

“Vibration: Good Practice in Measurement, Elimination and Control” Workshop

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**All slide presentations and recorded presentations from the workshop are available at the following link:

http://cre-msd.uwaterloo.ca/vibration_workshop.aspx

1. Overview

Vibration can enter the body through any point that is in contact with a vibrating surface. There are three types of vibration that humans are exposed to; whole body vibration (WBV), hand-arm vibration (HAV), and foot-transmitted vibration (FTV).

Factors affecting human response to vibration:

- vibration magnitude
- direction of vibration
- frequency of vibration
- contact points with the body
- duration of exposure
- posture and mass of worker
- grip strength/coupling with the tool

Body segments resonate at different frequencies. There is increased risk of injury when the body segment is exposed to its resonating frequency.

Resonating frequencies of main segments affected by vibration:

Pelvis/Spine: 3-5 Hz; 10-12 Hz

Hand/Arm: 30-50 Hz

Fingers: 125-300 Hz

Feet/Toes: Unknown, but thought to be similar to Hand/Arm

2. Overview of Effects of Various types of Vibration

2.1. Effects of Whole Body Vibration

Some typical health effects of exposure to whole body vibration include discomfort, fatigue, and decreased proficiency; exposure to vibration can affect the

ability to carry out tasks requiring concentration. Additional adverse physiologic changes include increased heart rate, respiratory rate, and cardiac output.

Back disorders are common with exposure to whole body vibration. There is increased likelihood of low back pain, degenerative changes in the spine, and lumbar intervertebral disc disorders when the body is exposed to whole body vibration.

2.2. Effects of Hand-Arm Vibration

Vascular: Raynaud's phenomenon

- blanching of skin when exposed to cold or vibration
- related to duration and intensity of exposure to hand-arm vibration
- latency period can be short (<2 years) with high exposure
- The Stockholm-Workshop Scale (see Appendix A) contains various stages and descriptions of vascular and sensori-neural Raynaud's symptoms.

Neurologic:

- Digital sensory neuropathy
- Compressive neuropathies proximal to the hand (i.e., median neuropathy (CTS) and ulnar neuropathy)
- NIOSH (1997)
 - evidence (but not strong) for association between vibration and CTS (inadequate control of ergonomic factors); strong evidence for association between ergonomic factors (force and repetition) and CTS
- Palmer et al (2007), Carpal tunnel syndrome and its relation to occupation: a systematic literature review (Occup Med (Lond) 2007: 57(1):57-66)
- **Reasonable** evidence that regular and prolonged use of hand-held vibratory tools increases the risk of CTS >2 fold.
- Substantial evidence for similar or even higher risks from prolonged and highly repetitious flexion and extension of wrist, especially when allied with a forceful grip.

Musculoskeletal:

- Decreased grip strength
- Changes in musculature due to direct muscle injury and motor nerve injury

2.3. Effects of Foot Transmitted Vibration (FTV)

Foot transmitted vibration tends to present similarly to HAVS, with respect to symptoms. There have been cases of "white foot"; similar to "white finger" or

Raynaud's (Thompson AM, House R, Krajnak K, Eger T. Vibration white foot: a case report. *Occup Med (Lond)* 2010; 60: 572-574).

3. Reporting/Recognizing Vibration Injuries

The main source of information on the occurrence of HAVS in Canada is compensation board data. The reporting/incident rate of HAVS is quite low. It is assumed that this is because of under-recognition of the signs and symptoms of vibration syndromes and under-reporting of these syndromes.

In Canada, there is no legislation in place for exposure to vibration:

- Ontario: No regulations for HAV or WBV
- British Columbia and New Brunswick: legislation that specifically mentions the ACGIH TLVs, however enforcement of this can be difficult.

European Union

- European Union Directive 2002/44/EC – Hand-arm & Whole Body Vibration
 - Exposure Limit Value (ELV)
 - Daily Exposure Action Value (EAV)
 - When EAV is exceeded, the employer is required to institute a program to reduce exposure train workers.

