



PROTECTING WORKERS AGAINST EXPOSURE TO OCCUPATIONAL NOISE AND VIBRATION

DUANE BESTER

REGISTERED OCCUPATIONAL HYGIENIST (SAIOH)



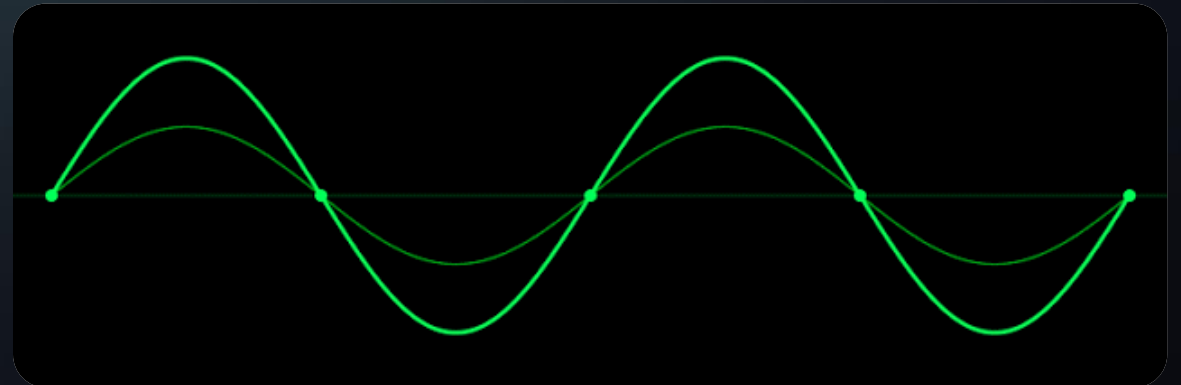
OUTCOMES

- The Physics of Noise & Vibration
- Wellness conservation related to noise and vibration exposure
- Engineering Control Solutions
- Administrative Control
- PPE! Or is it PPE?

VIBRATION PHYSICS



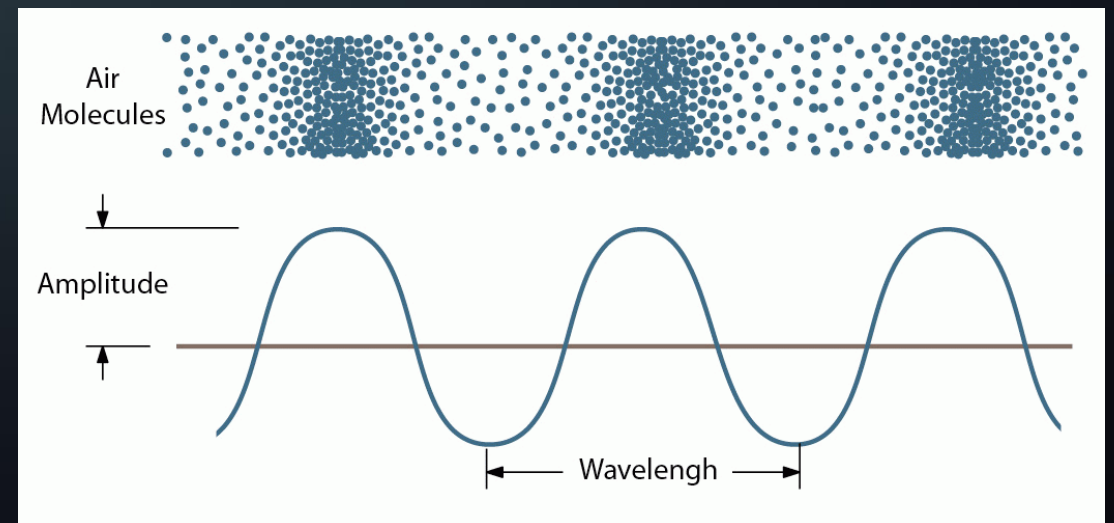
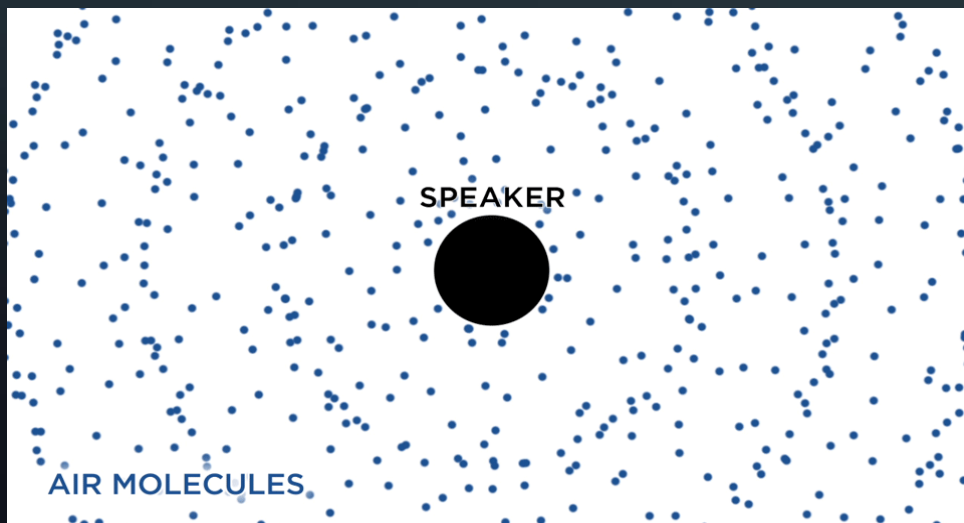
- A mechanical phenomenon where a system oscillates around a fixed resting point.
- Mechanical energy that is generated as a result of
 - Physical displacement in the molecular mesh of structures coupled to a driving force
 - Air/fluid turbulence and vortices generated by rotating objects, pressure discharges or obstacles in high speed fluid flows
- When a mechanical system vibrates, the energy generated travels through one of two routes
 - Through solid surfaces in contact with the
 - Through air – resulting in auditory noise



