Lesson 13a. Radiation

Hazards & Safety

April 21, 20056

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Radiation In Our Environment

Radiation has been in our environment since the beginning of time. All plants and animals are continuously bombarded by NATURAL BACKGROUND radiation. Man-made radiation was discovered in 1895

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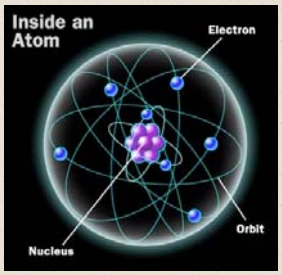
Radiation means matter or energy moving outward from a point of origin.

Ionizing radiations are generated by interactions occurring within the atom.



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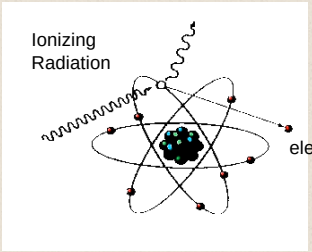
Ionizing Radiation

has enough energy to remove electrons from atoms.



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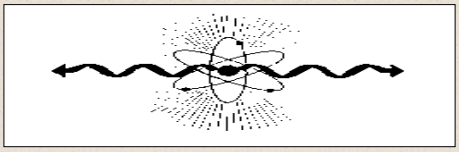
Ionizing Radiation

Atoms emit ionizing radiation to reduce excess energy and attempt to achieve stability.



Some naturally occurring atoms do this spontaneously, other atoms are forced into instability by man-made processes.

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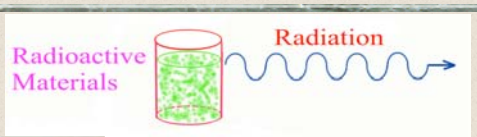
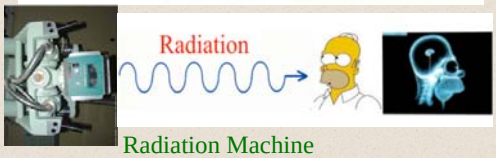
Materials Vs. Machines





Radiation Machine

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Materials vs. Machines

- **Radioactive Materials** (Naturally occurring or man-made [reactors, accelerators, nuclear weapons])
  - Produce radiation at all times, but decays away over time.
  - Often loose material and can be spread around
- **Radiation Machines** (X-ray machines, cyclo-trons, accelerators, etc.)
  - Most produce x-rays, but high energy machines may produce other radiations.
  - Only produce radia-tion when turned on.
  - A by-product of high energy machines can be radioactive materials.

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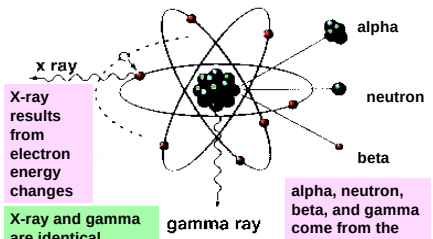
Five basic types of ionizing radiation

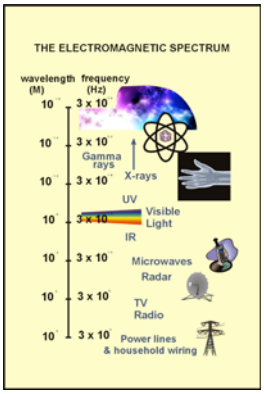


X-ray results from electron energy changes

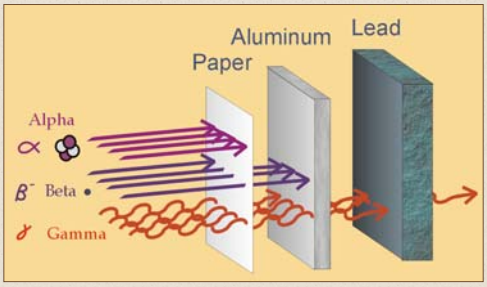
X-ray and gamma are identical except for origin

alpha, neutron, beta, and gamma come from the nucleus

Gamma rays and x-rays are forms of energy, similar to visible light and radio, but much more energetic.



