

Thank You for Attending Today's Webinar:

Noise Primer for Environment Health and Safety



Your Host

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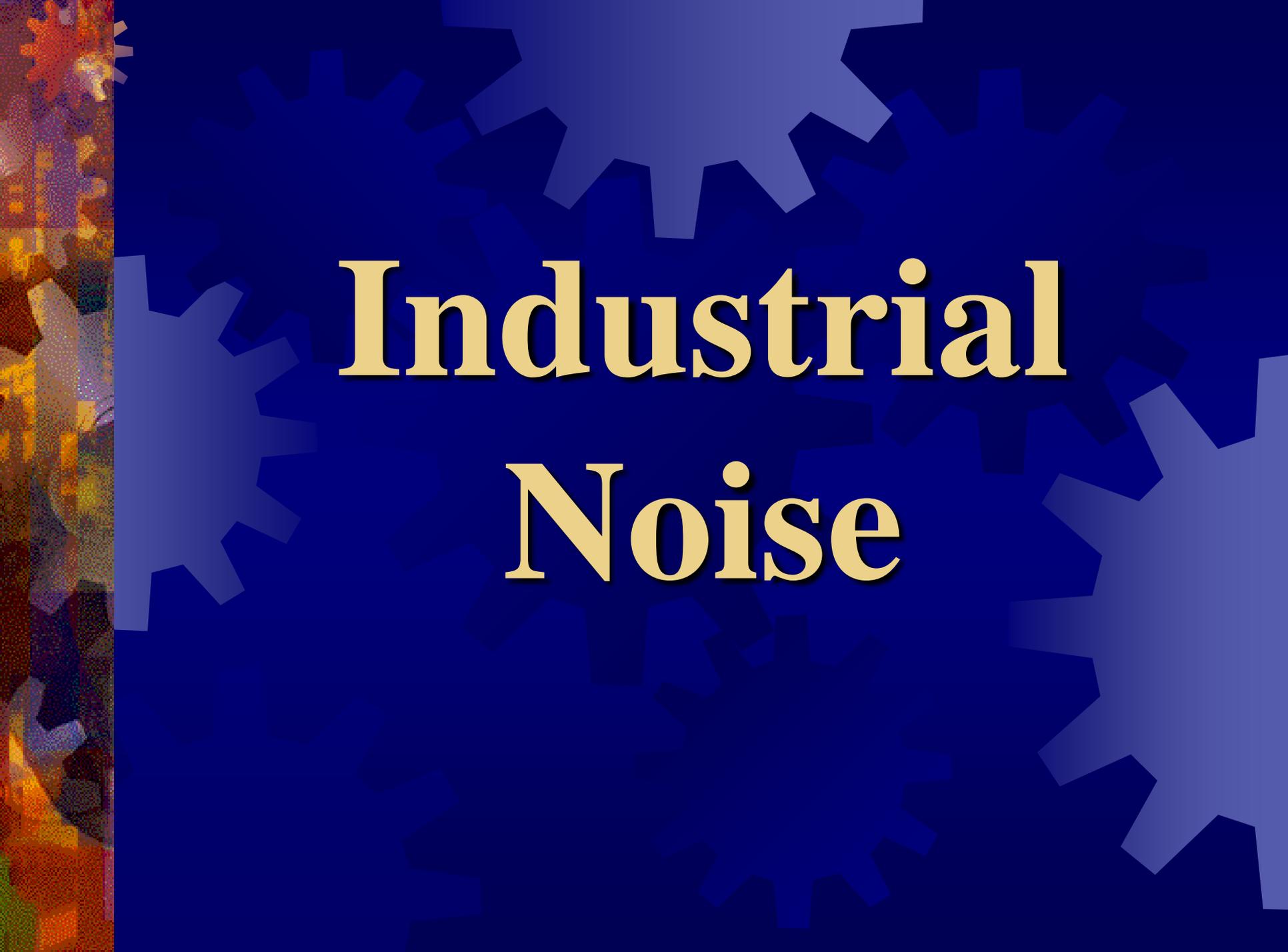


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The background of the slide is a dark blue field filled with various sizes of gear silhouettes. On the left side, there is a vertical strip with a textured, metallic appearance, showing a close-up of interlocking gears in shades of orange, yellow, and brown. The main text is centered in a bold, yellow, serif font with a slight drop shadow.

Industrial Noise

Four Characteristics Of Sound

☀ Frequency

- ☀ Measured in Hz

☀ Intensity

- ☀ Measured in dB

☀ Speed

- ☀ Measured in feet or meters/second

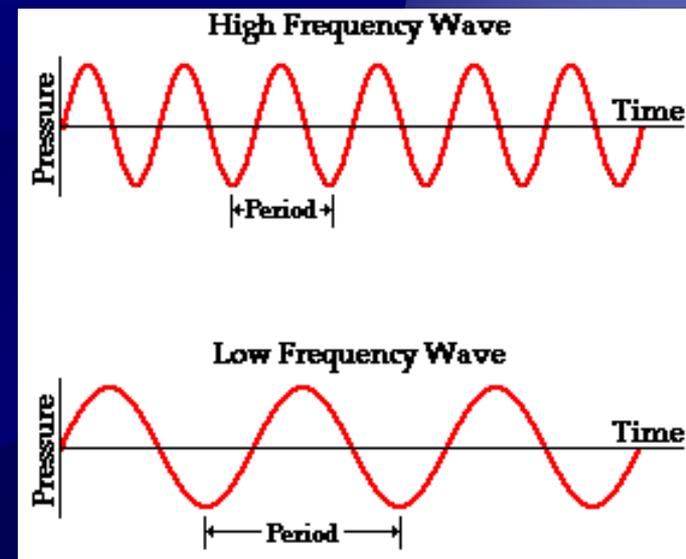
☀ Wavelength

- ☀ Measured in feet or meters

Noise Definitions

★ Frequency

- ★ Number of times per second a vibrating body traces one complete cycle of motion
 - ★ Is a measure of the cycles completed in one second
- ★ Determines the nature of sound
- ★ Humans hear frequency as pitch
 - ★ Low pitched or bass sounds are low frequency sounds
 - ★ Humans can hear around 30 Hz such as the rumble of the largest pipe organs
 - ★ High pitched or treble sounds are high frequency sounds
 - ★ Humans can hear up to 15,000 Hz such as the shrill screech emitted by old TV sets



Frequency Response & Weighting

- ★ The human ear is capable of responding to frequencies ranging from 20 Hz to 20 kHz
 - ★ **The ear is less efficient at high and low frequencies**
- ★ Most people hear from 250 Hz to 8000 Hz
- ★ In the range from 500 Hz to 4 kHz a normal human ear is very sensitive
 - ★ **Male voice 2000 hertz**
 - ★ **Female voice 2500 – 3000 Hertz**

Noise Definitions

★ Frequency

★ **Cycles/second = Hertz (Hz) = f**

★ **One hertz is one cycle per second**

★ **Kilohertz (kHz) 1 kHz = 1000 Hz**

★ **Megahertz (MHz) 1MHz = 1000 kHz**

● **A healthy young person can hear sounds in the range of 20 – 20,000 Hz**

● **Human speech is mainly in the range of 500 – 5,000 Hz**

● **In the range from 500 Hz to 4 kHz a normal human ear is very sensitive**

● **For measurement purposes the broad range of frequencies is divided into nine octave bands**

Table 21.2 — Commonly Used Octave Bands

| Name of Octave Band (Center Frequency (Hz)) | Defining Frequency (Hz) | | A-Weighting of Octave Band (dB) | C-Weighting of Octave Band (dB) |
|---|-------------------------|-------|---------------------------------|---------------------------------|
| | Lower | Upper | | |
| 31.5 | 22.4 | 45 | -39.4 | -3.0 |
| 63 | 45 | 90 | -26.2 | -0.8 |
| 125 | 90 | 180 | -16.1 | -0.2 |
| 250 | 180 | 355 | -8.6 | 0.0 |
| 500 | 355 | 710 | -3.2 | 0.0 |
| 1000 | 710 | 1400 | 0.0 | 0.0 |
| 2000 | 1400 | 2800 | +1.2 | -0.2 |
| 4000 | 2800 | 5600 | +1.0 | -0.8 |
| 8000 | 5600 | 11200 | -1.1 | -3.0 |

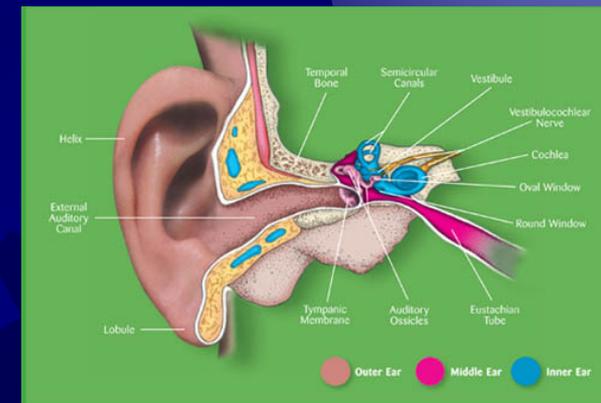
Noise Definitions

- ★ **Wavelength of sound is important in designing noise control treatments**
 - ★ **Sound-absorptive treatments should be at least $\frac{1}{4}$ wavelength thick for optimum absorption**
 - ★ **To be effective at high temperatures, sound absorptive treatments need to be very thick (8 to 16”), especially for low frequencies**



