INTERNATIONAL STANDARD

ISO 10819

Second edition
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Mechanical vibration and shock — Hand-arm vibration — Measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand

Vibrations et chocs mécaniques — Vibrations main-bras — Mesurage et évaluation du facteur de transmission des vibrations par les gants à la paume de la main

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2, www.iso.org/directives.

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 4, *Human exposure to mechanical vibration and shock*.

This second edition cancels and replaces the first edition (ISO 10819:1996), of which it constitutes a technical revision. The main changes are stronger criteria for antivibration gloves and the addition of a method for measuring the material thickness.

Introduction

Because of the growing demand to reduce health risks associated with exposure to hand-transmitted vibration, gloves with vibration-reducing materials are often used to attenuate vibration transmitted to the hands. These gloves normally provide little reduction in hand-transmitted vibration at frequencies below 150 Hz. Some gloves can increase the vibration transmitted to the hands at these low frequencies. Gloves with vibration-reducing materials that meet the requirements of this International Standard to be classified as an antivibration glove can be expected to reduce hand-transmitted vibration at frequencies above 150 Hz. These gloves can reduce but not eliminate health risks associated with hand-transmitted vibration exposure.

Field observations indicate that gloves with vibration-reducing materials can result in positive and negative health effects. Positive health effects can occur with gloves that reduce finger tingling and numbness and that keep the hands warm and dry. Negative health effects can occur with gloves that increase the vibration transmitted to the hands at low frequencies and that increase hand and arm fatigue because they increase the hand grip effort required to control a vibrating machine.

Gloves tested in accordance with the requirements of this International Standard are evaluated in a controlled laboratory environment. The actual vibration attenuation of a glove in a work environment can differ from that measured in a controlled laboratory environment.

Vibration transmissibility measurements made in accordance with the requirements of this International Standard are performed only at the palm of the hand. The transmission of vibration to the fingers is not measured. When evaluating the effectiveness of a glove with a vibration-reducing material used to reduce vibration transmitted to the hand, vibration transmission to the fingers should also be assessed. However, research subsequent to the publication of this International Standard is needed to develop a measurement procedure that can be used to measure the vibration transmissibility of gloves at the fingers.

The measurement procedure specified in this International Standard only addresses glove properties that can reduce health risks associated with hand-transmitted vibration in work environments. It does not address glove properties necessary to reduce other hand-related health and safety risks in work environments.

The measurement procedure specified in this International Standard can also be used to measure the vibration transmissibility of a material that is being evaluated for use to cover a handle of a machine or for potential use in a glove.

Mechanical vibration and shock — Hand-arm vibration — Measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand

WARNING — This International Standard defines a screening test procedure for measuring the vibration transmission through gloves with an embedded vibration-reducing material. Many factors not addressed in this International Standard can influence the transmission of vibration through these gloves. Therefore, use the vibration transmissibility values obtained in accordance with this International Standard with caution in the assessment of the vibration-reducing effects of gloves.

1 Scope

This International Standard specifies a method for the laboratory measurement, data analysis, and reporting of the vibration transmissibility of a glove with a vibration-reducing material that covers the palm, fingers, and thumb of the hand. This International Standard specifies vibration transmissibility in terms of vibration transmitted from a handle through a glove to the palm of the hand in one-third-octave frequency bands with centre frequencies of 25 Hz to 1 250 Hz.

The measurement procedure specified in this International Standard can also be used to measure the vibration transmissibility of a material that is being evaluated for use to cover a handle of a machine or for potential use in a glove. However, results from this test cannot be used to certify that a material used to cover a handle meets the requirements of this International Standard to be classified as an antivibration covering. A material tested in this manner could later be placed in a glove. When this is the case, the glove needs to be tested in accordance with the measurement procedure of this International Standard and needs to meet the vibration attenuation performance requirements of this International Standard in order to be classified as an antivibration glove.

NOTE ISO 13753[1] defines a method for screening materials used for vibration attenuation on the handles of machines and for gloves.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 5349-1, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements*

ISO 5805, *Mechanical vibration and shock — Human exposure — Vocabulary*

ISO 8041, *Human response to vibration — Measuring instrumentation*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

EN 388, *Protective gloves against mechanical risks*

EN 420, *Protective gloves — General requirements and test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041, ISO 5805 and the following apply.