VIBRATION PHYSICS



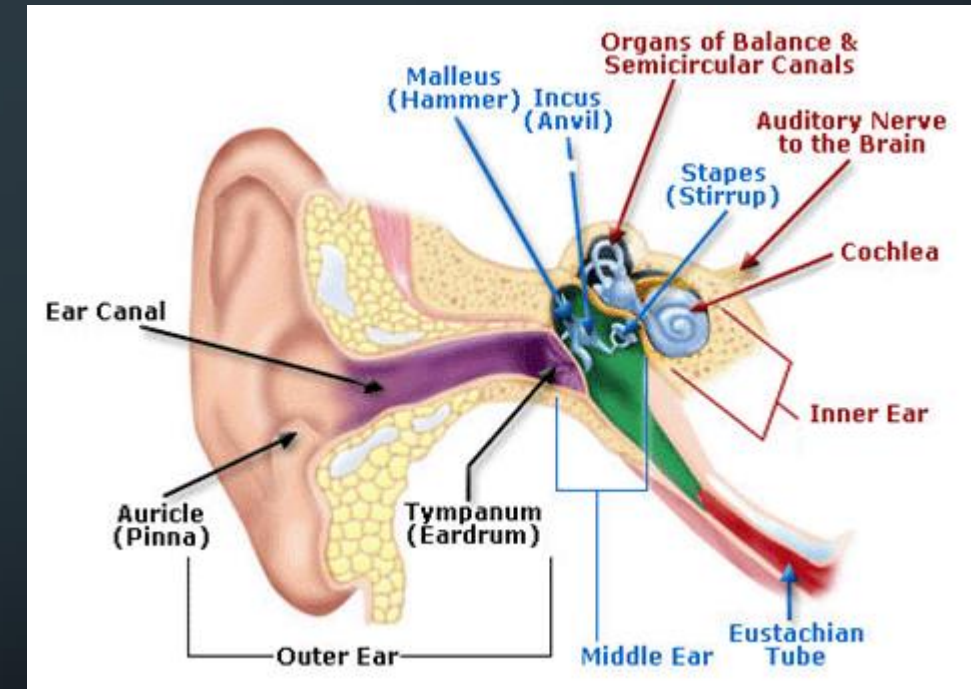
- Auditory Noise:
 - Oscillation of air molecules adjacent to a vibrating source
 - As the wave oscillates adjacent air molecules, these collide with molecules adjacent to it, resulting in a chain reaction.
 - The point at which the greatest concentration of air molecules are compressed in the wave is known as the wave amplitude.
 - This is followed by negative pressure disturbances resulting in rarefaction



VIBRATION PHYSICS



- Noise Exposure:
 - Noise is measured in units of sound pressure in Decibels (specifically dBA) and weighted to provide a rating of industrial noise that indicates the injurious effects noise has on hearing.
 - As the human ear is exposed to noise the variations in sound pressure reaching the eardrum causes it to vibrate.
 - These vibrations are amplified by the ossicles and transmitted as wave energy through the liquid of the cochlea.
 - The embedded hair cells of the cochlea bend and stimulate the auditory nerve to transmit information to the brain regarding the pitch and loudness observed.
 - Noise-induced hearing loss occurs as a result of