Penetrating Energy



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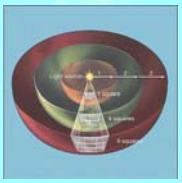
Radiation Intensity Changes with Distance

RADIATION LEVELS DECREASE AS YOU MOVE AWAY FROM THE SOURCE:



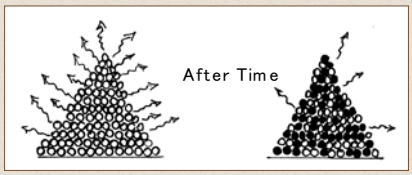
CONVERSELY, RADIATION LEVELS INCREASE CLOSE TO A SOURCE

Follows the "inverse square" ($1/r^2$) relationship

For example; doubling your distance cuts exposure to 1/4, and tripling distance cuts exposure to 1/9.

12

Radioactive Decay
(Materials)



Pure Sample
Full Activity

Decayed
Sample
Lower Activity

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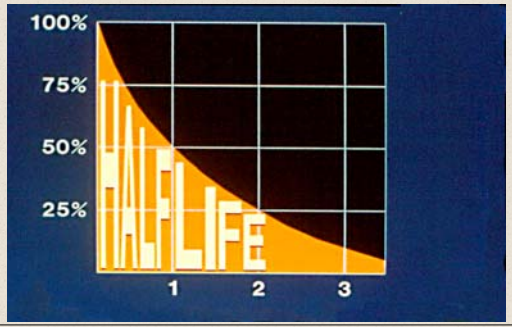
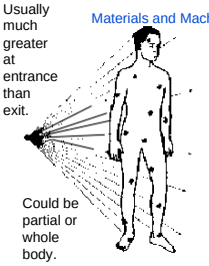
Radioactive Decay
(Materials)



Radiation Hazards
(External vs. Internal)

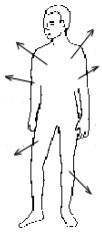
Usually much greater at entrance than exit.

Materials and Machines



Could be partial or whole body.

Materials Only



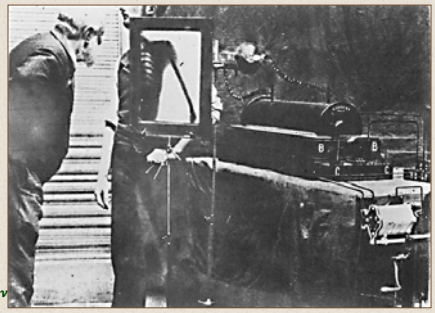
May come from inhalation, ingestion, injection, absorption, or injury

Often concentrates in particular organs.

Early Radiation Injury

Radiation injury to the skin of a Spanish-American War soldier as a result of an x-ray examination (1898)

Fate of Early Radiologists



Radiologist Fingers

Fig. 3-10. The hands of a distinguished diagnostic radiologist. The total dose is unknown but the changes are classic—a dry, easily flexed skin with many hyperkeratotic and precancerous lesions. The right middle finger was amputated for a squamous cell carcinoma of the skin.

Human Use of Radiation

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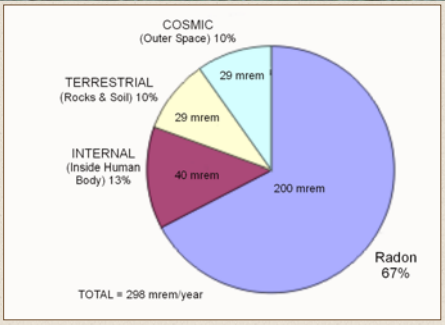
Natural Background Radiation



