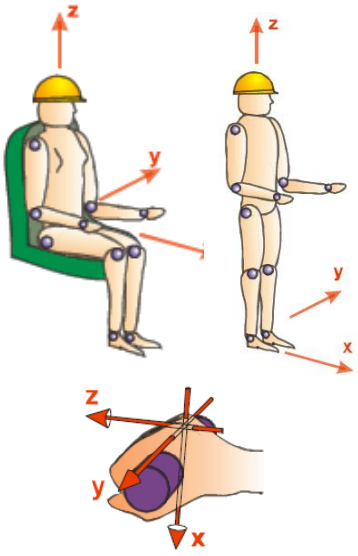
Ergonomics

MSD Risk Factors – Vibration

Risk Factors
Introduction
Forceful Exertions
Awkward Postures
Vibration
Repetition
Contact Stress
Torque Reaction
Solutions

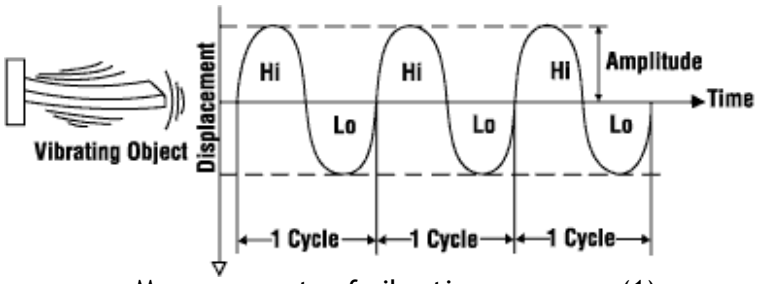
Inside This Issue



Vibrations are usually measured for the x, y and z axes or vectors (2 and 3).

Definition

Vibrations occur when an object oscillates or rapidly moves back and forth about its stationary point, like a swinging pendulum. Vibrations are defined by the frequency (how fast the object is moving) and the magnitude or amplitude (the distance of the movement). Frequency is measured in cycles per second or hertz (Hz). One Hz is one cycle per second. The magnitude is usually measured as acceleration in meters per second per second, that is how fast is the speed of the vibration changing from zero at either end of the oscillation to its maximum speed at the normal stationary point. (1)

