Chapter 14

Tests of gloves intended for protection against vibration according to EN ISO 10819:2013

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Abstract
Anti-vibration gloves are the most commonly used means of personal protection against hand-arm vibration. The EN ISO 10819:1996 standard specifies the criteria for assessing their anti-vibration properties, also provides the laboratory test method and test bench requirements. In 2013 many changes were introduced to the standard, as a result of which the previously applied test method has become obsolete. The new requirements relate mainly to the extended vibration frequency range in which the measurements are carried out, the increased number of vibration, measurement signals, the test signal and the sequence and number of measurements. This article presents changes in the test methodology of anti-vibration gloves resulting from the requirements introduced in EN ISO 10819:2013.

Keywords: anti-vibration gloves; hand-arm vibration; transmissibility of vibration

1. Introduction

Anti-vibration gloves are a widely used personal protection against hand-arm vibration. Although the structures of devices used by employees are more and more technologically advanced, vibrations generated by tools and machines are still a serious problem [1-3]. In Poland, according to the Statics Poland (GUS) "Work Conditions" (2012-2016) [4-8], the risk of mechanical vibrations in the analyzed period of time remains at a similar level and affects approximately 15-17 thousand people. The actual number of people exposed to vibrations is, however, much higher, since the data on employees only apply to employees employed on the basis of an employment relationship (employment contract), in establishments with a number of employees over 10 persons. Disorders caused by mechanical vibrations involve high costs both by the state (financial costs) and employees themselves (financial and health costs). It is important to prevent the risk of mechanical vibrations by using anti-vibration gloves [3, 9]. The EN ISO 10819:1996 [10] standard specified the criteria for assessing their anti-vibration properties, also provides the laboratory test method and test bench requirements. The aim of this work is to present changes in the method of testing and assessment of anti-vibration gloves used so far in connection with the introduction in 2013 of a new version of EN ISO 10819:2013 [11]. These changes concern both research laboratories involved in measurement and assessment of the vibration transmissibility of gloves as well as designers and constructors of anti-vibration gloves, as well as employers who, in accordance with Directive 2002/44/EC [12], are obliged to ensure protection of employees against negative effects of mechanical vibrations at workstations.

2. Test Method according to EN ISO 10819:1996

The results of tests carried out in accordance with the standard in both EN ISO 10819:1996 and EN ISO 10819:2013 are the factors characterizing vibration transmission through gloves – the frequency-weighted corrected glove vibration transmissibility, however the methods and test conditions given in them differ significantly. In the case of the standard from 1996, the average corrected values of vibration transmissibility coefficients were determined for gloves intended for protection against vibrations: $\overline{T}_{(M)}$ and $\overline{T}_{(H)}$. They were calculated based on the results of vibration acceleration measurements transmitted from the test handle through the glove to the operator's hand. The mean corrected values of vibration transmissibility coefficients were determined during simulation of vibrations on the test handle by two test vibration signals M and H (Figure 1).

