Human Vibration
DEA 3250/6510
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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

• 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*

**Basicentric 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