What Construction Safety Professionals Need To Know About Reducing Risks Associated With Hand-Arm Vibration

Washington Metropolitan Area Construction Safety Association

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What is Vibration?

Physical/Natural and man-made phenomena characterized and described by:

- Frequency, pitch (Hz)
- Amplitude, loudness (decibels)
- Acceleration, units for measuring a vibrating object
  - Meters per second squared, m/sec²
Vibration Measurement

- Vibration is a vector quantity (magnitude and direction) measured simultaneously in three directions: x, y and z.
- Typically measured on the surface closest to the affected user
  - Vehicle seat for WBV
  - Power hand tool handle for segmental vibration

Vibration Exposure

- Two general categories
  - Whole body vibration – 0.5 to 80Hz
    - Heavy equipment operators, truck drivers
  - Hand-arm vibration (5 Hz to 1250 Hz)
    - Shipyards, foundries, construction work
    - NIOSH estimates 0.5-1 workers are at risk
      - No one knows for sure how many potentially exposed persons there are in the U.S. – only general estimates
What is Hand-Arm Vibration?

- Energy into the hands/arms from vibrating tools

- Important Factors:
  - magnitude
  - direction
  - frequency
Hand-Arm Vibration has these same issues:

- A major source of lost time
- Inadequate professional awareness and knowledge
- Limited exposure assessment data
- Lack of mandatory standards in the U.S.

Paschold and Mayton, Professional Safety, April 2011, “Whole Body Vibration - Building Awareness”
Hand-Arm Vibration Syndrome (HAVS)

- A disabling, preventable occupational disease
- Formerly called “Vibration White Finger” or Reynaud’s Disease of Occupational Origin
- Early stage HAVS is reversible assuming no continuation of exposure, however continued exposure causing later stage disease leads to a permanent, potentially disabling condition
- Consists of both neurological (sensorineural) and vascular components
- Workers are risking damage to nerves and blood vessels and muscles in the hand, wrist and arms by working regularly with hand-held or hand-guided high vibration power tools for more than a few hours each day.
- The disease can be minimized through a risk assessment and evaluation which considers vibration exposure and duration.

Early Signs of HAVS

- Tingling, pain and numbness in the fingers which can cause sleep disturbance
- Loss of feeling in the fingers
- Weakness in the hands (less able to hold objects or pick up small objects)
- Cold sensitivity
Hand Vibration Injuries

HAVS Classification System

- **Vascular Component**
  - 1, Mild: Occasional blanching attacks affecting fingertips
  - 2, Moderate: Occasional attacks of one or more fingers
  - 3, Severe and Very Severe: Skin changes

- **Sensorineural Component**
  - 1SN: Intermittent or persistent numbness with or without tingling
  - 2SN: Reduced sensory perception
  - 3SN: Reduced tactile discrimination and manipulative dexterity
An Ignored Disease?

- In 1918, Alice Hamilton identified and documented HAVS in Indiana limestone quarry workers.
- Sixty years later in 1978, NIOSH (Don Wasserman) completed a study at the same quarry and the incidence of disease was the same, about 80% of the exposed workers had symptoms of HAVS.
  - Up to 1978, there were no changes in pneumatic rock-breaking tools.
  - To this day, “attack rate” is about 50% for “at risk” exposed workers.

Population at Risk

- Health and Safety Executive (HSE) in Britain estimates 2 million persons are at risk in the U.K.
- NIOSH estimated 1.5 million at risk in the U.S.
  - Seems to underestimate the affected population based on the number of working persons in Britain compared to the number of worker persons in the U.S.
- Using HSE estimates, more than 3 million U.S. workers are at risk.
- The European Agency for Safety and Health at Work data shows between 5 and 10% of workers in the EU are exposed to a potential HAVS risk from the use of powered hand tools.
- No one knows for sure the number of U.S. workers at risk because of disease under-reporting.
Why has Hand Arm Vibration Syndrome Remained Under-Recognized and Poorly Controlled?

- Regulatory climate
- Medical community communication and attention
  - Confusion with Carpal Tunnel Syndrome
- Technical challenges in exposure measurement
- Safety professionals have not communicated issues to technical managers and process owners

Lack of Attention to Vibration in U.S.