Sound Pressure

- ☀ Sound is a slight rapid variation in atmospheric pressure caused by some disturbance or agitation of the air
- ☀ Only a few millionths of a pound per square inch can be heard by the human ear
- ☀ Damage to our hearing can result from pressures of only a few thousandths of a pound per square inch of pressure

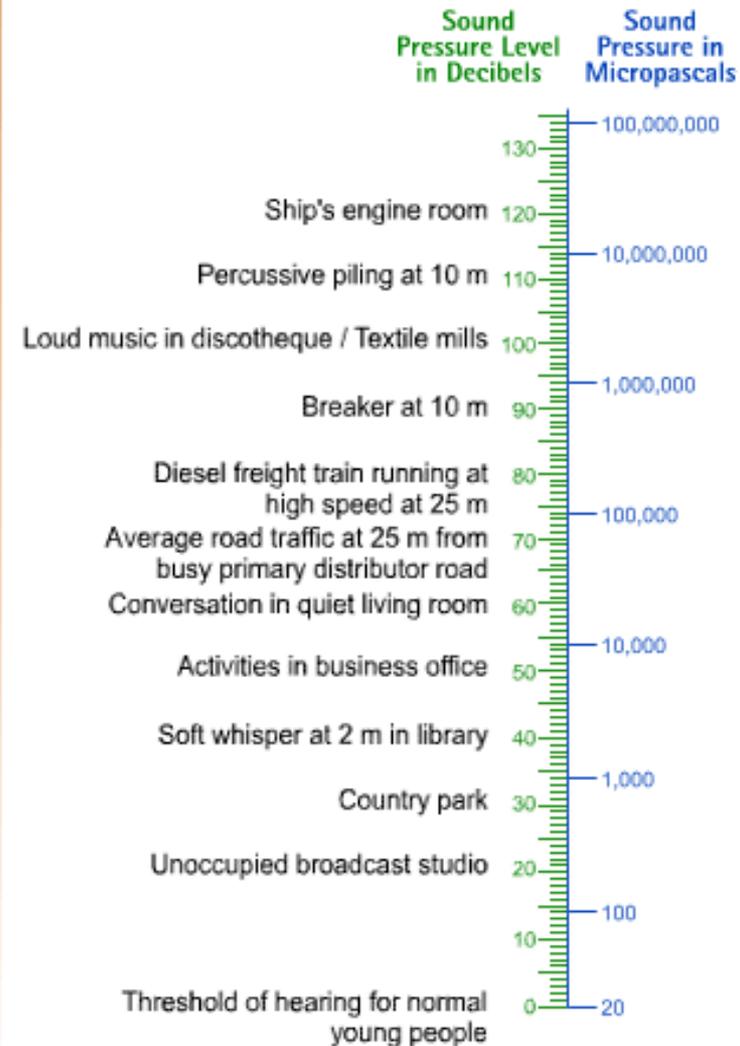


Decibel

☀ Decibel scale is a very large scale that allows us to measure very large ranges of noise

● **Very convenient to use**

● **It compresses the sound pressure range of 0.0002 Pa – 200 Pa into a manageable range of decibels from 0 – 140 dB**



Relation between sound pressure in micropascals and sound pressure level in decibels re 20 μPa.

Decibel Scales

☀ A scale

☀ Measures what humans hear

- ☀ De-emphasizes low & very high frequencies which pose less of a risk to hearing

☀ B scale

☀ Used by phone company

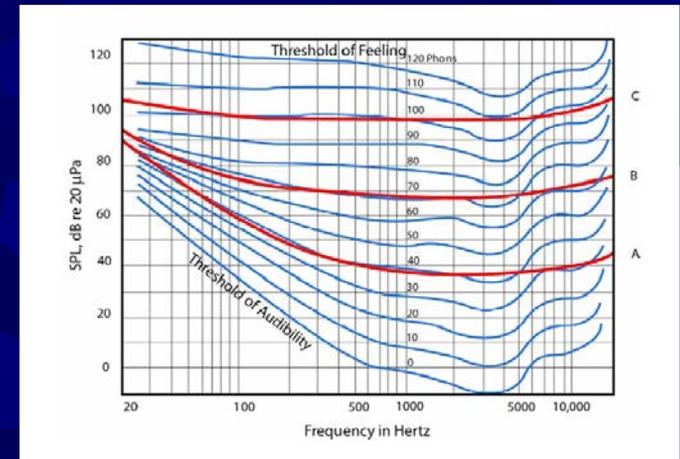
☀ C scale

☀ Measures all sound

- ☀ Used for hearing protector selection

☀ Have weighting for noise up to N scale

☀ Used for research



Fletcher-Munson Curves

EAR

Sections

- Outer ear
- Middle ear
- Inner ear

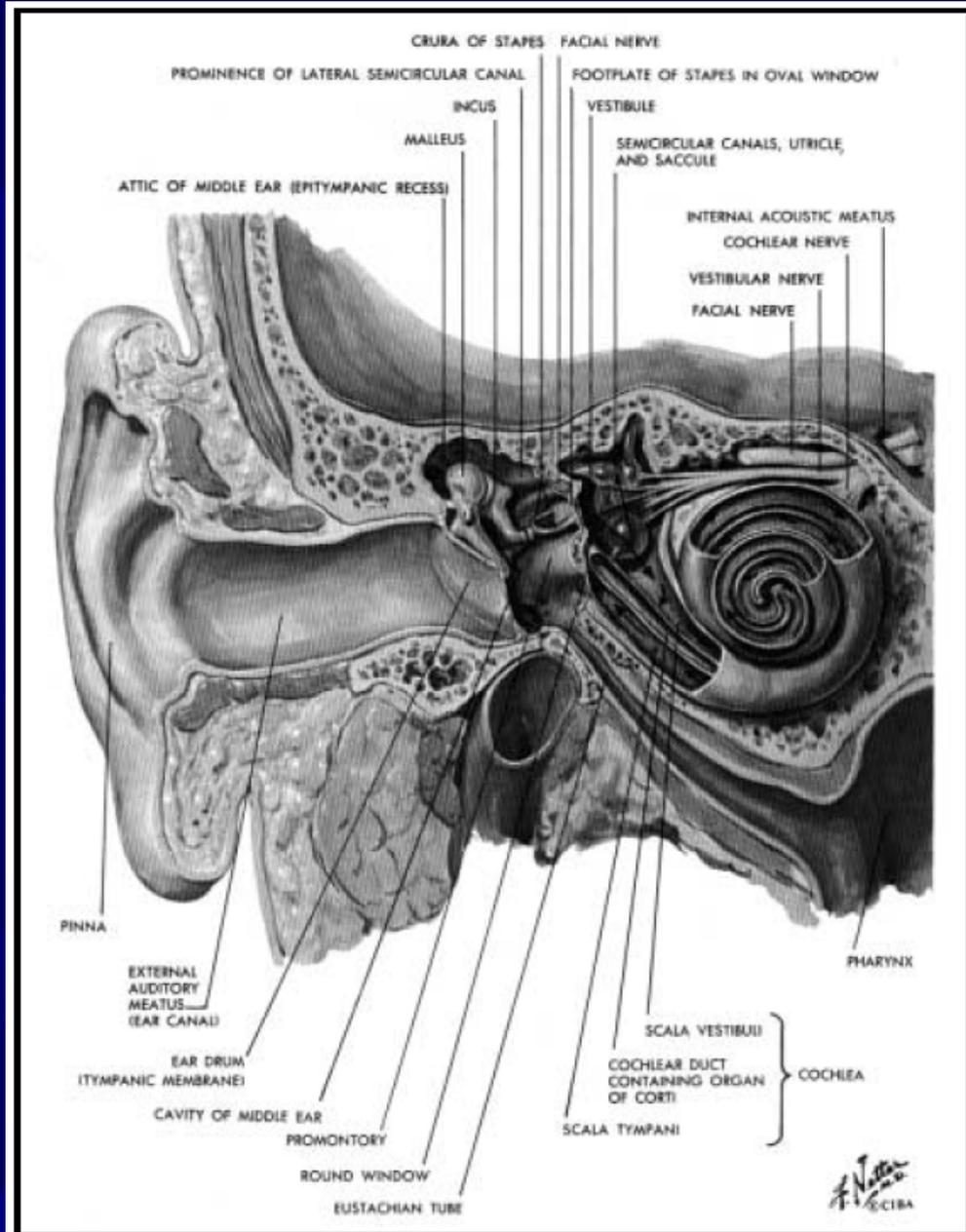
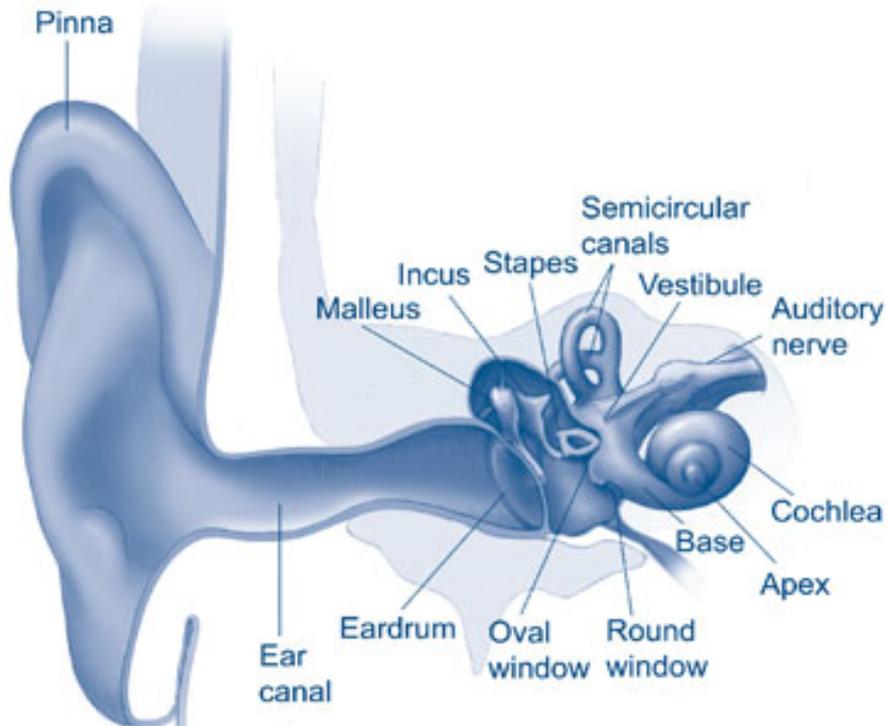


