Understanding and Applying OSHA's Noise Control Policy

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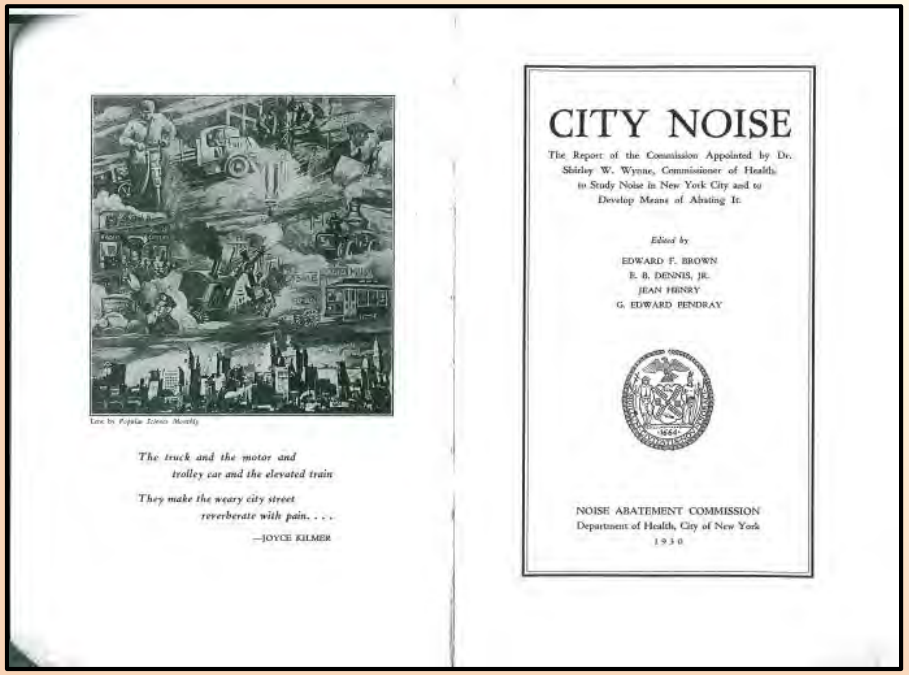
Relevant History

The **US Occupational Safety and Health Administration (OSHA)** Noise Exposure Regulation became effective in **1971**. Since 1983, OSHA's regulation has included an amendment to require specific components related to hearing protection, audiometric testing, and training.