United States

- ANSI S2.70 – 2006 – based on the EU Directive
- No OSHA regulation

4. Measuring and Analysis of Vibration Exposure

4.1. Standards/Guidelines for Vibration Exposure

Type of Vibration	Standard
Whole Body	ISO 2631-1
	ISO 2631-5
	EU Directive 2002/44/EC
Hand-Arm Vibration	ISO 5349-1
	EU Directive 2002/44/EC
	ACGIH TLV

Vibration Exposure Limits

"Probable" Health Risk	WBV		HAV	
	ISO 2631-1 (A(8) (m/s ²))	EU Directive (A(8) (m/s ²))	ISO 5349-1 (A(8) (m/s ²))	EU Directive (A(8) (m/s ²))
Low	< 0.45	< 0.5	< 2.0	< 2.5
Moderate	0.45 – 0.9	0.5 – 1.15	> 2.0	2.5 – 5.0
High	> 0.9	> 1.15		> 5.0

4.2. Vibration Measurement Data

Measurement of vibration requires a great deal of skill in accelerometer use and can be expensive; therefore it is recommended that a professional that is trained in vibration assessment is contacted for taking actual measurements on tools or vehicles. In Europe, all suppliers of hand-tools must make the vibration levels of their products public, however suppliers in North America are not required to provide this information.

The vibration measurements on various EU models of hand tools have been compiled in the diagram on the following page. This diagram could be a good starting point when searching for existing measurements.

Databases

A number of databases have been created that contain vibration measurements for various tools and vehicles. The databases have been populated with measurements from new tools/vehicles by suppliers and/or vibration professionals. The type, manufacturer, model, and power sources are required for the vibration level to be provided.

Some include:

- The Swedish (CEHAVD) Database (Department of Public Health and Clinical Medicine Occupational and Environmental Medicine, Umea University) (<http://www.vibration.db.umu.se/HavSok.aspx?lang=en>) *No registration is required
- HAVTEC Database (<http://www.operc.com/havtec/>) *Registration is required

4.3. Calculation of Vibration Exposure

A calculator has been created for determining exposure to hand-arm vibration: <http://www.hse.gov.uk/vIBRAtlon/hav/vibrationcalc.htm>

1. Determine the exposure to the tool(s).

Example: 5 shots of a gun lasting 2 seconds each for a 1 minute cycle, over 2 hours of work

= (5 * 2 sec) * 120 times
 = 1200 sec
 = 20 min of exposure

- Using a database or supplier data, determine the vibration level(s) of the tool(s).
- Enter these two pieces of data into the calculator for every tool that is being used throughout the worker's shift.

HSE
Health & Safety Executive

HAND-ARM VIBRATION EXPOSURE CALCULATOR

Version 4.3 January 2014

Tool or process name	Vibration magnitude m/s ² r.m.s.	Exposure points per hour	Time to reach EAV 2.5 m/s ² A(8)		Time to reach ELV 5 m/s ² A(8)		Exposure duration		Partial exposure m/s ² A(8)	Partial exposure points
			hours	minutes	hours	minutes	hours	minutes		
Tool or process 1	2.5	13	8		>24		2		1.3	25
Tool or process 2	7	98	1	1	4	5		30	1.8	49
Tool or process 3	15	450		13		53		45	4.6	338
Tool or process 4	1.5	5	22	13	>24		1		0.5	5
Tool or process 5										
Tool or process 6										

Lock Tool or process names

Zoom to fit
Help
Reset

Instructions for use:
 Enter vibration magnitudes and exposure durations in the white areas
 To calculate, press <Enter>, or move the cursor to a different cell
 The results are displayed in the yellow areas
 To clear all cells, click on the 'Reset' button
 Tick the 'Lock tool or process name' check box to prevent 'Reset' clearing these cells
 For more information, click the 'Help' button

Daily exposure m/s ² A(8)	Total exposure points
5.1	417

WARNING: Exposure above 5m/s²A(8) ELV (400 points)

For each tool, the user will be provided the length of time that a worker would need to be exposed to that tool/vibration level to exceed the medium and high risk ratings.

The calculator will also give you a green/yellow/red rating along with the daily exposure value, based on the EU's A(8) threshold values for the cumulative exposure of all tools.

5. Appendix A: Charts and References

5.1. The Stockholm-Workshop Scale

Table 2(a) The Stockholm Workshop classification scale for cold-induced vascular (blood flow) symptoms in fingers with hand-arm vibration syndrome		
Stage	Grade	Description
0	(none)	No attacks
1	Mild	Occasional attacks affecting only the tips of one or more fingers
2	Moderate	Occasional attacks affecting finger tips and middle of the finger and rarely also the finger parts close to the palm
3	Severe	Frequent attacks affecting most fingers
4	Very Severe	Same symptoms as in stage 3 with degenerate skin changes in the finger tips.