Figure 21.2 — Pathway of sound conduction showing anatomic relationships. (Copyright 1990 by Novartis Medical Education, Summit, N.J. Reproduced with permission from *Atlas of Human Anatomy* by Frank H. Netter, MD. All rights reserved.)

Physical Effects of Noise on Humans

- ✦ Dilatation of the pupil
- ✦ Secretion of thyroid hormone
- ✦ Heart palpitation
- ✦ Secretion of adrenaline
- ✦ Secretion of adrenaline cortex hormone
- ✦ Movements of the stomach and intestines
- ✦ Muscle reaction
- ✦ Constriction of the blood vessels
- ✦ Hearing Loss



Causes of Hearing Loss

- ★ **Overexposure to Noise**

- ★ **Chemicals**

 - ★ **Ototoxics**

 - ★ **Toluene**

 - ★ **Lead**

 - ★ **Manganese**

- ★ **Drugs / Medicine**

- ★ **Heredity**

- ★ **Wax build up**

- ★ **Measles / Otosclerosis**

- ★ **Aging**

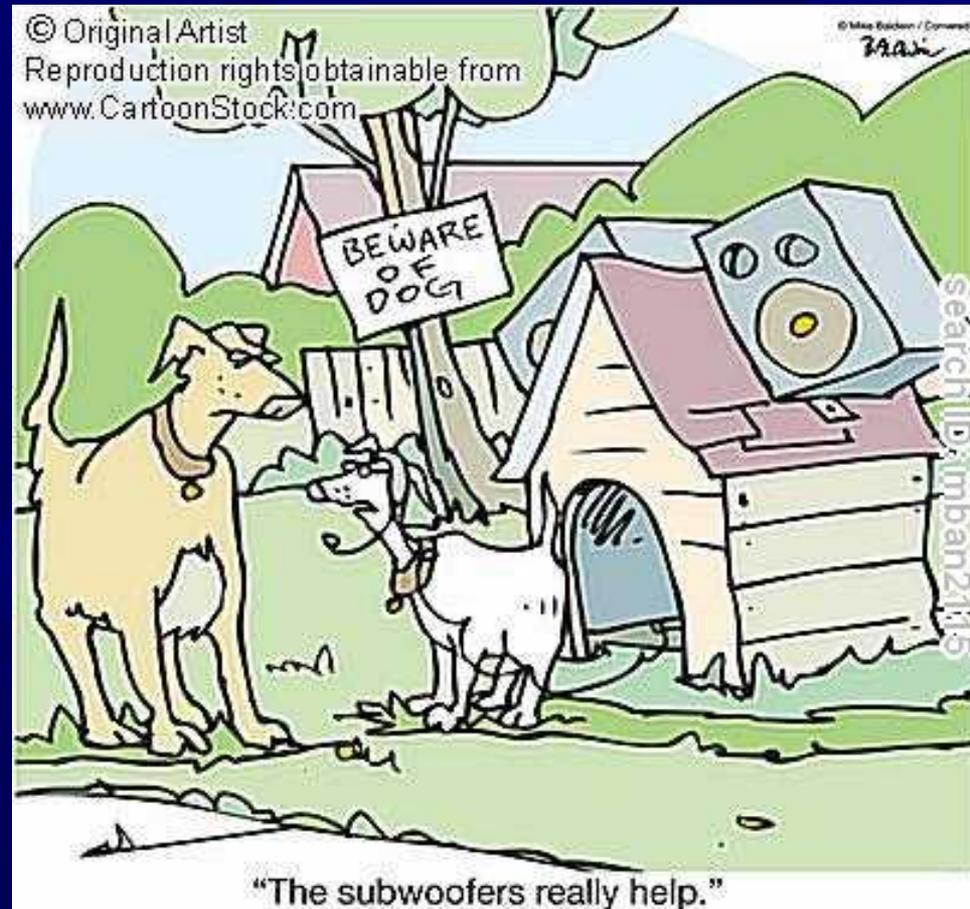
- ★ **Head injury**



4 P's of Hearing Loss

- ★ Painless
- ★ Progressive
- ★ Permanent
- ★ Preventable

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HEARING LOSS

Sensori-Neural

- Noise induced hearing loss
- Results from the damage to the hair cells or auditory nerves

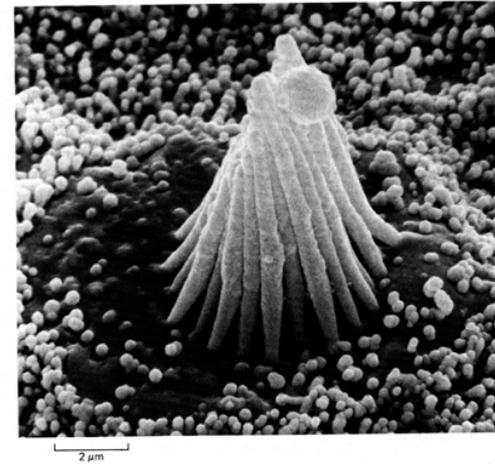
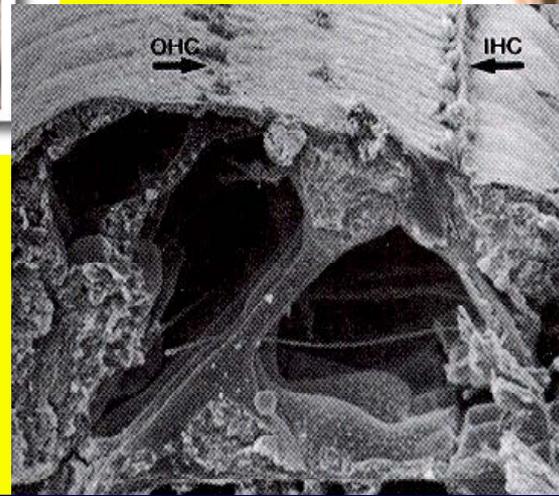
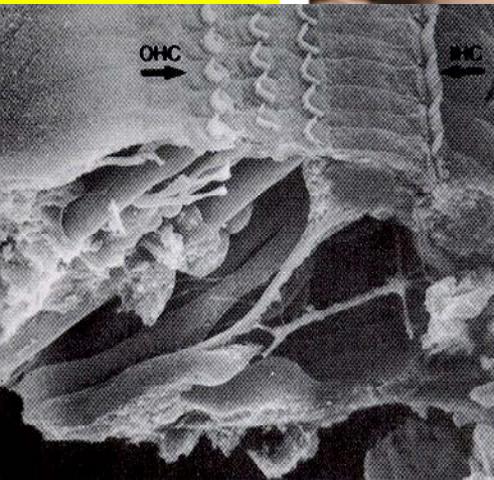


Figure 4-14 Scanning electron micrograph of the organ-pipe-like arrangement of stereocilia projecting from the surface of hair cells in the inner ear. (Courtesy of R. Jacobs and A. J. Hudspeth.)