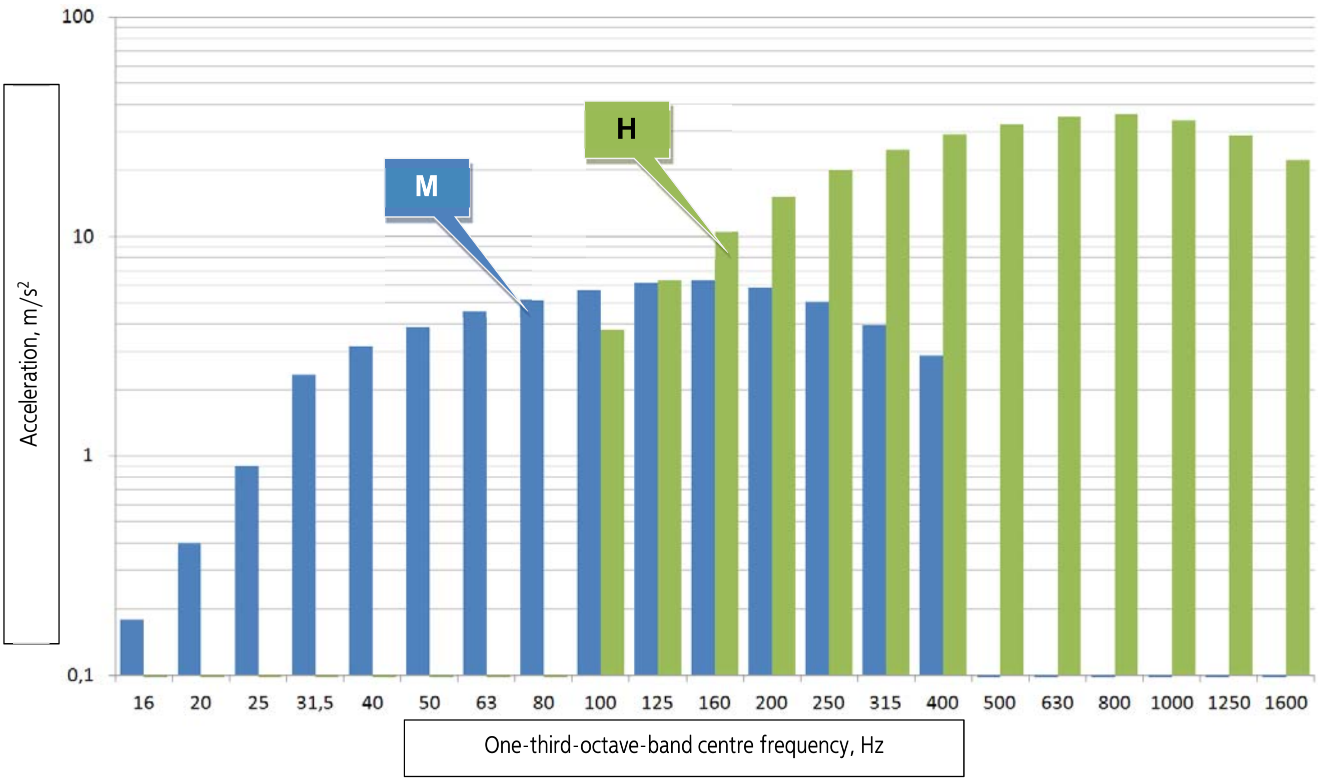

Figure 1. One-third-octave band handle acceleration values for M and H test signals

The test signal M included frequencies in the range of 31.5 ÷ 200 Hz, and the signal H for vibrations in the range of 200 ÷ 1250 Hz. Vibration transmissibility factors were calculated based on the results of vibration acceleration measurements on the test handle and on the operator's hand of the following relationships:

- transmissibility for vibration spectrum *s* measured on a hand without a glove:

$$TR_{sb} = \frac{a_{wsPb}}{a_{wsRb}} \tag{1}$$

where:

TR – frequency-weighted vibration transmissibility, a_{ws} – r.m.s frequency-weighted acceleration for vibration spectrum *s* (s = M or H) (*s* = M lub H), m/s^2, P – subscript denoting measurements taken on the palm of hand, b – subscript denoting measurements taken on a hand without a glove;

- transmissibility for vibration spectrum *s* measured on a gloved hand, i.e. between the glove and the hand

$$TR_{sg} = \frac{a_{wsPg}}{a_{wsRg}} \tag{2}$$

where:

g – subscript denoting measurements taken on a gloved hand;

- corrected vibration transmissibility of glove for vibration spectrum *s*:

$$TR_{s} = \frac{TR_{sg}}{TR_{sb}} \tag{3}$$

- mean corrected transmissibility of glove for vibration spectrum *s*

$$\overline{TR}_s = \frac{1}{6}\sum_{k=1}^{6} TR_{ks} \tag{4}$$

where:

k = 1, 2, … , 6 (2 measurements x 3 gloves).