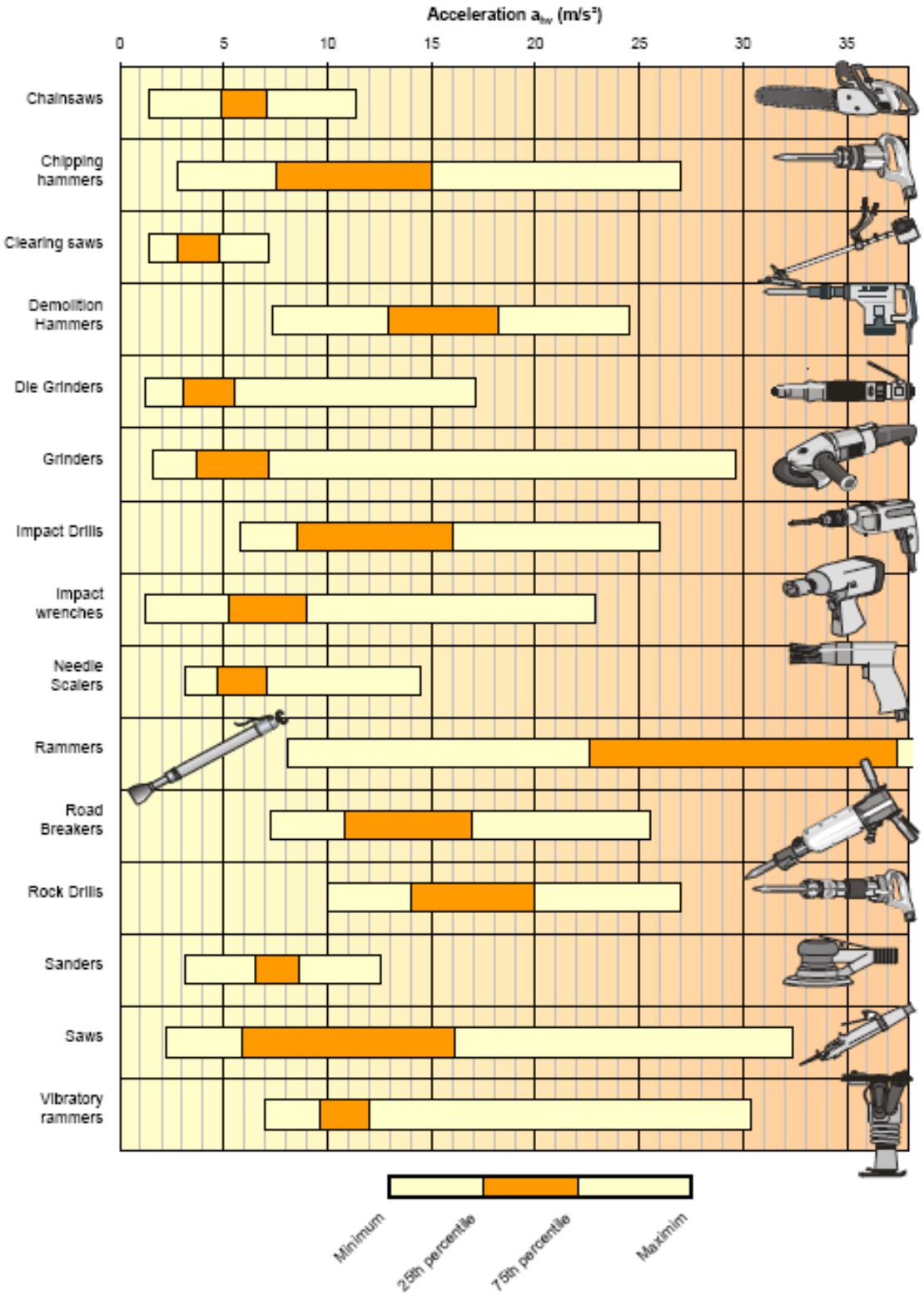


Measurements of vibration exposure (1)

Vibration exposure during manual tasks has two distinct types: hand-arm vibration and whole body vibration .

Hand-arm vibration (HAV) is typically associated with operating power tools. Exposure occurs when the tool vibrations are transmitted to the hand and arm. For HAV, the frequencies thought to be important (results in maximum health effects) range from about 8 Hz to 1000 Hz (2). Frequency information about a specific tool can generally be obtained from the manufacturer.

