Hand-transmitted vibration assessment on the human as an indicator of health risk

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Abstract

This study investigates the concept of assessing hand-transmitted vibration on the individual tool operator through the use of wearable technology as an indicator of health risk. Health risk to individual tool operators was quantified through the determination of temporary threshold shifts (TTS) in vibrotactile perception while performing live tool activities. Concurrent measurements were taken at the tool handle in accordance with ISO 5349-1 and on the subject utilising wearable sensors. The results indicate that a strong positive correlation exists between assessing hand transmitted vibration on the subject and the health risk.

Key words:

Hand-transmitted vibration, Temporary threshold shift, wearable sensors

Introduction

Employers who expose their workforce to hazardous vibration from mechanised tools are required by law in many countries to assess the severity of the risk faced through the use of tool vibration emission data. However, limitations identified of on tool assessment are recognised and listed within Annex D of ISO 5349-1 (1). CEN/TR 15350 (2) further identifies the difficulties of obtaining a precise value for probable vibration and the cost prohibitive nature of wide scale in-situ tool testing in live industrial environments. The effect on vibration transmission of many of the limitations identified within Annex D of ISO 5349-1 have been studied (3) and it is accepted that these limitations in reliable exposure data limit the ability to predict the pathogenesis of the condition within an exposed population.

Existing risk assessment methodologies based on static tool vibration emission data and tool use studies seldom capture the effects of task variation and or human interaction with the tool in the form of operator proficiency and coupling forces. Therefore, it may be desirable to assess the actual received dose by the operative in order to increase the likelihood of predicting risk of future disease and initiate more timely preventative intervention.

In this study the investigators seek to examine whether vibration dose assessment on human subjects using wearable sensors could capture the effect on transmitted energy of limitations identified within in Annex D of ISO 5349-1.

Method

A series of tool test scenarios where developed in order to recreate realistic tool use cases within a controlled laboratory environment. Workpieces were mounted to a custom reaction frame sufficient to provide a range of postures. A range of commonly used mechanised tools where employed in several different postures by test subjects to conduct live tool tests against appropriate substrates.

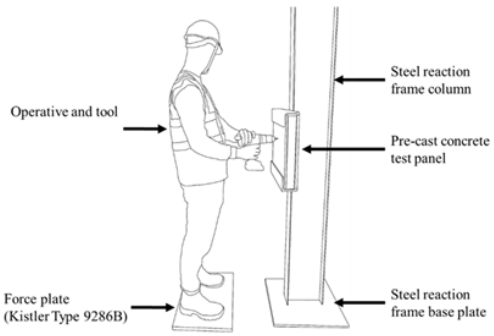

Figure 1 Test subject, reaction frame and force plate configuration

Test subjects varied in physiology and proficiency in tool use, therefor within the scope of the experiment multiple variables effecting vibration transmission were captured. Push force for each of the tool test activities was maintained at a predetermined force level (50 N) through the use of a force plate and digital

display (Kistler Type 9286B). A typical test configuration can be seen in Figure 1.

Simultaneous measurements were taken on the subject to determine hand-transmitted vibration using a wrist mounted wearable device (HVW-001, Reactec Ltd.) and on the tool using conventional ISO 8041 compliant analysis equipment to determine tool emission vibration. Mounting and frequency weighting filters were undertaken in compliance with ISO 5349-1 (BSI, 2001a).

Results

The test results are examined to determine the coefficients of correlation for the hand-transmitted vibration as assessed on the subject with the assessment of human response as measured by the TTS method relative to the coefficients of correlation for tool emitted vibration to that same human response. The results indicate that a positive linear relationship exists between vibration determined on the subject and the human response. The strength of this relationship could be seen to increase further when examined on a subject by subject basis as illustrated by figure 2.

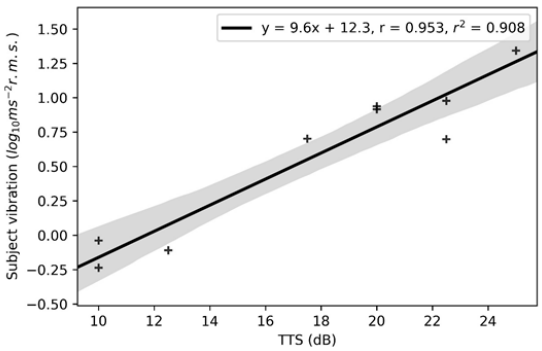

Figure 2 Vibration on subject correlating with TTS

Also evident within the results is a lack of correlation between on tool emission vibration and human response when examined across a subject group performing the same task and using the same tool as illustrated in figure 3. Despite a broad range of human response being visible through TTS the vibration measured on the tool remains essentially unchanged. This lack of correlation for tool emission data contrasted with a positive linear relationship present for on subject assessment for the same data set as illustrated in figure 4.

Discussion

The positive linear relationship between TTS and the hand transmitted vibration assessed on the subject seen in the results would support

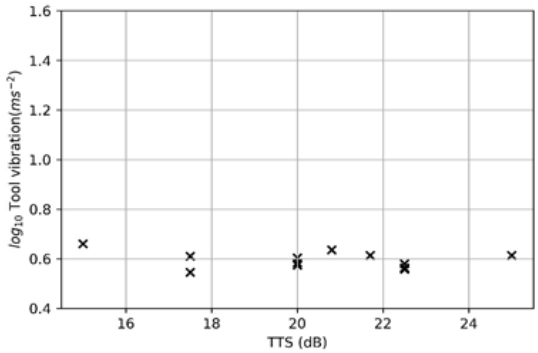

Figure 3 Broad range of human response against on tool vibration

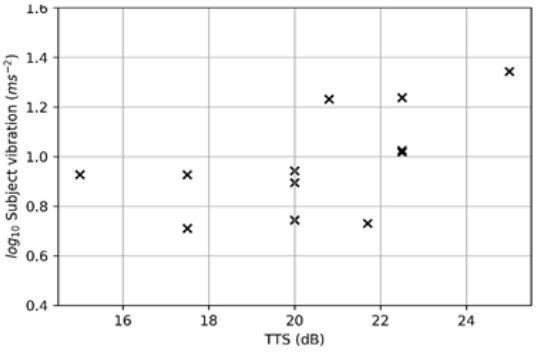

Figure 4 Broad range of human response against on subject vibration

the use of such data as an indicator of exposure risk. Very strong correlations in the data when analysing on an individual operator level supports the hypothesis that an individual's interaction with the tool heavily influences transmission and associated risk. The results for multiple operatives conducting a single test condition indicates that the measurement on the tool is not effective in discriminating the effects of the human physical interaction and other limitations listed within Annex D of ISO 5349-1.

Conclusion

The investigation concluded that wearable sensors can be useful as an indicator of potential harm to the individual. The research also concluded that the effects of human interaction with the tool on potential risk faced by the operator are not adequately captured by existing methods and that wearable sensors may be useful in addressing this limitation.

References

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