Understanding and Lowering the Risk of Hand-Arm Vibration Syndrome (HAVS)

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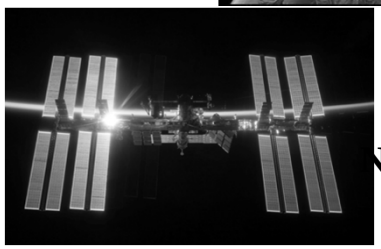
Neuromuscular cell biologist examining how tissues respond to the environmental stresses of gravity and vibration



NASA

NIOSH
R01 OH003493

Translate research to practice

Understanding and Lowering the Risk of Hand-Arm Vibration Syndrome

Overview

- Hand-Arm Vibration Syndrome (HAVS)
- Power tool vibration
- Risk assessment measurements
- Vibration injury reduction
- Worker responsibilities
- Employer responsibilities
- Information sources

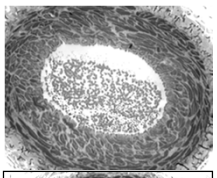
Workers exposed to hand-transmitted vibration in the USA

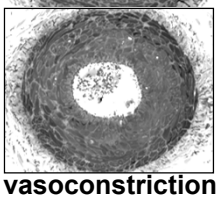
Industry	Type of tools	# of workers
Construction	Handtools	500,000
Truck, auto manufacturing	Handtools	250,000
Farming	Gasoline chain saws	200,000
Mining	Pneumatic drills	100,000
Steel	Furnace cleaning with powered tools	54,000
Furniture manufacturing	Handtools	34,000
Lumber and wood	Gasoline chain saw	30,000
Metal working	Handtools	14,000

National Occupational Research Agenda (NORA) Sectors: Agriculture, Forestry & Fishing; Construction; Manufacturing; Mining; Oil & Gas Extraction

1.25 million workers at risk estimated from Bureau Labor Statistics

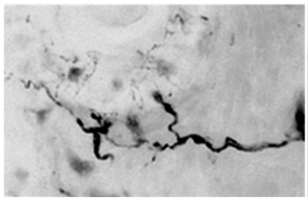
Hand-Arm Vibration Syndrome is a vasospastic, neurodegenerative and musculoskeletal disease





vasoconstriction

bone & joint degeneration



nerve degeneration

Carpal Tunnel Syndrome
tendons
nerves

Hand-arm vibration syndrome Stockholm Workshop staging scale

Stage Sensorineural Symptoms

0SN	Exposed to vibration, but no symptoms
1SN	Intermittent numbness with/without tingling
2SN	Intermittent or persistent numbness, reduced sensory perception
3SN	Intermittent or persistent numbness, reduced tactile discrimination and/or manipulative dexterity

Stage Vascular Symptoms (vibration white finger)

01	Blanching of fingertips, with/without tingling and numbness
02	Blanching beyond tips usually in winter, interference in non-work activities
03	Extensive blanching in summer/winter, interference in work activities
04	Extensive blanching, change in occupation

Level 3 disease is <u>irreversible</u>

Why does HAVS take years to develop and become permanent?

Indiana rock cutters in 1918 acquired HAVS after switching to percussive hammers and drills

Magnitude and duration of vibration from powered hand tools determine the rate and severity of injury

Repeated injury eventually exceeds the capacity or destroys the ability of the tissues to repair

Fundamental frequencies of powered hand tools

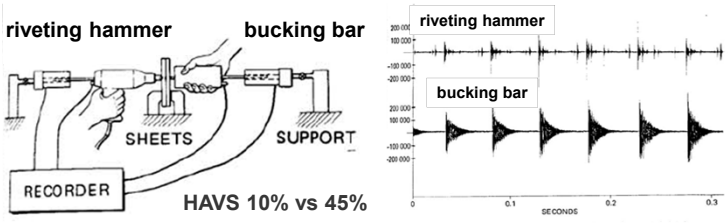
Power tool	Dominant frequency
Riveting hammer	30 Hz
Heavy duty sander	45 Hz
Impact wrench	50 Hz
Light duty sander	80 Hz
Palm orbital sander	90 Hz
Vertical polisher	100 Hz
Chainsaw	200 Hz

