



# Lecture 5

## NOISE AND VIBRATION

by  
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# NOISE

- ❑ Occupational noise exposure is the noise and sound that is present in industry and in the work place environment.
- ❑ Over exposure to noise can be hazardous to a workers wellbeing and health in industry as well as civilians in the surrounding community.
- ❑ Occupational noise can lead to permanent hearing loss known as Noise Induced Hearing Loss (NIHL)

# Noise Induced Hearing Loss (NIHL)

- Noise induced hearing loss is the impairment resulting from exposure to high decibels sound leading to the wear and degradation of a persons ability to hear.
- Noise induced hearing loss is permanent and can have the potential to effect a persons physical, mental, psychological wellbeing.

# OSHA Noise Guidelines (PEL)

- 29 CFR 1910.95 – Occupational Health and Environment
- 1926.101 – Hearing Protection ( Ear Protection)
- PEL = 90 dBA for an 8-hr workday
- 5 dBA exchange rate, up to 15 minutes
- No noise exposure for 140 dBA
- Action Levels are 85 dB (or 50% Dose) and 90 dB (or 100% Dose).

# Permissible Noise Exposure (PEL)

## Duration Per Day, (Hr)

- 16
- 8
- 6
- 4
- 3
- 2
- 1
- 1/2
- 1/4 or less

## Permissible Exposure “Slow” Response, (dBA)

- 87
- 90
- 92
- 95
- 97
- 100
- 105
- 110
- 115

# ACGIH Noise Guidelines (TLV)

- Hearing loss average of 2 dB at 500, 1000, 2000, and 3000 Hz
- 85 dBA for an 8-hr workday
- 3 dBA exchange rate

# Permissible Noise Exposure (TLV)

## Duration Per Day, Hr

- 16
- 8
- 6
- 4
- 3
- 2
- 1
- 1/2
- 1/4 or less

## Permissible Exposure “Slow” Response, dBA

- 82
- 85
- 88
- 91
- 94
- 97
- 100
- 103
- 106

# Dose

- $\text{Dose} = C_1/T_1 + C_2/T_2 + \dots + C_n/T_n$
- $\text{Dose \%} = (C_1/T_1 + C_2/T_2 + \dots + C_n/T_n) + 100\%$
- $C$  = Time of exposure at a specific noise level
- $T$  = Duration of exposure allowed at the noise level



# Time Weighted Average (TWA)

- Time – Weighted Average (TWA): Average exposure for an individual over a given working period, as determined by sampling at given times during the period. TWA for an 8-hr work shift is:
- OSHA: 90 dBA using a 5-decibel (dB) exchange rate
- ACGIH: 85 dBA using a 3-decibel (dB) exchange rate
- OSHA:  $L_{eq} = 16.61 \log_{10} (D/100) + 90$
- NIOSH:  $L_{eq} = 10.0 \log_{10} (D/100) + 90$

# Finding Average Noise Levels

- Average Noise Levels: similar to TWA except  $t \neq 8$  hours
- OSHA:  $L_a = 90 + 16.61 \log (D\%/12.5t)$
- NIOSH:  $L_a = 90 + 10 \log (D\%/12.5t)$

# How to Evaluate Noise Exposure

1. Verify if you have a problem
2. Survey the areas
3. Perform work shift sampling
4. Use instrumentation

# 1. Verify if you have a problem

- There are various factors that may indicate noise is a problem in the work place.
- Noisy conditions can make conversations difficult.
- High noise levels can cause adverse reactions or behavior.
- High noise levels can lead to NIHL (Noise Induced Hearing Loss) or other negative health effects.