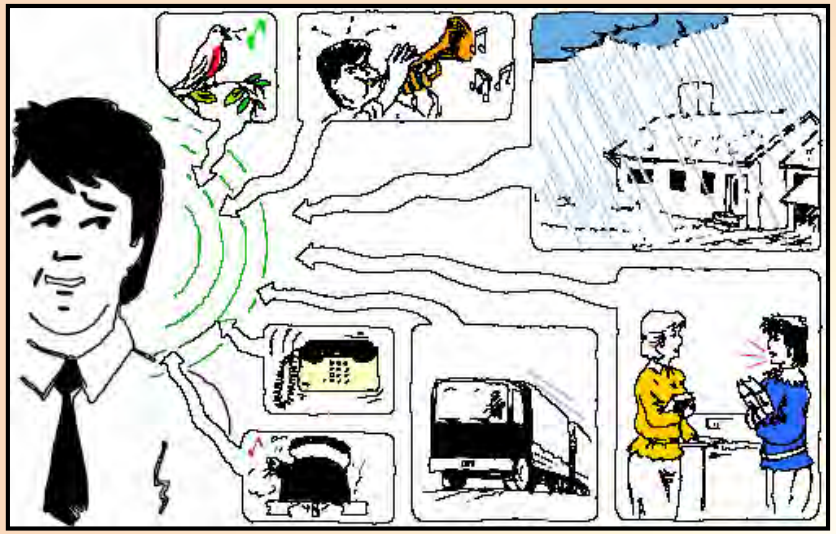


New York City Noise, 1930

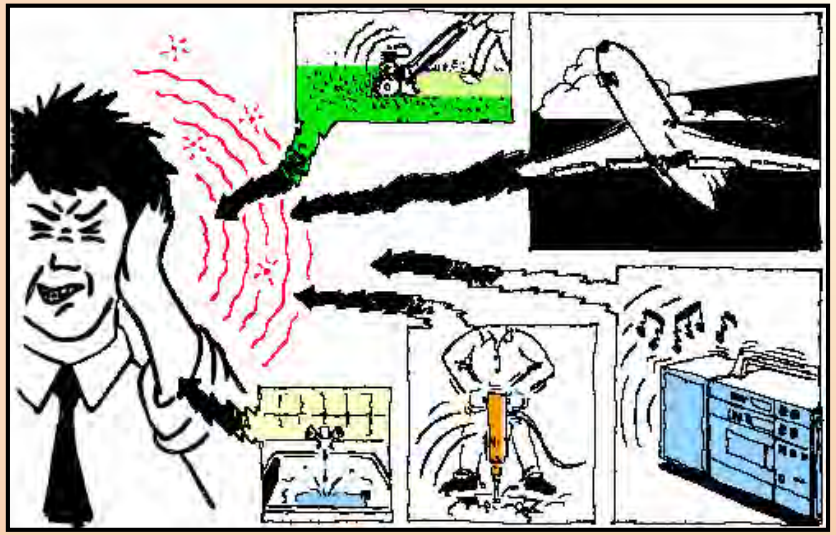
Dr. Maurice H. Miller

Dr. Alice H. Suter

Fundamentals of Sound



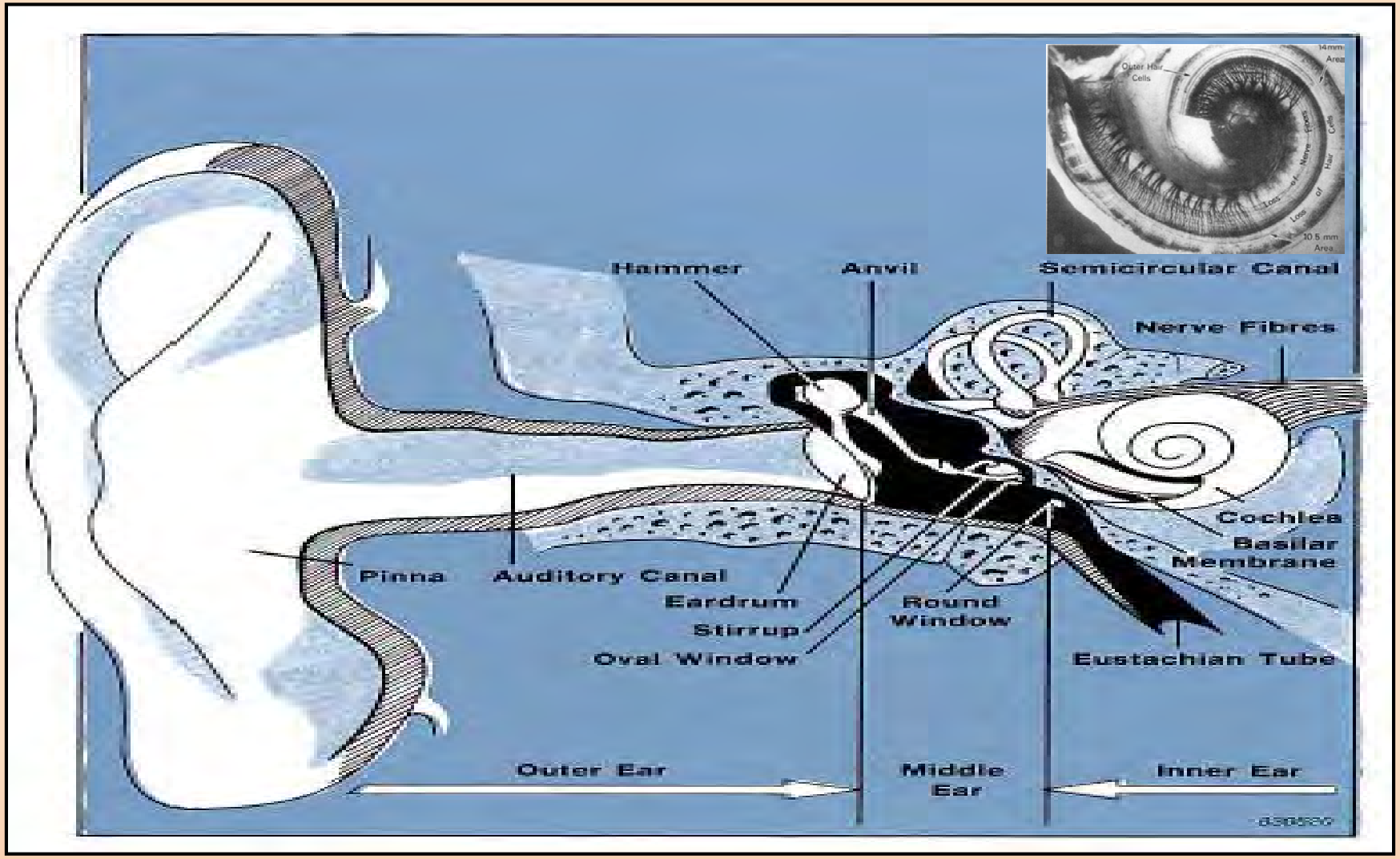
- Sound:
  - Pleasant, controllable, desirable, pleasing, understandable



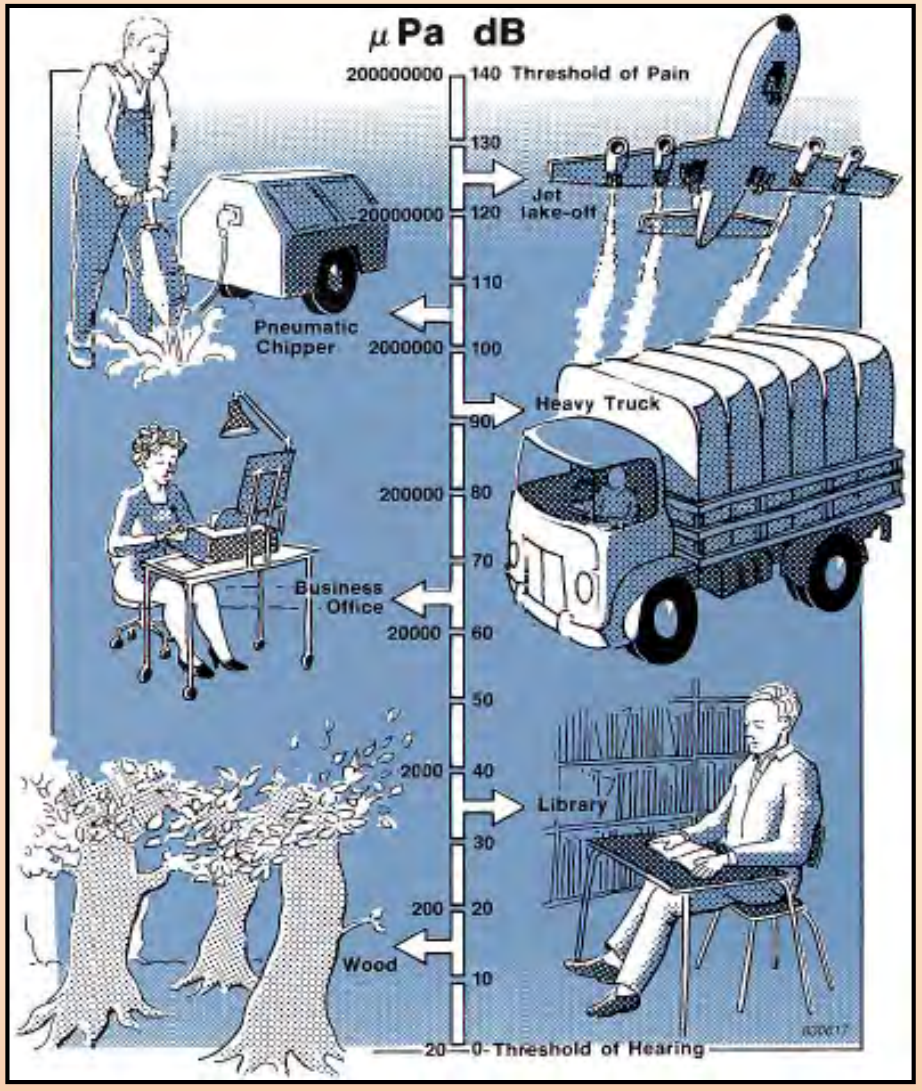
- Noise:
  - Too loud, annoying, uncontrollable, interfering, undesirable, dangerous

Noise is in the ear of the beholder.

