

- Some tools have adjustable grips to allow a worker to maintain good wrist posture.

Ergonomic Design: Pens/Pencils

- Many different pen/pencil designs, but the principles of optimal grip span and wrist posture still apply.
- Pens/pencils should:
 - Not be too thin or too thick
 - Have a padded, shaped grip
 - Not be too heavy
 - Be well balanced
 - Have easy flow nib/point

Ergonomic Instruments

- Musical instruments can be ergonomically designed.

Ergonomic Design: Handedness

- Depending on the definition of handedness, 10-30% of people are left-handed.
- On average, left handed people live 9 years less and are 5 times more likely to die of accident-related injuries than right handed people.
- Many products are designed for right handed people, but an increasing number of left hand designs are becoming available.

Ergonomic Design: Different abilities

- Hand tool use can become more difficult with many ageing disorders, such as arthritis.
- Numerous “add-ons” are available to help people with restricted dexterity to perform commonplace manual tasks.

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

Vibration Effects

- Vibrations are mechanical oscillations of the body or body segment
- 5 quantities are important:
 - Point of application (e.g. hand, arm, feet, buttocks)
 - Frequency (Hz)
 - Acceleration (m/s^2) – usual measure of vibration load
 - Duration
 - Individual frequency and resonance

Resonant Frequencies

- Everything has its own natural frequency. The closer a vibration is to this the greater its amplitude. For the human body:
 - 3-4 Hz: strong resonance in cervical vertebrae
 - 4 Hz: peak resonance for lumbar vertebrae
 - 5 Hz: shoulder girdle (very strong resonance up to double normal amplitude)
 - 20-30 Hz: resonance between head and shoulders
 - 60-90 Hz: eyeballs
 - 100-200 Hz: lower jaw

Direction of vibration

- Vertical (up/down)
- Horizontal (forwards/backwards)
- Lateral (side-to-side)

Vertical Vibrations

- Vibrations between 2.5-5Hz induce strong resonance in neck and lumbar vertebrae
- Vibrations between 4-6Hz induce strong resonance in trunk, shoulders and neck
- Vibrations between 20-30Hz induce strong resonance in head and shoulders

Vibrating Hand Tools

Vibration Effects

- Physiological effects – vibration initiates protective muscle reflexes (extended muscles shorten), which increases heart and respiration rate, and energy consumption
- Visual effects – visual acuity decreases and images are blurred and unsteady
- Skill – less able to perform skilled movements
- Information processing – less able to process information
- Speech – difficult to talk
- Driving – at 2-16Hz driving performance is impaired and errors increase

Vibration as a Nuisance

- 4-8 Hz – greatest subjective sensitivity
- 10 m/s² (1g) – ‘very severe intensity’
- 15 m/s² (1.5g) – dangerous and intolerable

Vibration Health Effects

- 0.2-0.7 Hz – motion sickness, nausea vomiting (max at 0.3 Hz)
- 1-4 Hz – interference with breathing
- 4-10 Hz – pains in chest, abdomen, rattling of jaws, muscular discomfort
- 8-12 Hz – backache

- 10-20 Hz – muscle tension, headaches, eyestrain, pains in throat, intestines, bladder, speech disturbances
- <40 Hz (e.g. pneumatic hammer) causes degenerative damage to bones, joints, and hand/arm tendons
- 40-300 Hz (e.g. power tools) – damage blood vessels and nerves in hands.

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). The symptoms of VWF are aggravated when the hands are exposed to cold.
- 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

Vibration White Finger

- 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.
- 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

Vibration Limits

- <2Hz – accelerations of 3-4 g are intolerable
- 4-14 Hz – accelerations of 1.2-3.2 g are intolerable
- >14 Hz – accelerations of 5-9 g are intolerable
- ISO has established vibration limits based on:
 - Criterion of comfort (divide acceleration by 3.15)
 - Criterion of maintenance of efficiency
 - Criterion of safety (multiply acceleration by 3.15)

ISO 2631 Vibration Limits

- 0.3-0.45 m/s² for 8 hrs day for tractors, heavy vehicles, construction machinery (mostly 2-5 Hz vibrations)
- Dampen hand-tool vibrations

Reducing Vibration Injuries

- Anti-vibration gloves – absorb vibration energy, can get some impairment of dexterity.
- Tool re-design – e.g. ‘Gentle Jack’ jackhammer:
 - 50% fewer parts than a conventional jackhammer
 - 50% less noise
 - 99% less vibration