## 2. Surveys

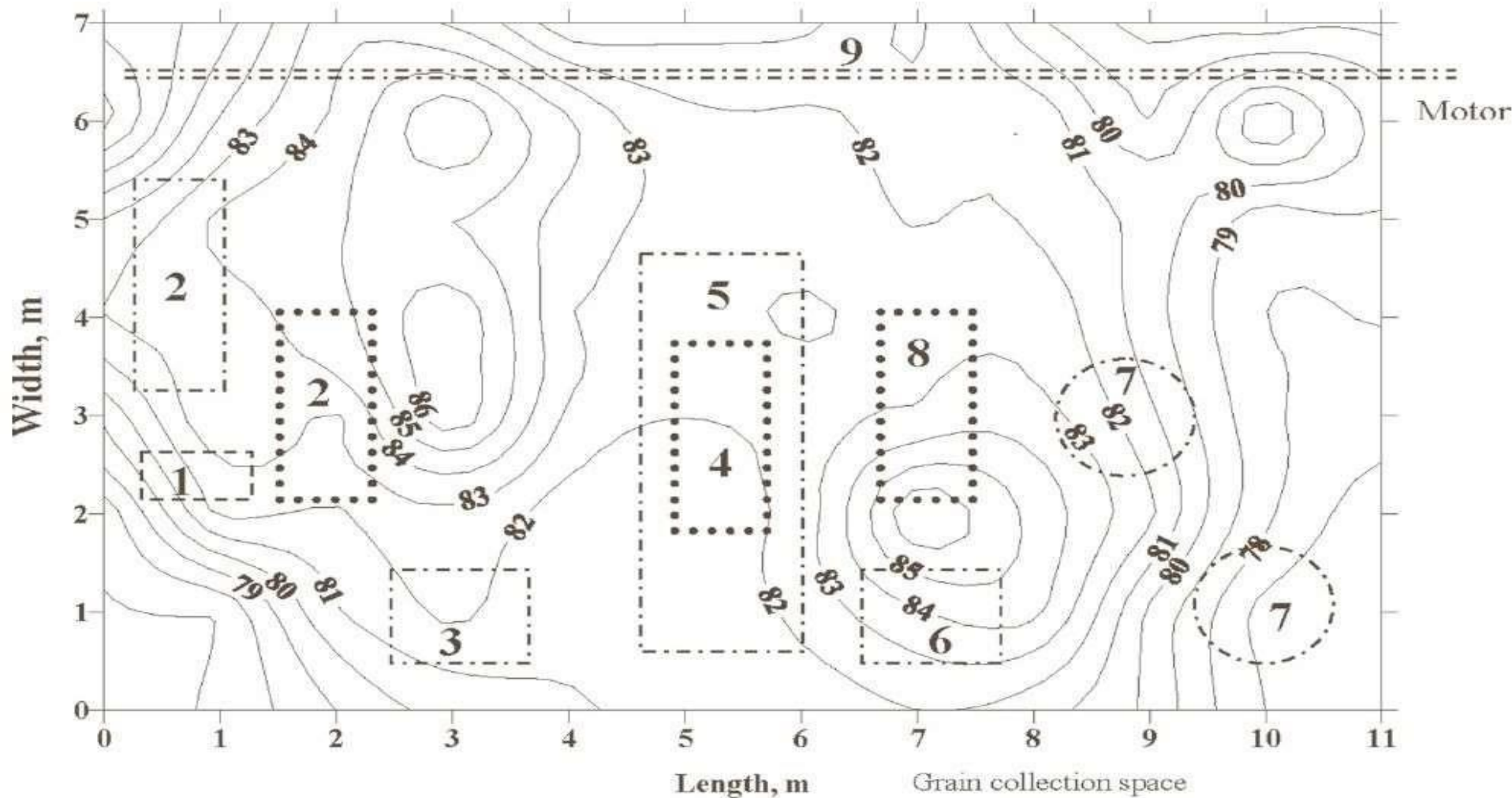


- Surveys should be performed to screen for noise exposure and to determine if additional monitoring is necessary.
- When screening for noise exposures, sound level meter measurements and estimates of the duration of exposure are necessary.

## 2. Surveys

- 1. Tour the facility and develop a detailed understanding of facility operations and potential noise sources.
- 2. Use a sound level meter to take spot readings of operations that are in question.
- 3. Estimate exposures by identifying workers and their locations and estimate the length of time they spend in different areas or how long they operate particular equipment or tools.

# Noise Survey Map



- |                          |                  |                        |                   |    |
|--------------------------|------------------|------------------------|-------------------|----|
| 1. Paddy feeding pit     | 2. Paddy cleaner | 3. Rubber roll sheller | 4. Husk separator |    |
| 5. Compartment separator | 6. Rice huller   | 7. Rice polisher       | 8. Rice cleaner   | 9. |
| Long shaft               |                  |                        |                   |    |

# 3. Work Shift Sampling

- When the results of the surveys indicate that noise levels may exceed those outlined in OSHA's noise standard 29 CFR 191095, additional monitoring is necessary.
- Sample of the noise exposures of representative employees from each job classification that may be potential over exposed.



# 4. Instrumentation

- Sound Level Meter
- Dosimeter
- Octave – Band Analyzer



# 4. Instrumentation



- Each noise instruments and devices must be properly adjusted and calibrated.
- Employers are required to train employees on how to properly use the instruments and devices.
- Data and statistics from instruments and devices must be properly stored and accessible.

# Hearing Conservation Program

- OSHA and NIOSH recommend that HCPs be implemented for all workers whose unprotected 8-hr TWA exposures equal or exceed 85 dBA:
- ❖ Initial and annual program audits of procedures
- ❖ Assessment of noise exposures
- ❖ Audiometric evaluation and monitoring
- ❖ Education and motivation of workers
- ❖ Recordkeeping

# Initial and Annual Program Audits

- An Initial audit should be conducted before and HCP is implemented or any changes are made to an existing program.
- This audit will serve as a basis for assessing the effectiveness of an improved program.

# Exposure Assessment



- Monitoring procedures should be specifically defined to ensure consistency.
- Instrumentation, calibration, measurement parameters, and methods for linking results to worker records should be clearly delineated.
- Exposure assessment should be done during typical work shift.

# Exposure Assessment

- ❖ Intensity of the noise
- ❖ Potential changes in exposure due to changes in equipment or production
- ❖ Rate of significant threshold shift noted among workers
- ❖ Requirements of various governmental regulations
- ❖ Workers' compensation requirements of individual states
- ❖ Union contract stipulations
- ❖ Specific company policies

# Workers Rights

- Workers shall be notified of the noise exposure level determined for their particular job classifications and the relative risk that such an exposure poses to their hearing.
- This information should also be cross-referenced to individual worker records.
- Notification should include a description of the specific hazardous noise sources in the workers' area, the purpose and proper use of any noise control devices, and equipments of hearing protectors, if appropriate.

# Hierarchy of Controls

Most  
effective

**Elimination**

Physically remove  
the hazard

**Substitution**

Replace  
the hazard

**Engineering  
Controls**

Isolate people  
from the hazard

**Administrative  
Controls**

Change the way  
people work

**PPE**

Protect the worker with  
Personal Protective Equipment

Least  
effective



# Engineering Controls

- “Any modification or replacement of equipment, or related physical change at the noise source or along the transmission path (with the exception of hearing protectors) that reduces the noise level at the employee’s ear”.
- The most effective way to prevent Noise Induced Hearing Loss (NIHL) is to remove the hazardous noise from the work place or to remove the worker from the hazardous noise.

# Engineering Controls



- ❖ Reducing noise at the source
- ❖ Altering the noise path
- ❖ Reducing reverberation
- ❖ Reducing equipment vibration

# Engineering Controls

- Any reduction in noise serves to make the noise hazard more manageable, reduces the risk of hearing loss, improves communication, and lowers annoyance and related extra-auditory problems associated with high noise levels.
- When the noise can be reduced to acceptable levels through engineering controls, employers may forego some of the additional difficulties and expenses related to provide hearing protectors, education and motivation program and program evolutions.