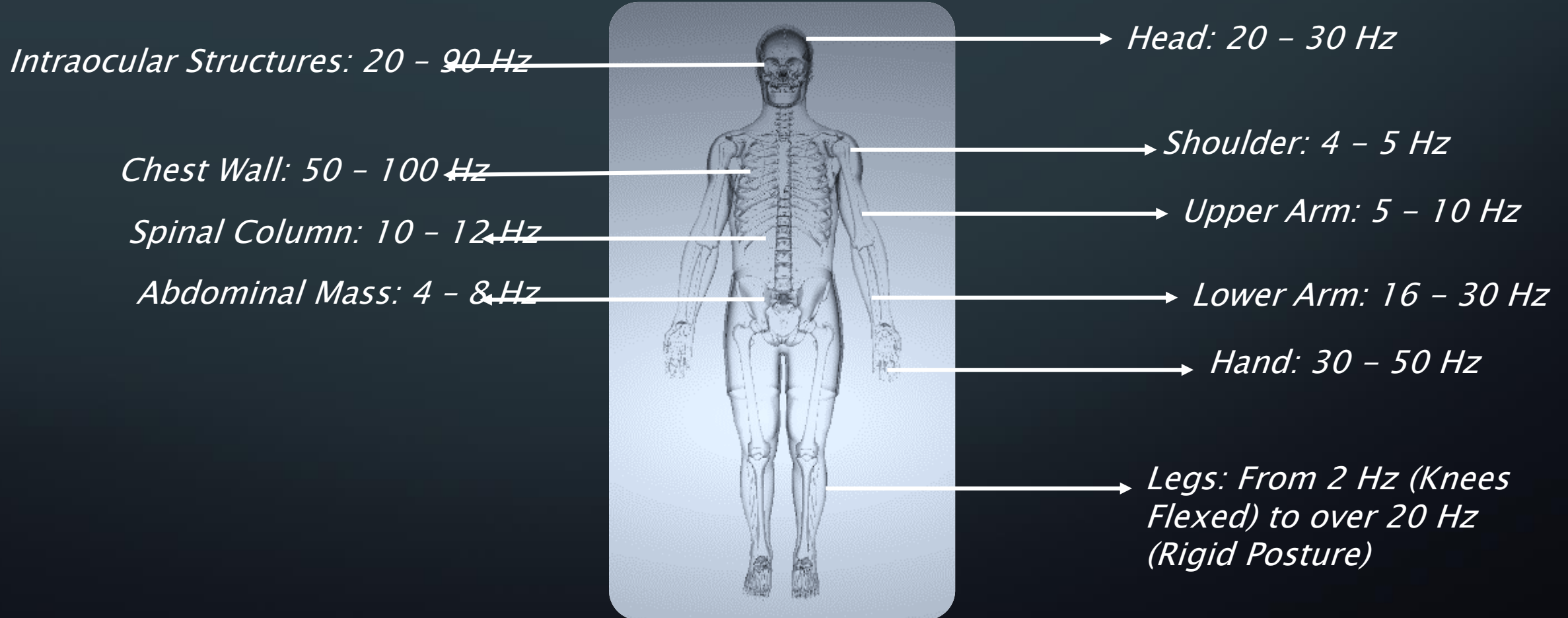


VIBRATION PHYSICS

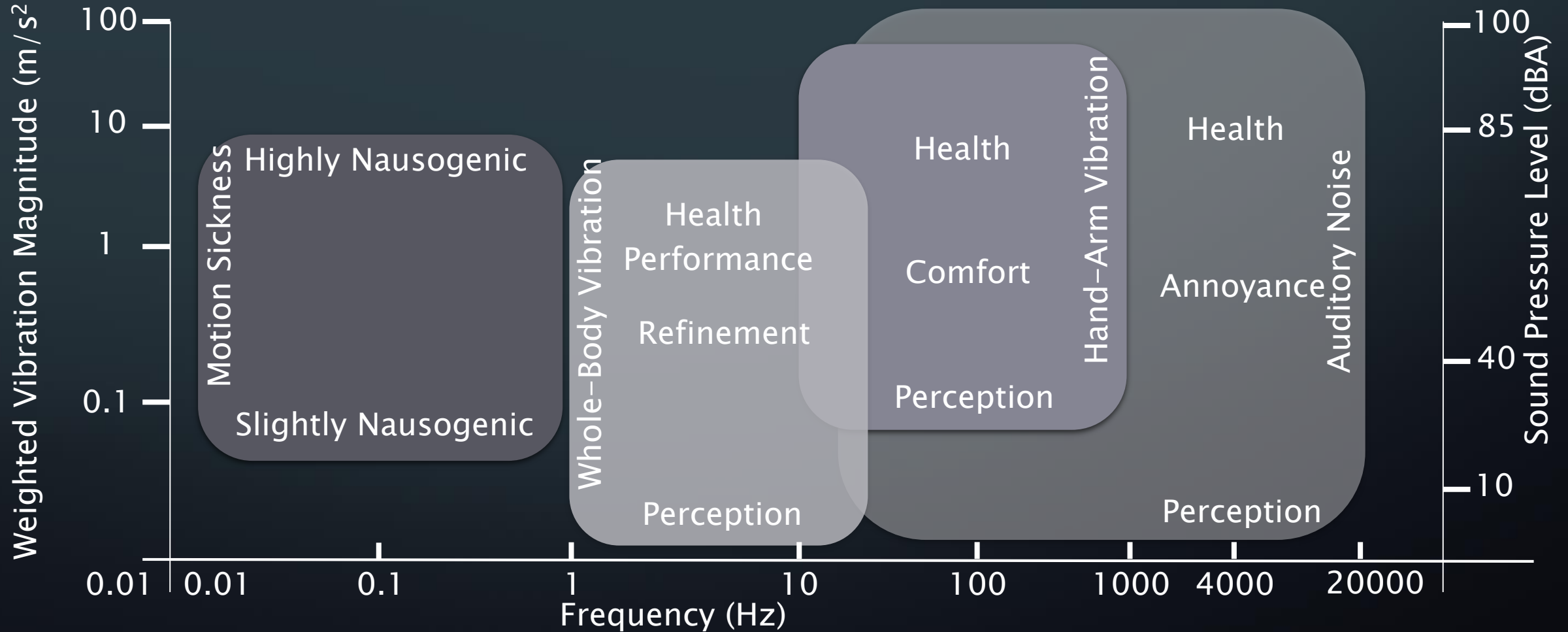


- Vibration exposure:
 - With respect to Human Vibration Assessments, **ACCELERATION** (m/s^2) is used as a measure of vibration magnitude
- Classification by contact site, effects & frequency
 - Localized:
 - usually only affects the hand–arm system, caused by direct contact between the hand and a vibrating tool
 - Primary Frequency range of concern is approximately 8 – 1000 Hz
 - May cause HAVS:
 - Characterized by disorders of the muscles, nerves, bones, joints and circulatory system
 - Whole–Body:
 - Affects the entire body, transmitted through seat surfaces, backrests and the floor
 - Most exposure is associated with transportation
 - Primary Frequency range of concern is approximately 1 – 20 Hz
- Vibration Causing Motion Sickness:
 - Affects the entire body, but differs from WBV in that:
 - Exposure is associated with frequencies below 1 Hz
 - Effects pertain to the vestibular system that controls balance and may result in vertigo,

VIBRATION PHYSICS: NATURAL FREQUENCIES IN THE BODY



VIBRATION PHYSICS: CLASSIFICATION BY EFFECT & FREQUENCY



WELLNESS CONSERVATION PROGRAM RELATED TO VIBRATION AND NOISE EXPOSURE

- To ensure that employees are adequately protected against the adverse effects of Vibration and Noise Exposure, the following elements need to be included in a holistic approach
 - Exposure monitoring
 - Instituting engineering, work–practice and administrative controls
 - Provision of adequate hearing protection (in the case of hearing conservation programs) and/or suspension–class seating (whole–body vibration exposure)
 - Training of employees on associated hazards and means of protection against excessive exposure
 - Monitoring employee exposure through baseline and routine medical surveillance (audiometry, functional assessment testing, employee symptom questionnaires, vibrotactile response testing, thermal threshold

