IOHA 2005
6th International Scientific Conference
Pilanesberg, South Africa

Occupational Vibration Exposure

Canadian Centre for Occupational Health and Safety
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Materials were used from the following:

- Richard Neitzel, MS, IHIT
- Michael Yost, PhD
- University of Washington
- Department of Environmental Health
- Queensland University Au website
Occupational Vibration Exposure

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Occupational Vibration Exposure
IOHA Conference 2005
Occupational Vibration Exposure

1. Introduction
2. Vibration Basics
3. Types of Vibration Exposure - Hand Arm and Whole Body Vibration Exposure
4. Why Worry About Vibration Exposure
Occupational Vibration Exposure

5. Hand Arm Vibration Exposure
6. Whole Body Vibration Exposure
7. Vibration Exposure Standards
8. Exposure Control
9. Case Examples
Introduction: The Work of Health and Safety

- Identify the Hazard
- Evaluate the Risk
- Develop a Program: Eliminate or Reduce Risk
- Implement the Program
- Evaluate Effectiveness
- Improve Continuously
Vibration Basics

- Vibrating Object
- Displacement
- Hi
- Lo
- Amplitude
- Time
- 1 Cycle

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Measures of Vibration Exposure

Magnitude: Acceleration meters per second squared (m/s²)

Frequency: Hz

Direction: x, y, z

Exposure duration: Years

Posture: Awkward. Static
Quantifying Vibration Exposure

- Measure vibration exposures by task, tool, trade, operation
- Determine worker exposure
- Identify problematic equipment
- Recommend appropriate control strategies
- Assess potential of worker self-reporting
Types of Vibration Exposure

Whole Body Vibration: Vibration transmitted through a supporting area to whole body: sitting in a chair, standing on vibrating ground 0.5 - 80 Hz; ISO 2631-2
Sea sickness 0.1 - 0.5 Hz, ISO 2631-1

Hand Arm Vibration: Vibration transmitted through hand: holding a vibrating tool, 5 - 1500 Hz, ISO 5349-1
Occupational Exposures

- Whole Body Vibration
- Agriculture
- Construction
- Forestry
- Transportation etc

- Hand-Arm Vibration
- Boiler Making
- Forestry
- Furniture Making
- Road Construction etc

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Why Worry About Vibration?

- Regular and frequent exposure to vibration can lead to permanent health effects.
- This is most likely when contact with a vibrating tool or work process is a regular part of a person’s job.
Vibration Adversely Affects the Body

- Mechanical Effects
- Psychological Effects
- Very difficult to assess
- Contributes to WMSDs
Risk Assessment of Vibration Exposure

- Magnitude, type and duration of exposure
- Health effects of exposure to vibration
- Effects of vibration on the workplace and work equipment
- Information provided by the manufacturers
Risk Assessment of Vibration Exposure

- Availability of replacement equipment designed to reduce vibration exposure
- Exposure beyond normal working hours
- Working conditions such as low temperatures
Hand-Arm Vibration Exposure
# Examples - Tools That Can Cause Hand-Arm Vibration Injuries

<table>
<thead>
<tr>
<th>Chipping Hammers</th>
<th>Grinders</th>
<th>Cutters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestal Grinders</td>
<td>Nut Runners</td>
<td>Sanders</td>
</tr>
<tr>
<td>Road Breakers</td>
<td>Power Hammers</td>
<td>Chainsaw</td>
</tr>
<tr>
<td>Hammer Drills</td>
<td>Trimmers</td>
<td>Lawnmowers</td>
</tr>
</tbody>
</table>
Health Effects

- Vascular (Vibration White Finger)
- Sensory Nerve Damage
- Musculoskeletal
When is it Hazardous

- Regular and frequent exposure to high levels
- Prolonged Contact with vibrating tools
- Occasional exposure is unlikely to cause injury
- People with medical conditions such as Reynaud’s disease are at high risk
Hand Arm vibration Can Affect Routine Activities

- It can limit the work we can do
- It can affect what we do in our leisure time
- We may have difficulties carrying out tasks that require fine movement or manipulation
Signs and Symptoms

