hazardous noise sources do not only exist at work. At home we may face hazardous noise sources from the activities we perform (I.e., lawn mowers, weed whackers, etc.) or the hobbies we choose (I.e., hunting, shooting, music, etc.).

## Fermilab Hearing Conservation

- Annual Training
- Annual Audiometric Testing
  - Baseline Hearing Test
  - Annual Hearing Test
  - Medical Department
- Accessibility to Hearing Protection
- Sound Level Measurements/Audiosimetry



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### Annual Audiometric Testing

Noise is like light in that as light is made up of many different wavelengths; noise is made up of many different frequencies. Frequency is measured in hertz (Hz). The human ear can adequately hear noise between 20-20,000 hertz, however the most sensitive range is between 2,000-5,000 Hz.

The pitch of human speech ranges between 300 and 4,000 hertz. These are the frequencies most vital for communication. When a person is first exposed to hazardous levels of noise, the initial change usually observed is a loss of hearing in the higher frequency range, usually a dip or notch at about 4,000 hertz.

You received a baseline test – this represents your best hearing capability. The baseline test shall be preceded by at least 14 hours without exposure to hazardous noise. Annually, you need to take another test to compare to your baseline. The test will pick up any slight changes in your hearing status – probably before you actually notice it. That's why it's important to take the test. Medical will schedule you for the test – you shouldn't do anything differently from your normal routine on the day you take your annual test.

Note: A standard threshold shift (STS) is defined as an average shift from baseline hearing levels of 10 dB or more at the audiometric frequencies 2000, 3000 and 4000 hertz.

Explain to the class how the audiometric tests are adjusted for age. Then explain the current arguments between the terminology of Presbycusis and Sociocusis. Presbycusis is the gradual loss in hearing due to the aging process, while Sociocusis is the gradual loss of hearing due to societal noise. Based on hearing test studies of remote tribes in Africa who show no loss in hearing ability over the course of their lifetime, leaving one to believe that the gradual loss in hearing is more likely due to societal noise rather than the aging process. In fact, an increasing number of your people are suffering from hearing loss as a result of listening to loud music.

Ask audience about hearing protection availability within their Division/Section. Remind employees that hearing protection devices shall never be altered (I.e., making holes in earmuffs for ventilation).

Show and Tell with Sound Level Meter and Audiosimeter.

# Hearing Protection Devices (HPD)

- **Ear Muffs**
- **Ear Plugs**
  - **Pinna Pull**
  - **Roll and Fit**
- **Occlusion Effect**
- **Hear better in louder environments**



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Whenever practical, sound levels should be reduced by engineering controls such as noise absorbing panels, mufflers or enclosures. If noise can not be reduced hearing protection devices are employed. These devices are worn to reduce employee noise exposure below 90 dBA.

The two types of hearing protection used at Fermilab are earplugs and earmuffs.

Muffs for the most part tend to be worn correctly. The key is to make sure the sealing pad is clean (soap and water) and if compressed, quickly springs back to its original shape. Another issue associate with the wearing of ear muffs is that at times where you may also be required to use other forms of Personal Protective Equipment (PPE) (I.e., glasses) glasses will interfere with the muff seal.

Demonstrate to the class how to properly don a earplug. The pinna pull, and Roll and Fit. To correctly insert these plugs:

Slowly roll and compress the plug into a thin cylinder.

While compressed, insert the plug well in to the ear canal. Fitting the plug is easier if the outer ear is pulled outwards and upwards during insertion.

With fingertips, hold the plug in place until it begins to expand and block the noise

Earplug fit can be tested in the presence of noise by alternately covering and uncovering the ears with tightly pressed hands. If the plugs fit properly, the noise levels should seem nearly the same whether or not the ears are covered.

Explain that the foam plug offers the best protection. Foam plugs should be disposed of on a daily basis.

**Ask the class the question; “Can you here with hearing protection in or over your ears?”** The occlusion effect occurs when the employee has a good seal with their hearing protection device. The result is when your voice comes across to you as a funny muffled sound. The reason for this phenomenon is because sound can also be heard through bone conduction.

In fact you will be able to hear better in louder environments because the background noise will be muffled and any noise that you do here will be that which is most important.

## Q & A

- **How can I tell when a noise may be harmful to my ears?**
- **I don't need hearing protection, I am used to the noise!**
- **Do earmuffs block out noise better than earplugs?**

### **How can I tell when a noise may be harmful to my ears?**

Rule of thumb says that if you are an arms length away from someone (3 feet) and you have to yell for the other person to hear you, you are in an area where noise exposures are likely above occupational health limits. Fermilab has done a good job in conducting area monitoring and ensuring that such high noise areas are labeled and require hearing protection.

### **I don't need hearing protection, I am used to the noise!**

The employee is not used to the noise! This is an indication that the employee has likely already lost some of his hearing.

### **Do earmuffs block out noise better than earplugs?**

Whatever hearing protection device you are comfortable with and one that you use is the best. If you took the best plug on the market and compared it to the best muff, the earplug when worn correctly would outperform the earmuff at most frequencies, primarily lower.

## Q & A

- **I've already lost some or most of my hearing: why should I have to wear hearing protection?**
- **What is the Noise Reduction Rating and what does it mean?**

### **I've already lost some or most of my hearing: why should I have to wear hearing protection?**

To protect what you have left.

### **What is the Noise Reduction Rating and what does it mean?**

The Noise reduction rating or NRR is the level of noise reduction a hearing protection device affords a user. There has been a great deal of debate surrounding this issue.

The NRR is calculated using laboratory methods. As provided by the manufacturer, the NRR of the respective plug or muff is never truly achieved under real world scenarios. A good rule of thumb is that the user will likely achieve an actual reduction in noise exposure of about 50% of its rated NRR in field application. Add an additional 5 decibels for double hearing protection.

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# Summary

- Anatomy and Physiology of the Human Ear
- What is considered hazardous noise
- Sound level measurement
- How noise effects the ability to hear
- The Elements of Fermilab's Hearing Conservation Program
- Ways to protect your hearing
- Q & A

Review what you told them.