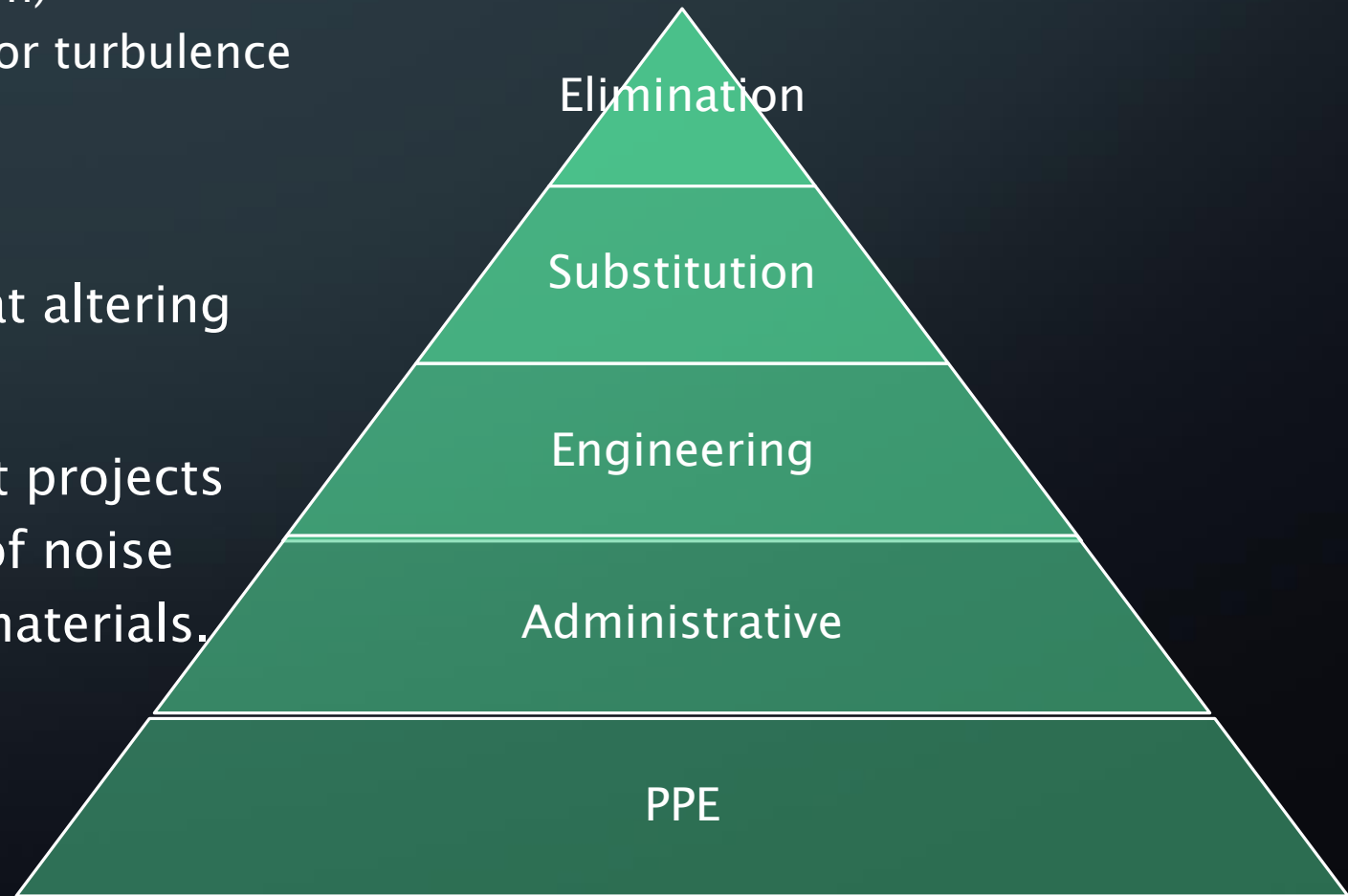
EXPOSURE MONITORING

- Exposure monitoring for Vibration and Noise exposure should be based on the following:
 - The characteristics of the stimulus – Impact, continuous, intermittent, steady, fluctuating etc.
 - The levels generated – defines the degree of risk
 - Frequency distribution – defines the physiological systems at risk
 - Exposure sources present in the workspace
 - Number of employees exposed
 - Propagation pathways and physiological sites at risk



IMPLEMENTATION OF CONTROLS

- Any noise/vibration problem can be described in terms of a
 - source (origin of mechanical vibration) – mechanical shock, impacts, friction or turbulence
 - transmission path and
 - Receiver (worker)
- Control measures should be aimed at altering any one or all of these elements
- All individuals involved in abatement projects should have a good understanding of noise control and proper use of acoustic materials.



SOURCE TREATMENT – NOISE AND VIBRATION



- There are 5 main causes of noise in industrial settings
 - Mechanical Impacts
 - High-velocity fluid flows
 - High-velocity air flows
 - Vibrating surface areas
 - Vibration of the product being manufactured
- Much industrial noise can be effectively controlled through simple solutions