Human Auditory System



1st Dimension: Loudness



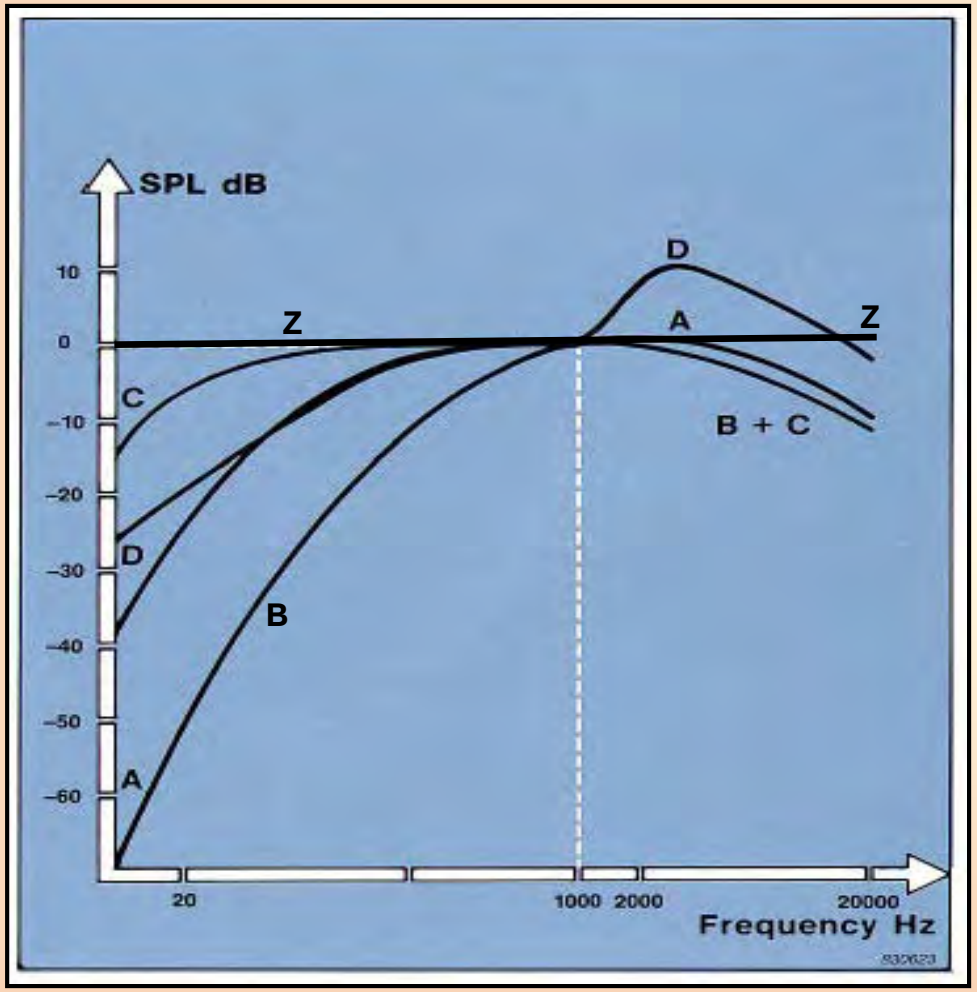
- Human ear can hear pressure range over seven orders of magnitude.
- More convenient scale needed: Decibels (dB)
  - Alexander Graham Bell
- $dB = 10 \text{ Log } (P/Po)^2$

  $= 20 \text{ Log } (P/Po)$

  Where $Po = 20\mu Pa$

Does 0 dB mean no sound?