According to the methodology described in ISO 10819:1996, tests were carried out for three types of gloves of a given type (one for each operator). One measurement was performed with the participation of each operator without a glove (3 measurements in total), followed by two measurement cycles for test signals M and H (in total 6 measurements for the test signal M and 6 measurements for the signal H). Figure 2 presents a scheme for determining the vibration transmissibility coefficients by the adapter and gloves and calculating the mean corrected transmissibility of glove coefficient, standard deviation and coefficient of variation in accordance with EN ISO 10819:1996.

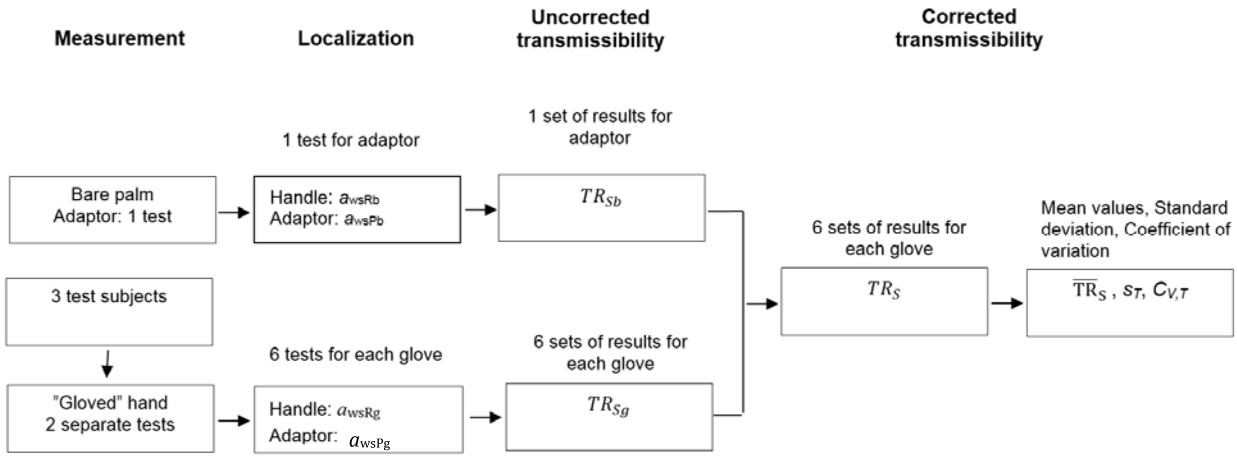

Figure 2. Flow diagram for determining the mean corrected transmissibility values, standard deviations and coefficients of variation according to EN ISO 10819:1996

Gloves were considered anti-vibration when they met both of the following criteria simultaneously: $\overline{TR}_M < 1$ and $\overline{TR}_H < 0,6$.

3. Test method according to EN ISO 10819:2013

According to the method given in the new version of EN ISO 10819, only the principle of determining vibration transmission coefficients is similar to the one given in the 1996 standard version. The introduced changes related to test signals apply to both their frequency range and their number. Two signals: M (31.5 ÷ 200 Hz) and H (200 ÷ 1250 Hz) were replaced with one band-filtered noise signal with a frequency range of 25 ÷ 1250 Hz, lowering the lower measuring frequency from 31.5 to 25 Hz. In the amplitude-frequency characteristics of the signal, two parts can be distinguished: the first one with a constant vibration velocity (from 25 Hz to 250 Hz) and the second one (315 to 1650 Hz) with a falling edge. Figure 3 presents the amplitude-frequency characteristics of acceleration of test signal vibrations in one-third bands.