# “Buy Quiet”

- “Buy Quiet” is the initiative to purchase the quietest noise emitting equipment, tools, and machinery in order to reduce occupational noise and sound exposures.
- Create a “Buy Quiet” agenda and program.
- “Buy Quiet” may initially cost more in the beginning but will ultimately save costs for the future.

# Administrative Controls

- Creating policies, procedures, rules, regulations, to minimize noise and sound intensity or duration of exposure.
- Posting hazards signs and warnings in effected areas.
- Worker and associates training to understand noise hazards and how to use proper PPE.
- Routinely changing worker schedule.

# Audiometric Evaluation

- Because occupational hearing loss occurs gradually, affected employees often notice no change in hearing ability until a relatively large change in their hearing sensitivity has occurred.
- The annual comparison of audiometric tests can trigger prompt hearing loss program interventions, initiating protective measures and motivating employees to prevent further hearing loss.

# Audiometric Evaluation

- Audiometry shall, at a minimum, consist of pure-tone air conduction threshold of each ear at 500, 1000, 2000, 3000, 4000, and 6000 Hz.
- Although this entire frequency range is not used in the assessment of OSHA's standard threshold shift (STS), all of these frequencies are important in deciding the probable etiology of a hearing loss.
- To enhance the decision about probable etiology, testing at 8000 Hz should also be considered.
- Sufficient time should be taken to conduct the test accurately.
- Testing too quickly sacrifices accuracy and gives the worker the impression that audiometry.

# Education and Motivation

- 29 CFR 1910.1200
- Under the standard, employers in the manufacturing sector must establish in comprehensive hazard communication program.
- The hazard communication program is to be written and made available to workers and their designated representatives.



# Employee Training

- Annual training shall be provided to employees exposed to noise levels at or above 85 dBA as an 8-hr TWA.
- Workers must be informed of the possible consequences of noise exposure and of the various control methods available to protect their hearing. When an HCP is implemented, workers should be informed of the provisions of the program and the benefits of their full participation and cooperation in the program.

# Employee Training

- ❖ The employer **must institute a training program** for all the employees with noise exposures at or above the action level and ensure employee participation.
- ❖ Training must be **repeated annually** for each employee in the hearing conservation program.
- ❖ Information must be **updated** to be consistent **with any changes** in protective equipment and work processes.

# Employee Training

- ❖ Requirements of and rationale for the occupational noise standard
- ❖ Effects of noise on hearing
- ❖ Company policy for the elimination of noise as a hazard
- ❖ Hazardous noise sources at the work site
- ❖ Training in the use of hearing protectors
- ❖ Audiometry
- ❖ Individual responsibilities for preventing hearing loss

# Audiogram

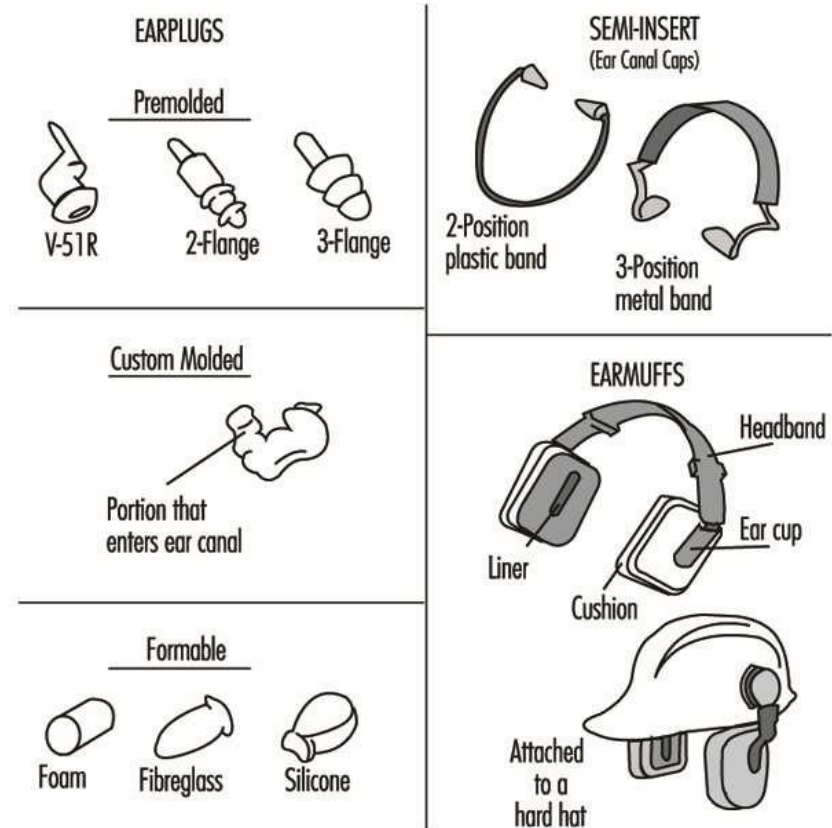
- 1. Pre-employment (Baseline Audiogram)
- 2. Prior to initial assignment in a hearing hazardous work area (Baseline Audiogram)
- 3. Annually as long as the employee is assigned to a noisy job ( a time-weighted average exposure level equal to or greater than 85 dBA) (Monitoring Audiogram)
- 4. At the time of reassignment out of a hearing hazardous job (Exit Audiogram)
- 5. At the termination of employment (Exit Audiogram)

# Hearing Protection Devices

- A hearing protection device is any device designed to reduce the level of sound reaching the eardrum.
- Hearing protectors should be used when engineering and administrative controls are not feasible for reducing noise exposures to safe levels.
- Earmuffs, earplugs, ear canal caps, helmets, etc;

# Hearing Protection (PPE)

- PPE is considered the last resort in controlling hazardous because it puts the responsibility on the worker.
- Ear protection provides protection and defense from noise and sound hazards.
- Ear protection provides protection against occupational noise exposures and NIHL (noise induced hearing loss).