Cochlea Severely Damaged By Noise Over Exposure

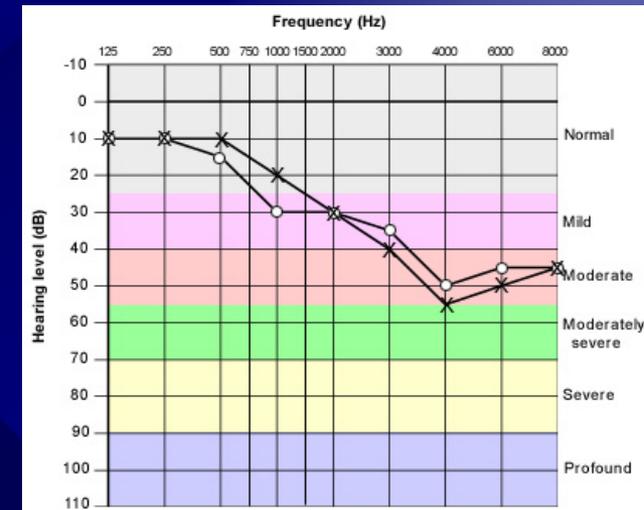
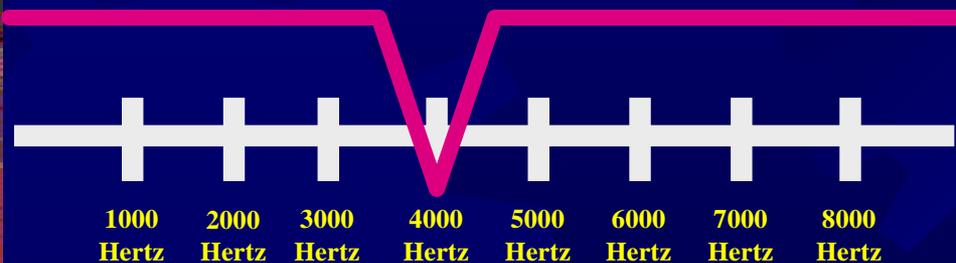
Normal Cochlea



Characteristics of Noise-Induced Hearing Loss

★ Main characteristics are

- ★ Some individuals are more susceptible to noise-induced hearing loss than others
- ★ In the initial stages, noise-induced hearing loss is most pronounced at 4000 Hz but it spreads over other frequencies as noise level and/or exposure time increases



Presbycusis

- ★ Hearing sensitivity declines as people become older

- ★ Like noise-induced hearing loss everyone is not affected equally

- ★ Age-related hearing loss adds to noise-induced hearing loss

- ★ Hearing ability may continue to worsen even after a person stops work in a noisy environment



Sociocusis

★ Loss from non-occupational exposures

★ Environmental factors

★ City traffic, etc.

- One in five American teenagers now suffers from some type of hearing loss, an increase of 31% since the mid-'90s, new research shows
- Most cases of hearing loss are slight, affecting only one ear and involving mostly high-frequency sounds, according to a study in today's *Journal of the American Medical Association*
 - http://usatoday30.usatoday.com/news/health/2010-08-18-hearing18_st_N.htm

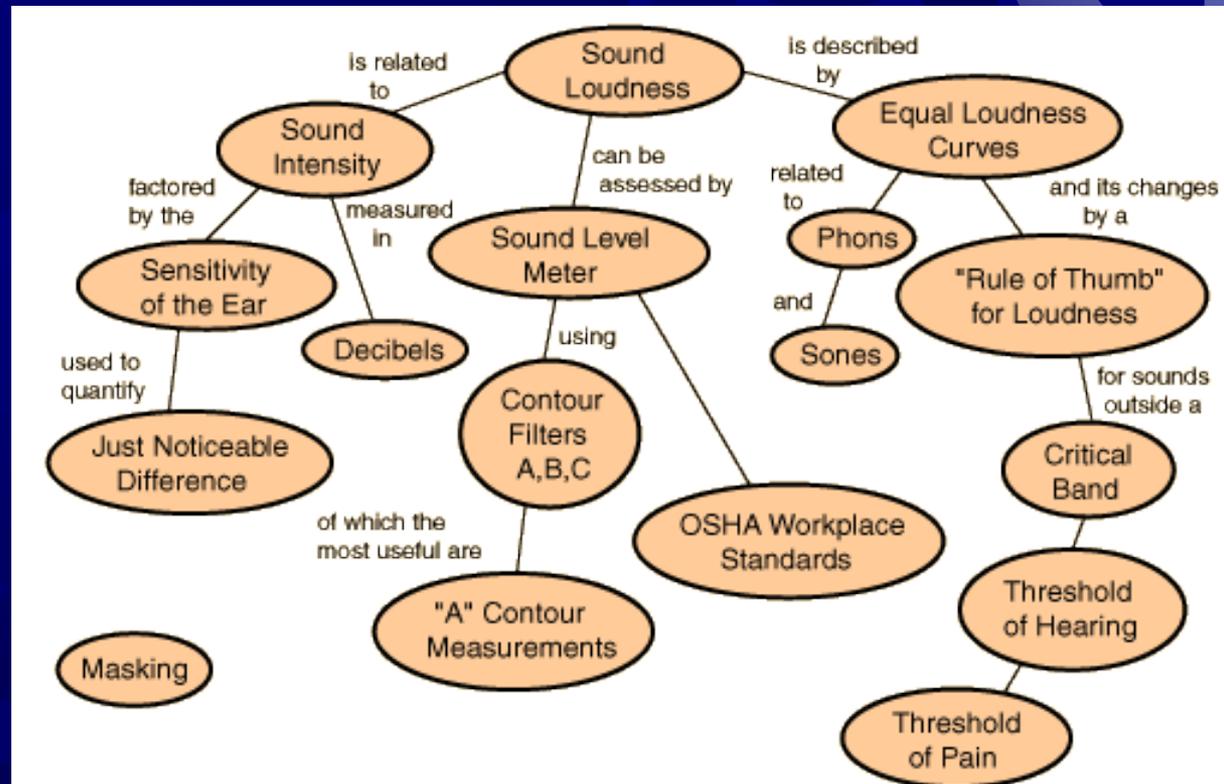


How Do We Measure Noise Levels ?

Utilizing sound measuring instruments

Types

- Sound Level Meter
- Noise Dosimeter
- Octave Band Analyzer



Background Noise

- ★ May influence the measured noise level
- ★ Only used when determining the noise from a source

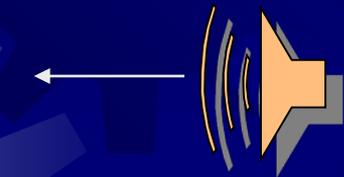


Background Noise

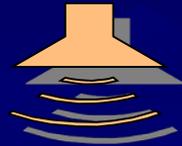
- ☀ In order to apply, 2 readings are taken, 1 with the machine running and with the machine off
 - ☀ **The difference minus a correction factor is the noise level due to the source**
- ☀ When the overall difference between the overall noise and background noise level is 10 dBA or more no correction is needed
 - ☀ **Walkthrough survey**

| Total Noise Level Background Noise Level dBA | Subtract from total noise level to get noise level due to source dBA |
|--|--|
| 8-10 | .5 |
| 6-8 | 1 |
| 4.5-6 | 1.5 |
| 4-4.5 | 2 |
| 3.5 | 2.5 |
| 3 | 3 |

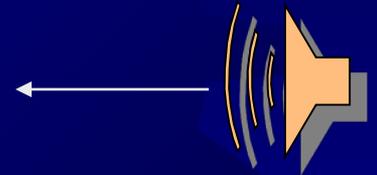
Types of Microphones



**Random
Incidence**



**Direct
Incidence**



**Pressure
Microphone**

Environment

☀ Temperature

- ☀ Will operate in temperatures up to 130 degrees Fahrenheit

☀ Humidity

- ☀ Not to much of a concern
- ☀ Most meters operate in relative humidity up to almost 100%

☀ Atmospheric Pressure

- ☀ Only an issue if over 9,000 – 10,000 feet

Environment

☀ Wind

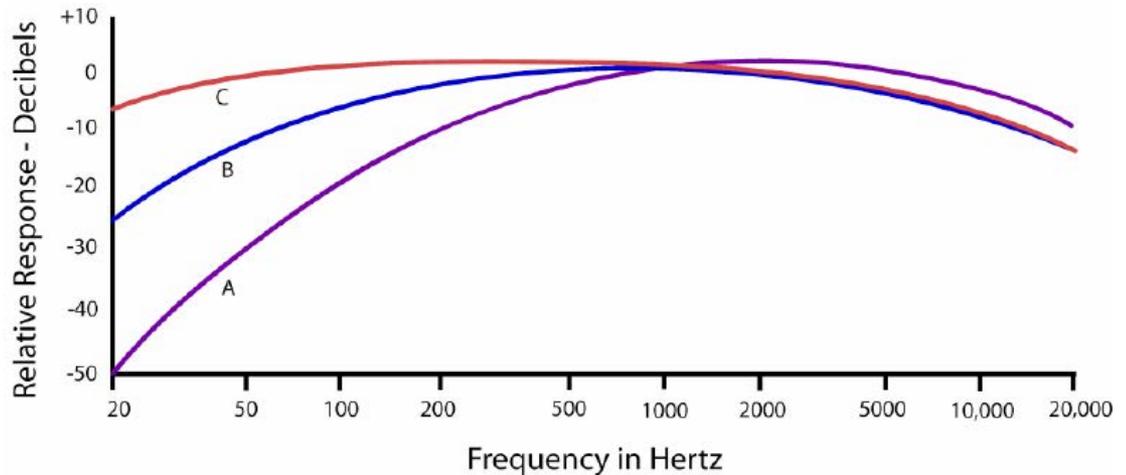
- ☀ Always use windscreen
- ☀ Windscreen safeguards units for winds up to 12 – 15 mph

☀ Radio Frequency and Magnetic Fields

- ☀ Can cause an instrument to read artificially high
 - If you suspect this, put the microphone into the calibrator with it turned off , the sound level should drop
 - If it does not a signal is getting in by some other means than the microphone