Hand-Arm Vibration Syndrome causation is linked primarily to 30-250 Hz sinusoidal vibration

Disease onset 3 to 5 years for tool use 4 hr/day

Impact percussive tools have low Hz and very high Hz shock wave energy

Impulse vibration from impact percussive tools has been studied less but may present a high HAVS risk

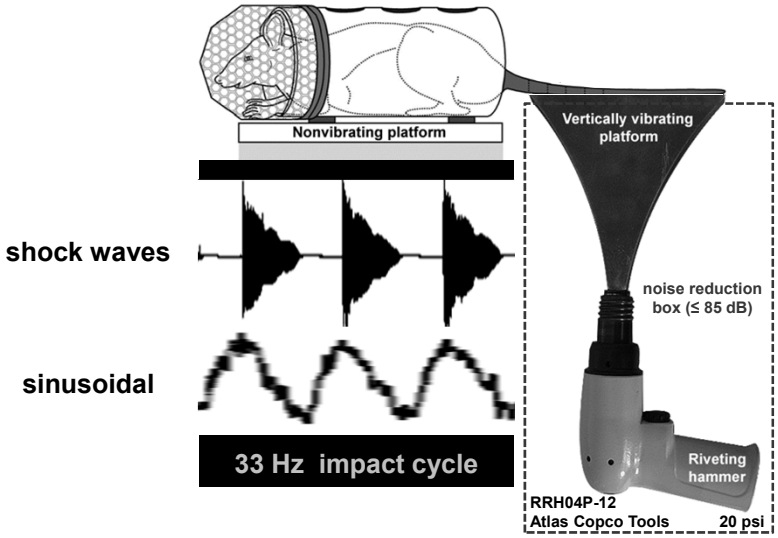


Dandanell and Engström, 1986

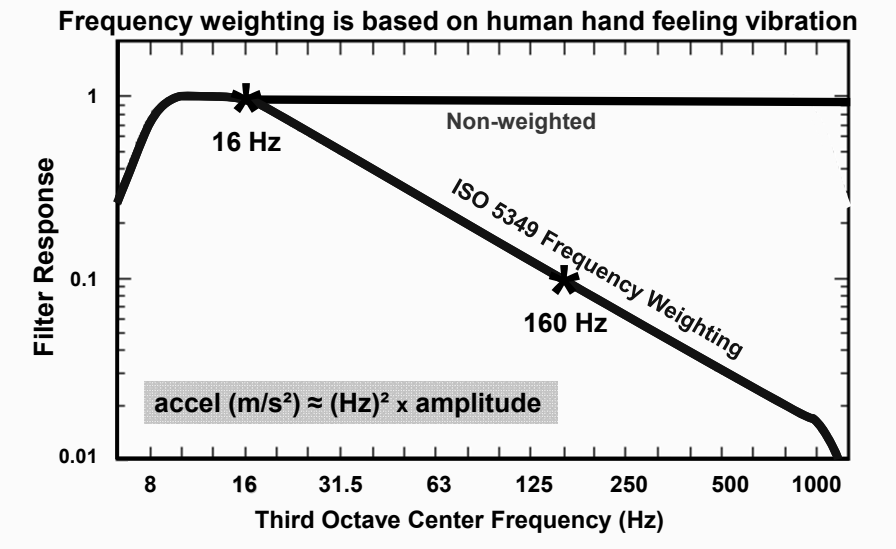
Increasing the total amount of daily use of impact tools shortens the time to onset of HAVS

use	onset
1 min/d	– 10 yr
15 min/d	– 2.5 yr
240 min/d	– 2.5 mo

Rat tail vibration model simulating bucking bar vibration exposure

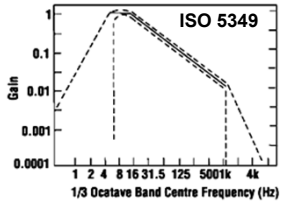


Is the European Standard ISO 5349 frequency-weighted reduction of acceleration magnitude underestimating injury risk?