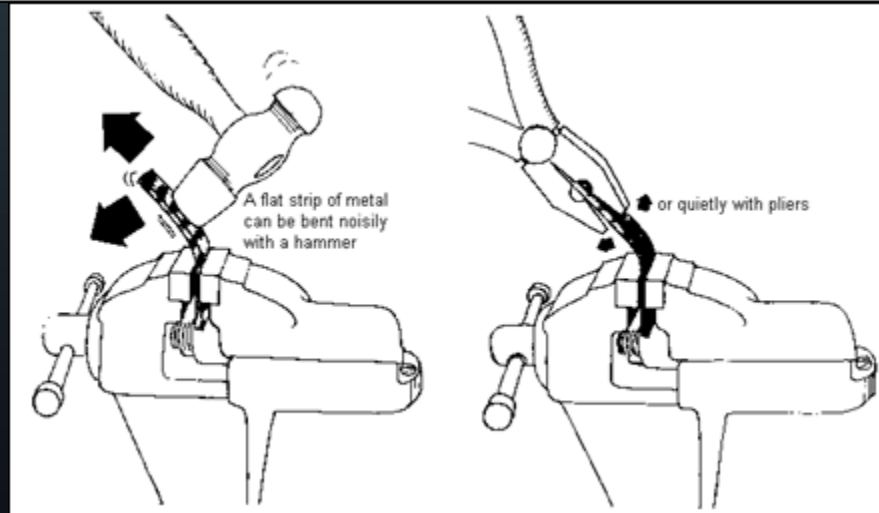
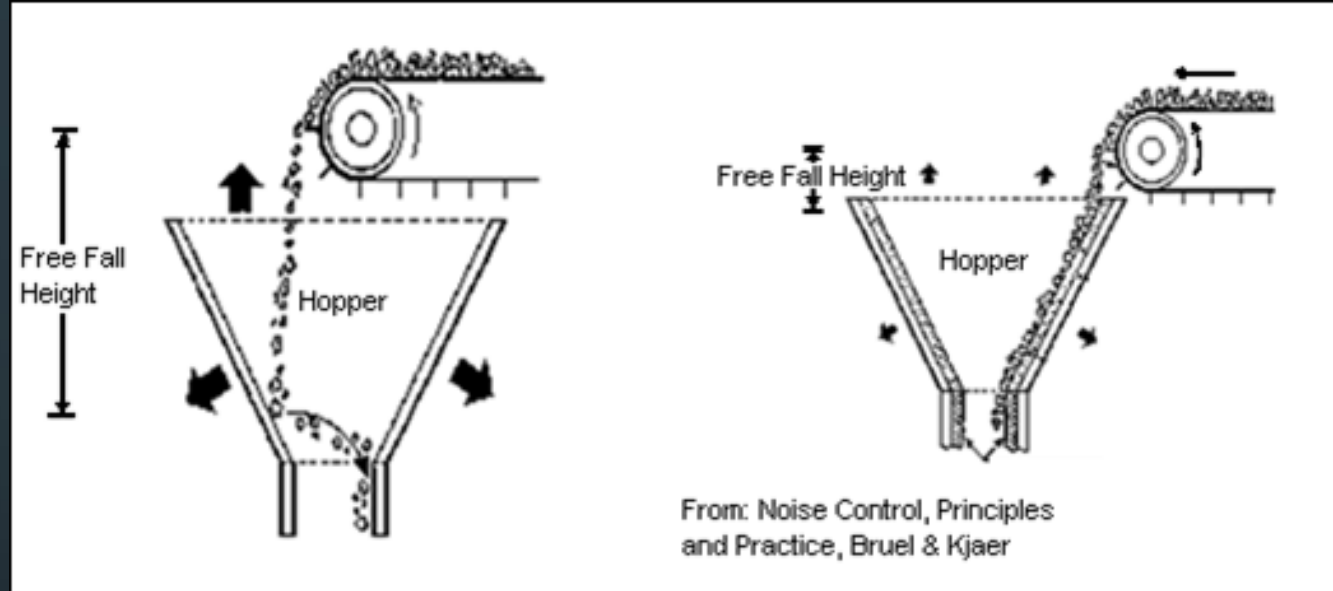
SOURCE TREATMENT – NOISE AND VIBRATION



- Mechanical impacts
 - Reduction of driving forces
 - Reduction of operational speed
 - Minimizing distance between impacting parts
 - Dynamic balancing of rotating parts
 - Isolation of vibration
- In order to be practical, the solutions should not affect production