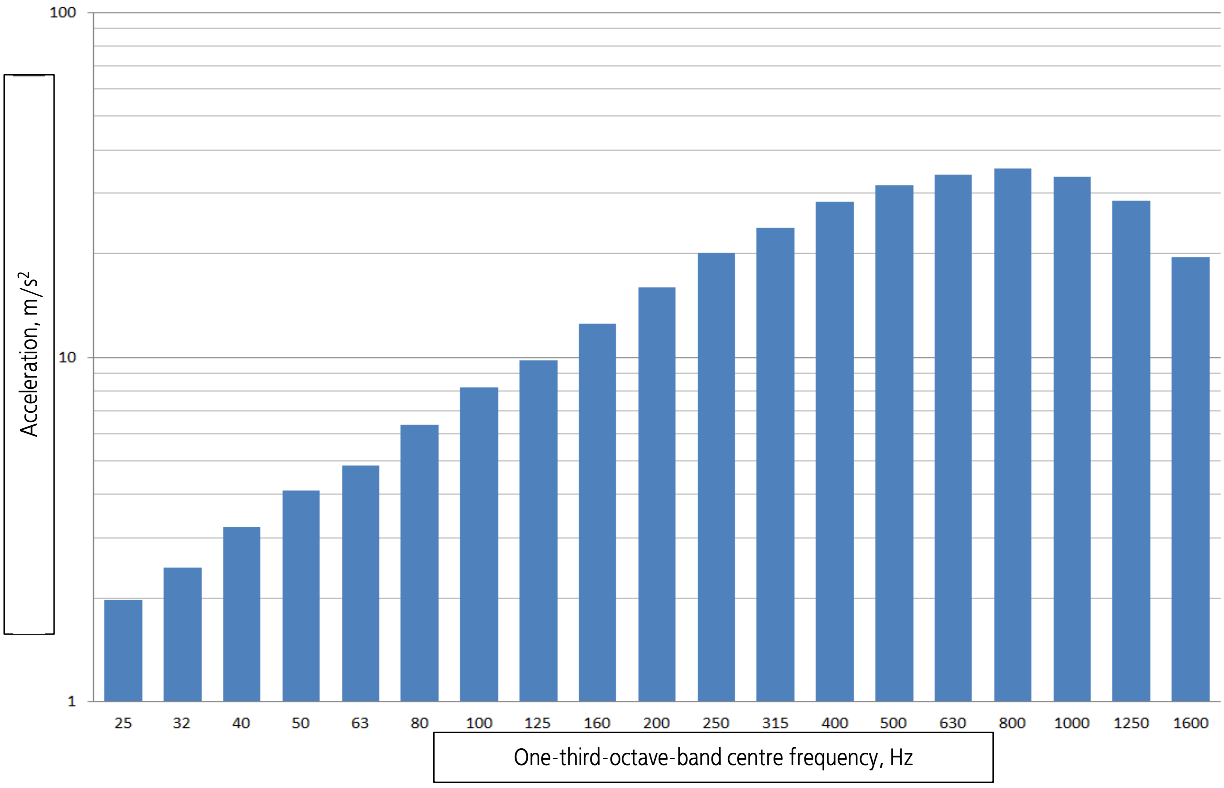

Figure 3. One-third-octave band handle acceleration values

Vibration transmissibility factors are determined for two ranges of one-third-octave bands:

- $\overline{T}_{(M)}$ in the frequency range Δ*f*M: 25 Hz ÷ 200 Hz
- $\overline{T}_{(H)}$ in the frequency range ΔfH: 200 Hz ÷ 1250 Hz.

According to the new version of the standard, the number of specimens of the type glove increased from 3 to 5 (each of the 5 operators participating in the tests one copy). Before testing the gloves one measurement of vibration acceleration in one-thirds of the adapter band fixed to the test handle is carried out. During this measurement the adapter is not held by hand (on the test handle). The unadjusted vibration acceleration values in the one-third-octave bands on the test handle and the measuring adapter are measured simultaneously and used to calculate the vibration transmissibility between the adapter and the handle. Next, using the adapter, for each piece of glove there are separate measurements of the vibration acceleration in the one-third-octave bands inside the gloves with the participation of each of the five operators (15 measurements in total). The unadjusted vibration acceleration in one-third-octave bands is measured simultaneously on the test handle and on the adapter placed on the operator's palm inside the glove, and then used to calculate the vibration transmission factor by the gloves. The vibration transmissibility factors are calculated based on the results of vibration acceleration measurements on the test handle and on the operator's hand of the following relationships:

