Certified anti-vibration gloves:

Test methods and the limits to their effectiveness

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Abstract
Protective gloves against vibration also called “anti-vibration gloves” are the only items of personal protective equipment for reducing hand-arm vibration. This paper presents the key test requirements of standard ISO 10819 [2] in existence since 1996 and the changes in the current new version. It also outlines the properties additionally necessary for the certification of “protective gloves” and refers to the still existent gaps in the scale of testing. Finally, the paper presents the limits to the use of these gloves and estimates their effectiveness with reference to a practical example.

1. Introduction
Personal protective equipment (PPE) that carries the CE marking in Europe has to satisfy the requirements of EU Directive 89/686/EEC [1]. PPE is graded into three categories according to the type and stringency of the protective requirements. Anti-vibration gloves fall within category II, for which an EC type examination by a notified body is obligatory. The Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) is not only a test body but also a certification body. The test method of international standard ISO 10819 [2] is concerned with the measurement and evaluation of vibration transmission behaviour; for further fundamental health and safety requirements, only general reference is made to EN 388 [3] and EN 420 [4]. Equally, with a test result in accordance with ISO 10819 [2], it is not currently possible to assess the degree of risk reduction in the use of anti-vibration gloves in practice. To evaluate the informative power of test results, it is important to look at the test method and the still existent gaps.
2. Design of anti-vibration gloves

Anti-vibration gloves have a highly flexible outer fabric or soft leather or nitrile-coated material and padding of the palm and fingers with an elastic material. This in most cases viscoelastic material can be multi-layered or textured with studs (Figure 1).

![Different designs of anti-vibration gloves](image1)

Essentially, it is this material and its structure that are responsible for the damping properties. Another variant involves vibration damping with air bladder cushions. The glove gains its damping properties only when the air bladder cushions are inflated. The glove in its uninflated state can be used without its capacity for damping. The variant with air bladder cushions is usually much lighter than a glove with a viscoelastic lining [5].

3. Method of testing and testing facility

3.1 Current testing standard ISO 10819:1996

The test method involves the measurement of vibration transmission in the palm of the hand. Two standard vibration spectra H and M are generated on a cylindrical handle with a diameter of 40 mm (see Figure 2).

![Test spectra with tolerance range](image2)
The direction of vibration is horizontal and parallel to the axis of the lower arm (Z measurement axis of the hand-arm system). A standardised adapter is placed between the glove and palm of the hand in such a way that the vibrations are measured in the same direction (Z measurement axis). During measurement, the push and grip forces are controlled and kept constant by the test person (see Figure 3). The working frequency range with a tolerance of 1 dB is 31.5 to 200 Hz for the M spectrum and 200 to 1000 Hz for the H spectrum. In the extended frequency range for band limitation, the tolerance is 2 dB.

![Experimental set-up with test person](image)

Per spectrum and test person, the tests comprise two measurements with a glove and a control measurement without a glove. The procedure is repeated with three different gloves of a glove type and with different test persons. The mean vibration transmissions are obtained for the two spectra as TR\textsubscript{M} and TR\textsubscript{H} and form the basis for the assessment. According to the standard, gloves only qualify as vibration-damping when TR\textsubscript{M} < 1.0 and TR\textsubscript{H} < 0.6 and the material properties of the palm are the same for the fingers (i.e. the hand’s entire contact surface). The test standard does not extend to further factors, e.g. placing the products of a series on a sound statistical basis or even general requirements that gloves have to satisfy.

### 3.2 Important changes in the new ISO/DIS 10819:2011

The tests are performed with a vibration spectrum in the frequency range of 31.5 to 1000 Hz (see Figure 4) with the range extended from 25 to 1600 Hz for band-limiting. The vibration transmission is measured for the entire frequency range (including band-limiting) for each 1/3 octave band and then calculated for spectrum M and H.