3.1
glove vibration transmissibility
ratio of the acceleration measured on the palm adaptor of the gloved hand to the acceleration measured on the instrumented handle

Note 1 to entry: Glove vibration transmissibility values greater than 1 indicate that the glove amplifies the vibration, and values lower than 1 indicate that the glove attenuates the vibration.

4 Symbols and abbreviations

The following symbols and abbreviations are used.

$a_{\mathrm{h(Pb)}}(f_i)$	unweighted r.m.s. acceleration measured on the bare adaptor in the ith one-third-octave band
$a_{\mathrm{h(Pb}x,y,z)}(f_i)$	value of $a_{\mathrm{h(Pb)}}(f_i)$ on three mutually orthogonal axes, respectively
$a_{\mathrm{h(Pg)}}(f_i)$	unweighted r.m.s. acceleration measured on the palm adaptor of the gloved hand in the ith one-third-octave band
$a_{\mathrm{h(Pg}x,y,z)}(f_i)$	value of $a_{\mathrm{h(Pg)}}(f_i)$ on three mutually orthogonal axes, respectively
$a_{\mathrm{h}(S)}(f_i)$	unweighted r.m.s. acceleration for spectrum S in the ith one-third-octave band
$a_{\mathrm{hw}(S)}(f_i)$	frequency-weighted r.m.s. acceleration for spectrum S in the ith one-third-octave band
$a_{\mathrm{R}}(f_i)$	unweighted r.m.s. acceleration measured at the reference position on the handle in the ith one-third-octave band
$C_{V,T}(f_i)$	coefficient of variation for the corrected handle-gloved hand transmissibility in the ith one-third-octave band
$C_{V,T(S)}$	coefficient of variation for the handle-gloved ISO-weighted hand transmissibility for spectrum S
f_i	centre frequency of the ith one-third-octave band
H	subscript representing one-third-octave frequency bands from 200 Hz to 1 250 Hz
i_{L}	frequency band number of the lowest one-third-octave band associated with each spectrum S according to Table 2
i_{U}	frequency band number of the uppermost one-third-octave band associated with each spectrum S according to Table 2
M	subscript representing one-third-octave frequency bands from 25 Hz to 200 Hz
S	spectrum, $S = S_{\mathrm{M}}$ or S_{H}
$s_T(f_i)$	standard deviation for the corrected handle-gloved hand transmissibility in the ith one-third-octave band
$s_{T(S)}$	standard deviation for the handle-gloved ISO-weighted hand transmissibility for spectrum S
$T_{\mathrm{b}}(f_i)$	handle-adaptor bare adaptor transmissibility in the ith one-third-octave band
$T_{\mathrm{g}}(f_i)$	handle-gloved hand transmissibility in the ith one-third-octave band

$T_{b(S)}$	handle-adaptor bare adaptor ISO weighted transmissibility for spectrum S
$T_{g(S)}$	uncorrected handle-gloved hand ISO weighted transmissibility for spectrum S
$T(f_i)$	corrected handle-gloved hand transmissibility in the ith one-third-octave band
$T_{(S)}$	corrected handle-gloved ISO weighted hand transmissibility for spectrum S
$\bar{T}\left(f_i\right)$	mean value for the corrected handle-gloved hand transmissibility in the ith one-third-octave band
$\bar{T}_{(S)}$	mean value for the handle-gloved ISO-weighted hand transmissibility for spectrum S
W_{hi}	ISO frequency-weighting factor specified in ISO 5349-1 for the ith one third-octave frequency band associated with each spectrum S

5 Measuring principle and equipment

5.1 General principle and setup

The method specified in this International Standard is used to measure the vibration input to a gloved hand that is transmitted through the glove at the palm of the hand, which grips and pushes on an instrumented handle. The glove vibration transmissibility (3.1) measured at the palm is used as an index to judge the vibration-reducing effectiveness of the glove. A vibration excitation system (normally an electromechanical shaker) shall be used to generate the required vibration input. The vibration in the direction of the excitation shall be simultaneously measured at the middle point of the top of the instrumented handle (see Annex A) and between the palm of the hand and glove by means of a palm adaptor. The adaptor shall contain an accelerometer and shall be placed inside the glove between the hand and handle. To compensate for the frequency response of the palm adaptor, the glove vibration transmissibility is calculated as the ratio of the vibration transmissibility values at the palm of the hand with a glove, as measured with the palm adaptor, divided by the corresponding transmissibility values associated with the bare palm adaptor attached to the handle.

