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Experimental evaluation of uncertainty in hand–arm vibration measurements

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ABSTRACT

Hand–arm vibration measurements are necessary for vibration exposure risk assessment and for the determination of vibration emission values in hand-guided machines. It has been reported that there is a high degree of uncertainty associated with this kind of measurement. The main goal of the present work is to investigate which factors cause uncertainty in hand–arm vibration evaluation and how much they contribute to the total uncertainty of the measurements. Some experiments were carried out in order to evaluate separately the factors relating to instrumentation and the methods of fixing accelerometers. The experiments were performed with handles belonging to real machines while being handheld by an operator. The results of this investigation show that the fixing method and the accelerometer behaviour are the two main sources of uncertainty. The total uncertainty of the measurements in this work, considering both instrumentation and fixing method, reaches up to 8% of the values measured. It is concluded that the adaptors for fixing the accelerometer with metallic stripe hose clips cause less uncertainty than handheld adaptors and should therefore be used as the first option.

Relevance to industry: A good accuracy in hand–arm measurements is the key for a correct assessment of the risk of developing HAVS (Hand–Arm Vibration Syndrome). Knowledge of the uncertainty factors will help the technicians who carry out the measurements to improve their quality.

1. Introduction

All around the world thousands of workers use handheld power tools and are thus exposed to hand–arm vibration. This can lead to the risk of developing HAVS disease (Hand–arm Vibration Syndrome) which includes circulatory, sensory and musculoskeletal disorders. One of the keys for evaluating the risk of developing HAVS is the field measurement of hand–arm vibration at workplaces. The main purpose of this study is to evaluate which factors cause higher uncertainty in this kind of measurement. Knowledge of these factors may help to improve the accuracy of the measurements and consequently the quality of risk assessment. The experimental work has been carried out in a laboratory under controlled conditions. This work is a part of a broader research project which includes the analysis of uncertainty in real work conditions.

The 'Vibration Directive' (Directive 2002/44/EC, 2002) sets minimum standards for controlling the risks from exposure to hand–arm vibration. This directive has had to be implemented in the national legislation of the member states of the European Union since at least 2005. The Vibration Directive sets threshold exposure limit values above which workers must not be exposed (limit value of 5 m/s^2) together with action value (of 2.5 m/s^2). The assessment of exposure may be based on measurement results or based on information of vibration emission levels provided by machine manufacturers. In fact, the 'Machinery directive' (Directive 2006/42/EC, 2006) states that machines must be designed and manufactured in such a way that the vibration risk is reduced to the lowest possible level. Apart from this, manufacturers of hand-guided machines have to include in the instructions manual the total vibration value if this exceeds 2.5 m/s^2 and the measurement uncertainty. This information must be obtained from hand–arm vibration measurements performed following the standardised test codes suitable for each kind of machine. Thus, the vibration values for a power tool used for risk assessment according to the Vibration Directive are measured either at the work place or previously by the manufacturer. Anyway it has been reported that the vibration values declared by the manufacturer are usually lower than those measured at real workplaces, opening the possibility of underestimating the risk when using declared values. In order to compensate this difference, the technical report CEN/TR 15350 (2006) proposes to use multiplication factors to obtain the assessment vibration value from the declared emission value, depending on the kind of machine. A statistical study for different kind of machines (Rimmel et al., 2008) shows that in general the declared values underestimated the vibration measurements while the adjusted values tended to overestimate the measurement

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