HAND ARM VIBRATION MITIGATION AT WORKPLACE: A REVIEW OF VIBRATION PERCEPTION THRESHOLDS SHIFT

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Introduction

The prolonged use of hand-held tools workers may develop Hand-Arm Vibration Syndrome (HAVS), which affects the vascular, neurological, and musculoskeletal systems at the hands[1]. Vascular disease results in finger blanching (Raynaud's phenomenon) and finger coldness. Neurological disease results in pain, dysesthesia, paraesthesia, tingling and numbness. Musculoskeletal disease results in pain, loss of muscle power and manual dexterity, and deformity of bones and joints. A shift in the Vibrotactile Perception Threshold (VPT) has historically been used in a number of countries for the diagnosis of HAVS, especially the diagnosis of neurological injuries[2]. This paper is to review the existing VPT research, identify the relationship between the measurement of vibration dose value and VPT measurements.

Vibrotactile perception threshold and existing research

As detailed in the standard ISO 13091-1[3], VPT is defined as skin surface acceleration level for detecting a pure-tone oscillatory stimulus in the psychometric function. After prolonged vibration exposure from the use of hand-held tools, workers can develop a chronic disorder known as Hand-Arm Vibration Syndrome (HAVS). The increased awareness of the risks posed by this sensory neuropathy has resulted in an interest in quantitative sensory testing for screening and diagnosis of vibration-induced neuropathy.

Radzyukevich[4] suggested that the temporary threshold shift (TTS) in vibrotactile perception threshold at the end of a working day was correlated with the permanent threshold shift (PTS) that would develop over occupational exposure to vibration. Malinskaya et al.[5] found that the mean TTS of workers after a day of work that included vibration exposure was an indicator of the PTS of vibratory sensation that occurred in the group after 10 years of exposure. These findings suggest that the TTS after daily exposure may be used to indicate the PTS after prolonged exposure to vibration. Based on these results, further research looked to determine the relationship between TTS in VPT and other influencing factors of hand-arm vibration exposure, such as those highlighted in Annex D of ISO 5349-1[2].

The measurement of VPT as an indicator of PTS is used as a diagnostic criterion, in order to determine the risk for development of HAVS. A significant level of research has been undertaken using VPT as an intermediary in the relationship between the different vibration exposure conditions and the human response to vibration.

Vibration dose and TTS

ISO 5349-1[2] recognizes the presence of factors that may influence vibration exposure, which are not accounted for in the current vibration dose calculation:

- Direction of the vibration
- Working method and operator's skill
- Age, constitution and health

- Coupling forces (grip and feed forces)
- Hand, arm and body posture
- Condition of the machinery and accessories/workpieces used

The idea of a daily dose $A(8) = a_{hv}\sqrt{t/8}$ as required to inform risk management, would suggest that if A(8) has the same magnitude, then any worker being deployed to this activity will be facing a uniform risk from the tool vibration exposure in the workplace. Furthermore, it has been considered that tool manufacturer's Vibration Declaration Values can be used as a_{hv} for risk management purposes. While controlled to stringent test protocols it is recognised that these declaration values seldom represent the tool activity in a real working environment. Research highlights the difficulties of A(8) following ISO5349-1[2] as an adequate indicator of risk, such as the effect of i) handle diameter, ii) postures, iii) coupling forces, and iv) subjective variability[6,7]. From such research although the A(8) values were often consistent, the human response to vibration, such as TTS values were not the same. Many researchers are reporting that the human response to vibration is affected by the issues highlighted in Annex D of ISO 5349-1[2] without identifying an alternative approach or consideration.

Discussion

The vibration dose value from a measurement according to ISO5349-1[2] cannot accurately predict and evaluate the risk of worker under the varied working conditions at the workplace. Therefore, this value is not ideal for workplace hand arm vibration mitigation. The literature suggested the human response to vibration as indicated by a measurement of TTS, varied depending on subjective and environmental factors in a manner which was very inconsistent with a defined measurement of vibration taken in accordance with ISO5349-1[2]. This means the vibration magnitude measured on the tool handle will not provide an accurate predication on vibration risk and furthermore to be used to define the mitigation measures needed. To prevent HAVS and mitigate the hand arm vibration at the workplace, consideration should be given to new measurement method or devices, which allow the personal exposure risk management tailored for the individual workers.

References

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