Adapted with permission from Nixon and Berger 1991.

# Recordkeeping

- The purpose of OSHA recordkeeping regulations is to assist employers in recognizing and correcting workplace hazards by tracking work-related injuries/illnesses and their causes.
- The most important features of good records should be accuracy, thoroughness, organization and legibility.
- Records should be consistent with the company's policies.

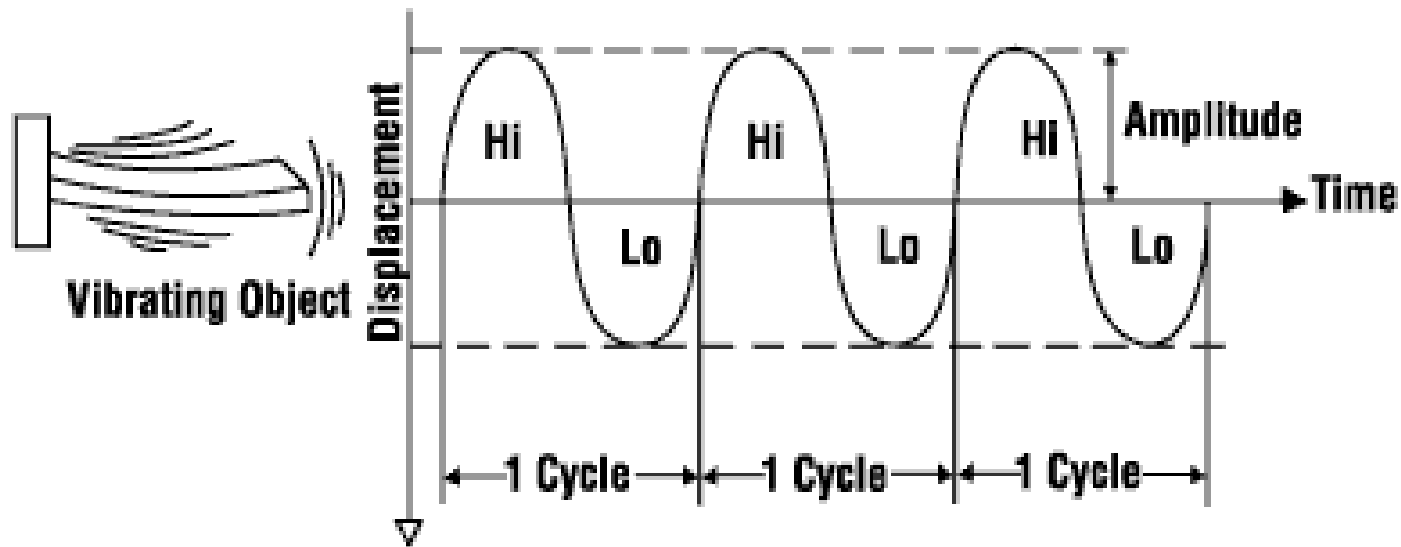


# VIBRATION



# Introduction

- ❑ Vibration is a physical factor which acts on human body by transmission of mechanical energy from sources of oscillation.
- ❑ Vibration is mechanical oscillation about a reference position.
- ❑ It can be defined as oscillatory motion of solid bodies and can be visually linked to waves .



# Characteristics of wave

❑ Period : It is the time required to complete one pressure cycle and is reciprocal of frequency. It is measured in seconds (T).

❑ Frequency : It is the number of cycles completed in unit second. Its unit is cycles/sec or Hertz (Hz).

$$f = 1 / T$$

❑ Resonance : Every object tends to vibrate at one particular frequency that depends on the composition of the object , its size , structure, weight and shape. This frequency is called the resonant frequency.

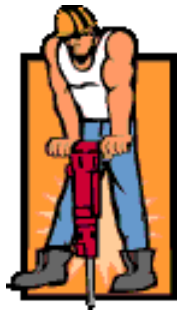
❑ Amplitude : Amplitude is the acceleration given by meters per second( $m/s^2$ ) and denotes how far the surface moves each time when it vibrates

# How does the vibration exposure Occur ?

- ☐ Contact with a vibrating machine transfer vibrating energy to a person's body.
- ☐ Depending upon the exposure, it affect a major part of the workers body or particular organ.
- ☐ Each organ of the body has its own resonant frequency. If exposure occur at or near to these resonant frequencies, the resulting effect is greatly increased.
- ☐ For occupational health the exposures to hand-arm vibrations and whole-body vibrations are concerns.



# Segmental Vibration Exposure



❑ 'Segment of body' such as hand-transmitted vibration (known as hand-arm vibration or HAV) .

Example : chipping tools, jackhammers, grinders who use hand vibrating tools.







# Whole Body Vibration Exposure



☐ Vibration transmitted through the seat or feet (known as whole-body vibration or WBV).