Table 2(b) The Stockholm Workshop classification scale for sensorineural changes in fingers due to hand-arm vibration syndrome	
Stage	Symptoms
OSN	Exposed to vibration but no symptoms
1SN	Intermittent numbness, with or without tingling
2SN	Intermittent or persistent numbness, reduced sensory perception
3SN	Intermittent or persistent numbness, reduced tactile discrimination and/or manipulative dexterity

Source: Gemne, G., et al. Scandinavian Journal of Work, Environment and Health. Vol. 13, no. 4 (1987). p. 275-278.

Chart from:

http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration_effects.html

5.2. Vibration levels of common tools

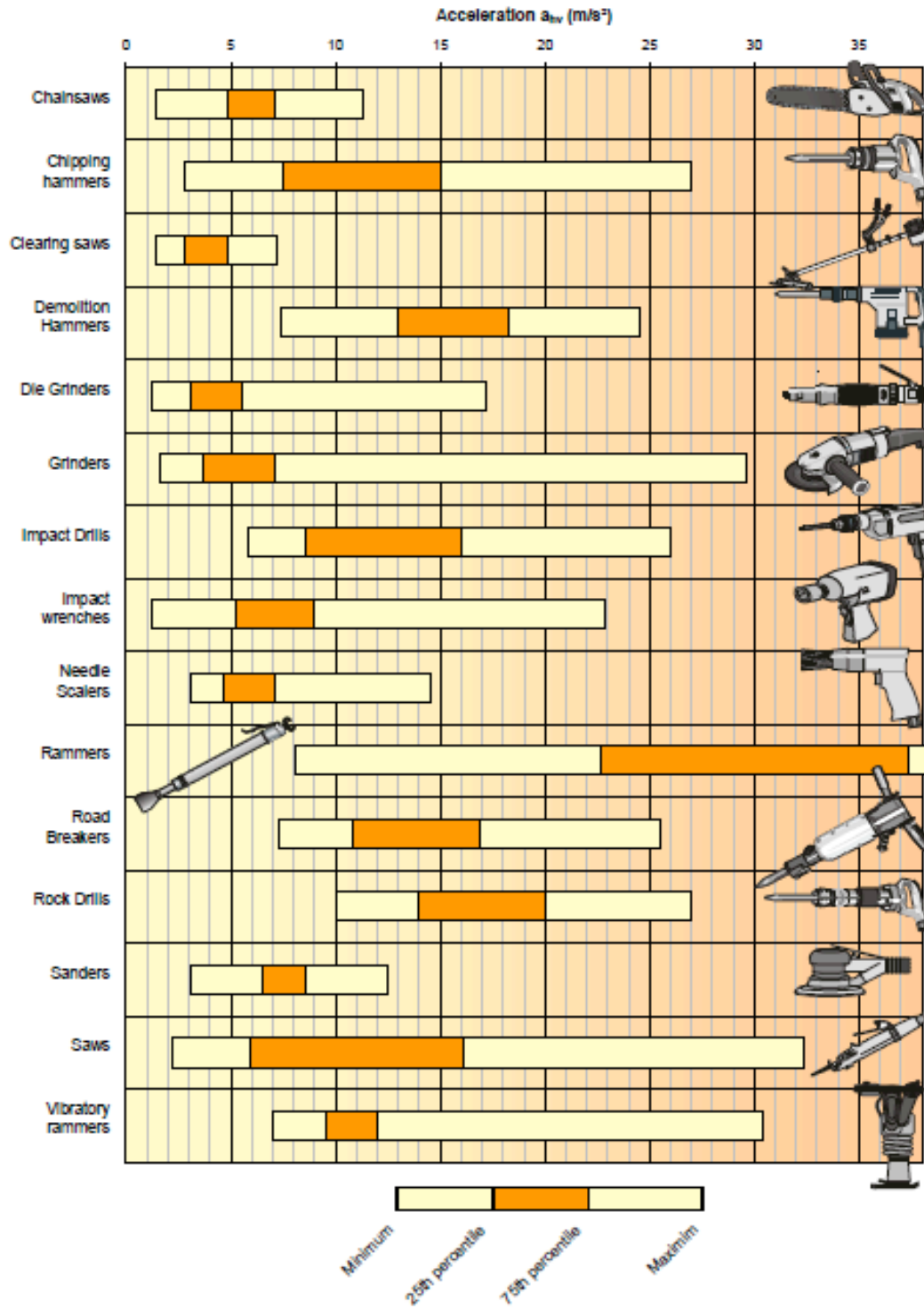


Chart from: EU Good Practice Guide to HAV

<http://resource.isvr.soton.ac.uk/HRV/VIBGUIDE/HAV%20Good%20practice%20Guide%20V7.7%20English%20260506.pdf>