About 3 mSv (300 mrem) per year

20

Radiation Dose Equivalent

- Dose Equivalent – Unit to express the amount of radiation energy absorbed in matter, adjusted for biological damaging ability.
- sievert (SI unit - Sv), or rem (traditional unit)
- millisievert or millirem is 1000 times smaller
- 1 SV = 100 rem
- 1 mSv = 100 mrem

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Annual Radiation Dose Limits

- Occupational
  - 0.05 Sv (5 rem or 5000 mrem) whole body
  - individual organs, skin and extremities (50 rem)
  - Exception: Lens of eye = 0.15 Sv (15 rem)
- Embryo/Fetus (of radiation worker)
  - 5 mSv (0.5 rem)
- General Public
  - 1 mSv (0.1 rem)

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Radiation Health Effects

- High-level radiation effects are acute effects which are manifested shortly after (hours, days, weeks) a large exposure (1 Sv or 100 rem+).
- Low-level radiation effects are described as either latent effects, appearing many years after a "non-lethal" acute dose, or
- as chronic effects after many years of small doses (like radiation workers).

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Acute/High Level Radiation Effects in Humans

- Radiation Burns (over 2 Sv or 200 rem) – local or whole body
- Cataracts (over 1.5 Sv or 150 rem)
- Whole Body Bone Marrow Injury (over 1 Sv or 100 rem) – may cause death if injury is severe.
- GI Tract Injury (over 6 Sv or 600 rem) – causes death in days or weeks.
- Central Nervous System Injury (over 50 Sv or 5000 rem) – causes death in hours or days.
- Other?

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Low Level Radiation Health Effects

- Genetic mutations – probably takes 1 Sv (100 rem) to double mutation rate in man.
- Abnormalities induced in an exposed fetus – about 4% chance of occurrence per 0.1 Sv (10 rem)
- Cancer in the exposed individual – 0.1 Sv (10 rem) given to 100 people in U.S. population would be expected to cause about 1 extra cancer over a lifetime. About 42 of these people would be expected to get cancer from natural causes.

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Radiation Protection puts many scientific principles and techniques into practice.

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Substitution

- Fossil fuel plants can replace nuclear power plants.
- Magnetic Resonance Imaging can replace x-ray imaging in a few situations.
- Fluorescent markers can replace radionuclides in some lab tests.
- Downside – Cost, other hazards?

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Treatment?

- Success is poor. Attempts to "irradiate" radioactive materials and turn them into different radioisotopes with shorter half-life nearly always fail.
- If someone suggests that you invest in a radioisotope treatment scheme – save your money!

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Isolation (Burial)

- Radioactive materials have historically been put into isolation and burial sites – with arguable success.

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Shielding

- Shielding stops *alpha* and *beta* particles and greatly reduces *x-ray* and *gamma* radiation.
  - Distance reduces exposure by $1/r^2$ for x-ray and gamma radiation
    - Distance in air stops *alpha* and *beta* particles.
  - Reducing the amount of time around a radiation source directly reduces radiation exposure.

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Methods to Reduce Internal Intake

- Containment and/or exhaust (fume hoods in labs).
- Contamination surveys.
- Good hygiene - washing hands, contaminated skin, and contaminated articles.
- Good personal habits – no hand to face/mouth contact, no eating/drinking, no application of cosmetics.

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Methods to Reduce Internal Intake

- Use of protective clothing and personal protective equipment.
- General Protective Measures:
  - Knowledge of hazards.
  - Area Control: signage, records, and security.
  - Appropriate facilities and equipment for use and control of radioactive materials.

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Encountering Radiation in the Workplace

Research

Medicine

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Encountering Radiation in the Workplace (Continued)

Measurement and Quality Control

Static Control

34

Man-Made Radiation in the Environment

Biomedical/Industrial wastes or byproducts

Lost sources

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Man-Made Radiation in the Environment

Active Production or Processing Sites

Closed/Abandoned Production or Processing Sites

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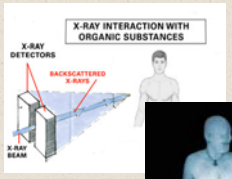
Dirty Bombs (Radiological Dispersal Devices) ?