☐ Energy enters the body through a seat or floor which effects the entire body or a number of organs

Example : operators of bus, trucks, tractors etc



# Source of Vibration Exposure

Industry	Type of Vibration	Common Source of Vibration
Agriculture	Whole body	Tractors
Construction	Whole body Hand-arm	Heavy equipment vehicles Pneumatic tools, Jackhammers
Forestry	Whole body Hand-arm	Tractors Chain saws
Furniture manufacture	Hand-arm	Pneumatic chisels
Machine tools	Hand-arm	Vibrating hand tools
Textile	Hand-arm	Sewing machines, Looms
Transportation	Whole body	Vehicles
Mining	Whole body Hand-arm	Vehicle operation Rock drills

# Measurement of Vibration Exposure

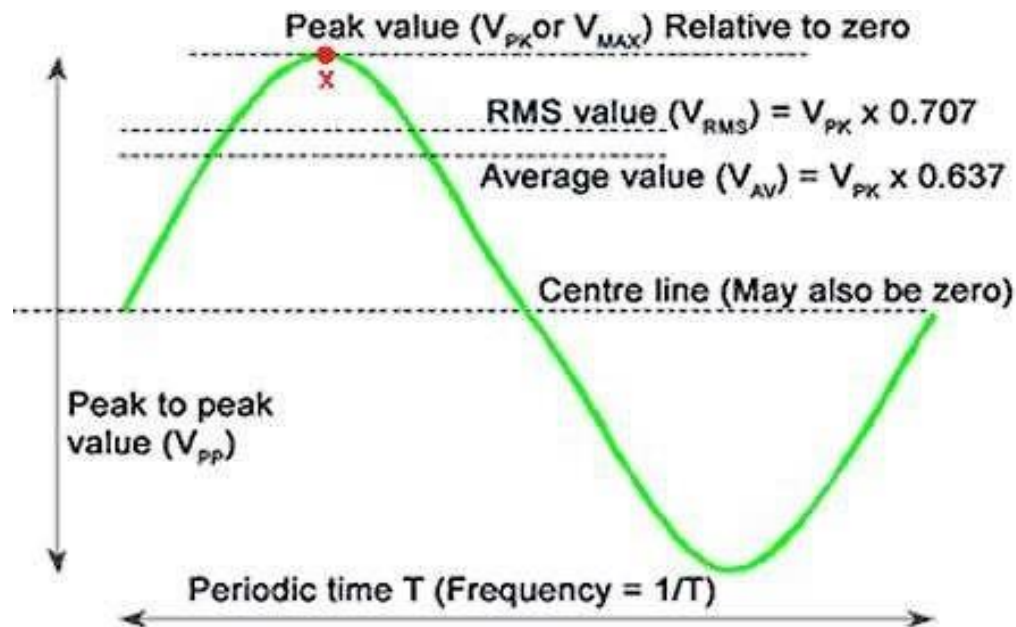


- ❑ Measurement of vibration includes three parameters :
  1. The vibration amplitude (Acceleration), which is the characteristic to describe the severity of the vibration.
  2. Frequency spectrum
  3. Duration of Exposure



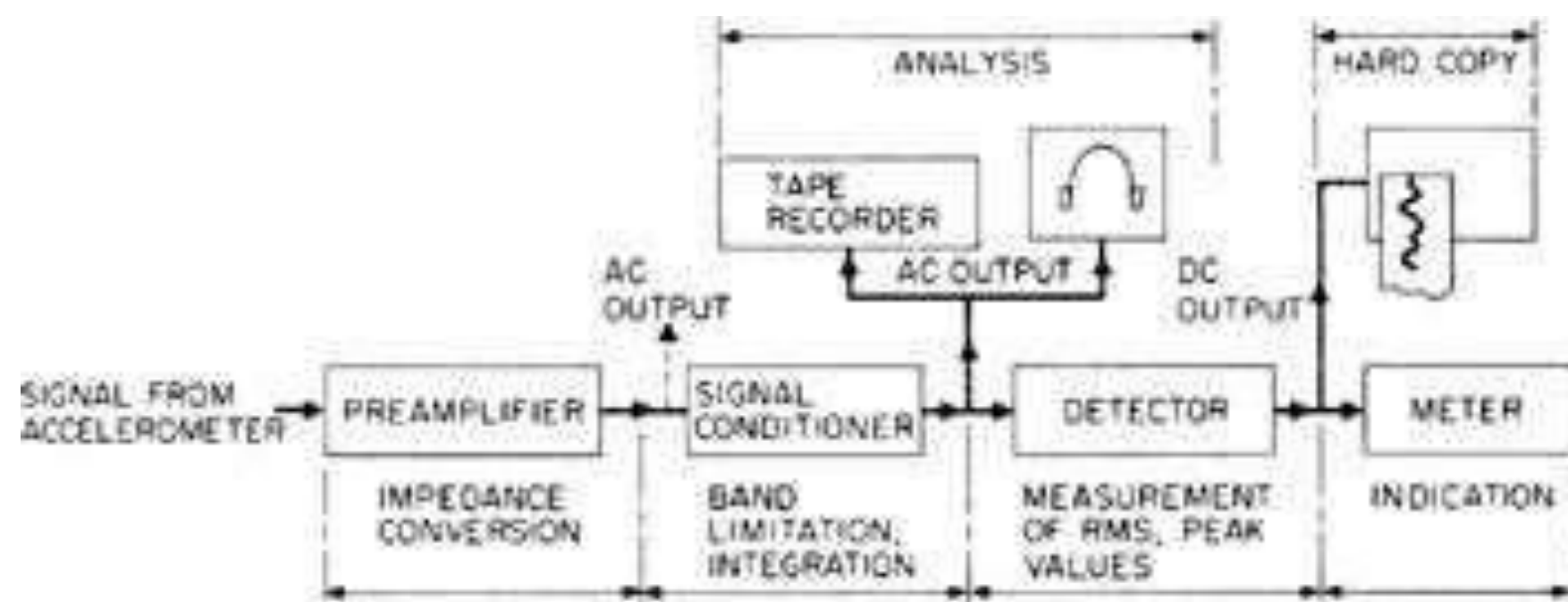
❑ Vibration amplitude/ Acceleration / Vibration level consists 4 type of values :

1. The peak-to-peak value is valuable in that it indicates the maximum excursion of the wave,
2. The peak value is particularly valuable for indicating the level of short duration shocks etc.
3. The rectified average value.
4. The RMS(Root Mean Square) value.