![New test spectrum](image)
The evaluation criterion at $TR_M \leq 0.9$ has been raised slightly for the M spectrum and for spectrum H remained at $TR_H \leq 0.6$. The number of test runs per test person has been increased to 5 in each case and the property of the test person has been defined with glove sizes 7 to 10. To reduce negative effects due to thick and inflexible glove materials, the test criteria were extended to include glove design. The purpose of this is to if possible prevent increased grip effort due to poor dexterity, which would result in poorer vibration attenuation. Poor dexterity can also cause new accident risks due to the unsafe operation of machines. Greater glove flexibility due to larger distances between the damping materials, then again, can give rise to vibration transmission bridges. The thickness of the damping material in the palm has been limited to 8 mm and a reduction to the 0.6-fold of this figure for the fingers has been allowed. To test these properties, a special test set-up has been defined. The distances (gaps) between the various elements of the damping materials must not exceed the value of material thickness. Figure 5 shows thickness measurement with a defined test body.

![Experimental set-up for the measurement of material thickness](image)

The area between the index finger and thumb must be covered with damping material. The material around the thumb must also be secured in such a way that it does not slip out of position during normal use. How this demand is to be checked has not been defined with greater precision. Since in many practical applications the coupling force is strongest between the index finger and thumb and additional frictional forces can occur, this requirement is a special challenge.

4. Further requirements for certification

4.1 Requirements in accordance with Directive 89/686/EEC

The general requirements that protective gloves have to meet are contained in EN 420. The factors tested are the glove sizes, glove innocuousness, glove marking and instructions for use. For instance, the parts of the glove that come into contact with the user must not have any deleterious effects on the health and hygiene of the user. For leather gloves, the chromium (VI) content and possibly the pH have to be measured, for example. The instructions for use must also contain warnings on service life and on the unsuitability of the characteristic values for an assessment of health risk [7]. Further tests are to be conducted in accordance with the gloves’ performance features with protection from mechanical risks in conformity with EN 388. These tests cover resistance to abrasion, blade cutting, tearing and puncturing.
4.2 Specifications missing in the standards

Changes in the damping characteristics of the material due to ageing, moisture uptake, temperature and creep behaviour due to high push forces are not covered. Also lacking is a test criterion for detecting vibration bridges on open surfaces and for excluding gloves with open surfaces for certain grip situations and applications. Furthermore, the damping material is only considered sufficiently positioned and fastened with the aid of a visual inspection based on the tester’s experience. The test method for the cutting test according to EN 388 is unsuitable for anti-vibration gloves. Figure 6 shows the test device defined for the test of the cutting resistance of protective gloves conforming to EN 388 [3].

![Test device for cutting resistance conforming to EN 388](image)

The test specimens are cut with a circular rotating metal blade under a defined load until the material is pierced. The results of this test do not reflect the glove’s robustness in practice, but are referred to when comparing products or materials. The existing test method conforming to EN 388 has its limitations, e.g. if due to the nature of the glove material the cutting blade is braked or blunted during the cutting test. This can be observed particularly with anti-vibration gloves with thick damping material. This is why this test method might not be applicable to many anti-vibration gloves.

A factor that has so far been disregarded is that the damping material is usually sufficiently resistant to cutting, but only the slightest damage to the surface can cause the admission of moisture, which may modify the material’s characteristics. Equally, a slight shift in position can also impair the damping effect.