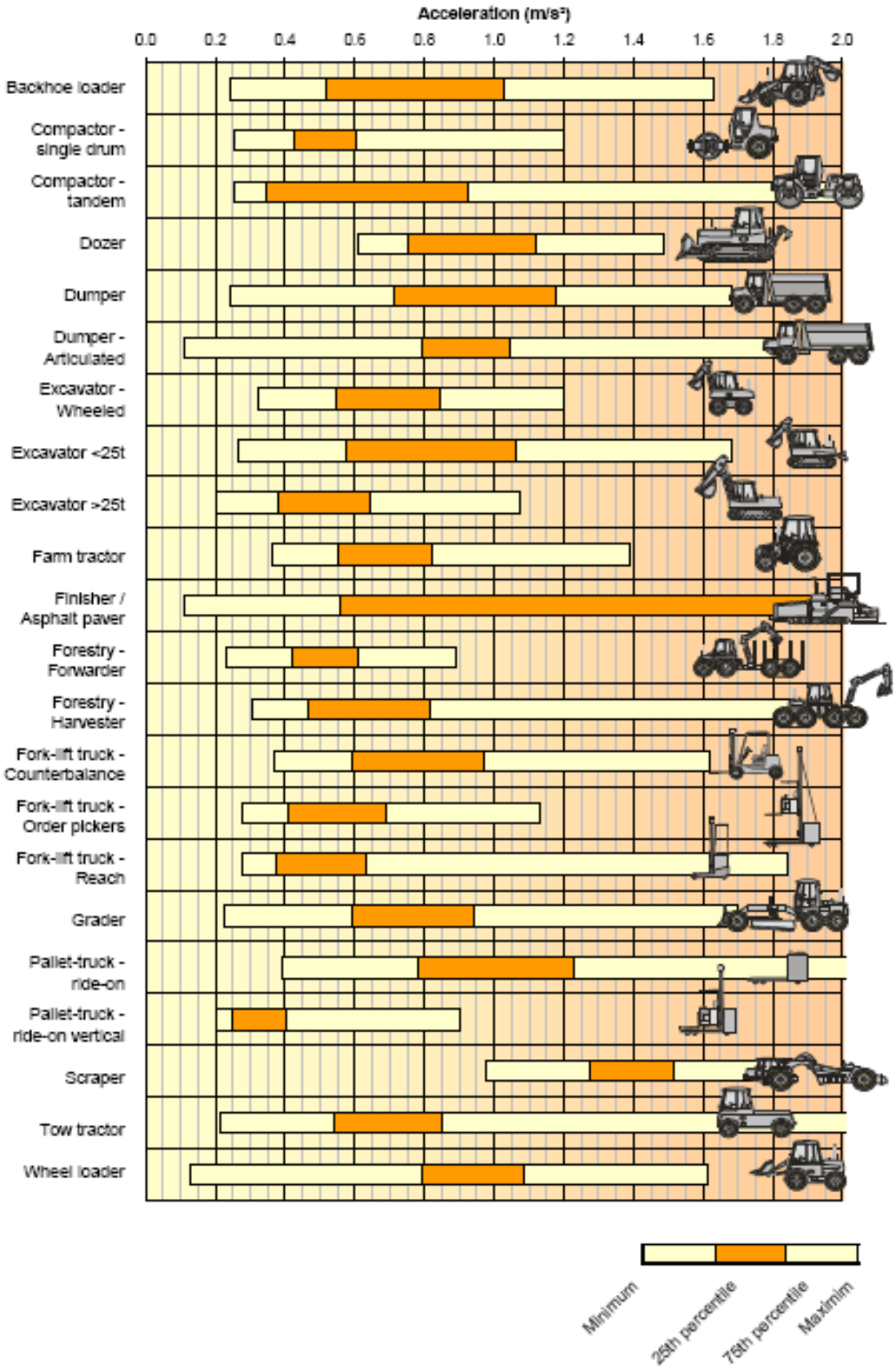
Whole-body vibration (WBV) is typically associated with standing or sitting on a vibrating surface. WBV exposure occurs when vibrations are transmitted usually through the feet if standing, or the legs and hips if seated. WBV can affect the entire body, including internal organs. For WBV, the frequencies that have the maximum affects are 0.5 to 80 Hz (3).



Rock drills used for mining have one of the highest exposure levels for hand-arm vibration.

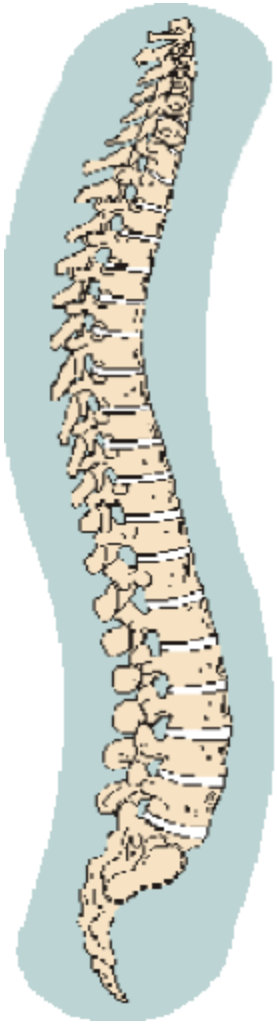
Examples of HAV levels for common power tools. Fifty percent of the exposures measured fell within the range of the gold bar. The higher the acceleration, the greater the exposure. (2)

As shown in the graph, operating haul trucks (dumper), excavators, loaders, graders, and dozers can result in significant exposures to WBV.