# Vibration Measurement System

- ❑ A Typical Vibration System consist of :
  1. A transducer( convert mechanical to electrical energy) to sense the vibration .( Suitable transducers for human vibration measurement is the Accelerometer)
  2. A pre-amplifying device
  3. Frequency weighing filter( to allow for the variation of human response to vibration of different frequencies & compared the measured vibration with standards)
  4. Tape recorder to collect information for further analysis
  5. Signal analyzer to obtain relevant parameters like acceleration and peak values

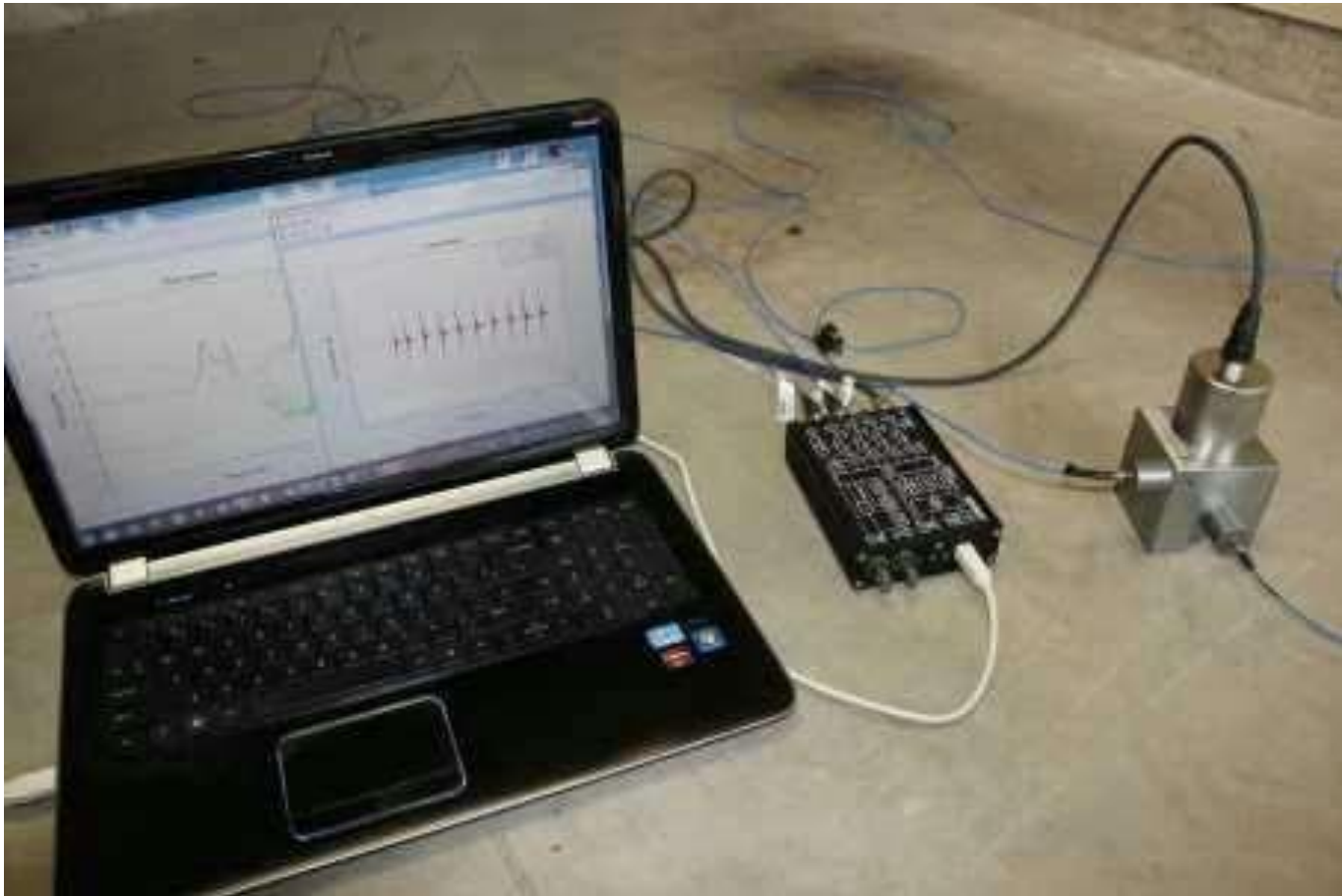


# Transducers

❑ Vibration is usually measured using accelerometers housed in mounts so they do not compress the seat or distort the posture too much. A "seat transducer", comprising a deformable pad that follows the seat contour and containing a tri-axial accelerometer for simultaneous measurements in three axes of vibration, is commonly used these days.

❑ This seat transducer is placed on a seat with a driver sitting on it or is strapped either to the driver's back or the seat back-rest.





❑ To measure whole-body vibration transmitted through the floor, the seat transducer is placed on the floor with a small weight on top to ensure a good contact between the floor and the transducer.

# Vibration Meter

❑ It measures magnitude of vibration as accelerations at different frequencies and directions using a transducer, amplifier and recorder.

❑ The acceleration is measured using a transducer located at the source of vibration or area through which the vibration is transmitted.



# Standards for Vibration Exposure

❑ TLV of vibration (HAV or WBV), as given by ACGIH Booklet (2007) is as under -

Total daily exposure time to vibration	Component acceleration which should not be exceeded $\text{m/s}^2$
4 to less than 8 hrs	4
2 to less than 4 hrs	6
1 to less than 2 hrs	8
Less than 1 hr	12

- ❑ Exposure limits are given as frequency-weighted acceleration that represents a single number measure of the vibration exposure level.
- ❑ Table gives acceleration levels and exposure duration to which ACGIH has determined most workers exposed repeatedly without severe damage to fingers.
- ❑ Hand-arm vibration syndrome (HAVS) cannot be controlled by working within TLV only. It advises that these guidelines be applied in conjunction with other protective measures including vibration control such as ,
  - anti vibration tools and gloves,
  - proper work practices and
  - medical surveillance program are also necessary.