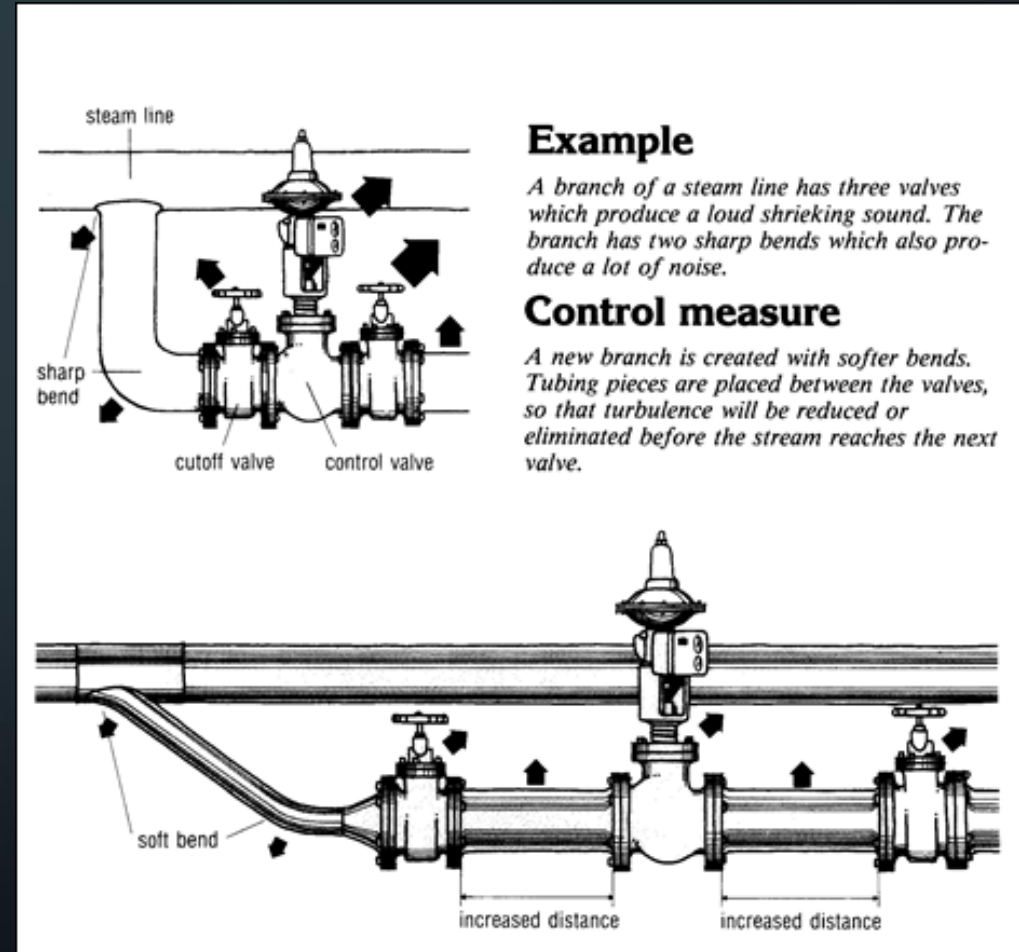
SOURCE TREATMENT – NOISE AND VIBRATION



SOURCE TREATMENT – NOISE AND VIBRATION



- High velocity fluid-flow
 - Objective is to decrease turbulence
 - Locate control valves in straight runs of pipe
 - Locate L and T bends in pipes at least 10 diameters downstream of a valve
 - Ensure that soft included angles (15–20 degrees) are present in pipe reducers or expanders
 - Introduce soft bends
 - Reduce the fluid-flow velocity to less than 9 m/s
 - Maintain laminar flow as far as possible



SOURCE TREATMENT – NOISE AND VIBRATION



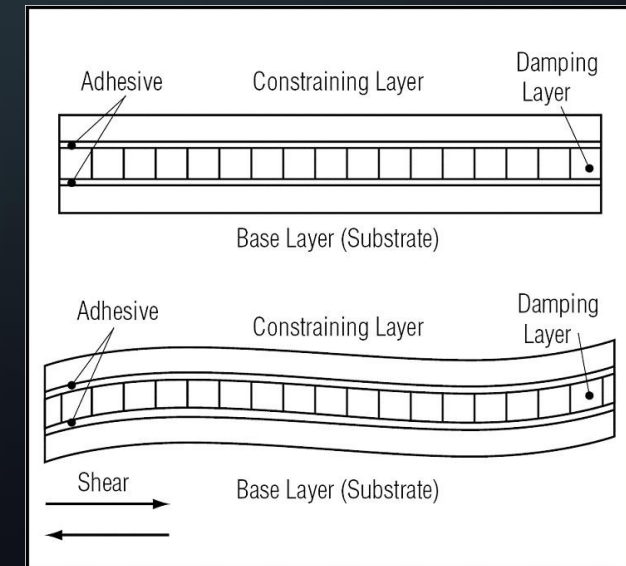
- High velocity air-flow
 - Objective is to lower the pressure gradient between high-velocity air make-ups and ambient air
 - Adjust the pressure regulator to the minimum pressure needed to accomplish a given task.
 - Replace noisy air nozzles with quieter, built-in noise control features
 - Installing additional air pressure control valves so air lines can be manually adjusted during operation



SOURCE TREATMENT – NOISE AND VIBRATION



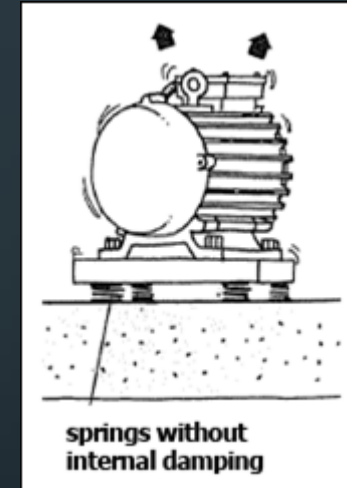
- Vibrating Surface Areas
 - Objective is to dissipate energy from mechanical vibration through **dampening**:
 - Free-Layer damping – consists of rubbery viscoelastic materials that can be adhered to a vibrating surface
 - Constrained layer dampening – addition of a second rigid layer over the viscoelastic material to increase the dampening effect
 - Constrained-layer laminates – Same principle, but with multiple layers of sandwiched viscoelastic material between rigid materials
 - The most effective control needs to be selected based on the temperature and frequencies present in the equipment and consult the damping material manufacturer to identify an optimal product.