Sensory Nerve Damage

- Loss of sense of touch or temperature
- Numbness or tingling in the fingers (possibly constantly)
Signs and Symptoms

**Musculoskeletal**

- Loss of grip strength in the hands
- Pain in your hands and fingers
- Painful wrists
White Finger

www.whitefinger.co.uk/images/hand.jpg
Hand Arm Vibration Syndrome 2

Rare case of gangrene in hands of vibrating pneumatic hand-tool operator at terminal stage of irreversible Hand Arm Vibration Syndrome 2
Correlation of Vibration Data

Correlation of vibration data and latent interval
### Table 4: Average Latent Periods for Vibration-induced Diseases in Different Occupations

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Stage of VWF</th>
<th>Latency (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundry worker</td>
<td>Tingling</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Numbness</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>Blanching</td>
<td>2.0</td>
</tr>
<tr>
<td>Shipyard worker</td>
<td>Tingling</td>
<td>9.1</td>
</tr>
<tr>
<td></td>
<td>Numbness</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>Blanching</td>
<td>16.8</td>
</tr>
<tr>
<td>Chainsaw operator</td>
<td>Numbness</td>
<td>4</td>
</tr>
<tr>
<td>Grinder</td>
<td>Blanching</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Source: Vibration effects on the hand and arm in industry. Edited by A.J. Brammer et al. New York: John Wiley and Sons, 1982
Vibration Induced Disorders of the Hand

- Hand-Arm Vibration Syndrome (HAVS)
- Vascular Disorders - Raynaud's Syndrome (white-finger); complex reduction of blood flow
- Bone and Joint
- Neurological and Muscular disorders
- Sensory loss
- Muscle atrophy: voluntary & involuntary contractions contributing to fatigue
### Stockholm (Revised) Hand-arm Vibration Syndrome Classification System (Vascular)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Attacks</td>
</tr>
<tr>
<td>1</td>
<td>Occasional, 1 or More Finger Tips</td>
</tr>
<tr>
<td>2</td>
<td>Occasional, Distal &amp; Middle Finger</td>
</tr>
<tr>
<td>3</td>
<td>Frequent Attacks All / Most Fingers</td>
</tr>
<tr>
<td>4</td>
<td>Same as 3 With Skin Change in Finger Tips</td>
</tr>
</tbody>
</table>
# Stockholm (Revised) Hand-arm Vibration Syndrome Classification System (Sensory Neural)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>0SN</td>
<td>No Attacks</td>
</tr>
<tr>
<td>1SN</td>
<td>Intermittent Numbness</td>
</tr>
<tr>
<td>2SN</td>
<td>Same as 0SN + Reduced Sensory Perception</td>
</tr>
<tr>
<td>3SN</td>
<td>Same as 2SN with Reduced Tactile &amp; Discrimination &amp; Manipulative Dexterity</td>
</tr>
</tbody>
</table>
Objective Tests

- Cold Provocation Test
- Plethysmography
- Two Point and Depth Sense
- Vibro-Tactile Threshold
- Moberg Pick-up and Object Recognition
- Nerve Conduction Velocity
## Effect of Smoking on Railway Track Maintenance

<table>
<thead>
<tr>
<th></th>
<th>#</th>
<th>Age (y) Mean(sd)</th>
<th>Work (y) Duration (sd)</th>
<th>VWF %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonsmoker</td>
<td>53</td>
<td>37.6 (13)</td>
<td>11.7 (9.6)</td>
<td>8.0</td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>70</td>
<td>46.8 (10.4)</td>
<td>17.1 (10.2)</td>
<td>16.9</td>
</tr>
<tr>
<td>Smoker</td>
<td>127</td>
<td>39.0 (10.3)</td>
<td>12.2 (7.2)</td>
<td>18.4</td>
</tr>
</tbody>
</table>

*Int J Ergo 13 (1994) 247*
What increases the risk?