June 2005: US Senate surveys government officials and other US and international experts. Ordinary explosives pared with radioactive material seen as the likeliest "Weapon of Mass Destruction".

Backscatter Security X-ray

TSA expects to begin using the controversial backscatter x-ray later this year to show airport screeners a clear picture of what's under a passenger's clothes.

-- USA TODAY, May 15, 2005



Susan Hallowell, Director of TSA's Security Laboratory

Airport Baggage Scanning Equipment

New Airport explosive detection systems are being used in US and many non-US airports to x-ray scan **checked baggage**. The new equipment uses much higher levels of radiation than equipment used to inspect carry-on baggage (which will not noticeably damage most films). Example:

Non-X-rayed film

Radiation damaged film

Questions

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Break

Noise & Noise Pollution

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Lesson 13b. Noise

Hearing Loss Prevention

May 16, 2006

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University of Washington
Dept. of Environmental and Occupational Health Sciences

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Overview

- What we'll be covering today:
  - Noise, hearing and hearing loss
  - Occupational noise
    - How to measure it
    - How much is too much?
  - Hearing loss prevention
    - Controls
    - Hearing protectors
  - Non-occupational noise
  - Community noise

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Noise

- Definition= Unwanted sound (vibrations in air)
- Measured by: sound pressure (loudness)
  - decibels (dB)
- And: frequency (pitch)
  - hertz (Hz) = vibrations per second

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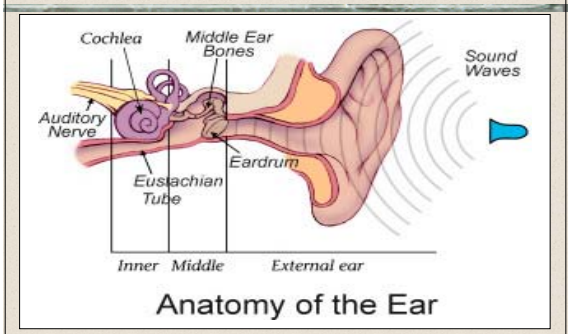
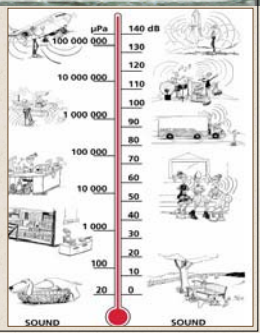
How We Hear



Anatomy of the Ear

Loudness

- Human ear: extremely large range of sound pressure sensitivity
- Convenient to convert linear scale (sound pressure, P_a) to log scale (sound pressure level, dB)



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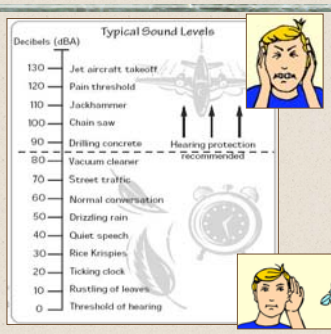
Noise Levels

Noise Levels of some familiar sounds



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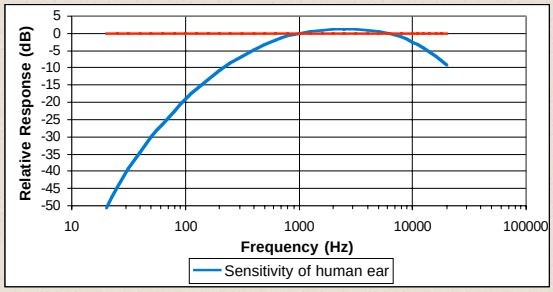
Frequency is Important, too ...



