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Assessment of Front-End Loader Operator Exposure to Occupational Whole-Body Vibration at an Australian Port

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INTRODUCTION / AIMS AND OBJECTIVES

INTRODUCTION

In Australia vibration exposure affects a significant proportion of Australian workers and is an often-overlooked hazard. Health effects of vibration exposure are wide-ranging from fatigue to low back pain to cardiovascular and gastrointestinal issues. Operation of mobile equipment provides a common source of whole-body vibration (WBV) exposure, however this has not been quantified in an Australian port context.

AIMS AND OBJECTIVES

This project aimed to characterise occupational exposures to WBV for front-end loader operators at an Australian port and determine if the exposures are a potential risk to their heath by:

- Conducting a literature review to determine health impacts of WBV exposure
- Quantifying front end loader operator WBV exposures using standard monitoring techniques
- Characterising measured WBV exposure as acceptable, significant or unacceptable and recommending appropriate control measures
- Determining if WBV exposure assessment by iOS WBV application technology provides and accurate methodology for future assessments

METHODOLOGY

Figure 1: Seat pad and iPhone placement

- WBV exposures measured using standard monitoring equipment as per ISO8041-1 and ISO2631-1 using Bruel and Kjær 4447 Human Vibration Analyser (Figure 1)
- Front-end loader operator WBV exposures measured for material blending (n=6), tipping (n=6) and loading (n=6) activities
- iPhone 6 running iOS 12.3.1 with WBV application used simultaneously with standard method
- Results assessed using IHSTAT+ (v235)
- Data compared against ISO2631-1 guideline values – caution and likely health risk zones (Figure 2)
- Bland-Altman assessment used to compare results between standard monitoring method and iPhone WBV app

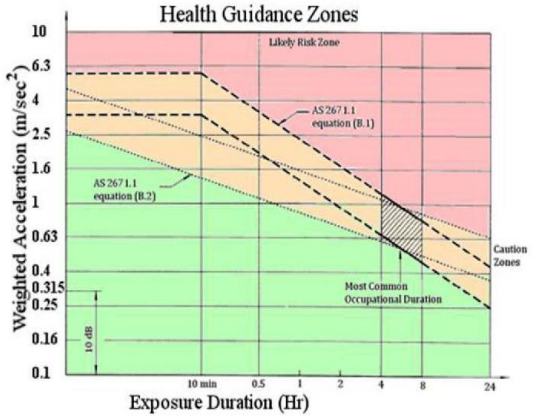

Figure 2: Health Guidance Caution Zones published in ISO2631-1. (Image source: Coyte et al., 2016 p2)

RESULTS

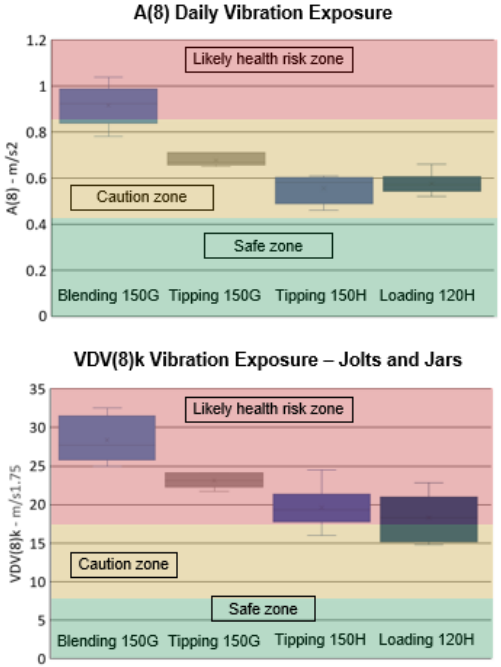

Figure 3:Comparison of WBV exposures for blending, tipping and loading activities

- Highest RMS acceleration occurred during phosphate rock blending activities (Figure 3)
- Crest factors for all tasks exceeded 9, requiring VDV to be considered
- Highest VDV was also measured during phosphate rock blending activities (Figure 3)
- Comparison between 150G and 150H FEL for tipping activities indicated 150H (newer FEL) generated lower WBV exposures
- The predominant axes of exposure in all monitored activities were either X- or Y-axis

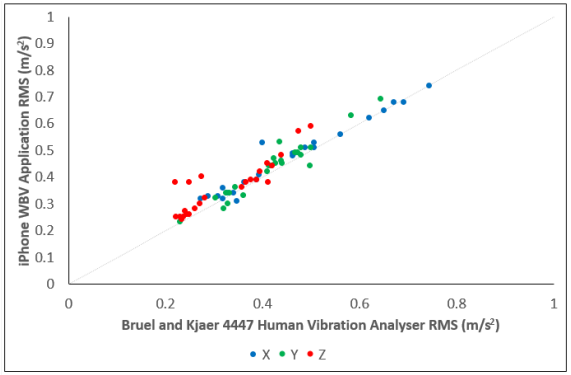

Figure 4: WBV data comparison between standard monitoring equipment and iPhone WBV app

- Results from the iPhone WBV app (Figure 4) suggest that it can be used to measure WBV with 95% confidence of ±0.06 m/s^2 RMS for the X- direction and ±0.091 m/s^2 overall

DISCUSSION / RECOMMENDATIONS

- Port operators were exposed to either significant or unacceptable WBV exposures during material handling activities using front-end loaders
- Magnitudes of exposure correlate with other published studies (Cann, Salmoni, Vi and Eger, 2003; Marin, et al., 2017)
- The iPhone WBV app is a low cost, simple to operate tool which could be routinely used as a WBV screening tool
- Recommended control measures to reduce WBV exposures include maintenance of road surfaces and seat suspension systems, WBV awareness training for operators, task rotation and operator health surveillance

Table 1: Assessment of WBV exposures

Port Operational Activity	Assessment	Health Guidance Caution Zone	RMS (8) m/s^2
Nil	Acceptable	< Caution Zone	<0.43
Soy bean meal loading Phosphate rock tipping	Significant	>Caution Zone <Likely Health Risk Zone	>0.43 <0.86
Phosphate rock blending	Unacceptable	> Likely Health Risk Zone	>0.86

Port Operational Activity	Assessment	Health Guidance Caution Zone	VDV (8) k $m/s^{1.75}$
Nil	Acceptable	< Caution Zone	<8.5
Nil	Significant	>Caution Zone <Likely Health Risk Zone	>8.5 <17
Soy bean meal loading Phosphate rock tipping Phosphate rock blending	Unacceptable	> Likely Health Risk Zone	>17

Cann, A., Salmoni, A., Vi, P., & Eger, T. (2003). An exploratory study of whole-body vibration exposure and dose while operating heavy equipment in the construction industry. *Applied Occupational and Environmental Hygiene, 18*(12), 999-1005.

Coyte, J.L., Stirling, D., Du, H., & Ros, M. (2016). Seated Whole-Body Vibration Analysis, Technologies, and Modeling: A Survey. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 46, 725-739.

Marin, L. S., Rodriguez, A. C., Rey-Becerra, E., Piedrahita, H., Barrero, L. H., Dennerlein, J. T., & Johnson, P. W. (2017). Assessment of whole-body vibration exposure in mining earth-moving equipment and other vehicles used in surface mining. *Annals of Work Exposures and Health, 61*(6), 669-680.