Safe Use of Hand Power Tools

James Glancey, Ph.D., P.E.
Daniel Brisach
Janelle Konchar
Matt Griffith
Steve Petfield
Center for Biomedical Engineering Research
Center for Composite Materials
University of Delaware
jglancey@udel.edu

Presentation Overview

• Motivation - Injury Prevention
• Vibration
• Noise
• Summary
• Tools & Meter Demos
My Background . . .

Polymer Capped Tools to Reduce Vibration, Shock, Sound, Sparks, and Shrapnel.

Hand-Arm Vibration
So, Why Worry About Vibration and Noise?

**Problem:**
- 2 to 4 Million People exposed to tool vibration in the US annually.
- 50% of people exposed develop injuries.
- Costs associated with ailments estimated to be in the 100's of millions of dollars and growing.

**Resulting Injuries:**
- Symptoms including
  - Numbness
  - Tingling
  - Decreased grip strength
  - Loss of dexterity and sensation
- Hearing Loss
  - Loss in perception across all sound frequencies
  - High frequency sounds the most damaging
Measured Tool Vibration

Acceleration at the hand

Thresholds of Exposure

Hand Vibration

<table>
<thead>
<tr>
<th>Total Daily Exposure Duration</th>
<th>Dominant Frequency-Weighted Component of Acceleration Which Shall Not Be Exceeded (RMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m/s²</td>
</tr>
<tr>
<td>4 to 8 hours</td>
<td>4</td>
</tr>
<tr>
<td>2 to 4 hours</td>
<td>6</td>
</tr>
<tr>
<td>1 to 2 hours</td>
<td>8</td>
</tr>
<tr>
<td>less than 1 hour</td>
<td>12</td>
</tr>
</tbody>
</table>

ACGIH recommendations
What is Vibration?

- Vibration is quantified using acceleration measurements.
- Acceleration is a vector quantity.
  - Magnitude
  - Direction
- Magnitudes combined using the root-mean-square (RMS).
- Units = m/s² or g's
- The degree of injury is related to the magnitude of vibration.
- Most jurisdictions and agencies use acceleration as a measure of vibration exposure.

\[
a_{\text{RMS, total}} = \sqrt{a_{x,\text{RMS}}^2 + a_{y,\text{RMS}}^2 + a_{z,\text{RMS}}^2}
\]

Hand-Arm Vibration - Filter (ISO 5349)

Hand and Arm Most Susceptible

\[
a_{\text{RMS, f}} = \sqrt{\sum W_i a_i^2}
\]
Implications

- Hand and arm most susceptible to injury at vibration frequencies between 4 and 20 Hz.
- As frequency increases above 20 Hz, threat of injury decreases.
- These rules apply to continuous vibration.
- Impact (shock) related vibrations are not as well understood.
- As vibration increases, total daily exposure must be reduced.
  - Limit amount of time
  - Use of Low Vibration Tools

Common Vibration Characteristics

<table>
<thead>
<tr>
<th>Tool</th>
<th>Vibration Magnitude</th>
<th>Maximum Exposure Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chipping hammers</td>
<td>10-40 ms(^2)</td>
<td>2-40 minutes</td>
</tr>
<tr>
<td>Sand rammers</td>
<td>25-40 ms(^2)</td>
<td>2-6 minutes</td>
</tr>
<tr>
<td>Angle grinders</td>
<td>2-35 ms(^2)</td>
<td>3 minutes-16 hours</td>
</tr>
<tr>
<td>Disc cutters</td>
<td>4-10 ms(^2)</td>
<td>40 minutes-4 hours</td>
</tr>
<tr>
<td>Disc sanders</td>
<td>10-15 ms(^2)</td>
<td>16-40 minutes</td>
</tr>
<tr>
<td>Rock drills</td>
<td>15-35 ms(^2)</td>
<td>3-16 minutes</td>
</tr>
</tbody>
</table>

\(a_{\text{RMS, f}}\) - Correct tool rating
Typical Tool Ratings

- **Example**
  - Grinder: Lab = 2.5 m/s², Field = 2 to 5 m/s²

- **Interpretation:**
  - RMS values
  - Vibration data weighted using ISO 5349

Low Vibration (LV) Tools

- Dual Elastomer Cushions (DEC system)—absorbs shock and vibration to reduce user fatigue.
- Kevlar reinforced Flutter Disc—strong composite disc for long life.
- Vibration level: < 2.5m/s²
- Sound level: 3 dB lower than conventional air hammer

**Snap on Air Hammer**
- Cost: $239 (low vibration)
- Cost: $179 (conventional)
Workplace Assessment – Vibration

- Complete assessment of exposure to vibration requires (NIOSH & ISO):
  - measurement of acceleration in well-defined directions,
  - Frequency content of the vibration
  - Duration of exposure.