Vibration exposure risk

What you can't feel can hurt you



What you can hear can hurt you

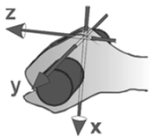
20 Hz – 20,000 Hz

Calculation of Hand-Arm Vibration daily exposure to weighted acceleration A(8) ISO 5349-1:2001

Sum of vibration magnitudes in 3 orthogonal axes (a_{hv})

triaxial accelerometer

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$



Daily exposure to vibration normalized to 8 hr day A(8)
T = total hr tool use, T_o = 8 hr

$$A(8) = a_{hv}\sqrt{\frac{T}{T_0}}$$

Are the European Union legal definitions of 8 hr day vibration exposure magnitude limits correct?

Exposure action value of 2.5 m/s^2 weighted A(8)

If exceeded, employer must take corrective action to lower exposure

Exposure limit value of 5.0 m/s^2 A(8)

If exceeded, stop activity immediately

Frequency weighting dismisses high frequency vibration energy and underestimates injury risk

HSE Health & Safety Executive

HAND-ARM VIBRATION EXPOSURE CALCULATOR

	Vibration magnitude m/s² r.m.s.	Exposure points per hour	Time to reach EAV 2.5 m/s² A(8) hours	Time to reach EAV 2.5 m/s² A(8) minutes	Time to reach ELV 5 m/s² A(8) hours	Time to reach ELV 5 m/s² A(8) minutes	Exposure duration hours	Exposure duration minutes
Tool or process 1	7.13	102	0	59	3	56		
Tool or process 2	98.6	19444	0	0	0	1		
Tool or process 3								

The frequency weighted acceleration of 7.13 m/s² is safe* for <59 min/day

*Staying below the EAV still leaves a 10% risk of getting HAVS in 12 years

Unweighted acceleration 98.6 m/s² requires stopping use in 1 min

Incidence of HAVS for riveting hammer

1 min/d – 10 yr

15 min/d – 2.5 yr

240 min/d – 2.5 mo

Is frequency weighting that reduces acceleration magnitude for frequencies above 16 Hz generating a false sense of security for vibration injury risk?

Yes, the weighted acceleration value underestimates risk

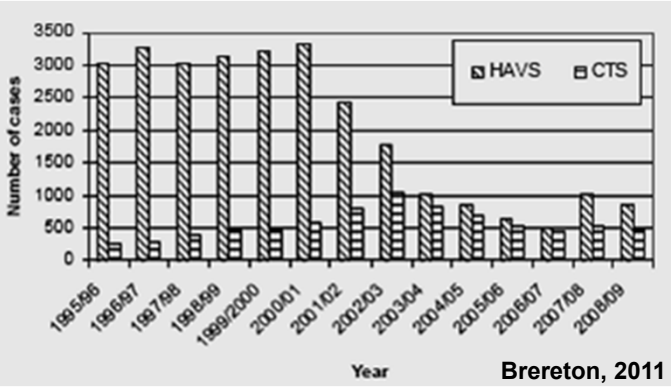
Has the implementation of vibration regulations reduced vibration injury?

Yes, but could do better with improved risk calculator

Currently, 3 schemes that include the high frequency energy components are being evaluated

Has implementation of vibration regulations reduced vibration injury in Great Britain?

