Vibration – Introduction Fact Sheet

WHY MEASURE OR EVALUATE VIBRATION EXPOSURE?

We can feel vibrations and know that people might be exposed to it. But we cannot determine if what we feel is going to be harmful. For that, we must measure vibration exposure.

Vibration is the mechanical oscillations of an object about an equilibrium point. The oscillations may be regular such as the motion of a pendulum or random such as the movement of a tire on a gravel road. The study of health effects of vibration require measures of the overall “pressure waves” (vibration energy) generated by the vibrating equipment or structure.

Vibration enters the body from the part of the body or organ in contact with vibrating equipment. When a worker operates hand-held equipment such as a chain saw or jackhammer, vibration affects hands and arms. Such an exposure is called hand-arm vibration exposure. When a worker sits or stands on a vibrating floor or seat, the vibration exposure affects almost the entire body and is called whole-body vibration exposure.

The risk of vibration induced injury depends on the average daily exposure. An evaluation of the risk takes into account the intensity and frequency of the vibration, the duration (years) of exposure and the part of the body which receives the vibration energy.

Hand-arm vibration causes damage to hands and fingers. It appears as damage to blood vessels, nerves and joints in the fingers. The resulting condition is known as white finger disease, Raynaud’s phenomenon or hand-arm vibration syndrome (HAVS). One of the symptoms is that affected fingers may turn white, especially when exposed to cold. Vibration-induced white finger disease also causes a loss of grip force and loss of sensitivity to touch.

The health effect of whole-body vibration (WBV) is poorly understood. Studies of drivers of heavy vehicles have revealed an increased incidence of the disorders of bowel and the circulatory, musculoskeletal and neurological systems.

However, disorders of the nervous, circulatory and digestive systems are not specific to whole-body vibration exposure only. These disorders can be caused by a combination of various other working conditions and lifestyle factors rather than by one physical factor alone.

What is vibration?

If we could watch a vibrating object in slow motion, you could see movements in

different directions. Any vibration has two measurable quantities. How far (amplitude or intensity), and how fast (frequency) the object moves helps determine its vibrational characteristics. The terms used to describe this movement are frequency, amplitude and acceleration.

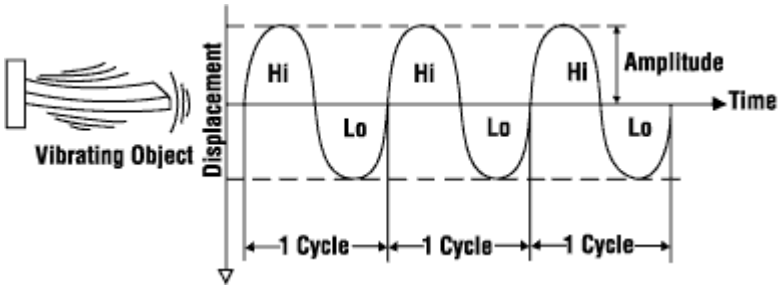

Figure 1 – Representation of the Measures of Vibration Exposure

Frequency

A vibrating object moves back and forth from its normal stationary position. A complete cycle of vibration occurs when the object moves from one extreme position to the other extreme, and back again. The number of cycles that a vibrating object completes in one second is called frequency. The unit of frequency is hertz (Hz). One hertz equals one cycle per second.

Amplitude

A vibrating object moves to a certain maximum distance on either side of its stationary position. Amplitude is the distance from the stationary position to the extreme position on either side and is measured in metres (m). The intensity of vibration depends on amplitude.

Acceleration (measure of vibration intensity)

The speed of a vibrating object varies from zero to a maximum during each cycle of vibration. It moves fastest as it passes through its natural stationary position to an extreme position. The vibrating object slows down as it approaches the extreme, where it stops and then moves in the opposite direction through the stationary position toward the other extreme. Speed of vibration is expressed in units of metres per second (m/s).

Acceleration is a measure of how quickly speed changes with time. The measure of acceleration is expressed in units of (metres per second) per second or metres per second squared (m/s2). The magnitude of acceleration changes from zero to a maximum during each cycle of vibration. It increases as the vibrating object moves further from its normal stationary position.

What is resonance?

Every object tends to vibrate at one particular frequency called the natural frequency. The measure of natural frequency depends on the composition of the object, its size, structure, weight and shape. If we apply a vibrating force on the object that has a frequency equal to the natural frequency of the object, it is a resonance condition. A vibrating machine transfers the maximum amount of energy to an object when the machine vibrates at the object’s resonant frequency.

How does the vibration exposure occur?

Contact with a vibrating machine transfers vibration energy to an organ(s) of the

body. We know that vibration affects the organ in contact such as the hands. But we do not fully understand how vibration may affect other parts of the worker's body or only a selected particular organ. The effect of vibration exposure also depends on the frequency of vibration. Each organ of the body has its own resonant frequency. If exposure occurs at or near any of these resonant frequencies, the resulting effect is greatly increased.

Segmental vibration exposure affects an organ, part or "segment" of the body. The most widely studied and most common type of segmental vibration exposure is hand-arm vibration exposure which affects the hands and arms. Exposed occupational groups include operators of chain saws, chipping tools, jackhammers, jack leg drills, grinders and many other workers who operate hand-held vibrating tools.

Whole body vibration energy enters the body through a seat or the floor, and it affects the entire body or a number of organs in the body. Exposed groups include operators of trucks, buses, tractors, and those who work on vibrating floors. Table 1 lists examples of vibration exposure in various industries.

Table 1
Examples of occupational vibration exposure

Industry	Type of Vibration	Common Source of Vibration
Agriculture	Whole body	Tractors
Boiler making	Hand-arm	Pneumatic tools
Construction	Whole bodyHand-arm	Heavy equipment vehiclesPneumatic tools, Jackhammers
Diamond cutting	Hand-arm	Vibrating hand tools
Forestry	Whole bodyHand-arm	TractorsChain saws
Foundries	Hand-arm	Vibrating cleavers
Furniture manufacture	Hand-arm	Pneumatic chisels
Iron and steel	Hand-arm	Vibrating hand tools
Lumber	Hand-arm	Chain saws
Machine tools	Hand-arm	Vibrating hand tools
Mining	Whole bodyHand-arm	Vehicle operationRock drills
Rivetting	Hand-arm	Hand tools
Rubber	Hand-arm	Pneumatic stripping tools
Sheet Metal	Hand-arm	Stamping Equipment
Shipyards	Hand-arm	Pneumatic hand tools
Shoe-making	Hand-arm	Pounding machine
Stone dressing	Hand-arm	Pneumatic hand tools
Textile	Hand-arm	Sewing machines, Looms
Transportation	Whole body	Vehicles