- How high the vibration levels are
- How long the equipment is in use
- How awkward it is to use the equipment
- How tightly the equipment is gripped
- How cold and wet the individual is during use
- Social & medical factors
Hand Arm Vibration Measurement

- Instrumentation
- Measurement methodology
Measurement of Hand Arm Vibration Exposure

- Triaxial accelerometer is typically used
- Standards (ISO 5349; ACGIH) provide detailed guidelines on measuring vibration.
- Acceleration levels are weighted according to frequency to determine if vibration level is "acceptable" for a certain exposure.
Measuring Hand Arm Vibration

\[ Z_h \]
\[ X_h \]
\[ Y_h \]
Measuring Hand Arm Vibration
Measuring Hand Arm Vibration

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Hand Arm Vibration Weighting Curve

![Hand Arm Vibration Weighting Curve](image-url)
Typical Vibration Levels
http://www.hse.gov.uk/vibration/index.htm

- Pneumatic stone-working hammers
  Vibration-reduced hammers & sleeved chisels 8-12 m/s²
  Older tools, conventional chisels 30 m/s²

- Chainsaws Typical 6 m/s²

- Brush cutters Typical 4 m/s², Best 2 m/s²

- Sanders (random orbital) Typical 7-10 m/s²
Examples of Hand Arm Vibration Exposure Levels

Notching Stumps: $A_{EQx} > 23.36 \text{ m/s}^2$
  - TLV less than 1 hr/day

Felling Trees: $A_{EQx} > 8 \text{ m/s}^2$
  - TLV: 1-2 hrs/day
Vibration Dose

- Combines vibration magnitude and time
- "Normalised" over standard 8-hour working day, expressed as the value, \( A(8) \) in m/sec\(^2\)
- The \( A(8) \) aids comparison between exposure patterns and assessment of health risk
- A programme of actions is recommended where the \( A(8) \) regularly exceeds 2.5 m/sec\(^2\)
Minimizing Exposure

- Make sure your tools are maintained
- Use the right tool for the job
- Do not use any more force than necessary
- Avoid long periods of use without a break
- Keep yourself warm
- Report any symptoms
Exposure Limits
Table 1: TLVs for Exposure of the Hand to Vibration in Either of the X, Y, or Z direction*

<table>
<thead>
<tr>
<th>Total Daily Exposure Duration (hours)</th>
<th>Maximum value of frequency weighted acceleration (m/s²) in any direction*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to less than 8 hours</td>
<td>4</td>
</tr>
<tr>
<td>2 to less than 4 hours</td>
<td>6</td>
</tr>
<tr>
<td>1 to less than 2 hours</td>
<td>8</td>
</tr>
<tr>
<td>less than 1 hour</td>
<td>12</td>
</tr>
</tbody>
</table>
EU Vibration Exposure and Action Limits, A(8)

Hand Arm Vibration

- Exposure Limit 2.5 m/s²
- Exposure Action Value 5.0 m/s²
Exposures Equivalent to the Daily Action and Limit Values
Recap

- Potential sources of Hand-Arm vibration
- Risk factors
- Signs & symptoms
- Use tools correctly
- Protect yourself
- Report problems
Whole Body Vibration
Fig. 1. Simplified mechanical system representing the human body standing on a vertically vibrating platform.
Health Effects of Prolonged Exposure to Whole Body Vibration

- Lumbar spinal disorders
- Hemorrhoids
- Hernias
- Digestive problems
- Urinary problems
Effect of Vibration on Spine

- Increased risk in low-back pain for drivers of trucks, buses, and vehicles, aircraft, power tools.

