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Referat pt. *Comprehensive Vibroacoustic Assesment of Workplaces*

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submitted by **Jacek Zając, Piotr Kowalski and Adrian Alikowski**,

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Comprehensive Vibroacoustic Assessment of Workplaces

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Motivation

- Simultaneous exposure to Whole-Body Vibration (WBV), Hand-Arm Vibration (HAV), and noise at many workplaces
- Assessment based on the PEL values can only be carried out separately for both types of vibrations and noise.
- The standardized methods for assessing exposure to vibrations and noise at workstations do not consider the occurrence of all three vibroacoustic factors simultaneously.
- The dose of energy absorbed by the employee is greater than when exposed to only one type of vibration or noise treated separately.
- Underestimated assessment of occupational risk at workstations.

Previous Research

A few studies describing the impact of the simultaneous effects of noise and vibrations on humans in the work environment:

- the need to continue research on this issue:

✓ Thaper R., Sesek R., Garnett R., Acosta-Sojo Y., Purdy G.T.: The Combined Impact of Hand-Arm Vibration and Noise Exposure on Hearing Sensitivity of Agricultural/Forestry Workers—A Systematic Literature Review. International Journal of Environmental Research and Public Health, 2023, 20, 42762023;

✓ Weier, M.H. The Association Between Occupational Exposure to Hand–Arm Vibration and Hearing Loss: A Systematic Literature Review. Saf. Health Work 2020, 11, 249–261

✓ Korzeb J., Nader M., Ilczuk P., Różowicz J.: Selected aspects of the analysis of vibroacoustic interactions in the vicinity of tram lines. XXIII Scientific Conference RAIL VEHICLES. [Wybrane aspekty analizy oddziaływań wibroakustycznych w otoczeniu linii tramwajowych. XXIII Konferencja Naukowa POJAZDY SZYNOWE] Katowice 2018.

✓ Dąbrowski Z., Dziurdź J.: Simultaneous Analysis of Vibrations and Noise in the Task of Minimizing Vibroacoustic Activity of Machines. Archives of Acoustics, 2016, vol. 41, No. 2, 303-308, DOI 10.1515/aoa-2016-0030

✓ Kowalski P.: Vibration and Noise in the road vehicles [Drgania i hałas w pojazdach drogowych]. Bezpieczeństwo Pracy 5/2007

Goals of This Work

- to develop a comprehensive vibroacoustic assessment method as a tool for employers and interested entities to meet the requirements of regulations implementing the provisions of EU Directives in the field of employee protection against noise and mechanical vibration;

- a proposal for a method of assessing the simultaneous exposure of employees to noise and vibration, using energy doses from each factor.

Mechanical Vibration and Noise Tests at Selected Workstations

Workstation 1 – industrial high-lift truck operator BT, type RRE 160, 2010

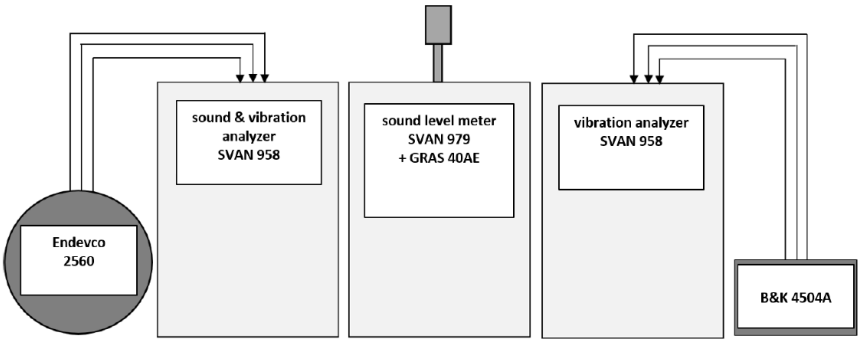
Workstation 2 — mobile x-ray system operator, Mercedes-Benz Sprinter 516 CDI, 2020

Workstation 3 — truck driver VOLVO/KH-KIPPER, model FM/Z, 2011

Workstation 5 – URSUS tractor operator, type 912, 1993

Workstation 4 — police boat operator, Sportis 6500

Diagram of the measurement system



Location of measurement points and measurement directions - example

Results –
assessment of vibroacoustic hazards

Object	Whole-Body Vibration		Hand-Arm Vibration		Noise	
	The PEL value exceedance for WBV, PEL_{WB}	Occupational risk	The PEL value exceedance for HAV, PEL_{HA}	Occupational risk	The PEL value exceedance for Noise, PEL_N	Occupational risk
Workstation 1 – industrial high-lift truck	0,41	small	0,59	medium	0,15	small
Workstation 2 – mobile x-ray system	0,50	small	0,29	small	0,002	small
Workstation 3 – truck	0,49	small	0,51	medium	0,06	small
Workstation 4 – police boat	0,21	small	0,31	small	0,48	small
Workstation 5 – tractor	0,70	medium	0,58	medium	0,32	small

A preliminary method for assessing vibroacoustic hazards **acting simultaneously**

$E_{TOTAL} \sim D_{TOTAL}$

$$D_{total} = A \cdot D_o + B \cdot D_M + C \cdot D_H$$

D_o – dose from WBV,
D_M – dose from HAV
D_H – dose from noise;

$$D_o = \sum_{i=1}^{n} a_{oi}^2 \cdot t_{oi} \qquad A = \frac{1}{D_{o,dop}} = \frac{1}{A(8)^2_{o,dop} \cdot T_0}$$

$$D_M = \sum_{i=1}^{n} a_{Mi}^2 \cdot t_{Mi} \qquad B = \frac{1}{D_{M,dop}} = \frac{1}{A(8)^2_{M,dop} \cdot T_0}$$

$$D_H \sim L_{EX,8h} \qquad C = \frac{1}{D_{H,dop}} = \frac{1}{L_{EX,8h,dop}}$$

A preliminary method for assessing vibroacoustic hazards **acting simultaneously**

- weighted vibration and noise doses as multiples of the permissible values:

$$K_{D_o} = \frac{D_o}{D_{o,dop}} \qquad K_{D_M} = \frac{D_M}{D_{M,dop}} \qquad K_{D_H} = \frac{D_H}{D_{H,dop}}$$

- indicator for assessing the combined exposure to WBV, HAV and noise:

$$K_D = K_{D_o} + K_{D_M} + K_{D_H}$$

- an indicator that takes into account the non-linear response of the human body to the action of vibroacoustic factors

$$K_{D,A} = \log\left(10^{K_{D_o}^2} 10^{K_{D_M}^2} + 10^{K_{D_H}^2}\right)$$

Results – assessment of vibroacoustic hazards

$0 < K_{D,A} \leq 0{,}5$ – small risk
$0{,}5 < K_{D,A} \leq 1$ – medium risk
$K_{D,A} > 1$ – high risk

Object	WBV	HAV	Noise	Comprehensive assessment	
	Occupational risk	Occupational risk	Occupational risk	$K_{D,A}$	Occupational risk
Workstation 1 – industrial high-lift truck	small	medium	small	0,68	medium
Workstation 2 – mobile x-ray system	small	small	small	0,60	medium
Workstation 3 – truck	small	medium	small	0,66	medium
Workstation 4 – police boat	small	small	small	0,61	medium
Workstation 5 – tractor	medium	medium	small	0,81	medium

Conclusions and observations

- The occupational risk results obtained using the comprehensive assessment show greater exposure than in the case of determining the risk based on only one factor.
- As part of further work, it is planned to develop a Standard for comprehensive vibroacoustic assessment of workstations.

Thank you for attention!

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