Sound Level Meter

- ☀ Measures the intensity of sound at a given moment
- ☀ Useful for determining the level of noise present for specific areas or operations
- ☀ Sound weighting filters are incorporated into noise-measuring equipment



SLM Weighting Curves - ANSI S1.4-1983

Sound Level Meter

- ✦ Measures the sound pressure level (SPL) in decibels
- ✦ The Type II meter is most frequently used
 - ✦ **Type II microphone only measure up to 143 dB**
- ✦ Type I is more expensive and used for engineering, laboratory, research and specialized applications
 - ✦ **Type I microphone only measure up to 160 dB**



Sound Level Meter

- ★ **All ANSI-approved meters meet minimum requirements**
 - ★ **A-weighted network**
 - Some only provide reading in A scale
 - ★ **Slow-response meter characteristic**
 - Averaging time is usually 60 seconds
 - ★ **Fully graduated scale with measurements ranging from 80 to 130 dBA**



Sound Level Meter

- ★ Used for the following types of measurement
 - ★ Spot check noise levels
 - ★ Identify noise sources
 - ★ Evaluate the effectiveness of noise controls
 - ★ Estimate employee noise exposure when a noise dosimeter is available



Sound Level Meter

☀ Use

☀ Calibration

- Prior to and immediately after taking measurements, it is a good practice to check, using a calibrator, the ability of the sound level instrument to correctly measure sound levels
- As long as the sound level readout is within 0.2 dB of the known source, it is suggested that no adjustments to the calibrator be made
 - If large fluctuations in the level occur (more than 1 dB), then either the calibrator or the instrument may have a problem
 - Check the calibration approximately every 4 hours if using continuously

Sound Level Meter

★ Special Considerations

- ★ **Always check the batteries prior to use**
- ★ **Use the microphone windscreen to protect the microphone when outdoors or in dusty or dirty areas**
 - ★ **The windscreen will not protect the microphone from rain or extreme humidity**
- ★ **Never use any other type of covering over the microphone to protect it from moisture**
 - ★ **These materials will distort the noise pickup, and the readings will be invalid**
 - **Plastic bag or wrap**

Sound Level Meter

☀ Special Considerations

☀ Never try to clean a microphone

- Particularly with compressed air, since damage is likely to result
- Although dirt and exposure will damage microphones, regular use of an acoustical calibrator will detect such damage so that the microphones can be replaced

☀ Remove the batteries from any meter that will be stored for more than 5 days

☀ Protect meters from extreme heat and humidity

Sound Level Meter

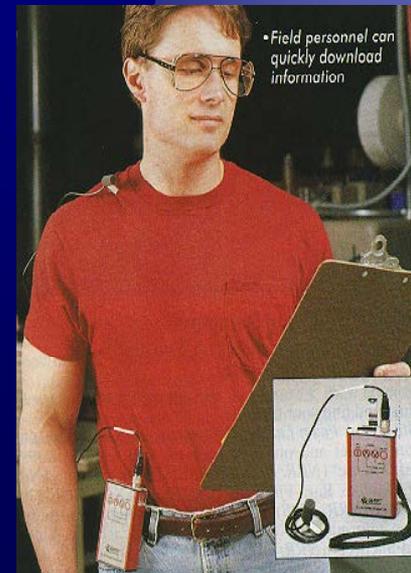
✦ Maintenance

- ✦ No field maintenance is required other than replacement of batteries



Noise Dosimeter

- ★ Measures and stores sound level measurements and integrates these measurements over time, providing an average noise exposure reading for a given period of time
- ★ Useful in determining an individual's amount of exposure to noise



Noise Dosimeter

✦ Noise dosimeters thresholds can be adjusted, but generally they accumulate noise exposure beginning at 80 dB

✦ A threshold is the level at which a personal noise dosimeter begins to integrate noise into a measured exposure

✦ Most current dosimeters have a threshold level of 80 dBA when measuring either the TLV or PEL

✦ The original OSHA standard had a threshold at its criteria level of 90 dB

✦ This led to the condition where an 8 hour exposure at 89 equated to a dose of 0% while an 8 hour exposure at 90 dB equated to a dose of 100%

Noise Dosimeter

- ★ The Type II noise dosimeter is most frequently used
 - ★ Type II microphone only measure up to 143 dB
- ★ Type I is more expensive and used for specialized applications
 - ★ Type I noise dosimeter only measure up to 160 dB



Noise Dosimeter

★ Time-weighted average

- ★ Sound level (in dB) that is accumulated for any time period but with its average level computed over an 8-hour period

★ Lavg (Average Level)

- ★ Lavg is the average sound level measured over the run time

- ★ Lavg is going to be greater than the TWA for less than 8 hours because it is always divided by the time sampled

- ★ Lavg and TWA will equal each other at 8 hours

Noise Dosimeter

Use

Calibration

- Calibrate at the measurement site according to the manufacturer's instructions both before and after each use
- Always check the batteries prior to use
- Be very careful with the microphone cable
 - Never kink, stretch, pinch, or otherwise damage the cable



Noise Dosimeter

Special Considerations

- Always check the batteries prior to use
- Use the microphone windscreen to protect the microphone when outdoors or in dusty or dirty areas
 - The windscreen will not protect the microphone from rain or extreme humidity

- Never use any other type of covering over the microphone to protect it from moisture

- These materials will distort the noise pickup, and the readings will be invalid
 - Plastic bag or wrap



Noise Dosimeter

★ Special Considerations

- ★ **Quest microphones omni directional**
- ★ **Never try to clean a microphone**
 - ★ **Particularly with compressed air, since damage is likely to result**
 - **Although dirt & exposure will damage microphones, regular use of an acoustical calibrator will detect such damage so that the microphones can be replaced**
- ★ **Remove the batteries from any meter that will be stored for more than 5 days**
- ★ **Protect meters from extreme heat & humidity**

Octave Band Analyzer

- ✦ Quantifies effective frequencies without looking at each frequency one at a time
- ✦ Standardized notation used to characterize the frequency dependence of noise
- ✦ Characterized by center frequency
- ✦ Covering range of human hearing (20 –20,000 Hz)
- ✦ Not needed for compliance measurements



Octave Band Analyzer

- ✦ A sound level meter utilizing an analyzer to determine where the noise energy lies in the frequency spectrum
- ✦ Identifies the pure tone components of noise
- ✦ An extremely useful diagnostic tool for finding and quieting the noise source
- ✦ They are also valuable for the calibration of audiometers



Measures of Noise

- ★ **Most important measures**

- ★ **Workplace noise levels in dB**

- ★ **Duration of exposure**

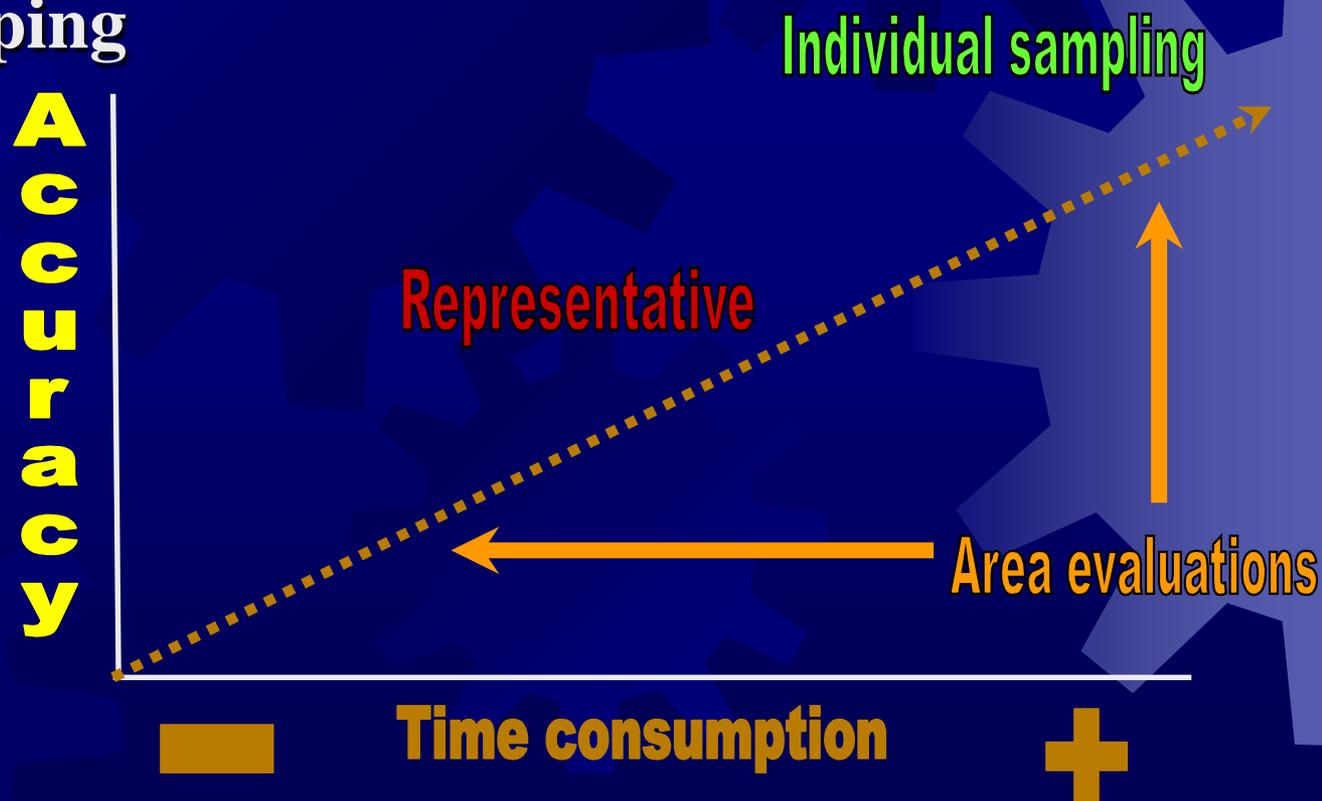
- ★ **Personal noise exposure of an individual employee**