Three Frequency Ranges
- Low Frequencies 0-2 Hz
- Middle Frequencies 2-20 Hz
- High Frequencies >20 Hz (cranes, vehicles, aircraft, power tools)
Vibration Measurement

- Triaxial accelerometer is typically used.
- Standards (ISO 5349; ACGIH) provide detailed guidelines on measuring vibration.
- Acceleration levels are weighted according to frequency to determine if vibration level is "acceptable" for a certain exposure.
Exposure Standards - Vibration
H-A and W-B vibration measured in 3 axes
Methods

- Workers participate voluntarily
- Participation incentives
- Exposures Measurement at various sites and for various tasks:
  - Workers fill out self-report task data cards listing timing of daily tasks/tools
  - Workers observed periodically to assess self-report accuracy
Instrumentation

Commercia[lly available

Log continuously throughout vibration event

PC download yields event runtime, overall $A_{EQ}$, and $L_{max}$, $L_{min}$, $L_{peak}$, and $A_{EQ}$ for three channels

Triaxial measurements using three piezoelectric accelerometers
Example of Results

Reading Type = Whole-Body, Weighted

<table>
<thead>
<tr>
<th>Tool or Equipment</th>
<th>Summary Aeq Level, m/s²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulldozer</td>
<td>18</td>
</tr>
<tr>
<td>Excavator</td>
<td>16</td>
</tr>
<tr>
<td>Front End Loader</td>
<td>14</td>
</tr>
<tr>
<td>Grader</td>
<td>12</td>
</tr>
<tr>
<td>Processor</td>
<td>10</td>
</tr>
<tr>
<td>Shovel</td>
<td>8</td>
</tr>
<tr>
<td>Stacker</td>
<td>6</td>
</tr>
<tr>
<td>Truck</td>
<td>4</td>
</tr>
<tr>
<td>Yarder</td>
<td>2</td>
</tr>
</tbody>
</table>

N = Number of Observations

Occupational Vibration Exposure
IOHA Conference 2005
Examples of Vibration data

Reading Type = Whole-Body, Weighted

Summary Aeq Level, m/s²

<table>
<thead>
<tr>
<th>Secondary Task</th>
<th>N</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving Truck</td>
<td>10</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Grading Road</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Idling</td>
<td>26</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Landing Logs</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Loading Logs</td>
<td>22</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Moving Logs</td>
<td>13</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving Vehicle</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Processing Logs</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Scraping Gravel</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Spreading Rock</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Stacking Logs</td>
<td>7</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Spreading Gravel</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Total Daily Exposure Duration, hrs</td>
<td>Value of Dominant RMS Acceleration Component, m/s²</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>8 to less than 16</td>
<td>2.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4 to less than 8</td>
<td>3.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 to less than 4</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to less than 2.5</td>
<td>8.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 min to less than 1</td>
<td>12.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 min to less than 25 min</td>
<td>14.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 min to less than 16 min</td>
<td>19.2</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Daily (8 hour) Exposure Limit (UK)

- Daily exposure limit value 1.15 m/s²
- Action value 0.5 m/s²
Whole Body Vibration Exposure ACGIH TLV

- Same as ISO 2631
- Presented a set of graphs
- Frequency Weighting
- Axis weighting
- Exposure time weighting
Vibration Exposure During Pregnancy: Prevention

It is advised that pregnant workers and those that have recently given birth avoid work that is likely to involve uncomfortable, whole body vibrations, especially at low frequencies, or where the abdomen is exposed to shocks or jolts.

South Africa 1998/reg98-1441
Directive 2000/14/EC (Almost all equipment for use outdoors)

- Daily exposure action value: 0.5 m/s²
- Daily exposure limit value: 1.1 m/s²
# Whole-body Vibration Exposure Limits in x, y, or z Directions

*Work Safe BC Canada*

<table>
<thead>
<tr>
<th>Daily Exposure Duration</th>
<th>Values of the dominant, frequency-weighted (rms), component acceleration, ms(^{-2})</th>
<th>Health risks likely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No clear effects</td>
<td>Caution</td>
</tr>
<tr>
<td>4 hours</td>
<td>Less than 0.6</td>
<td>0.6 to 1.1</td>
</tr>
<tr>
<td>8 hours</td>
<td>Less than 0.5</td>
<td>0.5 to 0.9</td>
</tr>
</tbody>
</table>

(rms = root mean square, ms\(^{-2}\) = metres per second squared)
Whole Body Vibration Case Study

What are the risk factors?