A schematic drawing of a recommended vibration measurement setup is shown in Figure 1. The acceleration at the reference point in the instrumented handle, $a_R(f_i)$, and the vibration at the palm of the hand, $a_{h(Pb)}(f_i)$ or $a_{h(Pg)}(f_i)$, shall be measured simultaneously. Annex A shows examples of instrumented handles. The diameter of that part of the instrumented handle that is clasped by the hand shall be (40 ± 0,5) mm.

The values of the grip and feed forces shall be displayed continuously so the test subject can continually monitor them and consistently apply the required grip and feed forces throughout a test.

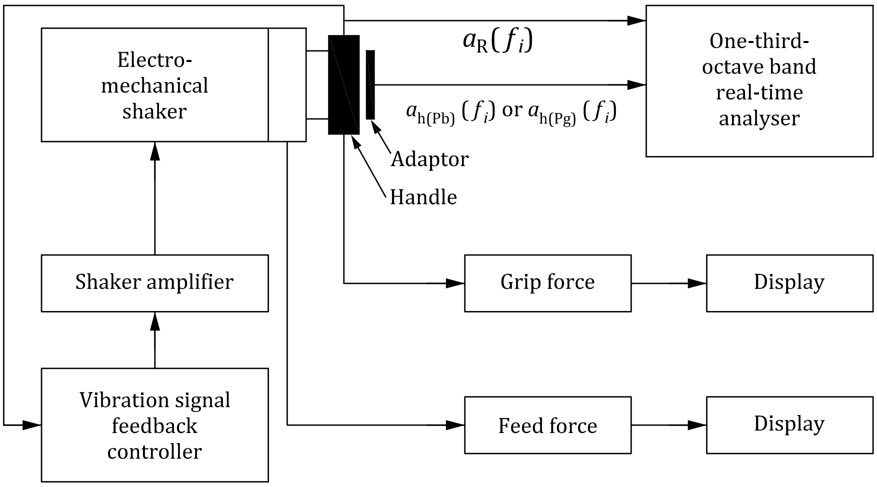


Figure 1 — Schematic diagram for measurement of glove vibration transmissibility

5.2 Measuring equipment

5.2.1 General requirements

A minimum of a two-channel, one-third-octave band real-time frequency analyser and two accelerometers are required.

The elements of the measuring chain shall fulfill the requirements of ISO 8041.

5.2.2 Transducer mounting

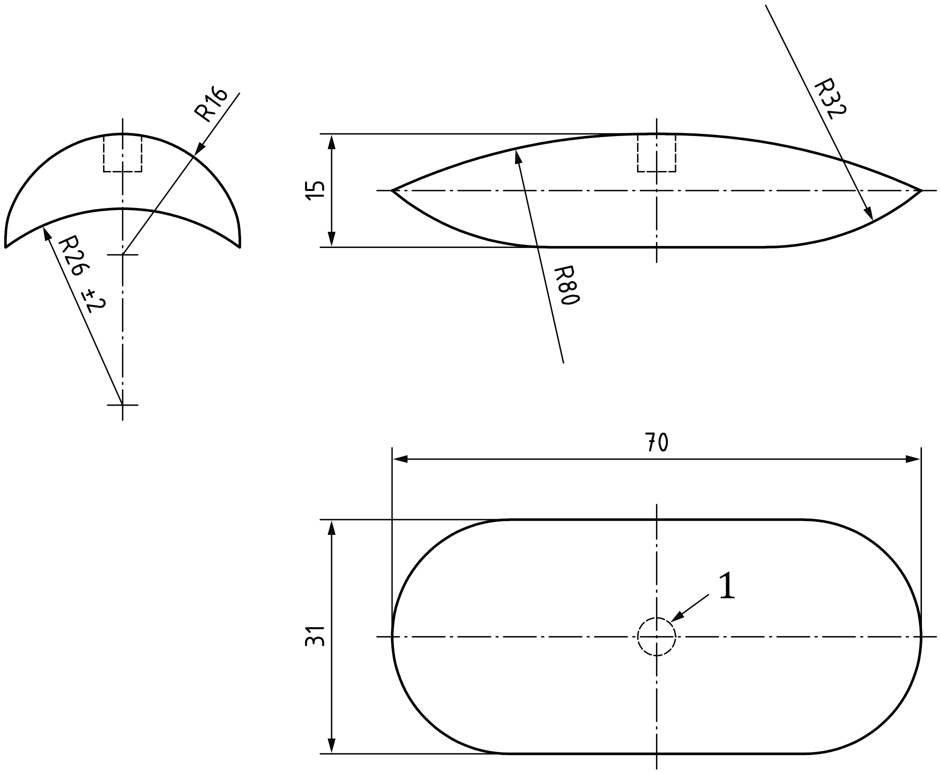
5.2.2.1 Mounting at the reference point in the handle

