Vibration Injury Network

Research Network on Detection and Prevention of Injuries due to Occupational Vibration Exposures

Frequency and magnitude functional dependence of absorbed power resulting from vibration transmitted to the hand and arm

Appendix H3F to Final Report

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Introduction

The power absorbed by the hand and arm of subjects professionally exposed to vibration is possibly related to the development of vascular, muscle and neurological disorders globally indicated as “hand-arm vibration syndrome” (Griffin 1990). In this paper we investigated the functional dependence of power absorbed during exposure to hand-transmitted vibration, on the frequency and the magnitude of the vibration. The main objective was to test the ability of the weighting curve defined in current standards for hand-transmitted vibration to predict the amount of energy absorbed. A further aim of this study was to clarify if the frequency weighting procedure suggested in International Standard ISO 5349-1 (or any other frequency weighting) can be defined independent of the vibration magnitude, as it is implicitly assumed in the current vibration assessment procedure.

Methods

The amount of energy per unit time (power) absorbed was measured for five healthy men, with no previous record of professional exposure to hand-transmitted vibration. The right hand was exposed to four sets of conditions, each consisting of seven frequencies. In the first two sets, the root-mean-square (rms) acceleration magnitude was fixed independent of frequency at a level of 5 and 20 ms^{-2} respectively, from 8 Hz to 500 Hz. In the third and fourth set the rms acceleration magnitude was adjusted to give the same frequency-weighted acceleration magnitude (5 and 10 ms^{-2} respectively) according to the frequency weighting included in the International Standard ISO 5349-1, throughout the frequency range of interest. A grip force of 20 N and a downward feed

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force of 20 N were applied in all tests. The vibration axis was the Y_h direction as defined in the International Standard ISO 5349-1.

Results

At the lowest acceleration levels, absorbed power increases with magnitude following approximately a power law $P \propto a^{\beta}$, with a slope $\beta \approx 2$ for all the frequencies investigated. As the magnitude increases, there is a general trend towards lower values of β, with values dropping to 1 – 1.2 at the highest levels (see Figure 1, where absorbed power has been normalized to the value at 5 Hz). Our results support and strengthen already existing evidence of similar behaviours along other vibration axes (Lundström et al. 1994).
At low vibration magnitudes, the existing weighting curve (which is basically a power law with slope α = -1 above 16 Hz) has been found to provide good estimates of absorbed power both in the low ($f \leq 16$ Hz) and in the high frequency range ($f \geq 63$ Hz). Values larger than expected were measured at 31.5 Hz, suggesting that the weighting curve underestimates the power absorbed at this frequency.
At high vibration magnitudes, results indicate a steeper functional dependence of absorbed power on frequency than predicted by the existing weighting curve.

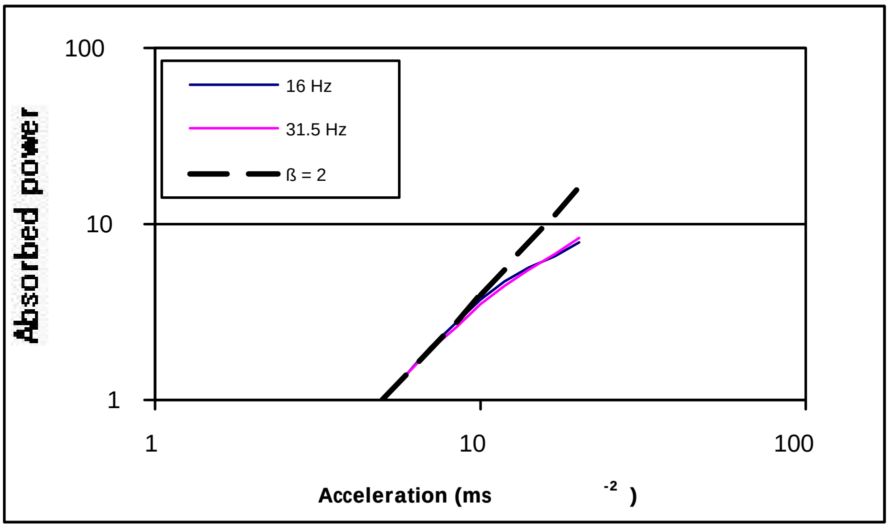

Figure 1: Absorbed power as a function of vibration magnitude

Conclusions

Exposures to vibration with different acceleration levels show that absorbed energy increases linearly with the total energy available in the oscillating system at low levels, but displays a trend towards a more shallow rise as vibration levels increase, hinting at the onset of saturation. Exposures to vibration with equal frequency – weighted levels show that the existing weighting curve provides a fair prediction of the amount of absorbed energy at low levels (except around 31.5 Hz, where some kind of mechanical resonance may be active), but it appears to be too shallow a function of frequency at high levels.

The hypothesis of a further steepening in the weighting curve beyond 250 Hz requires additional investigation.

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