- one-third-octave band vibration transmissibility for the bare adaptor:

$$T_b(f_i) = \frac{a_{h(Pb)}(f_i)}{a_R(f_i)} \tag{5}$$

where:

$a_{h(Pb)}(f_i)$ – one-third-octave band unweighted acceleration values on the bare adaptor, m/s^2,

$$a_{h(Pb)}(f_i) = \sqrt{a^2{}_{h(Pbx)}(f_i) + a^2{}_{h(Pby)}(f_i) + a^2{}_{h(Pbz)}(f_i)} \ \ [\text{m/s}^2] \tag{6}$$

where:

$a_{h(Pbx)}(f_i)$ – value $a_{h(Pb)}(f_i)$ in direction x, m/s^2, $a_{h(Pby)}(f_i)$ – value $a_{h(Pb)}(f_i)$ in direction y, m/s^2, $a_{h(Pbz)}(f_i)$ – value $a_{h(Pb)}(f_i)$ in direction z, m/s^2,

and

$a_R(f_i)$ – one-third-octave band unweighted accelerations obtained at the handle, m/s^2, (determined analogously as in the case of the test handle by the vector sum in three directions: x, y, z);

- the frequency-weighted bare adaptor vibration transmissibility, $T_{b(S)}$ for S_M and S_H:

$$T_{b(S)} = \frac{\sqrt{\sum_{i=i_L}^{i_U} [a_{h(Pb)}(f_i)\ W_{hi}]^2}}{\sqrt{\sum_{i=i_L}^{i_U} [a_R(f_i)\ W_{hi}]^2}}, \tag{7}$$

where:

W_{hi} – frequency weighting factors for hand-transmitted vibration for conversion of one-third-octave band magnitudes to frequency-weighted magnitudes;

- the uncorrected glove vibration transmissibility, $T_g(f_i)$, for the ith one-third-octave band:

$$T_g(f_i) = \frac{a_{h(Pg)}(f_i)}{a_R(f_i)} \tag{8}$$

where:

$$a_{h(Pg)}(f_i) = \sqrt{a^2{}_{h(Pgx)}(f_i) + a^2{}_{h(Pgy)}(f_i) + a^2{}_{h(Pgz)}(f_i)} \tag{9}$$

where:

$a_{h(Pgx)}(f_i)$ – value of $a_{h(Pg)}(f_i)$ in direction x, m/s^2, $a_{h(Pgy)}(f_i)$ – value of $a_{h(Pg)}(f_i)$ in direction y, m/s^2, $a_{h(Pgz)}(f_i)$ – value of $a_{h(Pg)}(f_i)$ in direction z, m/s^2;

- the frequency-weighted uncorrected glove vibration transsmissibility, $T_{g(S)}$, for S_M and S_H vibration spectra:

$$T_{g(S)} = \frac{\sqrt{\sum_{i=i_L}^{i_U} [a_{h(Pg)}(f_i)\ W_{hi}]^2}}{\sqrt{\sum_{i=i_L}^{i_U} [a_R(f_i)\ W_{hi}]^2}} \tag{10}$$

- the corrected glove vibration transmissibility, $T(f_i)$, for the ith one-third-octave band:

$$T(f_i) = \frac{T_g(f_i)}{T_b(f_i)} \tag{11}$$

- The frequency-weighted corrected glove vibration transmissibility, $T_{(S)}$:

$$T_{(S)} = \frac{T_{g(S)}}{T_{b(S)}}. \tag{12}$$

Figure 4 presents a scheme for the determination of vibration transmissibility coefficients by the adapter and gloves and the calculation of the average corrected vibration transmission coefficient, standard deviation and coefficient of variation according to EN ISO 10819:2013.

