

Human Vibration

DEA 325/651

Professor Alan Hedge

Vibration Issues

- Whole body vibration
 - Human performance effects
 - Motion sickness
- Segmental vibration
 - Vibration of one or more parts of the body

Definitions

- **Frequency** of the vibration (cycles/second) measured in Hertz (Hz)
- **Intensity** of vibration measured in:
 - **Amplitude**/displacement (cm or in)
 - **Velocity** (cm/s or in/s)
 - **Acceleration** (cm/s² or in/s²)
 - **Jerk** (rate of change of acceleration – cm/s³ or in/s³)
- **G** – force of gravity (32.2 ft/s² : 9.81 m/s²)
- **Power Spectral Density (PSD)** – the power at discrete frequencies within a selected bandwidth.
- **Root mean square acceleration (RMS)** – the total energy across the entire frequency range.

Whole Body Vibration

Whole Body Vibration

- Health effects (acute exposure):
 - Motion sickness
- Suspected Health effects (prolonged exposure):
 - Lumbar spinal disorders
 - Hemorrhoids
 - Hernias
 - Digestive problems
 - Urinary problems

Whole Body Vibration

- Performance effects:
 - Control errors (center mounted joystick errors 50% > side-mounted joystick)
 - Tracking errors increase up to 40% compared to non-vibration

performance (sinusoidal vibration in the range 4-20Hz, with accelerations > 0.2g is worse than random vibration)

- Visual performance is disrupted most in the range 10-25Hz

WBV Risk varies by Vehicle Type

WBV in Vehicles

- RMS varies by direction (vertical, lateral) for vehicle type by vehicle design, road quality, air turbulence etc.

Vibration varies by Body part and posture

WBV depends on Muscle Tension

NASA DISC Scale

- Scale of passenger discomfort (tested on 2,200 subjects)

NASA DISC Scale

Equal Motion Sickness Contours

Basocentric Axes of the Human Body, ISO

2631 - 1: 1997

ISO 2631-1 Standard (1997)

Acceleration (g forces)

Acceleration Tolerances

Vibrating Hand Tools

- Many types of hand tools vibrate.
- Vibrations can be:
 - Intentional – integral to the function of the tool
 - Incidental – a by product of tool operation
- Prolonged use of vibrating tool can cause vascular damage to the upper limbs.

Examples: Vibrating Hand Tools

Segmental Vibration

- The American Conference of Governmental Industrial Hygienists (ACGIH) gives Threshold Limit Values (TLVs) for vibration exposure from hand-held tools.
- Exposure limits are given as frequency-weighted acceleration and represented by a single number as a measure of the vibration exposure level.
- Acceleration levels and exposure durations which may be exposed repeatedly without severe damage to fingers.

- ACGIH guidelines should be applied in conjunction with other vibration protective measures.

**ACGIH TLVs for exposure of the
hand to vibration in X, Y, or Z direction***
Hand-Arm Vibration Syndrome (HAVS)

- Vibration-induced white finger (VWF) is the most common condition among the operators of hand-held vibrating tools.
- Vibration can cause changes in tendons, muscles, bones and joints, and can affect the nervous system.
- Collectively, these effects are known as Hand-Arm Vibration Syndrome (HAVS).

Hand-Arm Vibration Syndrome (HAVS)

- The symptoms of VWF are:
 - Attacks of whitening (blanching) of one or more fingers when exposed to cold
 - Tingling and loss of sensation in the fingers
 - Loss of light touch
 - Pain and cold sensations between periodic white finger attacks
 - Loss of grip strength
 - Bone cysts in fingers and wrists
- The symptoms of VWF are aggravated when the hands are exposed to cold.

Vibration White Finger (VWF)

- Stage 0 – No symptoms
 - OT - Intermittent tingling
 - ON - Intermittent numbness
 - OTN - Tingling and numbness
- Stage 1 - Blanching of one or more fingertips with or without tingling and numbness.
- Stage 2 - Blanching of one or more fingers with numbness, usually during winter only. Slight interference with home and social activities; no interference with work.

Vibration White Finger (VWF)

- Stage 3 -Extensive blanching with frequent episodes during both summer and winter. Definite interference with work, home and social activities; restricted hobbies.
- Stage 4 - Extensive blanching of most fingers; frequent episodes during summer and winter; finger ulceration, gangrene. Occupation change required to avoid further vibration exposure.

VWF Prevalence

- 50 percent of 146 tree fellers examined in British Columbia had Raynaud's phenomenon; it affected 75 percent of workers with over 20 years of experience.
- 45 percent of 58 rock drillers had attacks of white finger; 25 percent of workers with less than five years of experience, but 80 percent of those with over 16 years experience were affected.

VWF Latency

Reducing Vibration Injuries

- Anti-vibration gloves – absorb vibration energy, can get some impairment of dexterity.
- ISO Standard 10819 specifies the amplitude of vibration transmissibility that must be achieved for a glove to be classified as an antivibration glove.
- ISO 10819 requires the overall vibration transmissibility of a glove to be measured for mid frequencies (frequency range from 16-400 Hz) and for high frequencies (frequency range from 100-1,600 Hz).

Reducing Vibration Injuries

- Tool re-design e.g. 'Antivibe' hammer:
 - 500% improved vibration damping over other professional hammers
 - less vibration through the use of an internal tuning fork

Reducing Vibration Injuries

- Tool re-design – e.g. 'Gentle Jack' jackhammer:
 - 50% fewer parts than a conventional jackhammer
 - 50% less noise
 - 99% less vibration