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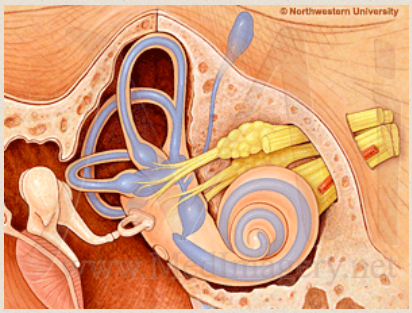
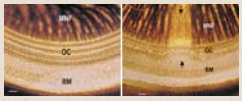
Hearing Loss



Types of Hearing Damage



- Conductive (outer or middle ear)
  - Sometimes reversible
  - Acoustic trauma, accident, etc
- Sensorineural (inner ear)
  - Damage to nerves; irreversible
  - Includes NIHL, presbycusis

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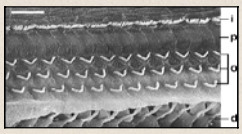
Inside the Cochlea…

- Before noise:
  - Inner and outer hair cells neatly arranged



- After noise:
  - Hair cells in disarray, or even missing

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Types of Hearing Damage

- Also:
  - Temporary Threshold Shift
  - Permanent Threshold Shift
  - Tinnitus (more on this later)

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How is Hearing Tested?

- Sound-treated booth
- Tympanometry
- Standard audiometry
  - Pure tone air conduction
  - Pure tone bone conduction
  - 5 dB steps
- Other (newer) tests available, as well

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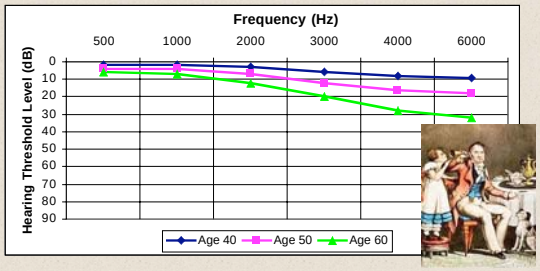
Age-related Hearing Loss

Even by age 60, the average person doesn't have hearing impairment from age alone



Effects of NIHL

- NIHL affects high frequency hearing first
- NIHL makes it harder to communicate:
  - On the job
  - In situations w/ background noise (jobsite, restaurant)

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Effects of NIHL

- NIHL may affect ability to work
- NIHL can make it difficult to hear critical warnings:
  - Back-up alarms
  - Traffic on a street

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Other Effects of Noise

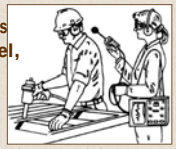
- Dilation on the pupil
- Secretion of thyroid hormone
- Heart palpitations
- Secretion of adrenalin
- Secretion of adrenalin cortex hormone
- Movement of the stomach and intestines
- Muscle reaction
- Constriction of blood vessels

57

Ways to Measure Noise

- Sound Level Meter
  - Area/personal measurements, point-in- time levels
  - Cheap, easy, good for continuous noise, immediate HPD needs

- Dosimeter
  - Area/personal measurements
  - Point-in-time or average level, continuous or variable noise
  - Expensive, but low labor



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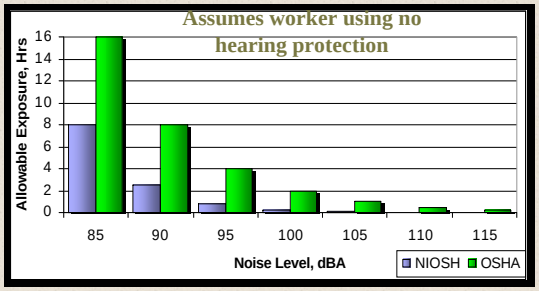
Noise Standards OSHA vs. NIOSH