Workplace Assessment – Vibration

- Hand Grip force is another important factor in the exposure assessment.
- A tighter grip transfers energy (vibrations) more efficiently, causing greater damage to the user.
- This is, in part, why field measurements usually differ from lab measurements.
Measuring Devices

- Vibration Meter
  - Measures X, Y, and Z accelerations
  - Computes RMS frequency weighted accelerations
  - Selectable Frequency Weighting (Hand-Arm, Whole Body)

(from Larson Davis)

Work-Place Assessments

*Use of Vibration Meter*
Preventing Injury by Controlling Exposure

- Identify Potential Sources
- Perform Vibration Measurements when Necessary
- Low Vibration Tools
- Personal Protective Equipment, PPE
  (Anti-Vib Gloves, Hearing Protection)
- Safe Work Practices
  (Loose Grip, Tool Does the Work)
- Employee Education and Awareness

Vibration Measurement Demo
Hearing Damage and Prevention

Hearing in the News

• 28 million Americans currently have some degree of hearing loss
• 78 million by 2030
What Constitutes Hearing Loss?

- Hearing loss is measured in decibels hearing level (dBHL).
- A person who can hear sounds across a range of frequencies at 0 to 20 dBHL is considered to have normal hearing.
- The thresholds for the different types of hearing loss are as follows:
  - **Mild**: 25-39 dBHL
  - **Moderate**: 40-68 dBHL
  - **Severe**: 70-94 dBHL
- Deaf people, who cannot hear sounds quieter than 95 dB, usually communicate using sign language and lip reading.

Sound Level Benchmarks

<table>
<thead>
<tr>
<th>dBA Level</th>
<th>Approx. Equivalent</th>
<th>Maximum Unprotected Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Faintest sound heard by human ear.</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Whisper, quiet library</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Normal conversation</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>Lawn mower, shop tools, truck traffic</td>
<td>8hrs/day</td>
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<tr>
<td>100</td>
<td>Chainsaw, pneumatic drill, snowmobile</td>
<td>2hrs/day</td>
</tr>
<tr>
<td>115</td>
<td>Sandblasting, rock concert, car horn</td>
<td>15min/day</td>
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<tr>
<td>140</td>
<td>Gun shot, jet engine – even brief exposure causes pain</td>
<td>Must always have ear protection</td>
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Hearing Impairment Mechanism

Undamaged

- Think of the cochlea as “a piano, with 15,000 keys rather than 88”.
- Damage is permanent.

Damaged

94%

6%

Tinnitus

No Tinnitus

Percent of People With Tinnitus

Non-Noise Exposed Worker

6%

No Tinnitus

Tinnitus

79%

Noise Exposed Workers

No Tinnitus

Tinnitus
The Consequences of Long-Term Exposure

Legal Requirements for on-the-Job Exposure

- Habitual exposure to noise above 85 dB will cause a gradual hearing loss in a significant number of individuals, and louder noises will accelerate this damage.

- For unprotected ears, the allowed exposure time decreases by one-half for each 5 dB increase in the average noise level. For instance, exposure is limited to 8 hours at 90 dB, 4 hours at 95 dB, and 2 hours at 100 dB.

- The highest permissible noise exposure for the unprotected ear is 115 dB for 15 minutes/day.