A single-axis accelerometer shall be embedded within the top surface of the test handle that will be in contact with the palm adaptor. The accelerometer shall be placed near the centre of the length of the handle, and its measurement axis shall be parallel to the vibration excitation axis. The exact location of the accelerometer shall be marked on the surface of the handle.

5.2.2.2 Mounting for measurement at the palm of the hand

To measure vibration at the palm of the hand, a palm adaptor shall be used that contains an accelerometer (may be a single axis or triaxial accelerometer) with the dimensions and shape shown in Figure 2. Its mass, which includes the mass of the accelerometer, shall not exceed 15 g. The palm adaptor shall be made of a rigid material, such as wood or hard plastic.

Dimensions in millimetres



Key

1 accelerometer location

NOTE Unless otherwise specified, all tolerances are ±0,5 mm.

Figure 2 — Adaptor for holding the accelerometer in the palm of the hand

To ensure measurement accuracy, the calibration consistency of the two accelerometers installed in the handle and the palm adaptor, respectively, shall be checked by affixing the adaptor to the test handle with a contact force of (80 ± 10) N. The adaptor shall be positioned on the surface of the handle as close as possible to the accelerometer installed on the handle (see Annex A), and the adaptor shall be aligned with the vibration axis of the handle. The palm adaptor shall be held in place by means of a lightweight elastic element (e.g. rubber bands). The measured bare palm adaptor vibration transmissibility shall be within the amplitude range of 0,95 to 1,05 over the one-third-octave frequency range of 25 Hz to 1 250 Hz.

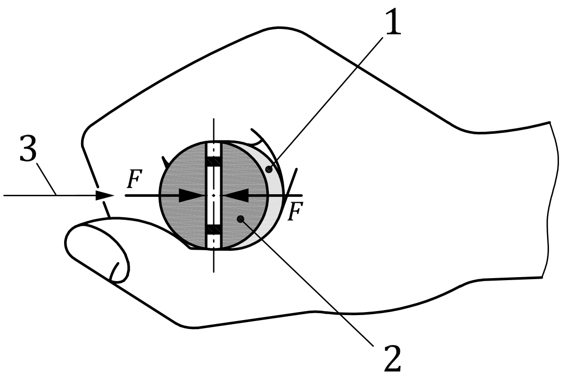
Care should be taken to ensure that the palm adaptor has solid contact with the test handle along a single straight line that runs the length of the adaptor. Deviations from unity transmissibility in excess of ±5 % can occur when the palm adaptor, which has a radius greater than the test handle radius, does not have good contact with the test handle.

5.2.3 Frequency analyses

Frequency analyses in one-third-octave frequency bands shall be conducted. The one-third-octave band filters shall fulfill the requirements for one-third-octave filters specified in IEC 61260, class 1.

5.2.4 Grip force measuring system

Grip force is the force used to grip the handle along the axis of vibration (see ISO 15230[2]). It is measured according to the scheme shown in Figure 3.



Key

1 adaptor

2 handle

3 axis of vibration

F force

Figure 3 — Grip force to be measured

The grip force shall be measured using the instrumented handle (refer to Annex A). The grip force measurement system shall fulfill the following requirements:

a) dynamic range: 10 N to 80 N;

b) resolution: better than 2 N;

c) measuring errors: less than 4 N;

d) integration time for visual display: 0,25 s to 0,50 s.

5.2.5 Feed force measuring system

Feed force means the horizontal force that pushes toward the vibration excitation system along the axis of vibration (see ISO 15230[2]).