- HAVS is an internationally recognized preventable occupational disease that currently receives little attention from U.S. regulatory authorities.
  - Worker exposures continue virtually unabated
- Industry needs awareness and fiscal motivation in the anticipation, recognition, evaluation and control of hazards from hand-arm vibration and the prevention of vibration-induced disease.
- U.S. regulations, particularly OSHA Permissible Exposure Limits (PELs), continue to lag behind other nations, particularly Europe.
  - No OSHA criteria for segmental vibration.
  - No apparent plans to introduce vibration current regulatory criteria and improvements in the process designed to promote such worker protection.
Vibration Regulations

- No U.S. regulatory requirements (although there are ANSI Standards)
- NIOSH published a *Criteria for a Recommended Standard for occupational exposures to hand-arm vibration* in 1989.
- Vibration risk assessment and control is a legal requirement in the EU
  - EU Directive 2002/44/EC 25 June 2002 sets minimum health and safety requirements regarding the exposure of workers to the risks arising from vibration
  - UK “Control of Vibration at Work Regulations became law in 2005 to protect workers from vibration

Hand-Held Power Tools at Risk

- Concrete breakers
- Hand held Sanders
- Grinders and disc cutters
- Hammer drills
- Chipping hammers
- Chainsaws, brush cutters and hedge trimmers
- Powered mowers
- Scabblers
- Needle guns
- Cut-off saws
- Impact wrenches
- Jigsaws
- Polishers
- Power hammers and chisels
- Rivet guns
Definitions

- **ELV – Exposure Limit**
  Value EU legal limit on vibration, \( A(8) = 5 \) m/s²

- **EAV – Daily Exposure**
  Action Value: \( A(8) = 2.5 \) m/s²

- **EU Requirements:**
  Develop program of controls to reduce HAVS risk
  - Health surveillance
  - Information and training for affected persons
Occupational exposure limits for hand-arm vibration demonstrate a good correlation between exposures to vibration (measured as acceleration) and the incidence & prevention of disease.

An example from the forestry industry (Koskimies et. al. 1992):

<table>
<thead>
<tr>
<th>Equipment Type (Chain Saw)</th>
<th>Vibration (m/s²)</th>
<th>Prevalence of HAV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing equipment (unimproved) (1972)</td>
<td>14 m/s²</td>
<td>40%</td>
</tr>
<tr>
<td>Anti-vibration design (1990)</td>
<td>2 m/s²</td>
<td>5%</td>
</tr>
</tbody>
</table>

Process | Vibration magnitude (m/s²) | Time to reach | Alternative methods |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EAV</td>
<td>ELV</td>
<td></td>
</tr>
<tr>
<td>Breaking concrete, asphalt, etc. with hand-operated breakers</td>
<td>5 (lowest)</td>
<td>8 hr</td>
<td>Minimize breaking through concrete with construction plan</td>
</tr>
<tr>
<td></td>
<td>12 (typical)</td>
<td>20 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 (highest)</td>
<td>10 min</td>
<td></td>
</tr>
<tr>
<td>Demolition of concrete/masonry using hand-held hammers/breaker</td>
<td>8 (lowest)</td>
<td>45 min</td>
<td>Use alternative equipment</td>
</tr>
<tr>
<td></td>
<td>15 (typical)</td>
<td>16 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25 (highest)</td>
<td>5 min</td>
<td></td>
</tr>
<tr>
<td>Concrete surface preparation (Scabbling)</td>
<td>5 (lowest)</td>
<td>2 hr</td>
<td>Specify finishes that do not require scabbling. Use alternative methods where technically appropriate: chemical retarders and pressure washing</td>
</tr>
<tr>
<td></td>
<td>18 (highest)</td>
<td>10 mins</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40 (highest)</td>
<td>2 mins</td>
<td></td>
</tr>
<tr>
<td>Drilling masonry or concrete with hammer drills</td>
<td>6 (lowest)</td>
<td>1½ hr</td>
<td>Design and plan to avoid unnecessary drilling. Use, where appropriate: jig-mounted drilling; core drilling cast-in anchors and channels for wall fixings instead of drill-and-fix types;</td>
</tr>
<tr>
<td></td>
<td>9 (typical)</td>
<td>40 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25 (highest)</td>
<td>5 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1½ hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2½ hr</td>
<td>20 min</td>
<td></td>
</tr>
</tbody>
</table>
Risk Assessment Procedure, Part 1

- List all vibration tools/equipment and what sort of work it is used for
- Collect information from the manufacturer about the tool/equipment: make, model, power and vibration levels
- Make a list of employees who use the vibrating tool/equipment and which jobs they do
- Estimate how long an employee's hands are actually in contact with the tool (trigger-time). Time may only be a few minutes or hours depending on the work task
- Ask workers which tools/equipment seem to have the highest vibration and about any problems they have in using the tool (e.g., awkward positions/postures, or difficulty in holding or operating)
- Record information and make judgments about the assessment of who is likely to be at risk

Risk Assessment Procedure, Part 2

Group work activities: High, Medium or Low risk

- High risk: Individuals are exposed above the exposure limit (ELV). High exposures can particularly occur when tools are not the most suitable for the job; Persons who regularly (daily) operate hammer action tools for more than about 1 hour per day, or rotary and other action hand-tools