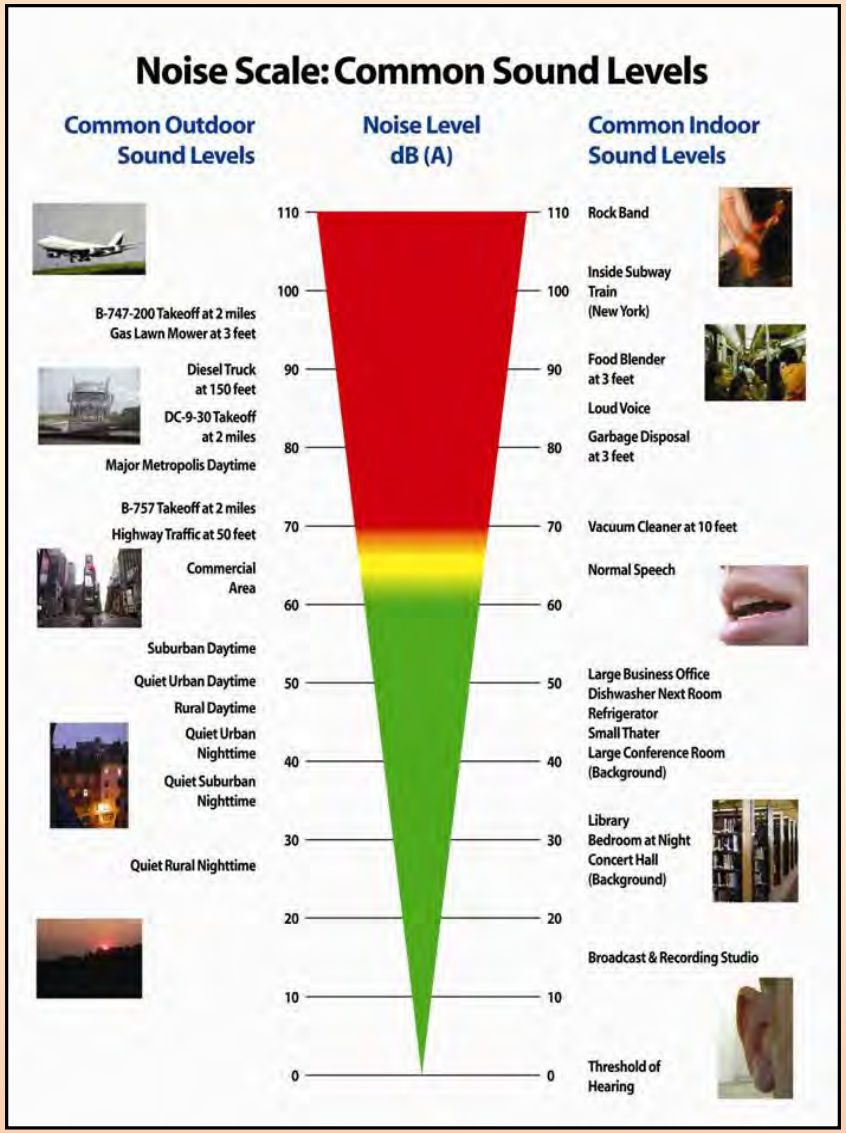
2nd Dimension: Frequency



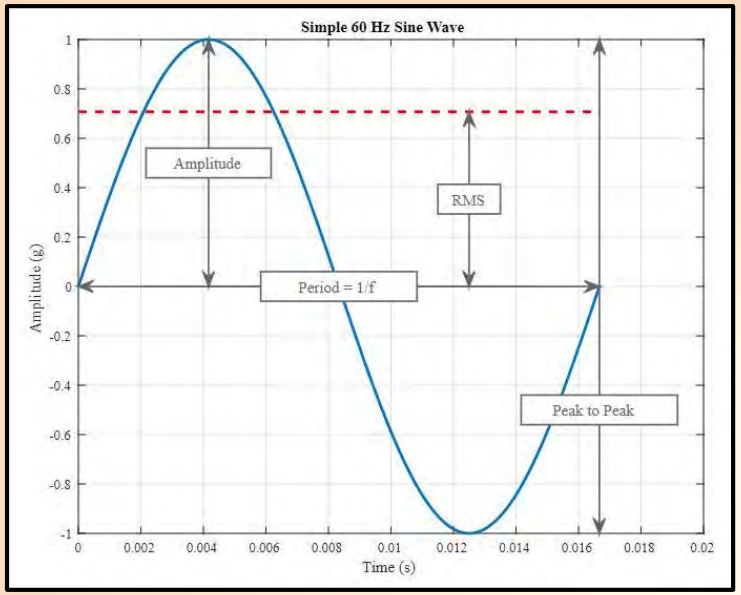
- Audible frequency range: 20Hz to 20kHz
- Hear most efficiently from 1kHz to 4kHz
- Less sensitivity at lower and higher frequencies
- A-weighted decibel dBA, dB-A, dB(A)

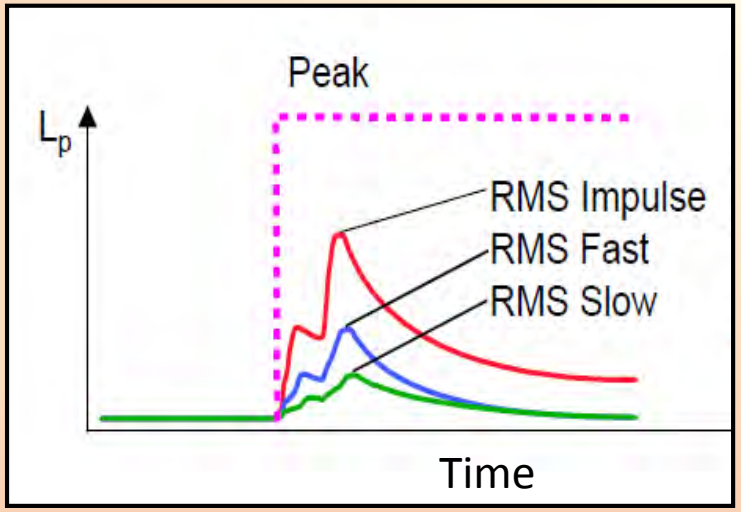
Example of natural evolution?

