AN INTERLABORATORY EVALUATION OF THE VIBRATION TRANSMISSIBILITY OF GLOVES FOLLOWING THE ISO 10819 TEST METHOD

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1. INTRODUCTION

Numerous studies have dealt with the difficulties associated with the application of the ISO 10819 test method for evaluating the vibration transmissibility of gloves at the palm of the hand (GRIFFIN, 1998; HEWITT, 1997). The most widely recognized difficulties relate to lack of repeatability caused by performing tests with human subjects, the difficulty in correctly aligning the hand-held adapter to measure the vibration transmitted inside the glove, the complexities associated with the experimental set-up design needed to monitor and control the grip and feed forces and generation of complex vibration excitations defined by M- and H-spectra.

In a previous study involving three different European laboratories (HEWITT, 1997), the reproducibility of the standard test for anti-vibration gloves, as defined in the ISO 10819 standard, had been shown to be adequate under the medium frequency excitation (M-spectrum) but inadequate under the high frequency excitation (H-spectrum). Although the factors leading to these discrepancies could not be clearly identified, it has been suggested (O'BOYLE and GRIFFIN, 2001) that increasing the number of subjects and the number of tests per subject could perhaps contribute to reduce the observed variability. In an effort to identify the sources of variations, this study presents the results of testing four different gloves in three different laboratories (two North American and one European), where some variations to the ISO 10819 test protocol are introduced by certain laboratories, specifically by increasing the number of test subjects and test trials and by providing control for hand-held adapter orientation.

2. MEASUREMENTS

2.1 Gloves

Four types of gloves were incorporated as part of the round-robin tests of the three laboratories. There were three large size right hand gloves of each type, originating from the same batch. The gloves contained a variety of different materials : elastomer matrix for glove 1, two-layer foam and viscoelastic material for glove 2, two-layer cushioning material for glove 3 and air membrane for glove 4. All except glove 3 were CE marked, denoting their compliance with the European Union Directive for personal protective equipment.

2.2 Glove Vibration Transmissibility Measurements

The basic evaluation procedure defined in the ISO 10819 standard was followed by the different laboratories. According to this Standard, the mean corrected frequency-weighted transmissibility of the gloves, $\overline{\mathrm{TR}}_s$, must be reported under both medium frequency (s=M) and high frequency (s=H) random spectra covering the ranges 31.5 to 200 Hz and 200 to 1000 Hz, respectively. Mathematically, TR_s represents the ratio of frequency-weighted rms acceleration measured inside the glove, a_{wg}, to that measured on the handle, a_{wh}, divided by the overall frequency-weighted transmissibility of the adapter, TR_a, measured with the ungloved hand :

$$TR_s = \frac{a_{wg}}{a_{wh} \cdot TR_a} \qquad (1)$$

In the above, the frequency weighting to be applied is that defined in the ISO 5349-1 standard. According to the ISO 10819 standard, the mean values of TR_s under each spectral class must be established for 3 subjects with hand size between 7 and 9, each performing 2 trials. The overall mean M- or H- spectrum transmissibility $\overline{TR}_M$ or $\overline{TR}_H$ for a glove is thus obtained from the average of six corrected transmissibilities. During the tests, the grip force must be maintained at 30 ± 5 N and the push force at 50 ± 8 N. The criteria for an antivibration glove are : $\overline{TR}_M < 1.0$ and $\overline{TR}_H < 0.6$.

2.3 Round-Robin Tests

The gloves were tested in three laboratories. All used a vibration shaker system with feedback control mechanism to generate the required excitation spectra. Laboratories 2 and 3 used an identical shaker system with a similar handle design involving two parts to enable grip force measurement. Laboratory 1 used a different shaker system with a handle machined from a single solid piece of aluminium. Both laboratories 1 and 2 measured push force from a force plate supporting the subjects. Laboratory 3 used a load cell inserted between the handle and the shaker head to measure push force. Laboratories 1 and 3 applied

the frequency weighting defined in ISO 5349-1 :2001 in reporting the transmissibility values, while laboratory 2 used the weighting defined in the earlier version of that Standard. Furthermore, the results reported by laboratory 2 involved a mathematical correction to account for adapter misalignment. Both laboratories 1 and 2 performed the measurements with 3 subjects, laboratory 2 requesting 3 trials per subject but retaining only the two closest measures. In contrast, laboratory 3 performed the measurements with 5 subjects, each realizing 5 tests, while the results were grouped to comply with the ISO 10819 requirements and later compared with the overall mean.