- Medium risk: Individual are or may be exposed above the action level (EAV): Persons who regularly use hammer action tools or other hand power vibratory tools for more than 15 minutes per day; Rotary tools and other action tools used by an individual about 1 hour per day

- Low risk: Individuals not exposed to vibratory tools or exposed less than 15 minutes per day

Conduct field measures of vibration exposures using industrial hygiene instrumentation

- First for persons/work activities in the high risk group

NOTE: Manufacturer rated vibration numbers cannot be used to determine actual workplace exposures.
Method for Estimating Risk

Obtain manufacturer rated vibration in m/sec²

<table>
<thead>
<tr>
<th>Vibration (m/s²)</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>10</th>
<th>12</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points per hour of trigger time</td>
<td>20</td>
<td>30</td>
<td>50</td>
<td>70</td>
<td>100</td>
<td>200</td>
<td>450</td>
</tr>
</tbody>
</table>

100 points per day = action limit (EAV)
400 points per day = exposure limit (exposure reductions required) (ELV)

Work Practices

- Keep fingers, hands, & body warm;
  - Both hands must be warm
    - Even if only one hand is affected by vibration, venous contraction will occur in both hands if one hand is cold
- Do not smoke;
- Let the tool do the work, grasping it as lightly as possible consistent with safe work practices;
- Do not use the tool unnecessarily;
- For pneumatic tools, keep the cold exhaust air away from fingers & hands;
- If signs & symptoms of potentially consistent with HAVS appear, seek medical help.
  - May be helpful to provide physician with background information on your work and concerns related to vibration
Don’t Forget Noise

- Tool selection (see NIOSH database)
- Support equipment selection and maintenance
  - Include compressors and generators
  - Location relative to work operations
- Hearing Conservation Program
  - Management attention
  - Training
  - Use of hearing protection
    - Worker input
    - Selection with reference to NRR/Personal Attenuation Rating
  - Enforcement
  - Medical management
  - Communication issues – including possible application of advanced technology

NIOSH Test and Evaluation of Anti-Vibration Gloves

Study Objective: Help identify and select appropriate gloves for protection against HAVS

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Method

- Five male subjects
- Eight models of gloves:
  - (1) Chase: 2 models (Glove A and D)
  - (2) Impacto: 5 new models (Gloves B, C, E, F, and G)
  - (3) Impacto: 1 old model (Glove I, reference glove)
- Vibration transmissibility at the palm of the hand:
  - (1) ISO 10819 (1996)
  - (2) Revised method for new ISO 10819/CD (2010)
- Grip strength reduction:
  - Recently developed by NIOSH researchers (Wimer et al., 2010)

Results

- **No glove significantly reduced vibration (>5% at less than 25 Hz)**
- **All the gloves with anti-vibration feature greatly reduce the grip strength (≥ 33%)**
NIOSH Conclusions

- It remains unknown whether and how much AV gloves could actually help reduce HAVS.
- The increased grip effort due to AV gloves on a task requiring repeated forceful grip action could cause more adverse effects than the benefit of the glove’s vibration reduction. The short-term symptoms of the adverse glove effects may include increased hand fatigue and discomfort. The long-term effects could be increased risk of carpal tunnel syndrome and other hand injuries. It is unclear how the benefits and adverse effects could be balanced.
- Regular working gloves can also keep the hand warm and provide some other protections.

NIOSH Data Base for Powered Hand Tools

NIOSH provides a power-tool data base on their website with information on belt sanders, circular saws, drills, grinders, hammer drills, impact wrenches, jigsaw, miter saw, orbital saw, reciprocating saw and powered screw drivers

Hand Arm Vibration Test Center (HAVTEC) – Off Highway Plant and Equipment Research Centre (OPERC)

http://www.operc.com/havtec/havinfo.asp

HAVTEC is the U.K. OPERC vibration testing facility. It provides independent assessment of hand-arm vibration exposures and vibration data for power tools tested (requires individual web registration).

Other Resources

The European Power Tool Association (www.epta.eu) which was formed in 1984, is the industry association for European power tool companies.

VENDORS WHO PROVIDE GOOD INFORMATION ON TOOL VIBRATION AND RELATED CONTROLS INCLUDE

- Atlas Copco
- The ATA Group (grinders)
- Dynabrade

GLOVES

- Chase Ergonomics and Impacto

MONITORING EQUIPMENT

- Quest
- Larson Davis
- B&K (Bruel and Kjaer)
Summary

- Description of vibration
- Potential effects and impacts
- Exposure criteria
- Control of exposures
  - Tools
  - Work practice
  - Protective Equipment
- Process management issues

Thank you!
Questions?