Daily exposure estimation from measurements of repetitive shock vibration

Frédéric Maître, Maël Amari
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1. Introduction

1.1. Context

- CRAMIF and INRS are public institutes for health and safety at work
- The evaluation of workers' exposure to hand-arm vibration is mandatory
- Measurements have to be carried out using the ISO 5349-1 standard
- Daily vibration exposure: \[ A(8) = a_{hv} \cdot \sqrt{\frac{T}{T_0}} \text{ (m} \cdot \text{s}^{-2}) \]

where

- \( a_{hv} \): vibration total value emitted by the machine (m \cdot s^{-2})
- \( T \): total daily duration of exposure of the operator (s)
- \( T_0 \): 28800 s (8 hours)
1. Introduction

• 1.2. Problem

- Some hand-held power tools generate repeated shocks of high amplitudes
- Measurements are rarely performed over the whole working day
- $a_{nv}$ and $T$ are often biased
- The estimation of $A(8)$ may not be representative of the real exposure
1. Introduction

1.3. Objective

- Compare 2 methods for the estimation of $A(8)$

<table>
<thead>
<tr>
<th></th>
<th>Conventional method</th>
<th>Alternative method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured (sample)</td>
<td>$a_{hv_{sample}}$</td>
<td>$A(8)_{sample}$</td>
</tr>
<tr>
<td>Available information (whole working task)</td>
<td>$T_{estimate}$</td>
<td>$R_{estimate}$</td>
</tr>
</tbody>
</table>

$$A(8)_{estimate} = a_{hv_{sample}} \cdot \frac{T_{estimate}}{T_0}$$

$$A(8)_{sample} = a_{hv_{sample}} \cdot \frac{R_{estimate}}{R_{sample}}$$
2. Material and methods

• 2.1. Assault riffle

- Zastava M70 AB2
- 7.62 mm caliber
- Accelerometer mounted on the body of the weapon
2. Material and methods

- 2.1. Assault riffle

![Graph showing hand-arm vibration with Semi-Automatic (S-A) and Full-Automatic (F-A) modes.]

**Semi-Automatic (S-A)**
- 1 round

**Full-Automatic (F-A)**
- 5 rounds
2. Material and methods

• 2.1. Assault rifle
2. Material and methods

- 2.1. Assault rifle

<table>
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<tr>
<td>$a_{hv_{\text{sample}}}$</td>
<td>$A(8)_{\text{estimate}}$</td>
</tr>
<tr>
<td>$T_{\text{estimate}}$</td>
<td>$R_{\text{estimate}}$</td>
</tr>
<tr>
<td>$1.1$</td>
<td>$300$</td>
</tr>
<tr>
<td>$2.6$</td>
<td>$2.1$</td>
</tr>
<tr>
<td>$5400$</td>
<td>$0.7$</td>
</tr>
<tr>
<td>$1.1$</td>
<td>$0.090$</td>
</tr>
</tbody>
</table>
2. Material and methods

• 2.2. Nail gun

  ▪ ALSAFIX C38/130 A1, 5.8 kg
  ▪ 125 mm nails
  ▪ Accelerometer placed on the auxiliary handle
2. Material and methods

2.2. Nail gun
2. Material and methods

- 2.2. Nail gun

<table>
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<th>Measured</th>
<th>Available information</th>
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<tr>
<td>$a_{hv_{sample}}$</td>
<td>$T_{estimate}$</td>
</tr>
<tr>
<td>$A(8)_{sample}$</td>
<td>$R_{sample}$</td>
</tr>
<tr>
<td>$R_{estimate}$</td>
<td></td>
</tr>
</tbody>
</table>

- Actual daily task (unknown)
- Measured work phase

Box 1, Box 2, Box 3, Box 4, Box 5, ...

$\text{ICHAV 6/9 JUNE 2023 - NANCY - FRANCE}$

- Hand-arm vibration

- $6-9$ JUNE 2023

- Pink zone
2. Material and methods

2.2. Nail gun

<table>
<thead>
<tr>
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<th>Alternative method</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_{hv_{sample}}$ (m. s$^{-2}$)</td>
<td>$A(8)_{estimate}$ (m. s$^{-2}$)</td>
</tr>
<tr>
<td>2.7</td>
<td>1.3</td>
</tr>
</tbody>
</table>
2. Material and methods

2.3. Impact wrench

- Chicago Pneumatic CP7783
- 8.4 kg
- 600 N.m torque socket
- Accelerometer placed on the auxiliary handle
2. Material and methods

• 2.3. Impact wrench
2. Material and methods

• 2.3. Impact wrench

![Graph showing vibration levels over time for different wheels and time intervals.]

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<tr>
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<th>Available information</th>
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<tr>
<td>$a_{hv_{sample}}$</td>
<td>$T_{estimate}$</td>
</tr>
<tr>
<td>$A(8)_{sample}$</td>
<td>$R_{estimate}$</td>
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</tbody>
</table>
2. Material and methods

2.3. Impact wrench

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<th>Alternative method</th>
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</thead>
<tbody>
<tr>
<td>$a_{hv_{\text{sample}}}$ ($m.s^{-2}$)</td>
<td>$A(8)_{\text{estimate}}$ ($m.s^{-2}$)</td>
</tr>
<tr>
<td>12.9</td>
<td>150 bolts (15 wheels)</td>
</tr>
</tbody>
</table>
3. Results

• 3.1. Method comparison

<table>
<thead>
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<th>Alternative method</th>
<th>Actual working task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$A(8)_{estimate}$</td>
<td>$A(8)_{estimate}$</td>
<td>$A(8)$</td>
</tr>
<tr>
<td></td>
<td>$(m \cdot s^{-2})$</td>
<td>$(m \cdot s^{-2})$</td>
<td>$(m \cdot s^{-2})$</td>
</tr>
<tr>
<td>Assault rifle</td>
<td>1.1</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Nail gun</td>
<td>1.3</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Impact wrench</td>
<td>3.2</td>
<td>1.8</td>
<td>1.8</td>
</tr>
</tbody>
</table>
4. Discussion and conclusions

4.1. Discussion

- Field measurement conditions are not always controlled.
- The sample is not always representative of the real working task.
- When possible, the estimation of the total number of shocks is easier to perform and more accurate than the estimation of T.
4. Discussion and conclusions

• 4.2. Conclusions

- The alternative method is often more reliable than the usual one.
- It also facilitates the implementation of technical prevention solutions.
- It should be preferred for single and repeated shocks.
Thank you for your attention

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