Reduced number new cases seeking Industrial Injuries Disablement Benefits for Hand Arm Vibration syndrome



Brereton, 2011

- positive impacts in education and engineering
- greater recognition of hazardous vibration in the workplace
- more health monitoring
- increased availability of low vibration tools

Regulations for hand arm vibration exposure in US

Occupational Safety and Health Administration (OHSA) None exist

National Institute for Occupational Safety & Health (NIOSH) No standards

1989 review literature 89-106, but no setting of exposure limits
recommend exposure and health monitoring
recommend against ISO 5349 frequency weighting; use unweighted acceleration

American National Standards Institute Recommend ISO 5349

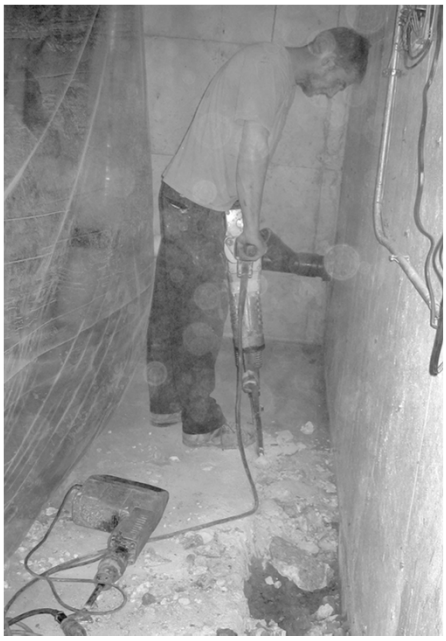
ANSI S2.70-2006 Threshold Limit Value (TLV)
recommend Daily Exposure Action Value 2.5 m/s^2
Daily Exposure Limit Value (8-hr equivalent exposure) 5.0 m/s^2

American Conference of Governmental Industrial Hygienist (ACGIH) Recommend Threshold Limit Values (TLV) 2008

4 m/s^2 limit to 4 to <8 hr/d
6 m/s^2 limit to 2 to <4 hr/d
8 m/s^2 limit to 1 to <2 hr/d
12 m/s^2 limit to <1 hr/d

Each exceeds ALV but less than ELV

Raise awareness of hazards



Low awareness of vibration disease "part of job"

cultural "wimps" wear PPE

low vibration tools more expensive (long run no)

years to develop disease (sinusoidal yes, but not impact)

always exceptions (60 yr Indiana disease-free stone driller)

no OSHA standards

surveillance (early intervention prevents chronic disease)

Antivibration gloves and medical monitoring reduce risk

Effective Intervention With Ergonomics, Antivibration Gloves, and Medical Surveillance to Minimize Hand–Arm Vibration Hazards in the Workplace

Jetzer T, Haydon P, Reynolds, R. J Occup Environ Med 2003

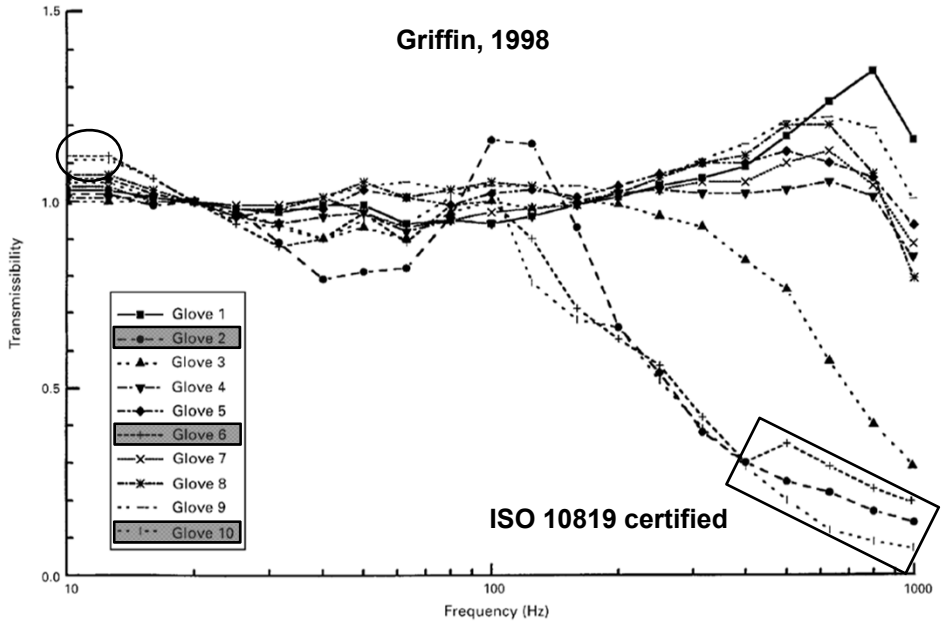
International Standards Organization ISO 10819:1966 and American National Standards Institute ANSI S3.40 :2002 define how to measure glove properties (transmissibility) for certification