A-weighted Sound Levels



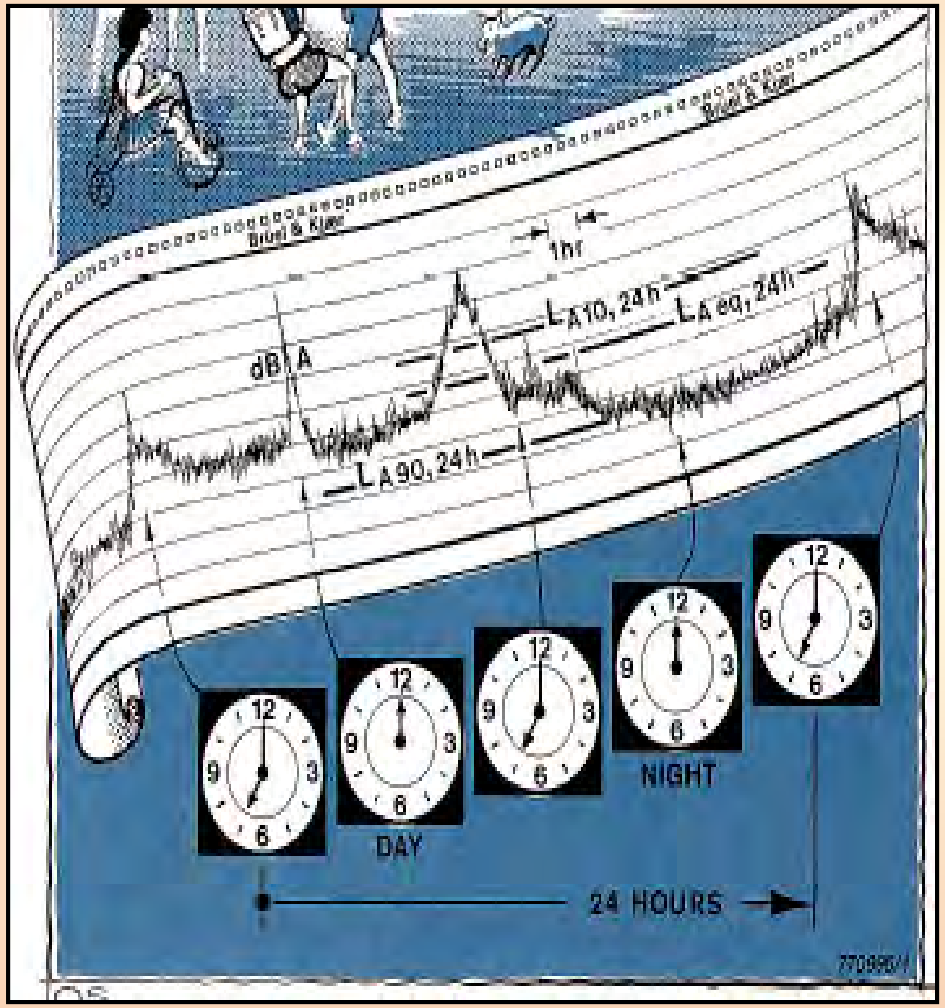
Peak vs. RMS





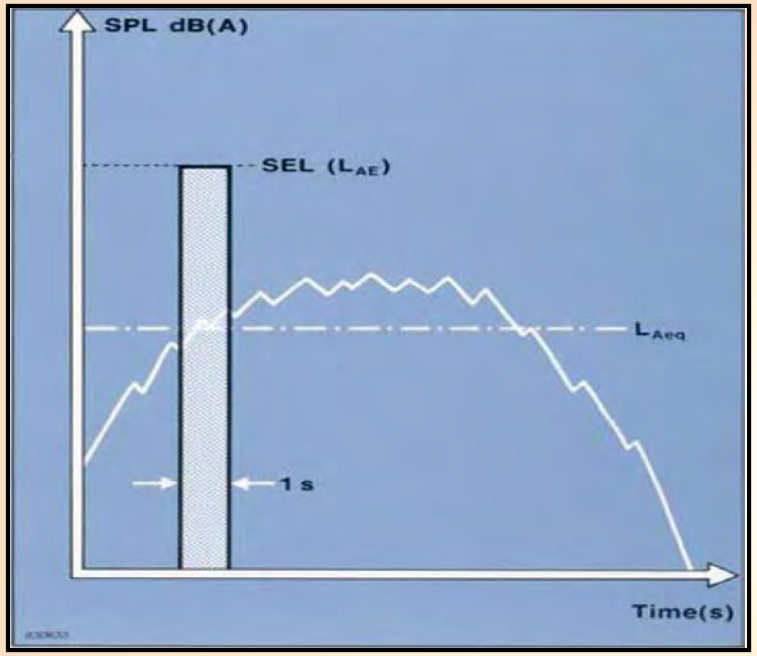
- Peak Level: Raw extreme highest instantaneous level (+ or -, not both)
- RMS Level: Root-mean-square is the energy-average level (can only be +)
- Crest Factor = Peak/RMS
  - Pure tone (sine) crest of 1.4 (3 dB)
- Peak, RMS Impulse, RMS Fast, RMS Slow
- OSHA uses Peak and RMS Slow

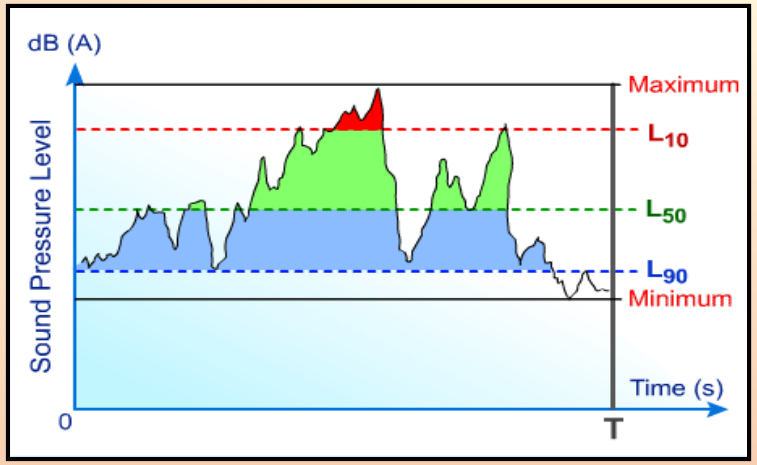
3rd Dimension: Temporal



- Exposed to fluctuating noise levels over time.
- Absolute (not relative) sound level a concern for hearing damage (i.e. air pressure).
- Dozens of noise metrics and descriptors.
- Lmax, Lmin
- Percentiles, L10, L50, L90
- Leq, TWA, Dose