5. Estimate of effectiveness in practical use

Vibration transmission is measured during testing under the constant factors of magnitude, frequency composition, coupling forces, handle shape and hand posture. Although typical values are defined for these parameters in the tests, they may deviate in practical use at the workplace and vary greatly during the work task in addition. For instance, for measurement reasons the grip force of 30 N and push force of 50 N are kept constant during testing. Higher coupling forces can result in less favourable damping characteristics and higher vibration transmission. It is also assumed in the test process that elastic materials behave linearly. However, depending on the material, this is only true within narrow bounds. The frequency composition has a large effect. For physical reasons, anti-vibration gloves only become effective from a frequency range in excess of 150 Hz. This means that anti-vibration gloves are totally unsuitable for vibration reduction in the case of tools with predominantly low-frequency vibration, e.g. hammer drills and chipping hammers.
Measurements under practical conditions on the side handle of an angle cutter, i.e. a typical tool with high-frequency vibration (Figure 7), only show between 10% and 27% damping for various tested anti-vibration gloves for which 41% damping for the H spectrum has been measured in the laboratory. The vibration transmission was measured on the optimised cylindrical side handle with an interior acceleration sensor (see Figure 8) during grinding work.

In addition, it is possible to make a rough estimation of the vibration reduction of a glove due to the measured transmission values of a test according to ISO 10819.

On the basis of the frequency analysis of the angle grinder, the vibration reduction forecast yields the following result:

Frequency-assessed acceleration in the frequency range multiplied by the vibration transmission value of the respective spectrum

\[
\begin{align*}
\alpha_{\text{raw}} (4 – 1250 \text{ Hz}) &> 2.94 \text{ m/s}^2 \\
\alpha_{\text{raw}} (4 – 31.5 \text{ Hz}) &= 0.61 \text{ m/s}^2 \times 1.0 = 0.61 \text{ m/s}^2 \quad \text{spectrum L} \\
\alpha_{\text{raw}} (31.5 – 200 \text{ Hz}) &= 2.49 \text{ m/s}^2 \times 0.89 = 2.22 \text{ m/s}^2 \quad \text{spectrum M} \\
\alpha_{\text{raw}} (200 – 1250 \text{ Hz}) &= 1.47 \text{ m/s}^2 \times 0.59 = 0.87 \text{ m/s}^2 \quad \text{spectrum H} \\
\alpha_{\text{pro}} (4 – 1250 \text{ Hz}) &= \sqrt{0.61^2 + 2.22^2 + 0.87^2} \\
\alpha_{\text{pro}} (4 – 1250 \text{ Hz}) &= 2.46 \text{ m/s}^2
\end{align*}
\]
The anticipated reduction thus amounts to 16.3 %.

The results from the forecast as well as from practical measurements clearly show that the damping values derived from the test results cannot be referred to directly for estimating the hazard reduction.

**Recommendations for the use of anti-vibration gloves**

Even if it is currently impossible to quantify the protective effect of anti-vibration gloves, their use can be recommended for the following workplaces [5]:

- Machines with exclusively or mainly high frequency shares > 150 Hz (corresponds to a rotary speed > 900 rpm), e.g. grinders.
- Machines that do not require a precise guidance force or particularly high coupling forces, e.g. hand-guided vibrating plate compactor
- Machines on which gloves are to be worn as protection from the cold or from mechanical risks, e.g. chain saws. This requirement from the regulation can also be fulfilled with conventional protective gloves.
- Workplaces at which vibrations are transmitted by the material or workpiece, e.g. when holding or pushing the workpiece.

**6. Conclusion**

Anti-vibration gloves in Europe have to be certified and thus comply with the safety requirements of Directive 89/686/EEC. This entails not only a positive test in accordance with EN ISO 10819, but also compliance with the general requirements for protective gloves laid down in EN 388 and EN 420.

The new test method in ISO/DIS 10819 fills gaps in the requirements concerning glove design. However, there is still a lack of requirements governing the application of the test results for gloves to the conditions of practical use. This means that it is not possible to reliably estimate the reduction in the vibration risk even when tested and certified anti-vibration gloves with the CE marking are used. Independently of this, anti-vibration gloves can be recommended with reservations for certain workplaces.

**7. References**

ISO/DIS 10819 Mechanische Schwingungen und Stöße – Hand-Arm-Schwingungen – Verfahren für die Messung und Bewertung der Schwingungsübertragung von Handschuhen in der Handfläche; Ausgabe; 2011-11
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