

WHOLE-BODY VIBRATION EXPOSURE AND DRIVER POSTURE EVALUATION DURING THE OPERATION OF LHD VEHICLES IN UNDERGROUND MINING

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Introduction

Load-haul dump vehicles (LHDs) are used to move waste rock and ore in underground mining operations. The LHD is designed for bi-directional operation and the driver sits sideways to the direction of travel. LHD operators have higher reports of low back pain and neck discomfort than other mobile equipment operators who do not sit sideways in the vehicle, but are exposed to whole-body vibration (WBV)¹.

Exposure to WBV is linked with reports of lower-back pain, neck problems and spinal degeneration^{2,3}. Static sitting postures, sitting with the neck and back twisted, and sitting with the back in an unsupported posture are also linked with an increased risk of developing back pain⁴. The objective of this study was to determine typical vibration exposure levels and driving postures for LHD operators.

Methods

Whole-body vibration exposure was measured at the seat-pan, in accordance with the ISO 2631-1 standard⁵, on seven LHD vehicles with a 10 yard bucket haulage capacity. Vibration data were recorded with a Biometrics™ DataLog II (P3X8) and stored on a 128 Mb Simpletech™ multimedia card. Comparisons were made to the ISO 2631-1 Health Guidance Caution Zone (HGCZ) in order to determine potential injury risk.

Operator posture was monitored with three digital video cameras which were secured inside each operator's cab to the top left corner, top right corner and back right corner. Reflective tape was placed on each driver's shoulders, head, and back in several locations and in several locations on the vehicle seat in order to aid in posture coding. Posture coding was performed with 3DMatch v4.50 multiple video view analysis feature. Vibration measurement and posture recording occurred simultaneously for 60 minutes while the LHD operator performed typical duties.

Results and Discussion

Results indicate LHD operators may be exposed to whole-body vibration levels putting them at risk for injury (Table 1). According to ISO 2631-1 the frequency weighted acceleration values corresponding to the lower and upper limits of the HGCZ (for an 8 hr exposure duration) are 0.45 and 0.90 m/s² respectively⁵. Six of the seven vehicles showed exposure levels within the HGCZ defined for 8 hours.

Preliminary video analysis indicated LHD operators were exposed to potentially harmful levels of WBV while adopting asymmetric postures (Table 2). For example, one LHD operator (Figure 1) worked with his neck twisted greater than 40 degrees for 93 % of a 60 minute work cycle. According to the Swedish National Work Injury Criteria, neck rotation should be less than 15 degrees if the motion is required for greater than 80% of the work time⁶. Results of this study highlight the need to further examine the contribution of non-neutral working postures and

WBV exposure in or above the ISO 2631-1 HGCZ given the development of higher than average levels of low back and neck injuries amongst LHD operators.

Table 1: Summary of frequency weighted acceleration (multiplying factor k for health evaluation applied) and the equivalent 8h frequency weighted acceleration (vibration cycle of 7 hours within an 8 hour work day) values for typical underground LHD operation. The axis associated with the dominant value is shown in bold.

| Mine & Model | Duration (min.) | aw_x (m/s ²) | aw_y (m/s ²) | aw_z (m/s ²) | a_v (m/s ²) | a_8 (m/s ²) |
|--------------|-----------------|----------------------------|----------------------------|----------------------------|---------------------------|---------------------------|
| 1 -B | 68 | 0.51 | 0.45 | 0.69 | 1.18 | 0.60 |
| 1 -A (1) | 70 | 0.70 | 0.47 | 0.81 | 1.44 | 0.70 |
| 1 -A (2) | 78 | 0.68 | 0.51 | 1.01 | 1.56 | 0.83 |
| 2 -F | 124 | 0.67 | 0.45 | 0.63 | 1.30 | 0.41 |
| 2 -C | 117 | 0.69 | 0.58 | 1.12 | 1.68 | 0.75 |
| 3 -C | 66 | 0.65 | 0.56 | 0.78 | 1.43 | 0.69 |
| 3 -H | 70 | 0.61 | 0.56 | 0.56 | 1.29 | 0.49 |

Table 2: Postures adopted along with the percentage of time spent in each posture during a 60 minute monitoring duration, for a typical LHD operator.

| Posture Adopted | % time adopted |
|---|----------------|
| Neutral neck rotation (< 15 degrees of rotation) | 3 |
| Mild neck rotation (15 - 40 degrees of rotation) | 4 |
| Severe neck rotation (>40 degrees of rotation) | 93 |
| Neutral trunk rotation (< 15 degrees of rotation) | 97 |
| Mild trunk rotation (15 – 30 degrees of rotation) | 3 |
| Severe trunk rotation (> 30 degrees of rotation) | 0 |
| Neutral trunk flexion (< 15 degrees of flexion) | 93 |
| Mild trunk flexion (15-30 degrees of flexion) | 7 |
| Severe trunk flexion (>30 degrees of flexion) | 0 |
| Neutral trunk lateral bend (< 15 degrees of bend) | 86 |
| Moderate trunk lateral bend (15–30 degrees of bend) | 14 |
| Severe trunk lateral bend (> 30 degrees of bend) | 0 |



Figure1. Typical posture adopted by LHD drivers.

Acknowledgment

Funding for this research was provided by the Workplace Safety and Insurance Board of Ontario with support from the Mines and Aggregates Safety and Health Association of Ontario and the Ontario Mining Industry.

References

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