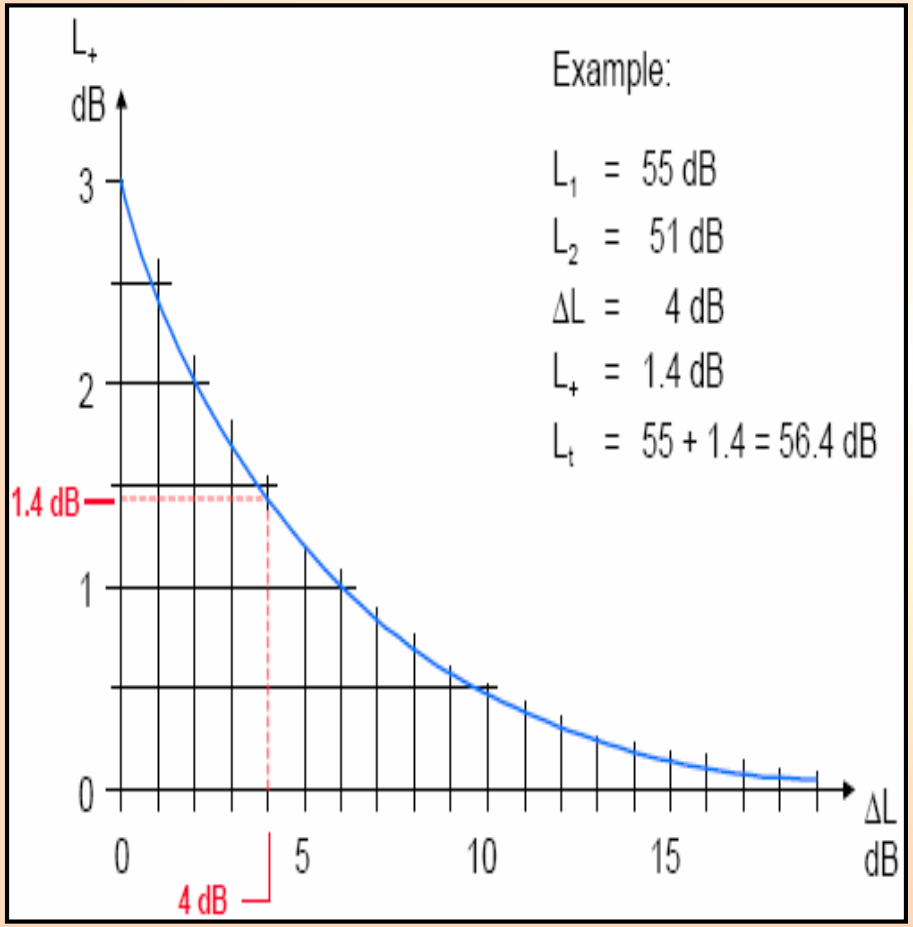
Key Noise Metrics





- Maximum (Lmax) and Minimum (Lmin) Levels
  - Instantaneous max. and min.
- Level Equivalent (Leq)
  - Energy-averaged level
- Percentile Levels (Ln)
  - Level exceeded n% of time
  - L50 = statistical median sound level
- Time Weighted Average (TWA)
  - OSHA's primary noise metric
  - Worker's daily exposure to noise normalized to an 8 hour day
  - Portion of time exposed to various sound levels – working, resting, etc.
  - TWA = $[SPL_1(T_1) + SPL_2(T_2)....SPL_N(T_N)] / T_{Total}$

Adding Decibels



- Logarithmic quantities
  - Total SPL = 10Log[10^(SPL1/10)+10^(SPL2/10)]
- Using curve
  - Find difference (dB2 – dB1)
  - Enter x axis, find y value
  - Add y value to louder source
- Rules of thumb
  - Two sources the same level, add 3 dB
  - Two sources differ by 10 dB, quieter source negligible

In this case, 1 + 1 ≠ 2

Or as Winston Smith learned, 2+2 = 5

OSHA Noise Regulation

29 CFR Parts 1910.95 & 1926.52

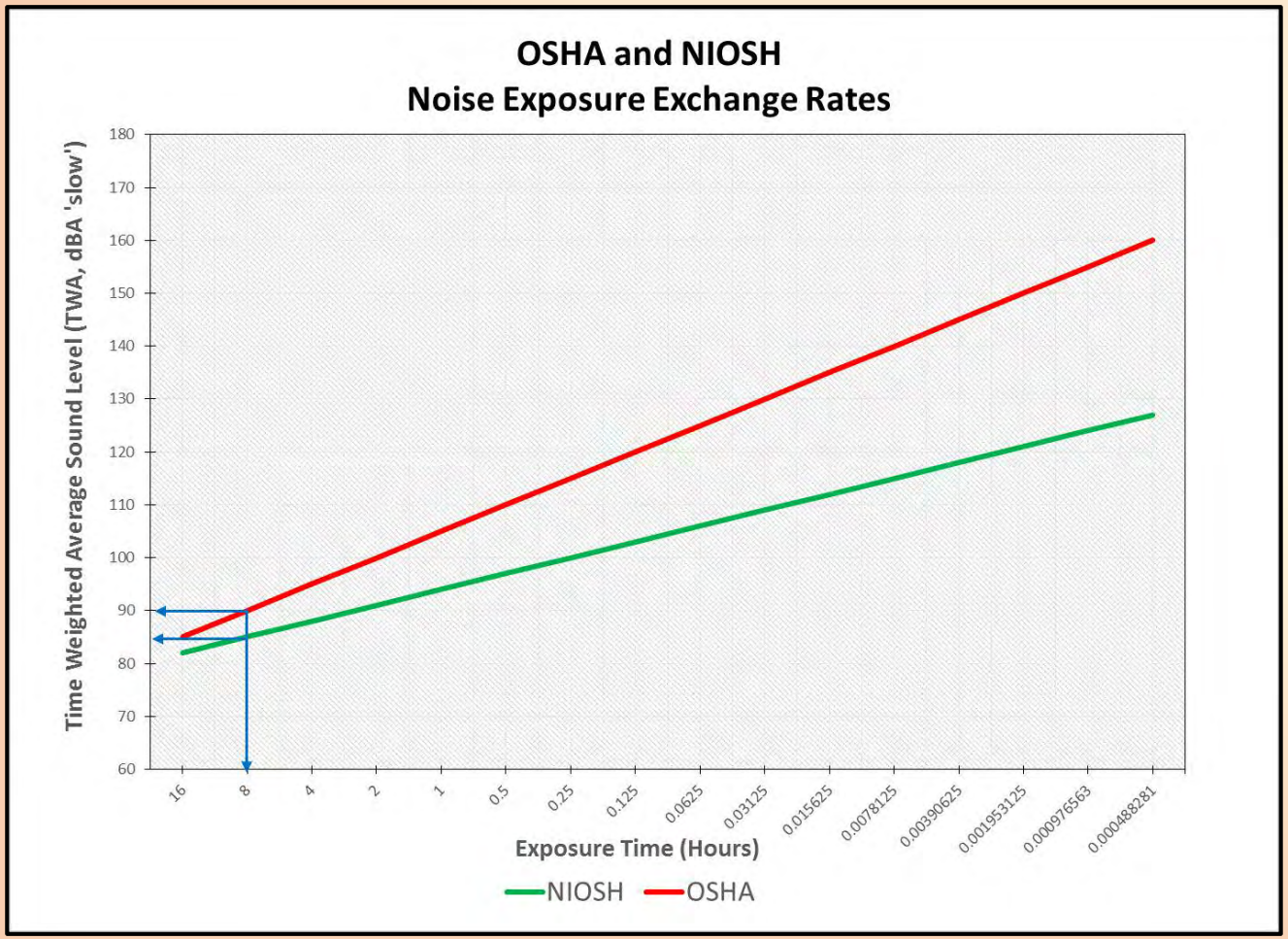
Time to reach 100% noise dose	Exposure level per NIOSH REL	Exposure level per OSHA PEL
8 hours	85 dBA	90 dBA
4 hours	88 dBA	95 dBA
2 hours	91 dBA	100 dBA
1 hour	94 dBA	105 dBA
30 minutes	97 dBA	110 dBA
15 minutes	100 dBA	115 dBA