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Top 10 SICs

by % workers >85 dBA

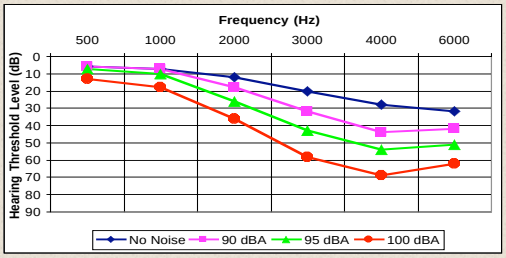
Economic Sector	Total no. production workers	No. noise-exposed	% noise-exposed
Tobacco products	106,399	57,764	54.3
Primary metals	824,725	269,270	32.7
Paper and allied products	488,101	164,808	33.8
Textile mill products	615,322	262,108	42.6
Lumber and wood products	475,730	196,489	41.3
Transportation by air	312,931	94,656	30.3
Fabricated metal products	1,151,777	336,919	29.3
Furniture and fixtures	428,539	121,271	28.3
Hvy construction (not bldg)	517,969	124,610	24
Oil and gas extraction	330,841	76,525	23.1

Source: NIOSH, 1998

60

Hearing Loss vs. Noise

- Noise-induced loss additive to age-related loss
- Enter age correction…



NIHL Claims

- How much is *your* hearing worth in WA?
- WA doesn't allow age-correction for claims
  - $10K maximum PPD payment for loss in 1 ear
  - $65K maximum PPD for both ears
- Differences in compensation for various occupations

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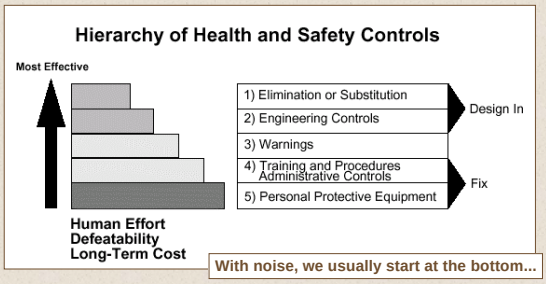
Ways Exposures Can Be Reduced



With noise, we usually start at the bottom...

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To Prevent Hearing Loss

- Employ the Engineering Control Strategies:
  - Substitution
  - Treatment
  - Isolation
  - Shielding

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Substitution

- Eliminate noise or use quieter sources
  - ← Don't use this …
  - ↓ When these will do!

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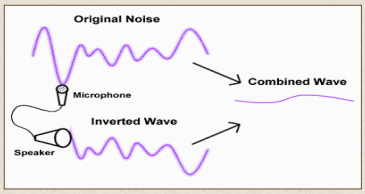
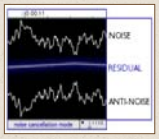
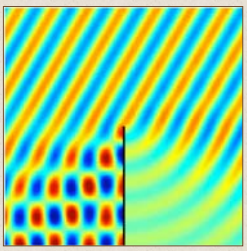
Treatment

- Active noise control (ANC)
  - Not good for everything, but pretty darn cool!





Isolation (Barriers)



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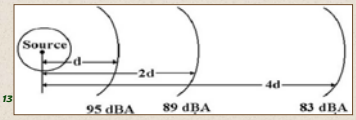
Inverse Square Law

- Use distance as a barrier
  - Distance/location: your friend for noise
  - Sources away from reflective surfaces, workers
  - 2x source-worker distance = 6 dB less
  - Move out of corner = 6 dB less
  - Move from 1 reflective surface = 3 dB less



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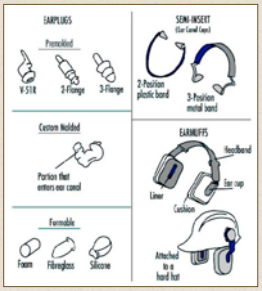
Shielding (PPE)

- Hearing Protection Devices (HPDs):
- 4 C's:
  - Comfort
  - Convenience
  - Communications
  - Cost



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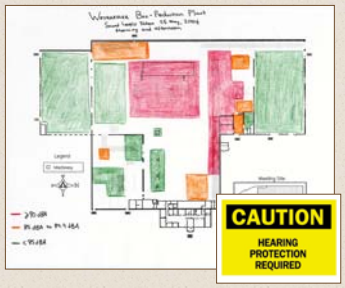
Administrative Controls

- Establish and label high noise zones, require HPD use
- Noise map: a good excuse to use crayons



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Administrative Controls

- Signs
  - Some signs are better than others…

BAD

BETTER

GOOD

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Other Developments in Hearing

- Hearing aids: friend or foe?
- Outer and inner hair cell regeneration
  - Birds do it - why can't we?
- Otoprotectants
  - A "morning after" pill?