- **In addition, frequency analysis of noise may be necessary to design engineering controls**



Typical Survey Techniques

- ✦ Individual Full Exposure Assessment
- ✦ Representative Sampling
- ✦ Task-Based Exposure Assessment Modeling
 - T-Beam
- ✦ Area Mapping



Individual Full Exposure Assessment

- ★ Full shift monitoring of each individual
- ★ Europe has started to require full shift monitoring for a week instead of a day for a better evaluation of employee exposure

Representative Sampling

- ✦ 2 different point of views
 - ✦ Monitor a portion of the work shift and expand the result to get the full shift equivalents
 - ✦ Pick one of several workers to monitor and assign their test results to others
- ✦ Only as good as your assumptions

Task Based Exposure Modeling

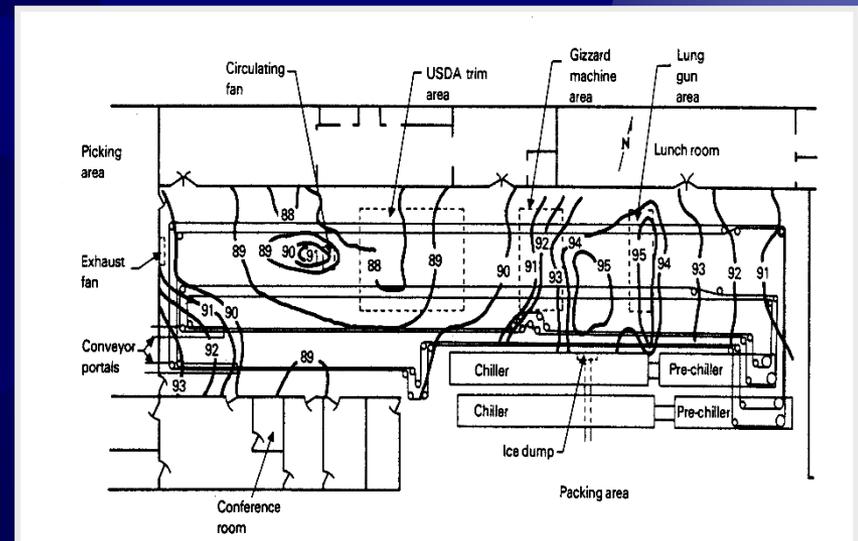
- ✦ Utilizing controlled sampling methodology to allow a surveyor to collect a multitude of data
 - ✦ **Uses modeling to determine risk potential**
 - ✦ Provides a very powerful tool to rapidly determine risk potential while at the same time provides significant information that makes the assessment easily defensible from a legal standpoint
 - This typically requires a much higher level of expertise in order to implement successfully.

Task Based Exposure Modeling

- ✦ Actual sampling is based on controlled elements and requires inputs from workers, process/supervisory personnel as well as actual sound level emissions, the surveyor must be capable of ensuring that the model inputs are valid
- ✦ **Poses a significant problem for companies with neither the time nor resources to consistently utilize this approach**

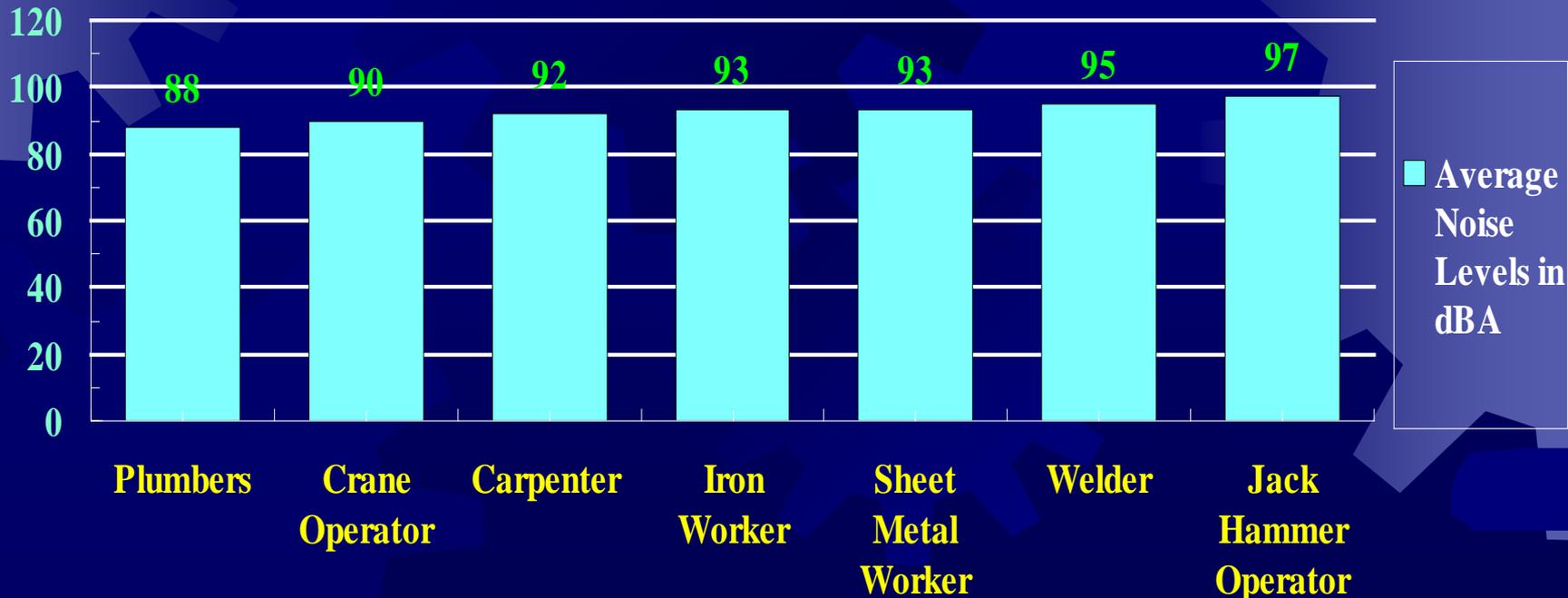
Area Mapping

- ☀ Starts with a detailed grid map of the workplace
- ☀ Measurements taken at the intersections of the grid lines and plotted on the map
 - ☀ Data is then teamed with time study information on the worker's activity pattern to calculate exposure
 - Accurate time study data is critical for this model to be effective



Analysis of Noise Exposure

- ★ Use the A - weighted sound level
- ★ Frequency duration distribution
- ★ Type of noise
 - **Impact vs. continuous**
- ★ Duration of exposure



Planning Noise Measurement

- ✱ Understand workplace operations
- ✱ Review any previous noise surveys
- ✱ Know applicable noise regulations
- ✱ Understand the purpose of noise measurement
- ✱ Identify sources of noise and the times when the sources are operating
- ✱ Familiarize yourself with the temporal patterns of noise
- ✱ Identify locations of exposed workers
 - ✱ **Continuous, variable, intermittent and impulse**
- ✱ Select proper instrumentation

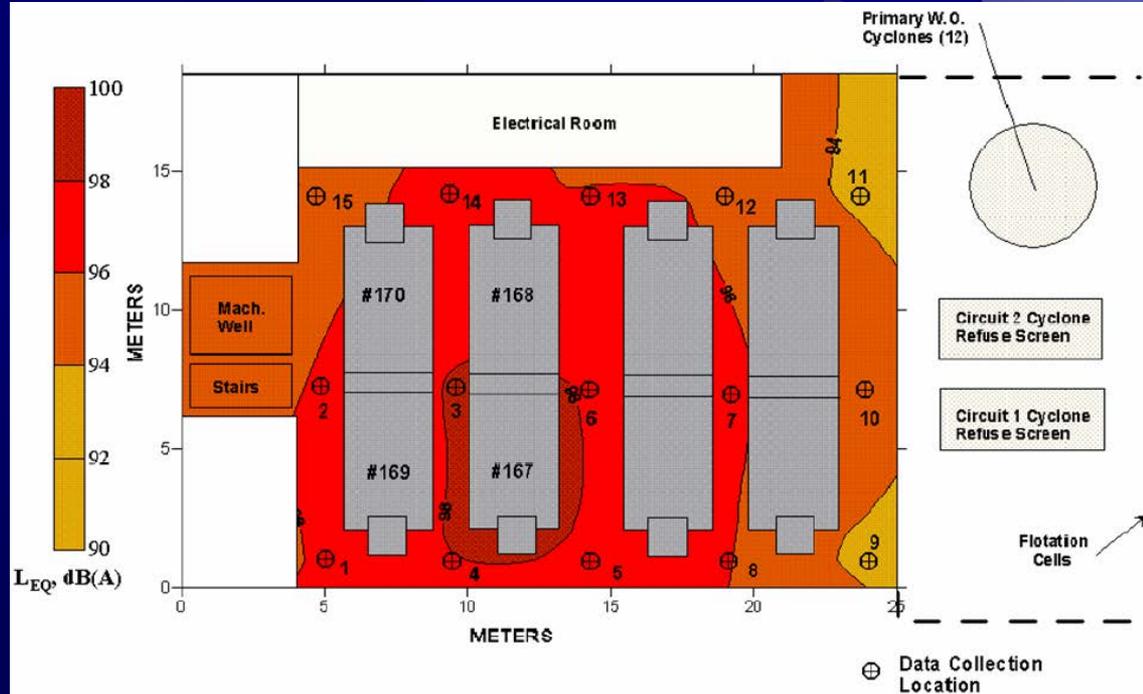
Measurement of Noise

- ✦ Identify the noise problem
 - ✦ **Walkthrough survey**
 - ✦ Compressed air is the biggest noise problem in industry