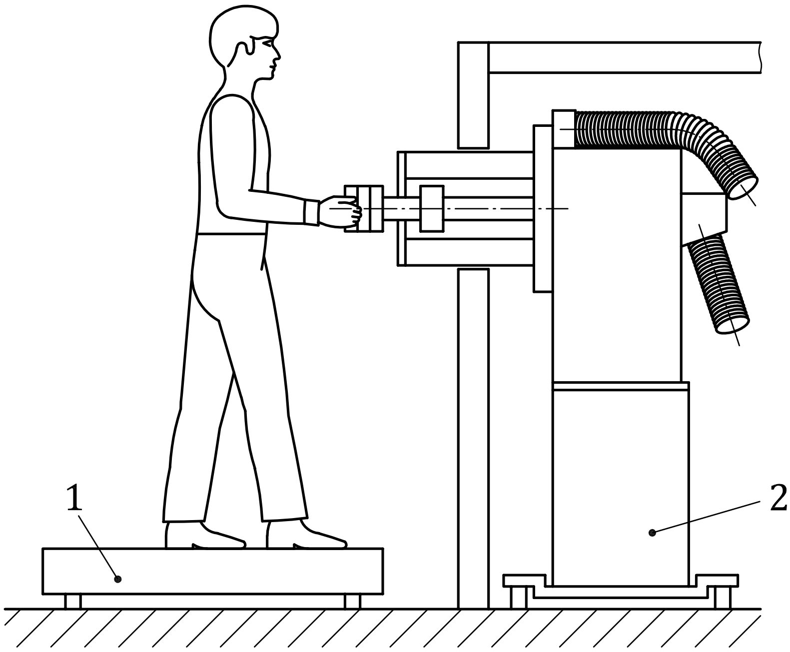
The feed force shall be measured using a horizontal force measurement device, which may be a force plate installed on an adjustable platform where the subject stands during the experiment (see Figure 4) or a force measurement system built into the instrumented handle (refer to Annex A). The feed force measuring system shall fulfill the following requirements:

a) dynamic range: 10 N to 80 N;

b) resolution: better than 2 N;

c) measuring errors: less than 4 N;

d) integration time for visual display: 0,25 s to 0,50 s.



Key

1 adjustable platform

2 vibration excitation system

NOTE Feed force can be measured at the platform or the electromechanical shaker.

Figure 4 — Posture of the test subject during measurements

5.3 Vibration excitation system

5.3.1 Characteristics of the instrumented handle

5.3.1.1 Dimensions and orientation of the handle

The handle shall have a circular cross-section with a diameter of (40 ± 0,5) mm and a minimum length of 110 mm (refer to examples of handles in Annex A). The orientation of the handle on the shaker shall be vertical (see Figure 4).

5.3.1.2 Resonance characteristics of the handle

The handle shall not have any resonances within the one-third-octave frequency range of 25 Hz to 1 250 Hz.

5.3.2 Position of the excitation system

The axis of vibration shall be horizontal and parallel to the forearm of the standing test subject (see Figure 4).

The excitation system or the platform the test subject stands on shall be adjusted so that the requirements regarding the test subject's posture, as defined in 6.1.4, are fulfilled.

5.3.3 Performance

The excitation system shall be able to produce the vibration amplitudes specified in 6.2 when a feed force and a grip force as specified in 6.1.3 a) and b) are applied.

6 Measurement conditions and procedure

6.1 Measurement conditions

6.1.1 Test subjects

Five adults with hand sizes between 7 and 10, as specified by EN 420, shall serve as test subjects. The test subjects shall use their dominant hand for the glove vibration transmissibility tests.

6.1.2 Test gloves

Five separate gloves of the same type shall be tested (one glove for each test subject).

6.1.3 Test conditions

For the measurements, the following conditions shall be observed.

a) Grip force — the grip force shall be displayed continuously. The test subject shall maintain the grip force at (30 ± 5) N throughout the test period.

b) Feed force — the feed force shall be displayed continuously. The test subject shall maintain the feed force at (50 ± 8) N throughout the test period.

c) Room temperature — vibration measurements shall take place at a room temperature of (20 ± 5) °C, and the room temperature shall be reported.

d) Humidity — the relative humidity shall be below 70 % and shall be reported.