Source: University of Queensland
Examples of Vibration Exposure Levels

Whole Body Vibration

- Bulldozer, FEL, Grader: $A_{EQz} > 4.84 \text{ m/s}^2$
  - 2.5-4 hrs/day recommended by TLV, but operated 8 hrs
  - Overall $A_{EQz}$ for Operating Vehicle: $2.39 \text{ m/s}^2 = 4-8 \text{ hrs/day}$
Examples of Vibration Exposure Levels

Hand-Arm Vibration

- Notching Stumps: \( A_{EQ} \times 23.36 \, m/s^2 \)
  - >12 \( m/s^2 \) ; TLV less than 1 hr/day
  - Chainsaw, Felling Trees: \( A_{EQ} > 8 \, m/s^2 \)
  - TLV: 1-2 hrs/day but done for 4-5 hrs
EU Vibration Exposure and Action Limits, A(8)

Whole Body Vibration
- Exposure Limit 1.15 m/s²
- Exposure Action Value 0.5 m/s²

Hand Arm Vibration
- Exposure Limit 2.5 m/s²
- Exposure Action Value 5.0 m/s²
Vibration Control

Reducing vibration produced and emitted by the source;

Preventing the propagation, and amplification of vibration;

Isolating the workers from vibrating tools and equipment.
Whole-body Vibration (WBV) Control

- Suspended adjustable seat with vibration-damping mechanism
- Balanced vehicle wheels
- Tires with a low vibration tread pattern
- Reduced speed over bumpy surfaces
- Avoid sudden load changes (pick up, drop off)
Whole-body Vibration (WBV) Control

- Avoid bumping into obstacles while driving
- Fit vibration-damping mechanisms
- Maintain shock absorbers on vehicles
- Isolate booths/cabs, etc.
- Train workers
Hand-arm Vibration (HAV) Control

- Properly maintained tools, anti-vibration mounts and suspended handles
- Grinders with effective, balanced, grinding discs
- Dynamically balanced. Rotary tools
- Grip on the tool handle with the least hand strength practicable
- Handles with a resilient wrapping layer cover
Hand-arm Vibration (HAV) Control

- "Antivibration" gloves meeting the requirements of *ISO standard 10819-1996*
- Tools with lower vibration level
- Substitution by a process to eliminate or reduce the need for vibrating tools
- Shorter daily exposure time by job rotation
Vibration Isolators
Selection a Vibration Isolator

- Establish the total weight and forcing frequency of the equipment to be isolated
- Determine the Static defecion required to provide the degree of isolation desired
- Select appropriate spring mounts from the listed spring constants of the mounts supplied by the manufacturer
Natural Frequency (Fn) of a Vibration Isolator

- \( \text{Fn (Hz)} = 4.98 \left[ \frac{1}{\text{static deflection, cm}} \right]^{1/2} \)

- \( \text{Fn (Hz)} = 3.13 \left[ \frac{1}{\text{static deflection, inch}} \right]^{1/2} \)
Active 'skyhook' or inertial damping (Karnopp 1975)

Transmissibility ($\frac{v_e}{v_b}$)

- Passive damping
  - $\zeta = 0.1$
  - $\zeta = 0.6$

- Skyhook damping
  - $\zeta = 0.6$

Excitation Frequency

Random base disturbance

Stiff base structure with imposed velocity

Absolute velocity feedback

Equipment mass

Equivalent skyhook damper

Equipment mass

Stiff base structure with imposed velocity
Mechanical system

Vibrations Suppression

Sensor

Controller

Interaction
Reduces vibrations
Reduces overall response
Destructive interference

Secondary vibrational response

Control signal sensor

Actuator

Occupational Vibration Exposure
IOHA Conference 2005
Example

A motor-generator unit weighing 700 lbs and 500 lbs, respectively, is to be installed in a vibration sensitive area. The motor turns 3600 rpm and the generator at 1800 rpm. Select four spring mounts which will provide a transmissibility of no more than 5%.
Whole Body Vibration Data Base

http://umetech.niwl.se/Vibration/WBVHome.html
Hand Arm Vibration Data Base

http://umetech.niwl.se/Vibration/HAVHome.html
Thank you for your attention