Exposure to impulsive or impact noise should not exceed **140 dB Peak**.
Could cause instantaneous hearing damage.

- OSHA noise limits are <u>required</u>. NIOSH noise limits are only <u>recommended</u>.
- Noise exposure limits in **dBA 'slow'** over a unit of time.
- Thus, a noise DOSE (magnitude and time exposure).
- Note, hearing damage will not occur with brief exceedances. Hearing loss takes prolonged exposure. OSHA's PEL assume a <u>30 year</u> exposure duration.

OSHA Noise Regulation

29 CFR Parts 1910.95 & 1926.52



- Exchange Rates ?????
- OSHA uses 5 dBA/Half Time.
- NIOSH uses 3 dBA/Half Time.
- If you do the math, NIOSH is correct. So why does OSHA use 5 dBA/Half Time?
- Politics and money!
- The insurance companies influenced OSHA policy making back in the original 1970s version to avoid excessive compensation payouts.

OSHA Noise Regulation

29 CFR Parts 1910.95 & 1926.52

Noise Dose Should remain below 1.0. Often expressed as percentage (0% - 100%).

$$D = \sum_{i=1}^{n} \frac{C_i}{T_i}$$

where

D: Daily noise dose (allowable D is ≤1)
C_i: Actual duration of exposure for at a noise level i
n: Number of different noise levels measured
T_i: Permissible duration of exposure at a noise level i and estimated by

Permissible Exposure Duration at a given sound level (Hours).

$$T = \frac{8}{2^{(L-90)/5}}$$

where L is the measured sound level in units of dBA.

Time Weighted Average Sound Level TWA (dBA).

The 8-hour time-weighted average sound level (TWA), in decibels, may be computed from the dose by means of the following formula:

$$TWA = 16.61 * \log(D) + 90.$$

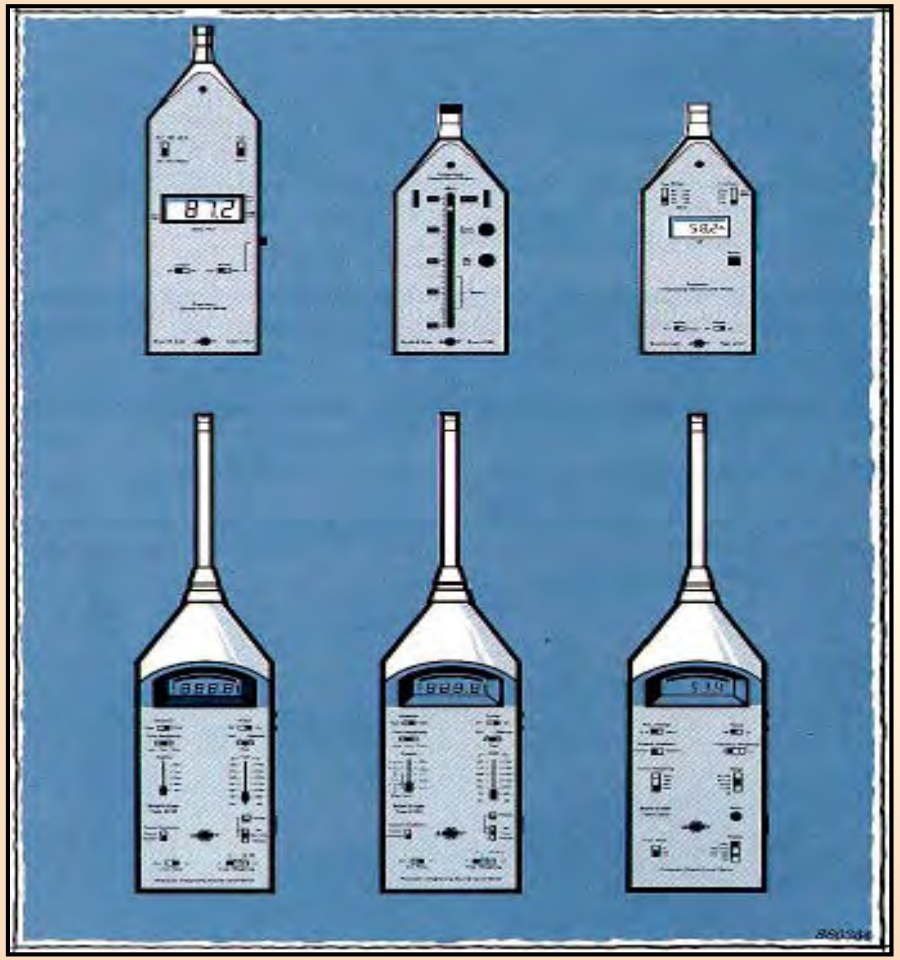
OSHA Noise Regulation

29 CFR Parts 1910.95 & 1926.52

- If TWA >= 85 dBA (Action Level)
  - Must implement an employee hearing conservation program
  - Education of the dangers
  - Annual audiograms
- If TWA >= 90 dBA (Exposure Limit)
  - Must implement noise control measures
  - Administrative controls – time shifting
  - Engineering controls – noise control