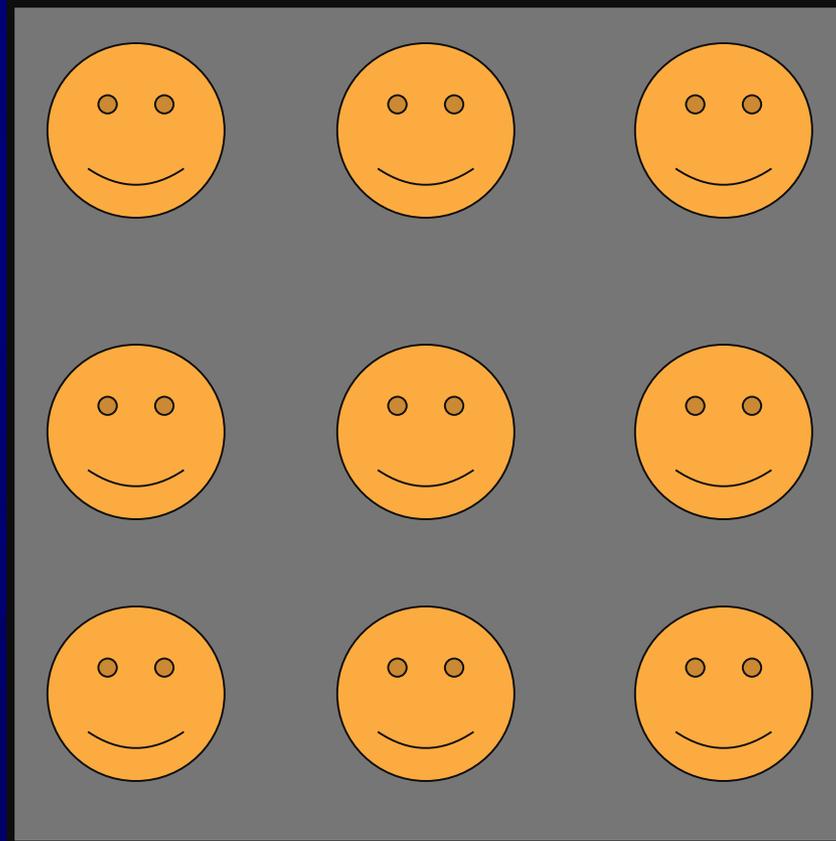
Noise Survey

- ★ Usually the initial measurement
- ★ Purpose is to determine
 - ★ Whether or not a noise problem exists
 - ★ Whether or not further measurements are needed
 - ★ Whether or not there is a need for hearing protection



Noise Survey

- ★ How many to sample for a representative sample?



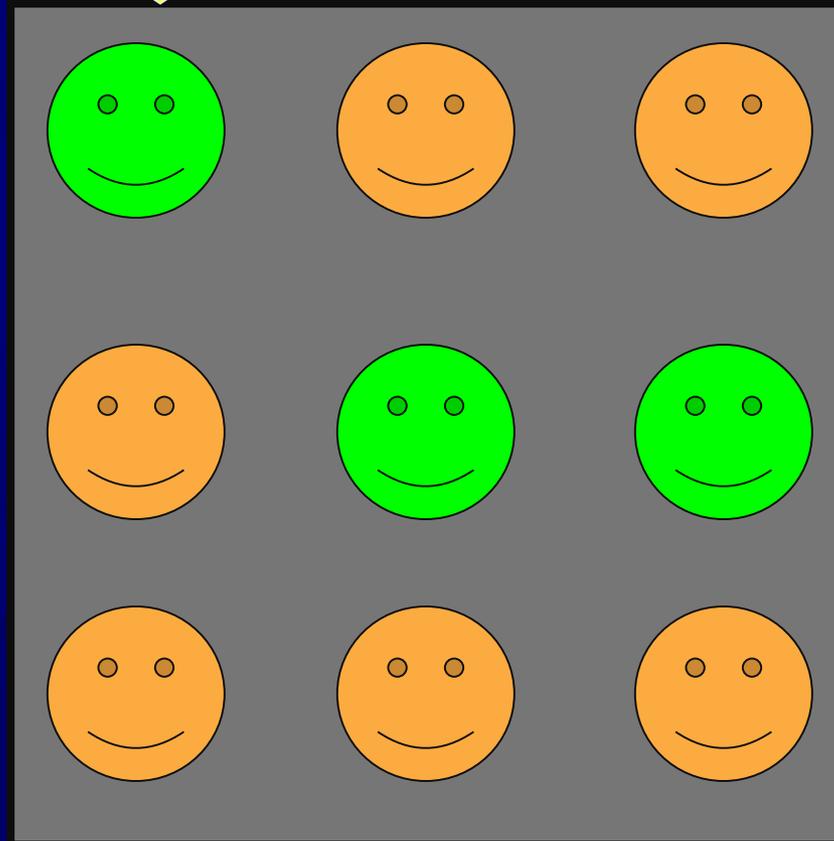
Noise Survey

★ 3

Reflection



Reflection



Reflection

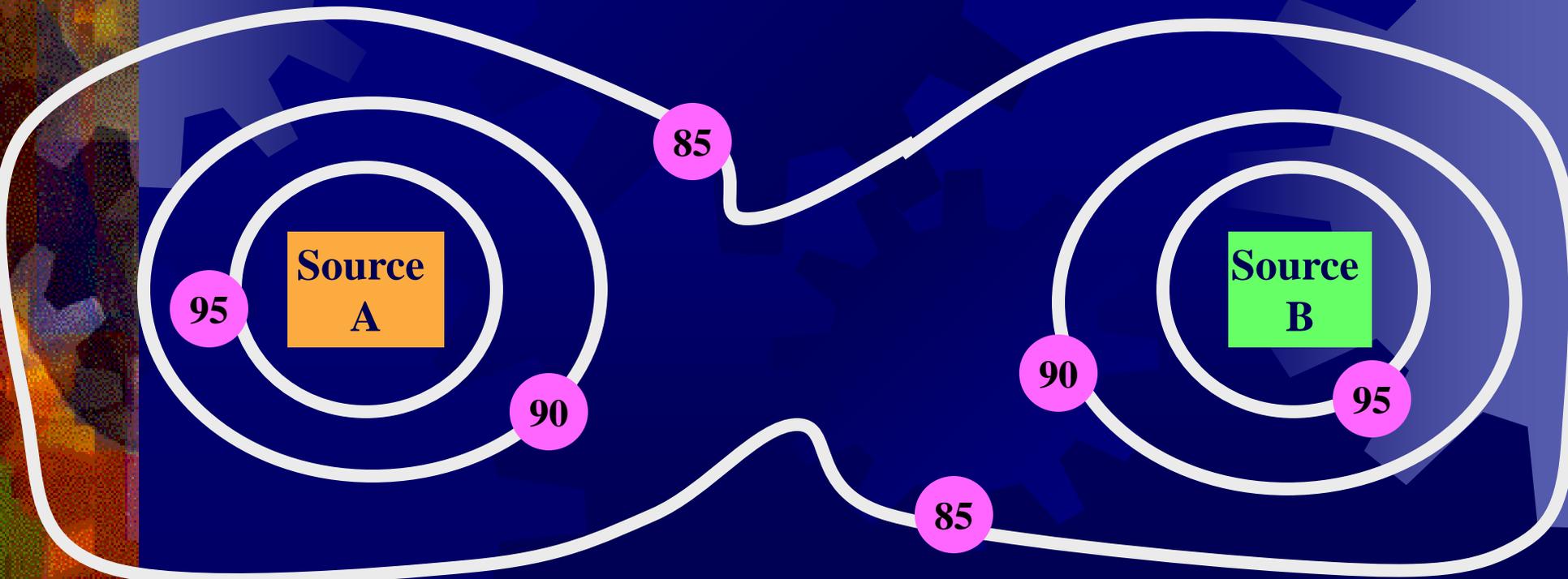


Noise Survey

- ★ Read the owner's manual
- ★ Select the desired SLM settings
 - ★ **Slow response**
- ★ Calibrate the SLM before & after each use
- ★ Identify locations for measurement
- ★ Draw a sketch of workers and machines
- ★ Measure the noise levels
 - ★ **Take the measurements with the SLM head at arms length at ear height for those exposed to the noise**
 - ★ Place the microphone as close as possible to the employee's ear
 - ★ **Record the level**