# Effects of Vibration Exposure

- ❑ Vibration can cause annoyance and noise to human body and physical damage to machines and structures. Vibration can harm only if some part of the body is in direct contact with a vibrating surface such as seat of a vehicle or the handle of a power tool.
- ❑ Effects of vibration are feeling of disoriented or displacement, giddiness, sickness, vibration disease and sometimes fatal.
- ❑ Whole body vibration can cause permanent damage to body or abdominal, spinal and bone damage.

❑ At low frequencies( up to 10Hz) the vibrations propagate through the entire body regardless of the location of input. In case of high frequency vibration, the zone of propagation is limited by the area of contact causing vascular disorder in that part

❑ Low frequency vibration(3-6 Hz)=effects the chest region and create the feelings of Nausea

❑ 20-30 Hz frequency region resonance effect on head, neck and shoulders

❑ 60-90 Hz frequency effect the eye ball

❑ 100-200 Hz frequency effect on lower jaw and skull system

❑ Between 3-400 Hz frequency will have normal ill effects

# Effects on Human body

Whole body vibration may cause

1. Increase in oxygen consumption.
2. Increase in pulmonary ventilation and cardiac output. Affects CNS, damages internal organs.
3. Difficulty in maintaining steady posture.
4. Effects on visual acuity and narrows the field of vision.
5. Marked changes in bone structure –
  - Spondylities.
  - Deformations.
  - Intervertebral Osteochondrosis.
  - Calcification of the intervertebral disc.

6. Blood changes -

- hypoglycaemia.
- hypocholesteremia.
- low ascorbic acid levels.

7. Alternations in the electrical activity of the brain.

8. Effects on endocrine, biochemical and histopathologic systems of the body.

☐ It causes numbness and blanking of the fingers with probable loss of muscular control and reduction of sensitivity to heat, cold or pain. It causes paleness of the skin due to oxygen deficiency. All vibration make us tired or irritable.

# White finger or Dead Finger

❑ Vibration-induced White Finger (VWF) known as dead hand or Raynaud's Phenomena is a damage to the blood vessels and nerves in fingers due to a long use of vibrating power tools such as chipping hammers, chisels and drills.





Hands of vibrating pneumatic hand-tool operator in later stages of irreversible Hand Arm Vibration Syndrome1

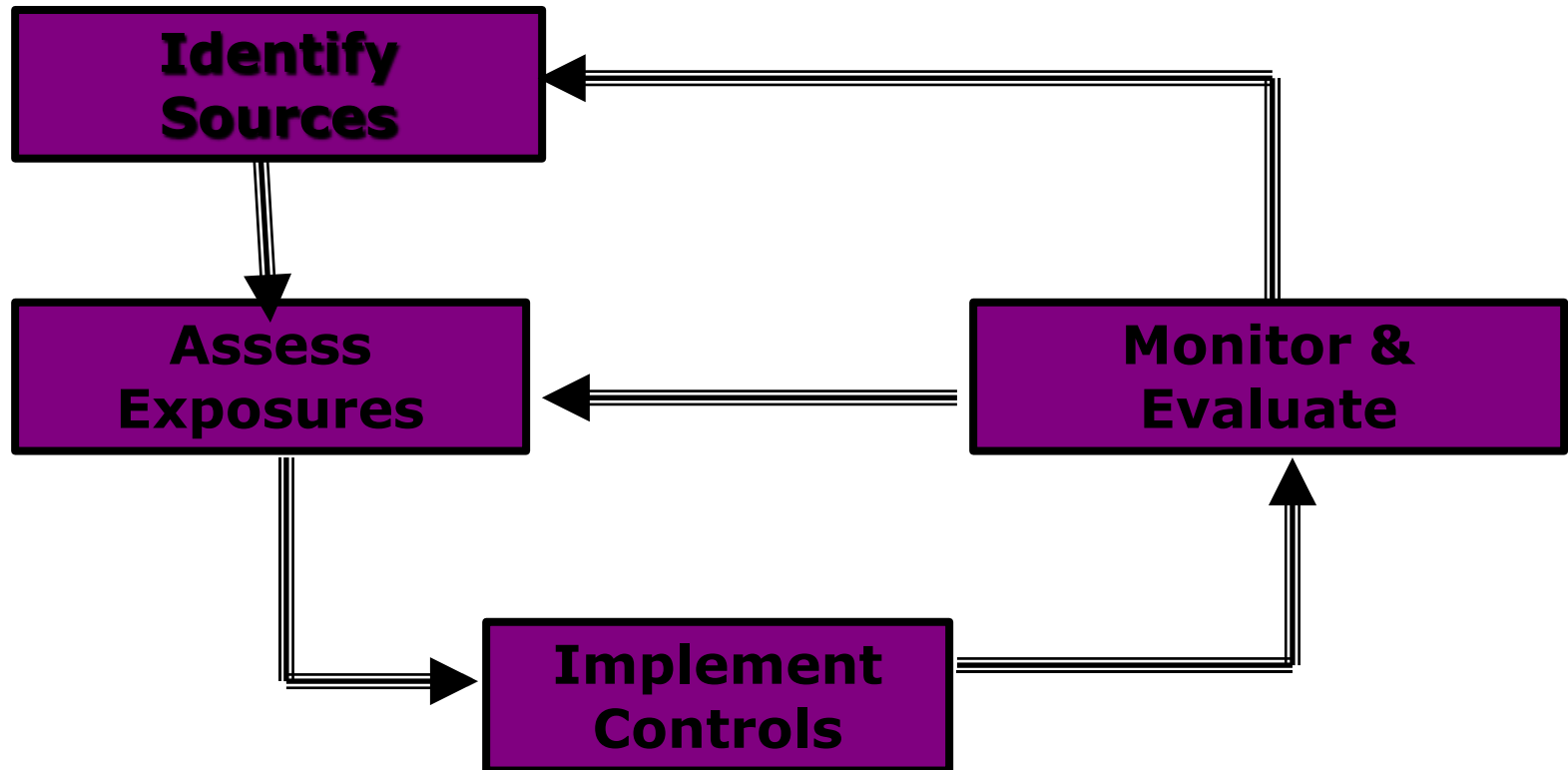


Rare case of gangrene in hands of vibrating pneumatic hand-tool operator at terminal stage of irreversible Hand Arm Vibration Syndrome2