Examples of WBV levels for mobile equipment - Fifty percent of the exposures measured fell within the range of the gold bar. The higher the acceleration, the greater the exposure. (3)

How Vibration May Lead to MSDs



In both types of vibration, HAV and WBV, the exposure impacts the MSD risk both directly and indirectly. Exposure of the upper limbs, and particularly the hands, to high frequency vibration associated with power tools is a direct cause of damage to nerves and blood vessels. Short term effects include temporary loss of sensation and control, and blanching, or whitening, of the fingers - hence "Vibration White Finger Syndrome". These effects may become irreversible with long term exposure and lead to gangrene and loss of the affected fingers (4). The degree of risk increases with higher amplitude vibration tools (hammer drills or jack hammers). Use of vibrating power tools is also an indirect cause of MSD risk to the upper limbs because the vibration increases the force required by the upper limbs to perform the task. Higher forces will lead to a faster onset of muscle fatigue, which will increase the MSD risk.

Similarly, long term exposure to WBV (typically from vehicles) is associated with back pain (5,6 and 7). As well as a direct effect on the back, exposure to whole body vibration also has an indirect influence on MSD risk by causing fatigue of the back muscles. Again, the risk is greater when the amplitude of vibration is high (heavy vehicles and/or rough terrain causing jolting and jarring).

Another condition that determines exposure levels is “resonance.” Objects tend to vibrate at a specific frequency, which is called its natural frequency. Because the natural frequency is determined by an object’s composition, size, structure, weight and shape, the different parts of the human body have different natural frequencies. When the frequency of the vibrating tool is the same as the natural frequency of the body part contacting the tool, the maximum amount of energy is transmitted, resulting in a higher exposure (1). Resonance may occur with any vibrating object. A well known example that demonstrates the degree of energy that can be transferred when resonance occurs is the collapse of the Tacoma Narrows Bridge in 1940 (8).

References:

1. Canadian Center for Occupational Safety and Health (CCOHS) (Oct 21, 2008). http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_intro.html.
2. European Union (Dec 6, 2006). European Union Guide to Good Practice on Hand-Arm Vibration, Version 7.7g.
3. European Union (Dec 6, 2006). European Union Guide to Good Practice on Whole-Body Vibration, Version 6.7g.
4. NIOSH (1989). *Criteria for a Recommended Standard: Occupational Exposure to Hand-Arm Vibration.* US Department of Health and Human Services. Pub. No. 89-106
5. Bovenzi M and Hulshof CT (1999). An updated review of epidemiologic studies on the relationship between exposure to whole-body vibration and low back pain (1086-1997). *International Archives Occupation Environmental Health* 72, 351-365.
6. Lings S and Leboeuf-Yde C (2000). Whole-body vibration and low back pain: a systematic, critical review of the epidemiological literature 1992-1999. *International Archives Occupation Environmental Health* 73, 290-297.
7. American Conference of Governmental Industrial Hygienist (2007). Whole-Body Vibration. *Documentation of the TLVs and BEIs with Other Worldwide Occupational Exposure Values-2007.* Cincinnati, Ohio.
8. Irvine, Tim. 1999. http://www.vibrationdata.com/Tacoma.htm.

Vibration Exposures and Mining Tasks

Hand-Arm Vibration
Operating power hand tools

Whole Body Vibration
Operating mining equipment

What's Next?

The next newsletter will discuss the risk factor of repetition. Repetition alone for some tasks can lead to MSDs. However, performing other tasks would not necessarily increase a person's risk for a MSD except when the task involves high repetition and exposure to another risk factor. Details about repetition, including examples found during mining tasks, will be presented.

The content for this newsletter is from DHHS (NIOSH) Publication No. 2009-107, Information Circular 9509, Ergonomics Processes: Implementation Guide and Tools for the Mining Industry (in press), Authors: Janet Torma-Krajewski (currently Colorado School of Mines, formerly NIOSH, jtorma@mines.edu), Lisa Steiner (NIOSH, Lsteiner@cdc.gov), Robin Burgess-Limerick (University of Queensland, robin@hms.uq.edu.au).