Occupational Noise Measurements

Instrumentation



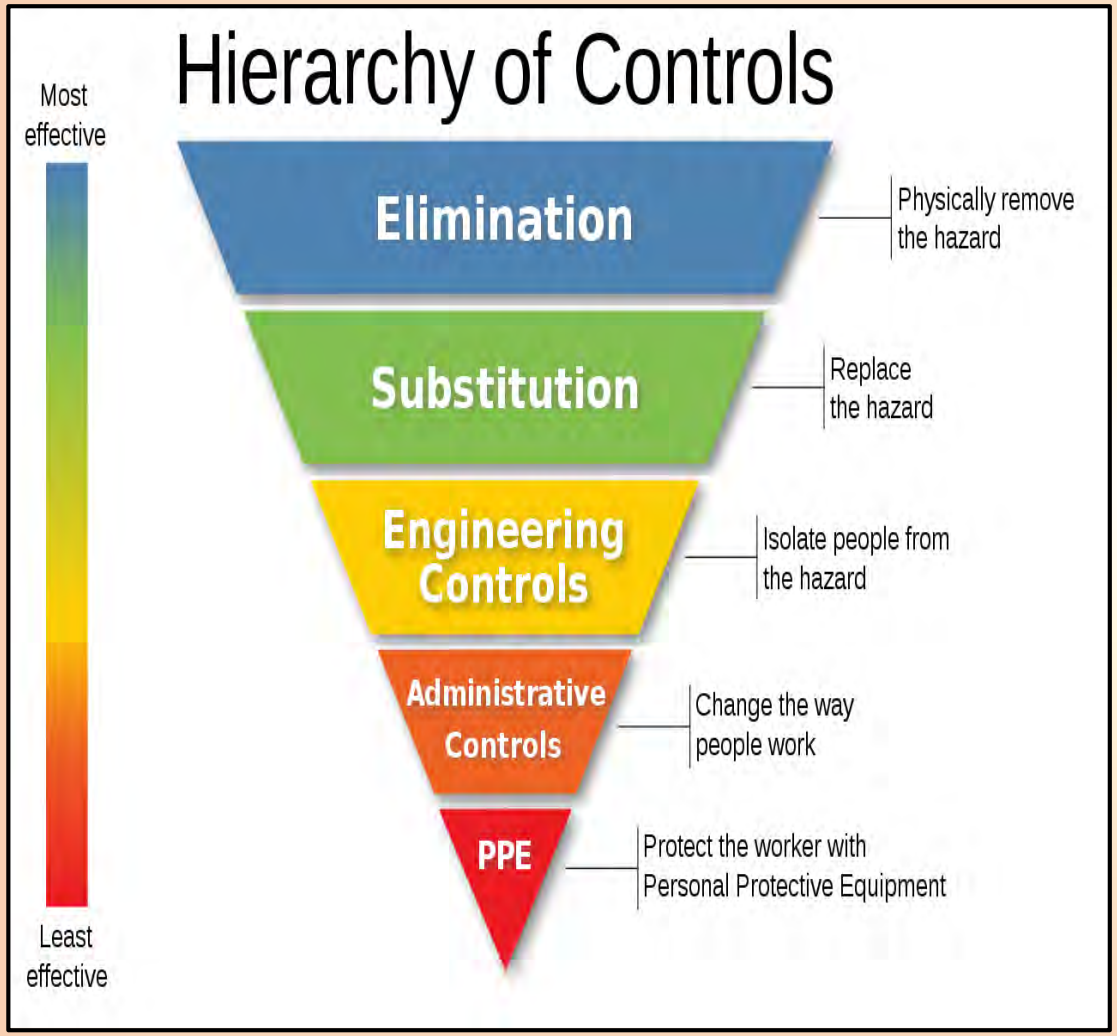
- Wide variety of noise instrumentation and manufacturers.
- Simple dosimeters to spectrum analyzers.
  - $1,000 to $25,000
- ANSI Standard S1.4.
  - Type 0 Laboratory
  - Type 1 Precision
  - Type 2 General Purpose
    (OSHA allows for Type 2)

Smartphone Apps? – No, Negative, Nope, Non, Nein, Niet, Na, Ne, Nej, Nee, Nie, Neyn!

Dosimeters Basics

- Called a “Personal” dosimeters for a reason.
- Worn on the worker for full shift.
- Measures his/her individual noise exposure.
- Rugged condenser microphone worn near ear position (beware wires).
- ANSI S1.4 Type 2 accuracy.
- Measures Dose (%) and TWA (dBA).
- Based on OSHA exchange rate of 5 dBA/Half Time.
- Download data for records keeping.

Noise Control Options



- TWA is a Dose, so you could mitigate worker exposure time and/or level.
- Example Noise Control Methods
  - Proper equipment maintenance!
  - Work shift rotation (administrative).
  - Quieter equipment and processes.
  - Noise enclosures, noise curtains, pipe/duct lagging, vibration isolators.
  - Remote controls.
  - Hearing protection (plugs and muffs).
  - But let's talk a little about hearing protection…..

Hearing Protection

- **Ear Plugs** – foam, easy to insert, comfortable, inexpensive, adequate for high frequency only.
- **Ear Molds** – rubber, form-fitted to individual's inner ear, not bad for lower frequencies, awkward to insert.
- **Ear Muffs** – plastic, over the ear, more noise reduction to lower frequencies, beware leaks around eyeglasses.
- **Noise Reduction Rating (NRR)** – in decibels per ANSI S3.19-1974, not good for electronic ear muffs, better standard needed, measured in-situ is best, NRR is NOT true noise reduction!
- dBNR = ((NRR – 7)/2). NRR of 30 = 12 dBNR.

Questions?