SOURCE TREATMENT – NOISE AND VIBRATION



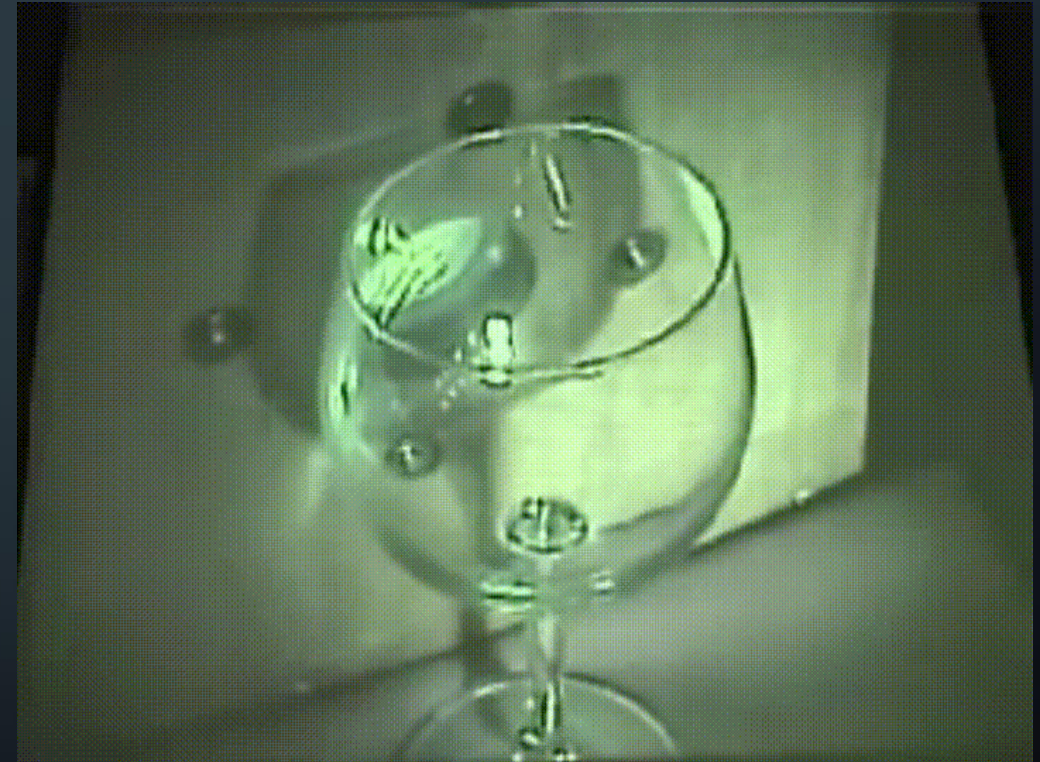
- Vibrating Surface Areas
 - Objective is to isolate the exiting force from a vibrating structure so secondary structures don't resonate
 - Isolation manipulates one critical factor in limiting resonance – the spring constant of the system
 - Results in a shift in the resonance frequency of secondary structures, resulting in lower magnitude vibration.
 - Vibration mounts require proper maintenance and lubrication to ensure adequate functioning



VIBRATION PHYSICS: RESONANCE



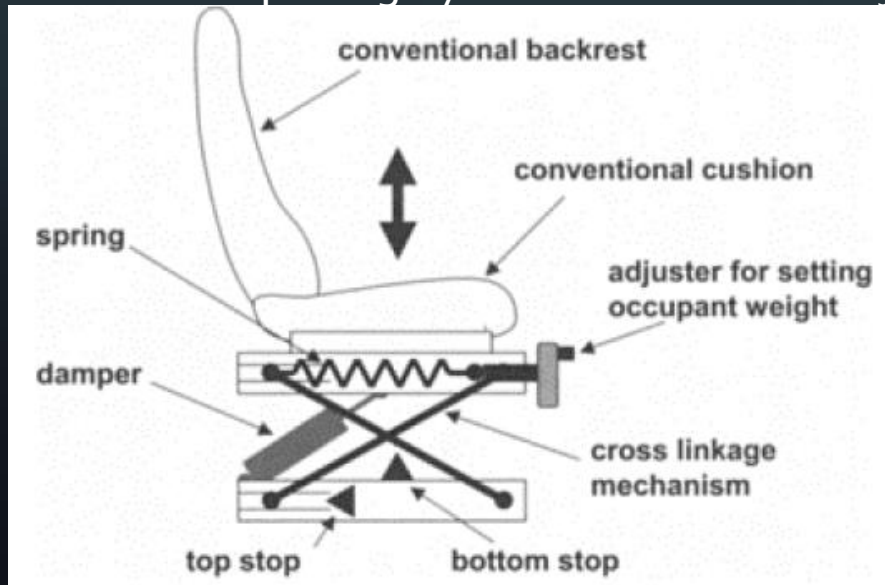
- Resonance is the frequency at which a system tends to oscillate in the absence of any driving or damping force
 - Forced vibration frequency may either be below, at or above the **natural frequency** of a system
 - Forced Vibration Frequency $>$ Natural Frequency = **ISOLATION**
 - Forced Vibration Frequency $<$ Natural Frequency = **FORCED MOVEMENT AS SINGLE COHERENT BODY**
 - Forced Vibration Frequency = Natural Frequency = **RESONANCE**
- The natural frequency of a system is dependent on:
 - The weight of the system (kg)
 - The Spring Constant of the System (N/m)
 - The Damping Constant of the system (N/(m/s))



SEATING DYNAMICS



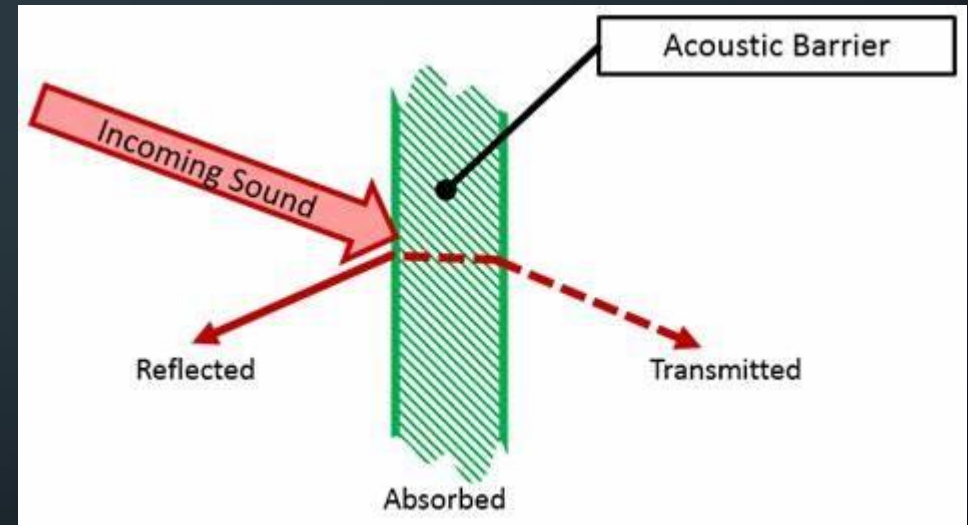
- Suspension Seating:
 - Consists of an independent suspension mechanism
 - Dampening mechanism constructed from springs and a damper.
 - The selection of specific dampening components are specific for the type of vehicle and its intended task.
 - Designed to isolate the occupant from vibration and impacts by altering the seat transmissibility
 - Resonant frequency set at 2Hz with isolation from 3Hz
 - The dampening system needs to be adjusted for the specific occupant weight of the seat, resulting in a high level of efficiency.