- Any noise above 140 dB is not permitted.
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### OSHA Noise Regulations

- **Hearing Conservation Program**
  - At or above 85 dBA for 8 or more hours, but less than 90 dB.
  - Employer is required to provide hearing protection and training
  - Provide annual audiometric exams
  - Conduct exposure monitoring

- **Noise Control Program**
  - At or above 90 dBA for 8 or more hours per day.
  - Required use of hearing protection with training
  - Provide annual audiometric exams
  - As sound level increases, daily exposure must be decrease
Thresholds of Exposure

### Permissible Exposure Limits for Occupational Noise

<table>
<thead>
<tr>
<th>Sound Pressure Level dBA</th>
<th>Duration Time (hours)</th>
</tr>
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<tbody>
<tr>
<td>80</td>
<td>32</td>
</tr>
<tr>
<td>90</td>
<td>8.0</td>
</tr>
<tr>
<td>95</td>
<td>4.0</td>
</tr>
<tr>
<td>100</td>
<td>2.0</td>
</tr>
<tr>
<td>105</td>
<td>1.0</td>
</tr>
<tr>
<td>110</td>
<td>0.5</td>
</tr>
<tr>
<td>115</td>
<td>0.25</td>
</tr>
<tr>
<td>120</td>
<td>0.125</td>
</tr>
<tr>
<td>125</td>
<td>0.063</td>
</tr>
<tr>
<td>130</td>
<td>0.031</td>
</tr>
<tr>
<td>140</td>
<td>never</td>
</tr>
</tbody>
</table>

OSHA Requirements

6 March 2007                    Tool Vibration and Noise                                           2007 DSA

Physics of Sound

- Sound pressure is inversely proportional to distance from source
- Sound pressure is reduced by half, as distance is doubled
- Sound Pressure Level decreases 6 dB as distance is doubled

<table>
<thead>
<tr>
<th>Distance From Source</th>
<th>% Sound Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) 1m</td>
<td>100%</td>
</tr>
<tr>
<td>B) 2m</td>
<td>50%</td>
</tr>
<tr>
<td>C) 4m</td>
<td>25%</td>
</tr>
</tbody>
</table>
Typical Dosimeters, ISLM's, & SML's

Dose Badges
Hearing Protection

- Properly fitted earplugs or muffs reduce noise 15 to 30 dB.
- The better earplugs and muffs are approximately equal in sound reductions.
- Earplugs are better for low frequency noise.
- Earmuffs are better for high frequency noise.
- Combined use should be considered when noise exceeds 105 dB.

Ear Muffs

Typical Ratings

- 29 dB NRR from certified US laboratory ANSI S3.19-1974
- 34 dB SNR as tested by certified European laboratory to CE EN-352-1
- Superb full spectrum and low frequency attenuation
- Extra wide ear cushions for highest comfort
- Soft padded headband with low force on head
- Suggested resale is $16.60
Detailed Earmuff Data

HB-650: ANSI S3-19-1974

<table>
<thead>
<tr>
<th>Frequency, Hz</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>3150</th>
<th>4000</th>
<th>6000</th>
<th>8000</th>
<th>H</th>
<th>M</th>
<th>L</th>
<th>NRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Attenuation, dB</td>
<td>22.1</td>
<td>27.9</td>
<td>34.9</td>
<td>35.8</td>
<td>37.3</td>
<td>41.4</td>
<td>42.3</td>
<td>41.6</td>
<td>41.2</td>
<td>37</td>
<td>33</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>2.9</td>
<td>2.8</td>
<td>3.4</td>
<td>2.9</td>
<td>2.8</td>
<td>2.7</td>
<td>2.8</td>
<td>3.1</td>
<td>3.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NRR – Noise Reduction Rating

Ear Plugs and Canal Caps

Why Can't I just Stuff My Ears with Cotton?
- Ordinary cotton balls or tissue paper are very poor protectors
- Reduces noise only by approximately 7 dB.
The NIOSH Noise Program

- Assess workplace factors and existing knowledge
- Conduct and evaluate intervention efforts
- Educate, disseminate information and evaluate efforts

In Summary...

- Safe use of tools can only be achieved with a multi-dimensional approach
  - Workplace assessments including measurements
  - Proper choice and use of tools
  - Protective gear
  - Education, training
- New tool technologies help make worker protection achievable without loss of productivity.
Changing Worker Perceptions

Low Vibration Safety Tools

• “Why didn’t someone invent this years ago?”

• “This thing really works.”

• “My co-workers and kids are now going to have to learn new curse words from someone else.”

Thank You!

Questions?

jglancey@udel.edu