Transmissibility Tz M Hz ≤ 1.0; Tz H Hz ≤ 0.6
Medium Hz (16-400 Hz) High Hz (100-1600 Hz)

Anti-vibration certified ISO 10819 (1996) revised so that the glove fingers no longer have to be identical to palm construction ISO 10819/CD 2010

M-spectrum 31.5-200Hz, H-range 200-1250Hz

Antivibration gloves block high Hz, may increase low Hz



Certified anti-vibration gloves

Glove vibration absorbing strategies

- polymer pad
- air bladder
- air cells

Manufacturers listing ISO 10819 certified gloves

- Chase Ergonomics Decade® (Gfom)
- ErgoAir (air bladder)
- Ergodyne (Nu^2O_2)
- Impacto (air cells)
- Valeo (air bladder)

To glove or not to glove?

The decision is not straightforward

Efficacy and durability field testing is needed for specific tools and tasks

Current EU position: Gloves can be used to keep hands warm, but should not be relied upon to provide protection from vibration below 500 Hz

If vibration energy in frequencies >500 Hz are causing injury, then gloves reducing the high frequency component should be beneficial

Positive effects	Negative effects
reduce HAVS risk (1 study with monitoring)	reduced ability to grip (30-45%)
keep hands warm	hand fatigue
keep hands dry	compression of blood flow
reduce high Hz impact vibration	reduced dexterity
	awkward postures carpal tunnel syndrome
	reduced sensory perception
	amplify low Hz vibration

Anti-vibration engineered tools

- Request low vibration engineered tools
- Check manufacturer's declared acceleration value
- Field testing and measurement recommended
- Success stories reengineered low vibration tools

  Chainsaw
  Rock drill

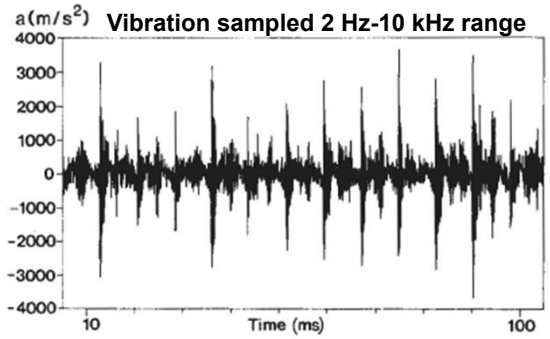
Chainsaw lacking antivibration mounts

1968
Model 090
3.5 ft bar

Prevalence of vibration white finger was 40% (1972)
Chainsaws manufactured with antivibration mounts 5% (1990)

Shock isolation of chainsaw handle from motor dramatically reduced vibration-induced disease

Homelite 1958 frame mounted engine
Raket 1982 anti-vibration mounted engine



Starck etal 1983; Starck 1984

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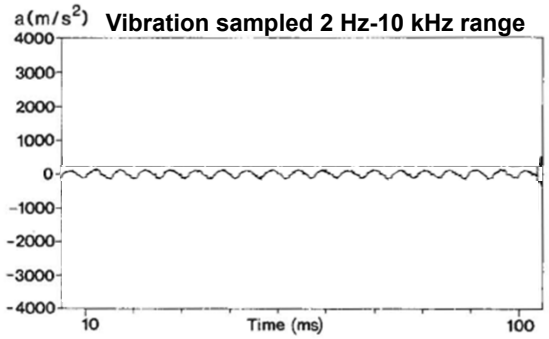