Noise Survey

- ★ Produce a noise map by drawing lines on the sketch between points of equal noise levels
- ★ Take as many measurements as possible
 - ★ The greater the number of measurements the more accurate the survey



Personnel Exposure Monitoring

- ☀ Next step after noise survey
- ☀ Allows for the evaluation of representative worker exposure
 - ☀ **Workers are usually expose to varying noise levels**



| Typical A-Weighted Sound Levels | |
|---|-------|
| NOISE SOURCE | dB(A) |
| pneumatic chipper at 1 metre | 115 |
| hand-held circular saw at 1 metre | 115 |
| textile room | 103 |
| newspaper press | 95 |
| power lawn mower at 1 metre | 92 |
| diesel truck (50 km per hour at 20 metres) | 85 |
| passenger car (60 km per hour at 20 metres) | 65 |
| conversation at 1 metre | 60 |
| quiet room | 40 |

Personnel Exposure Monitoring

- ☀ Be honest
- ☀ Inform employees
- ☀ Explain the importance of accuracy in assessing the need for noise control
- ☀ Emphasize the importance of wearing the dosimeter at all times of the monitoring period
- ☀ Explain the consequences of tampering with the microphone
 - ☀ **Shouting into the microphone, knocking on doors, etc.**
- ☀ Be friendly

Personnel Exposure Monitoring

- ★ Read the owner's manual**
- ★ Consult relevant standards and regulatory procedures**
- ★ Select the desired settings**
- ★ Calibrate the dosimeter before & after each use**
- ★ Identify locations for measurement**
- ★ Draw a sketch of workers and machines**
- ★ Record the worker's names and their jobs**
- ★ Record the start and stop time**
- ★ Periodically monitor the worker**
- ★ Record the dosimeter readings**

What To Record In Addition To Sound Levels

- ✱ **Dates and Times**
- ✱ **Model and Serial Numbers**
- ✱ **Pre and Post Survey Calibration Levels**
- ✱ **Workplace Descriptions**
- ✱ **Task Descriptions**
- ✱ **Environmental Factors**
- ✱ **Instrument Settings**
- ✱ **Unusual Conditions**

Survey Pitfalls!!!

- ✦ **Microphone Placement**
- ✦ **Employee**
- ✦ **Project Assumption**
- ✦ **Threshold Distortion**
- ✦ **Wind**
- ✦ **Battery & Calibration**

Personnel Exposure Monitoring

★ Noise Dose %

★ Gives the wearer's noise exposure compared to maximum permissible noise exposure limit

- A 100% dose indicates that the wearer has been exposed to the maximum permissible noise exposure limit
- Less than a 100% dose indicates that the wearer has been exposed to below the maximum permissible noise exposure limit
- Greater than a 100% dose indicates that the wearer has been exposed above the maximum permissible noise exposure limit

Convert percent noise dose to equivalent sound level (Leq) for an 8 hour work shift assuming 90 dBA exposure limit and 3 db exchange rate

| Noise dose % | Leq in dBA for 8 hour work shift |
|---------------------|---|
| 10 | 80 |
| 20 | 83 |
| 50 | 87 |
| 75 | 89 |
| 100 | 90 |
| 110 | 90.4 |
| 120 | 90.8 |
| 150 | 91.8 |
| 175 | 92.4 |
| 200 | 93 |

Personnel Exposure Monitoring

★ Noise Level

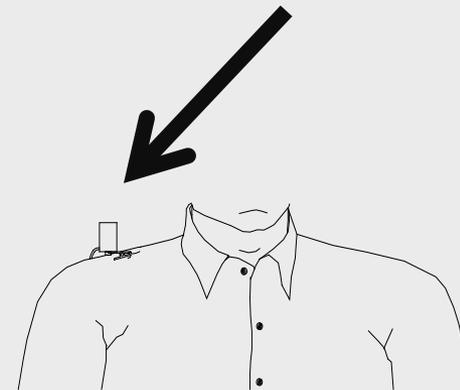
- ★ Most dosimeters give readings of maximum, minimum and equivalent noise level

★ Time history

- ★ Modern dosimeters have data storage capability



Proper Microphone Placement



Noise Exposure Standards

☀ **Three parts to any standard or guideline** Method of Sound

- ☀ **Criteria level**
- ☀ **Threshold level**
- ☀ **Exchange rate**

Proper Mounting



Criteria Level

- ✦ **Eight-hour average SPL above which risk for hearing loss exists**
 - ✦ **If exposed to SPL on average for eight hours, it would result in a maximum allowable exposure**
 - **Usually either 85 or 90 dBA**
 - **OSHA 90 dB for 8 hours**
 - **ACGIH, NIOSH, DOD 85 dB for 8 hours**

Threshold Level

- ★ **SPL below which no damage occurs**
 - ★ **dB level below which, all SPL's are assigned a value of zero**
 - Usually 80 dB

Exchange Rate

- ★ **Based on a damage model assumption**
 - ★ **Trade-off between exposure level and exposure time**
 - **Results in a doubling or halving of the maximum allowable exposure**

Critical Terminology

★ Average Level (LAVG and Leq)

- ★ If present continuously, would generate the same amount of energy as the varying levels that are present in the environment measured in decibels

★ Time Weighted Average (TWA)

- ★ A level average with an assumed fixed sample period of eight hours measured in decibels

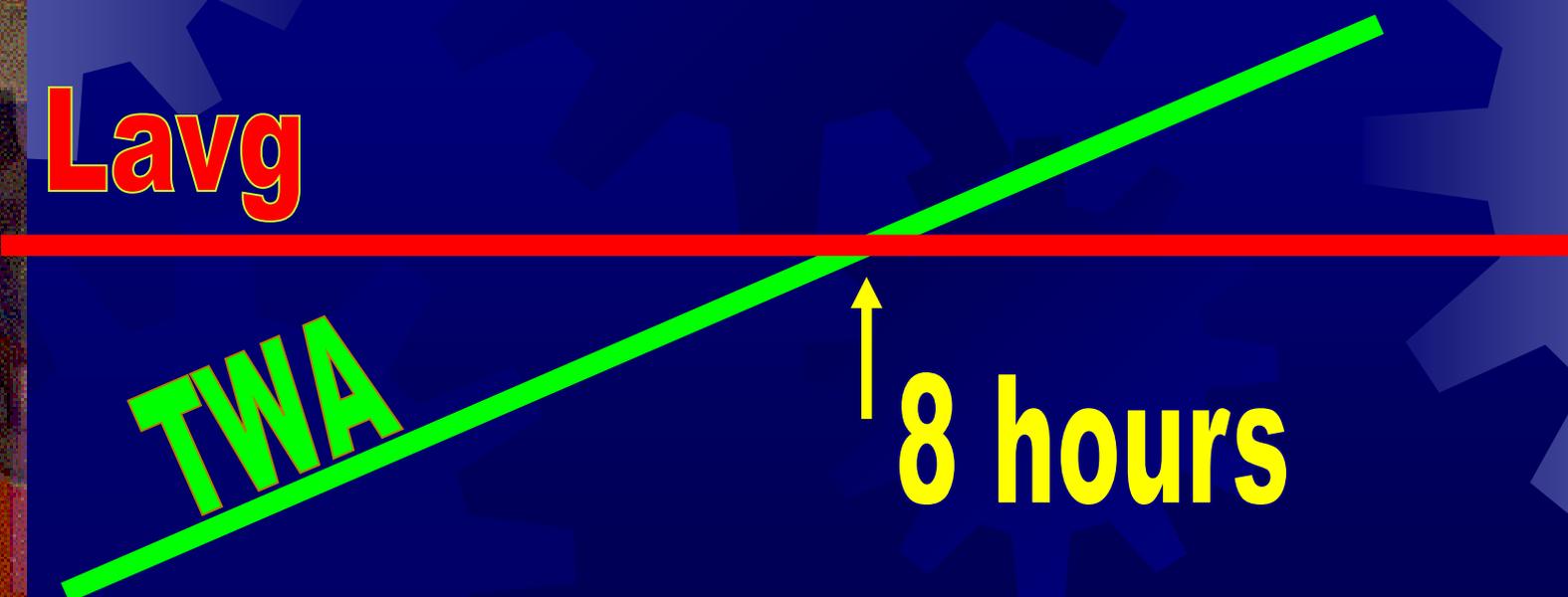
★ Dose

- ★ The allowable daily exposure value. A maximum allowable exposure is equal to 100% dose
 - ★ OSHA 90 dB x 8 hours = 100% Dose
 - ★ ACGIH & NIOSH 85 dB x 8 hours = 100% Dose

A Basic Concept...

- ☀ **TWA = Lavg @ exactly 8 hours**
- ☀ **DOSE = Follows the same line!**

Lavg



TWA

8 hours



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