PATH TREATMENT – NOISE AND VIBRATION



- Absorption
 - Objective is to absorb the sound wave before it can be reflected
 - Materials utilized are normally porous or fibrous
- Transmission loss
 - Objective is to create a barrier between the source and receiver to lower transmitted noise
 - Important to ensure that all gaps are adequately sealed to limit leaks



PATH/SOURCE TREATMENT – NOISE AND VIBRATION



- Acoustical enclosure
 - Objective is to enclose a noise source with a dense outer casing, with sound-absorbing material on the interior surface to help dissipate acoustical energy.
- Receiver Enclosures
 - Objective is to isolate the receiver from external noise – heavy vehicle cabins, control rooms, isolation booths





ADMINISTRATIVE CONTROLS

- If engineering methods are not reasonably practicable, then limiting the exposure time might be the only option (task optimization):
 - Reduce demands on the operator
 - Allowing slower completion rates
 - Task rotation to dilute exposure
- Commitment from employers to draft policies/procedures for
 - The purchase of less hazardous equipment
 - Ensuring equipment is utilized effectively and for its designed purpose
 - Routine equipment maintenance planning to minimize vibration caused by equipment
- Exposure abatement should form part of a larger holistic health management approach taking factors such as ergonomics into consideration
 - Correct seat positioning



ADMINISTRATIVE CONTROLS

- Training of exposed employees on
 - The content and scope of associated regulations
 - Potential sources of exposure and the identification and reporting of irregular and/or abnormal vibration and/or noise produced from process equipment
 - Potential risks to health
 - Measures taken by the employer to protect an employee
 - Precautions to be taken by the employee to protect themselves
 - The necessity, correct use, maintenance and limitations of PPE
 - The assessment of exposure and the purpose of stressor-specific monitoring and medical surveillance
 - Exposure limits and their meaning
 - Procedures for reporting, correcting and replacing defective PPE and/or engineering control measures
 - The legal responsibility of the employee to protect his own health

PPE – HEARING PROTECTION



- Considered the last option in the control of any stressor.
- The best hearing protector, when fitted correctly, is one that is accepted by the worker and worn properly
- Come in a variety of sizes, shapes and materials and can be reusable and/or disposable
- Ear plugs are designed to be fitted in the ear canal and ear muffs to cover the external ear
 - Ensuring that a proper fit is maintained and that the seal is not broken is critical!
 - Facial hair, safety glasses, respirators may all influence the seal of ear muffs, greatly reducing its efficacy
 - In very high noise areas, a single product may not be sufficient and may require the use of both earplugs and -muffs.



PPE – HEARING PROTECTION



- Ensure that the Hearing Protection offers suitable protection
 - Hearing Protection will have a NRR rating on its packaging (if tested in accordance with ANSI S3.19–1974)
 - NRR:
 - Protected dBA value = Unprotected dBA - [NRR - 7]
 - NIOSH further recommends derating the NRR by a multiplication factor of 0.75 for ear muffs, 50% for slow-recovery foam ear plugs and 30% for all other earplugs
 - Therefore, if my earplug slow-recovery foam earplug has a NRR of 32 and an employee is exposed to a continuous noise level of 90 dBA, the resultant protected noise level within the ear will be
 - $90 - [0.5 * 32 - 7] = 81$ dBA (for 98% of cases)



PPE – KIDNEY BELTS



- No other PPE is faced with more controversy and uncertainty than the kidney belt (back belt or weightlifter's belt):
 - The effectiveness of kidney belts in lessening the risks of back injury remains unproven, but several factors are mentioned that discredit its use as a means of protecting the individual from WBV
 - May produce temporary strain on the CVS. This combined with the increased blood pressure associated with exposure to low frequency vibration, therefore may increase the strain on the CVS.
 - Long-term use of back supports have been shown to decrease abdominal muscle tone and therefore increase the risk of developing spinal injury during discontinuation of use.
 - Kidney belts are designed for the “average” person in terms of anthropometric data. Therefore, individuals falling outside the “average” range may experience different



PPE – ANTI VIBRATION GLOVES

- Many pitfalls with the design and selection of such gloves that should be taken into consideration.
 - More effective at isolating high frequencies
 - Low frequencies considered more hazardous
 - Early gloves actually amplified low frequency vibrations
 - Due to this ISO 10819 was developed to ensure proper isolation.





PPE – ANTI VIBRATION GLOVES

- ISO 10819:
 - For a glove to be classified as a anti vibration glove, it must be tested in a laboratory environment using two vibration stimuli:
 - M Stimulus: frequencies in the range of 16 to 400 Hz
 - H Stimulus: Frequencies in the range of 100 to 1600 Hz
 - To pass the test, the ratio of the frequency-weighted accelerations measured within the glove measured with a “palm adaptor” to that on the test handle surface must be less than 1 for the M stimulus and less than 0.6 for the H Stimulus.
 - Problem with test is that gloves are being developed to **pass the test and not protect a worker!**
 - Example:
 - **Some gloves amplify vibration over a range of frequencies within the M Spectrum, but because they attenuate at other frequencies, the mean transmissibility remains less than 1.**
 - **Therefore, if the glove is used with a tool whose vibration is dominant at**

Questions?