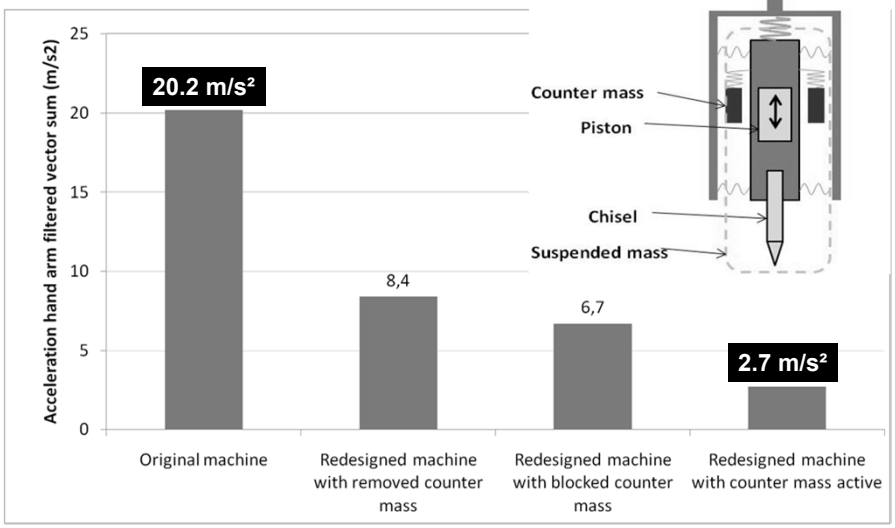
ISO 5349 weighted accelerations decreased from 9.1 m/s² to 2.2 m/s²

HAVS latency increased from 5 to 25 years and prevalence fell from 40% to 5%

Starck etal 1983; Stark 1984

Conventional rock drill jarring, bucking and noisy "Have to muscle it and feel it working"

Antivibration engineered



Swedish Institute of Production Engineering Research, Goteborg, Sweden

Antivibration rock drill not required to be manhandled Ergonomic and antivibration handle

Databases of vibration specifications for powered hand tools

CDC power Tools Database
http://wwwn.cdc.gov/niosh-sound-vibration/

Umeå University, Faculty Medicine, Depart Public Health Clinical Medicine, Occupational Environmental Medicine
http://www.vibration.db.umu.se/HavSok.aspx?lang=en

What should the worker know and do?

Understand when at risk for HAVS

When work regularly with sinusoidal hand powered tools more than a few hours each day or 15 minutes a day with impact tools

Recognize symptoms of vibration injury

Tingling and numbness in the fingers
Cold exposure triggers finger blanching (vibration white finger)
Weakness in the hands

Try to lower risk

Use low vibration and well maintained tools, short duration use, avoid over-gripping, warm tool handles, keep hands dry and warm, avoid nicotine, consider wearing antivibration gloves

Proactive awareness

Recognize early signs of HAVS, report symptoms to health officer and employee representative

Guidelines for safe use of vibrating power tools

- **Avoid bare hand contact to guide chisels, sockets, bucking bars and metal work pieces (you cannot feel the full energy of high Hz shock waves)**
- **Avoid increasing vibration-induced blood vessel constriction by using nicotine and exposing hands to cold temperature; keep hands dry and gloved to reduce loss of heat**
- **Grasp tool as lightly as feasible to reduce energy transfer**
- **Take 10 min breaks? (this is not documented; if works, positive effect may be from reduced daily exposure to vibration)**
- **Rotate off work tasks using vibrating tools to minimize daily exposure and not exceed daily exposure limits**
- **Use low vibration tools and maintain tools to minimize vibration**

What should the employer know and do?

Know what jobs are vibration hazardous

- accelerations of sinusoidal and impact tools used
- duration of vibration exposure

Provide training, protective gear, low vibration tools

- good work practices, gloves, tool maintenance

Understand hand-arm vibration syndrome

- early signs and symptoms and health effects

Establish health surveillance and monitoring

- identify workers at risk
- catch early (reversible) disease
- prevent disease progression and disability
- assess efficacy of vibration reduction measures

Contacts in Vibration Injury

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