# Effects on Machine and Structures

- ❑ Badly vibrating machines not only consume more power but also damage to the machine and its supporting structure.
- ❑ The vibrations also travel through the structure of the building and be radiated as noise at distant points. This is structure - borne noise.
- ❑ Vibration causes metal fatigue which results in failures of rotating parts and other stressed mechanical equipment.
- ❑ It can cause rupture in a pressurised equipment, the higher the pressure, more chances a rupture.

# Vibration Hazard Management & Control





❑ Vibration control measures include technical, organisational, hygienic, prophylactic and therapeutic measures.

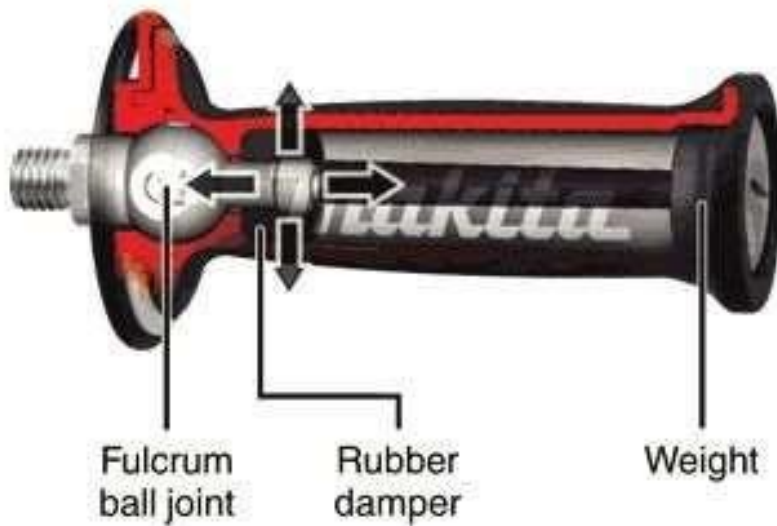
1. Technical or engineering measures include automation, remote control and eliminating or reducing vibration from the design stage or at source , use of vibration dampers, device for prevention, suppression, damping and insulation of harmful vibrations, use of automatic devices to avoid contact with the vibrating body, changes in the design parameters of machines, equipment and mechanised tools

2. Organisation measures include good preventive and corrective maintenance and arrangement of work schedules in such a way to decrease time of exposure.
3. Prophylactic and therapeutic measures – pre-employment and periodical medical examinations play an important role. Special gymnastics, hydrotherapeutic procedures, massage and UV radiation can prevent further development of vibration disease and preserve working capacity.
3. Special vibration absorbing handles fitted to hand tools, springs, suspension seats and shock absorbers are useful.

5. Reduction in exposure time. Rotate vibrative job and introduce rest schedules so that individual exposure is shortened.
6. Personal precautions include watching for symptoms, to apply loose grip, to wear gloves and footwear with shock-absorbing soles to damp vibration to use PPE and to get medical attention.
7. Automation and remote control system.

# Anti Vibration Tools

❑ Certain manufacturing Company produce anti vibration tools such as anti vibration pneumatic chipping hammers, pavement breakers, and vibration damped pneumatic riveting guns.



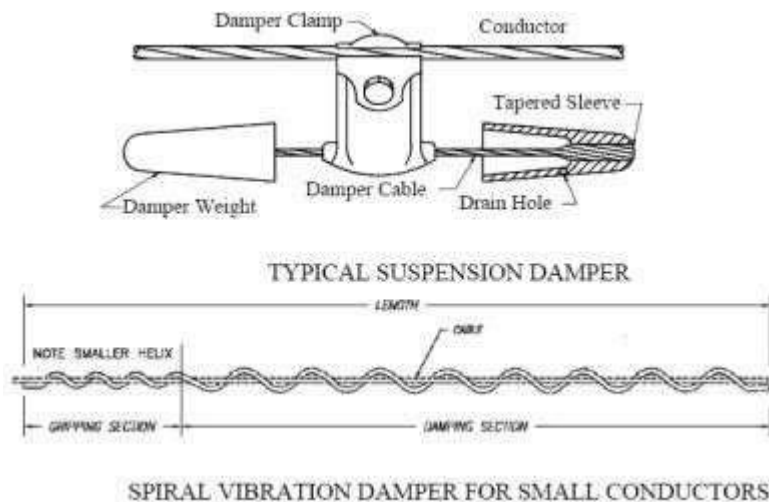
# Anti Vibration Gloves

- ❑ Anti vibration Gloves are made using a layer of viscoelastic material. Measurement have shown that such gloves have limited effectiveness in absorbing low frequency vibration, the major contributor to vibration related disorders , hence they have little effect on vibration induced finger syndrome, however gloves helps from cuts and abrasions and cold temperatures.



# Vibration Damping

❑ Vibration dampers (absorption) are used under machine foundation & machine should be installed in such a way that dampers come in contact between the building foundation & machine.



# Remote control vibratory plate

## Operator

vibration exposure - Zero





# **Mechanization removes the risk**

## **Machine-mounted pick replaces hand-operated breakers**





# Demolition without vibration

Use hydraulic crushers instead of demolition hammers



Thank you...