Table 1. Mean overall frequency-weighted glove transmissibility measured under M spectrum.

GLOVE #	Lab.#1	Lab.#2	Lab.#3 (1)	Lab.#3 (2)	Lab.#3 (3)	Lab.#3 (4)	Lab.#3 (5)	Lab.#3 (6)	Lab.#3 (all)
1	0.92 (0.05)	0.86 (0.04)	0.84 (0.04)	0.85 (0.03)	0.84 (0.04)	0.78 (0.07)	0.80 (0.04)	0.80 (0.09)	0.82 (0.06)
2	0.94 (0.06)	0.90 (0.03)	0.88 (0.07)	0.86 (0.08)	0.87 (0.07)	0.90 (0.06)	0.87 (0.08)	0.90 (0.07)	0.89 (0.06)
3	0.91 (0.03)	0.86 (0.03)	0.78 (0.08)	0.75 (0.10)	0.76 (0.12)	0.85 (0.04)	0.84 (0.05)	0.85 (0.04)	0.80 (0.10)
4	0.94 (0.02)	0.85 (0.05)	0.81 (0.05)	0.82 (0.05)	0.79 (0.07)	0.80 (0.04)	0.80 (0.03)	0.80 (0.04)	0.81 (0.04)

Table 2. Mean overall frequency-weighted glove transmissibility measured under H spectrum.

GLOVE #	Lab.#1	Lab.#2	Lab.#3 (1)	Lab.#3 (2)	Lab.#3 (3)	Lab.#3 (4)	Lab.#3 (5)	Lab.#3 (6)	Lab.#3 (all)
1	0.63 (0.03)	0.61 (0.04)	0.63 (0.06)	0.61 (0.04)	0.64 (0.04)	0.58 (0.08)	0.55 (0.03)	0.56 (0.07)	0.59 (0.06)
2	0.82 (0.03)	0.78 (0.06)	0.81 (0.09)	0.75 (0.17)	0.78 (0.13)	0.80 (0.07)	0.74 (0.15)	0.77 (0.12)	0.80 (0.11)
3	0.77 (0.04)	0.66 (0.12)	0.62 (0.03)	0.61 (0.06)	0.60 (0.06)	0.69 (0.05)	0.69 (0.02)	0.70 (0.04)	0.65 (0.06)
4	0.75 (0.05)	0.58 (0.06)	0.53 (0.09)	0.50 (0.10)	0.51 (0.11)	0.53 (0.09)	0.51 (0.11)	0.52 (0.12)	0.54 (0.08)

3. RESULTS

The mean overall frequency weighted transmissibility of the gloves reported by different laboratories under M and H spectra are reported in Tables 1 and 2, respectively, where the standard deviations are indicated in parentheses. All of these values represent the mean of 6 measurements carried out with 3 different subjects, with the exception of the last column reported for laboratory 3 which presents the mean and standard error based on 25 values (i.e. 5 subjects x 5 trials per subject). In addition, six sets of results are reported for this laboratory by grouping the 25 data sets (5 subjects x 5 trials) in groups of six (3 subjects x 2 trials).

While closest agreement between the 3 laboratories is observed for glove #2, gloves #3 and #4 lead to the largest differences. Laboratory #1 is found to consistently report values which are higher than those from the other two laboratories, which tend to provide mean values that are in better agreement, although the standard error on the mean often appears to be higher particularly under the H spectrum. In general the overall mean values reported by laboratory #3 based on 25 measurements tend to agree reasonably well with those based on 6 measurements, suggesting that increasing the number of subjects and test trials will not necessarily improve the reliability of the measured glove performance.

4. CONCLUSION

The degree of agreement on the mean values of transmissibility reported by the different laboratories was found to be influenced by the type of glove being tested, the excitation spectrum being used and the combination of subject and test trial being considered. The laboratory whose results differed the most from that of the other two laboratories also presented the smallest values for the standard deviation. For certain gloves, the large variability observed between the different laboratories suggest that improvement to the Standard test is desirable.

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