Regione Toscana

ISTITUTO SUPERIORE PER LA PREVENZIONE E LA SICUREZZA DEL LAVORO

USL7 Prevention Dpt.

2nd International Conference on Whole-body Vibration Injuries

Whole-body Vibration Injuries

7-9 November 2000
SIENA, Italy

EXTENDED ABSTRACTS

prepared for a Conference organised by:

Department of Prevention
National Health Service
AUSL 7 of Siena

Sponsored by:
EU Vibration Injury Network
Research Network on Detection and Prevention
of Injuries due to Occupational Vibration Exposure

Under the auspices of:
ISPESL
Institute of Occupational Medicine – University of Siena
Tuscany Region - Province of Siena - City of Siena

RIDERS SENSITIVITY TO MOTORCYCLE VIBRATIONS

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Background

Motorcycle riders are exposed to whole-body vibrations. To improve safety vibration levels have to be controlled, because they weaken the rider capability of perception and reaction. Moreover, long exposures to high levels of vibrations may impair the rider's health. Vibrations transmitted through handle-bars and foot-rests are the most annoying. The annoyance caused by motorcycle vibrations may be evaluated by means of test pilots, which ride the motorcycle under investigation and give a mark to the annoyance level. This method does not give quantitative results and completely relies on pilots' experience. Alternatively the annoyance may be evaluated on the basis of vibrations that are measured on the motorcycle. Since motorcycle vibrations have some spectral components and human sensitivity to vibrations depends on frequency, weighting curves are necessary to evaluate the equivalent acceleration and the annoyance level.

Methods

Three experienced test pilots were considered and both laboratory tests and road tests were carried out. Laboratory tests were performed by means of special equipment that makes it possible to excite riders' hands and feet with vibrations of different level and frequency. Road tests were performed by means of a motorcycle equipped with four accelerometers a data acquisition system and a microphone. Vibration levels at different engine speeds were measured, at the same time the feeling of the test pilot was recorded.
Weighting curves given by international standards [1] cannot be used for the evaluation of test pilots' sensitivity, because these curves refer to generic people and are evaluated considering body postures that are rather different from the rider' posture on a motorcycle. Therefore, the first step of the experimental analysis dealt with the determination of weighting curves of test pilots. The second step of the analysis was the determination of the correlation between pilots' marks and measured accelerations.

Results

The weighting curves for the hands and feet of test pilots, which have been evaluated by means of laboratory tests, are represented in figure 1. Since engines generating shaking forces [2] in the range 40÷400 Hz were considered, the weighting curves were set at 1 at a frequency of 125 Hz. Feet and hands sensitivities decrease with frequency. The feet are less sensitive than the hands at the high frequencies (due to the presence of the sole) and more sensitive at the low frequencies. For the hands the comparison with international standards shows that test pilots are more sensitive to vibrations in the range 80÷200 Hz. The validity of the weighting curves was confirmed experimentally, because the pilots had the same feeling when their hands and feet were excited by vibrations having several tones and the same equivalent acceleration.

Figure 2 depicts a nomograph relating the vibration levels measured on the handle-bars and foot-rests with the mark given by a rider (6 means sufficient comfort, 10 means high comfort). This nomograph was evaluated by means of laboratory tests, generating 125 Hz vibrations of different levels.

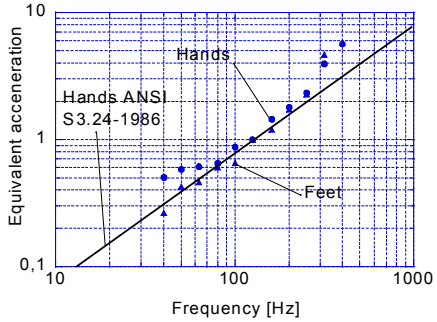

Figure 1: Weighing curves.

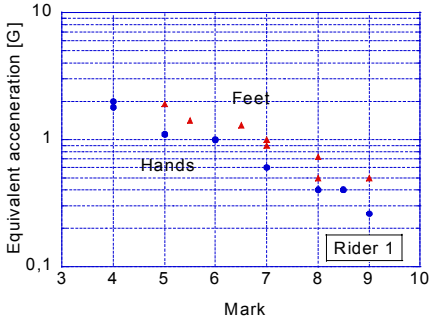

Figure 2: Laboratory tests results.

There is a very good correlation between the marks and the vibration levels, taking into account that the different levels were proposed to the test pilot in a random sequence. The pilot felt less annoying vibrations transmitted through the foot-rests, for this reason the corresponding points are higher.

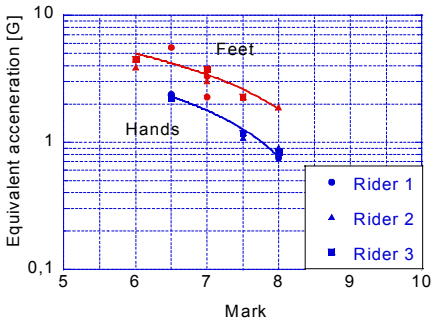

Figure 3: Road tests results.

Road tests were carried out at different piston frequencies (67, 83 and 100 Hz), the Fast Fourier Transforms of measured accelerations were calculated and the equivalent accelerations were evaluated by means of the weighing curves of figure 1. Figure 3 shows the experimental points and the fitting curves. There is a good agreement among the evaluations of the three pilots. The fitting curves show a good correlation between acceleration levels and pilots' marks. The comparison with figure 2 highlights that the curves evaluated by means of road tests are higher than the curves evaluated by means of laboratory tests.

Conclusions

Weighing curves typical of motorcycle test pilots were evaluated by means of laboratory tests. Road test showed that there is a good correlation between the pilots' marks and acceleration levels and that there is a small dispersion in the marks given by the different pilots. The comparison between laboratory tests and road tests highlights that a pilot, when riding a motorcycle, feels acceptable acceleration levels higher than the ones he felt acceptable during laboratory tests. This phenomenon takes place because the pilot of a motorcycle perceives a lot of sensations and concentrates on driving, hence, he considers less important the annoyance due to vibrations and tolerates higher vibration levels.

References

[1] Beranek, L. L., Noise and Vibration Control Engineering, Wiley& Sons, New York, 1992.

[2] Shigley, J. E., Theory of Machines and Mechanisms (Second Edition), MacGraw- Hill, New York, 1995.