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HPD Issues

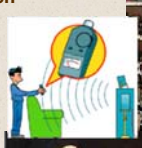
- Workers MUST have training, selection
- Most earplugs alter quality of sound at different frequencies
  - Exception: flat response
- Speak up - don't mumble

Administrative Controls

- Schedule noise for fewest workers
- Maintain/repair/lube equipment
- Rotation/break/limit time
- Signs
- No Walkman headphones!

Non-Occupational Noise

- Employers interested in non-occupational exposure
- Lots of sensational media reporting
- Little evidence of non-occupational NIHL
- If high occupational exposure, non-occupational noise insignificant



Non-Occupational Noise

- Hearing can be damaged by non-occupational activities, of course… For example:
  - Shooting (especially without HPDs)
  - Active duty/Guard military service
  - Excessive exposure to noisy non-occupational activities
  - Ototoxic exposures
- Best way to prevent non-occupational NIHL?
  - Education received as part of HLPP

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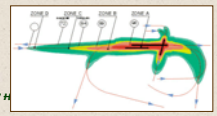
Community Noise

- Noise is consistently rated among the most annoying community issues in the US
- Lots of sources… Can anyone think of any?



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Community Noise

- Approaches used to control occupational noise exposure also work for community noise
- One difference:
  - With occupational noise, we want to prevent NIHL
  - With community noise, want to prevent NIHL, health effects, AND annoyance

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Recommended Exposure Levels

Effect	Situation	Effect Threshold Metric	Level (dBA)
Any Hearing Impairment	Occup Environ	8-hr average 24-hr average	75 70
Hypertension	Occup Environ	8-hr average Day-Night average	<85 70
Ischemic heart disease	Environ	Day-Night average	70
Annoyance	Occup Environ	8-hr avg Day-Night average	<85 42
Performance	School	Day average	70
Sleep disturbance			
Sleep pattern	Sleep	Night average	<60
Sleep quality	Sleep	Night average	40
Mood next day	Sleep	Night average	<60

Adapted from Passchier -Vermeer, *EHP* 2000

Conclusion

- **Preventing Hearing Loss**
  - **Hearing loss = Safety hazard, social isolation**
    - **Cannot be reversed with hearing aids, surgery, etc.**
    - **About 10 million US workers have NIHL**
  - **HLPPs (and especially noise controls) are best protection from NIHL**
  - **Hearing loss NOT necessary for growing old**
  - **Noise can be confusing, but there's a solution to any exposure problem…**

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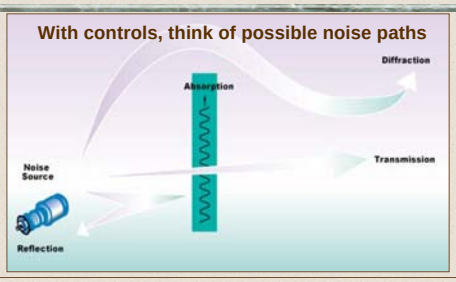
Noise Control

With controls, think of possible noise paths



There are several ways to stop noise – or even selectively let desired sounds through

The Problem with Noise Controls

- Engineers will tell you that there's no way a non-engineer could possibly develop or implement an effective noise control
  - Solution: avoid engineers at all costs!
- Controls CAN be developed, but they do require effort and resources, and (sometimes) technical knowledge
- Noise control development support critical

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Questions

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Next Lesson

Occ. Health & Safety and Accidents

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