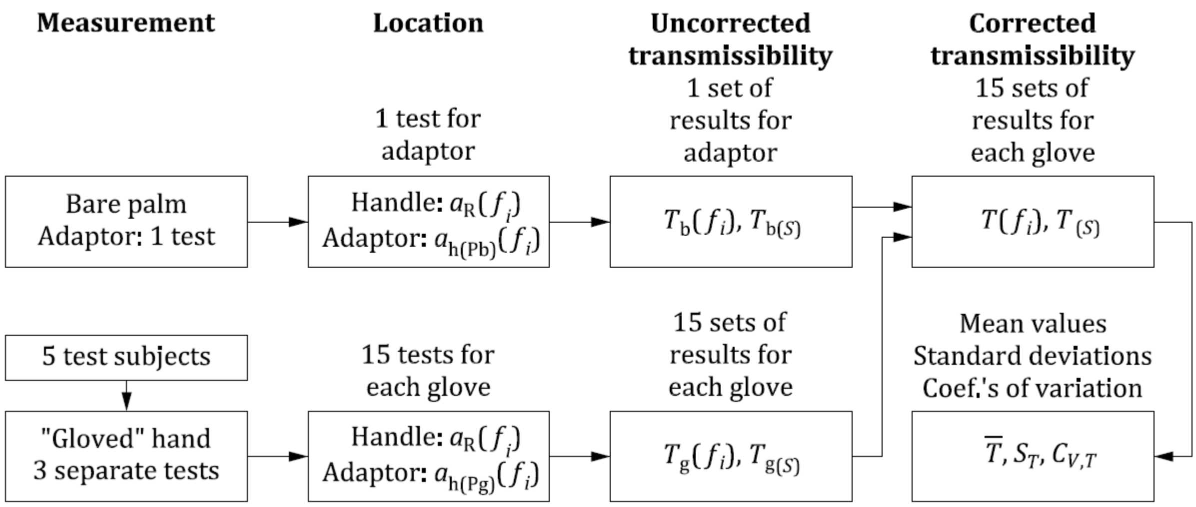

Figure 4. Flow diagram for determining the mean corrected transmissibility values, standard deviations and coefficients of variation according to EN ISO 10819:2013

The criteria for vibration transmission factors by gloves have also changed. Currently, gloves are considered anti-vibration when they meet both of the following criteria:

$$\overline{TR}_M \leq 0{,}9 \text{ and } \overline{TR}_H \leq 0{,}6.$$

4. Summary and Conclusions

On the basis of many years of testing of anti-vibration gloves in real conditions, it was found that many of this type of products not only do not meet the minimum requirements for vibration reduction, but even strengthen them. This brings the opposite effect to the intended one, negatively affecting the employee's health. The effectiveness of protection of anti-vibration gloves depends not only on their design, but also on the conditions in which they are used (the nature of the vibrations emitted by the tool, exerted by the force operator), which is why the correct selection is very important. The changes in the glove testing method introduced in 2013 tightened the requirements for their anti-vibration properties. The lower frequency of the third term band, reduced to 25 Hz, forces designers and manufacturers to introduce new solutions with increased effectiveness of protection against low-frequency vibrations. The criterion for assessing the vibration transmission coefficient has also been stricter, whose previous value of 1 meant only the requirement of no amplification of vibrations in the frequency range 31.5 ÷ 200 Hz. The current criterion value 0.9 means the requirement of vibration reduction in the range of 25 ÷ 200 Hz by at least 10%. Changes in the methodology of testing anti-vibration gloves related to the introduction of a new version of EN ISO 10819 proved to be so significant that they caused the need to rebuild the research station at the CIOP-PIB Mechanical Vibration Laboratory, currently the only laboratory in Poland that measures and evaluates the vibration transmission factor by gloves on the operator's hand. Despite the introduced changes in EN ISO 10819, the laboratory test method does not allow to clearly determine the impact of anti-vibration gloves on the reduction of vibrations in real conditions. Additional tests are still necessary for this estimation. However, the laboratory method allows the elimination of gloves with inadequate anti-vibration properties from the market and their initial selection for tools.

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