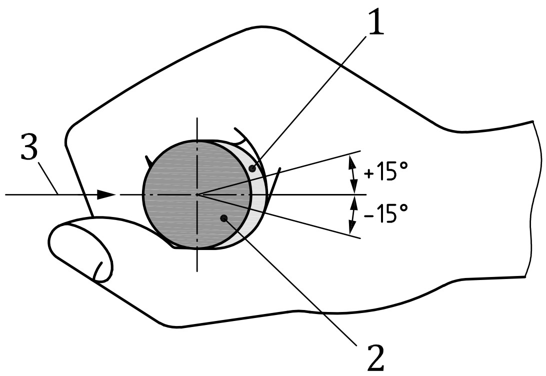
e) Conditioning of gloves — the gloves to be tested shall be stored at the temperature specified in c) for at least 30 min and worn by a test subject for at least 3 min before the test procedure is started.

f) Fitting of gloves — the size of the gloves shall be chosen according to EN 420.

g) Vibration measurement averaging time — the averaging time for the vibration tests shall be a minimum of 30 s.

6.1.4 Test subject's posture

The test subject shall clasp the handle with the palm adaptor as shown in Figure 5 for the glove vibration transmissibility tests. The operator shall stand upright on a horizontal surface (floor or platform) as shown in Figure 4. The forearm shall be directed along the axis of vibration. The elbow shall form an angle of 90° ± 15°. The elbow shall not touch the body during the measurements. The wrist shall be bent between 0° (neutral) and 40° (dorsal bending) maximum.



Key

1 adaptor

2 handle

3 axis of vibration

Figure 5 — Position of hand with handle and adaptor

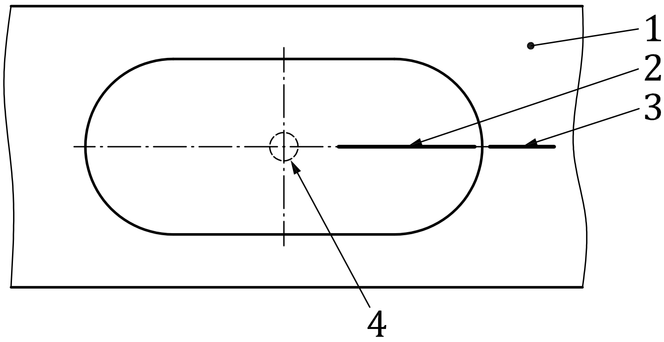
6.1.5 Position of the palm adaptor in glove vibration transmissibility tests

6.1.5.1 General

The palm adaptor shall be positioned in the gloved hand relative to the handle as shown in Figure 5. The axis of the accelerometer embedded in the adaptor should not deviate from the axis of vibration by more than ±15°. One of the following procedures shall be used to minimize measurement error associated with misalignment of the palm adaptor on the handle: method 1 with a single axis accelerometer, method 2 with a triaxial accelerometer, or method 1 with a triaxial accelerometer as specified in method 2.

6.1.5.2 Method 1: single axis accelerometer

Place a slit in the seam of the glove between the thumb and index finger so that the palm adaptor can be visually positioned between the palm of the hand and the top of the handle. To facilitate this alignment, place visible marks, as shown in Figure 6, on the top centres of the palm adaptor and the handle.



Key

1 handle

2 mark — top centre of palm adaptor

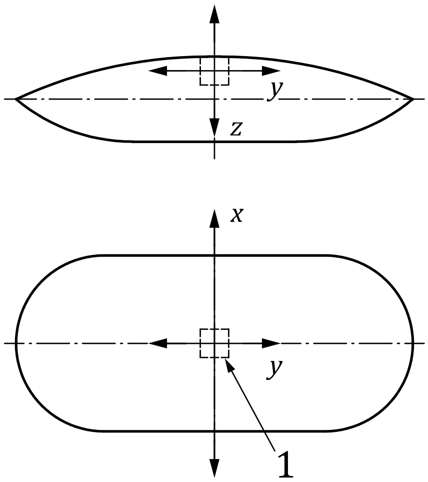
3 mark — top centre of handle

4 accelerometer location

Figure 6 — Palm adaptor alignment on top of handle

6.1.5.3 Method 2: triaxial accelerometer

Embed a miniature triaxial accelerometer in place of the single axis accelerometer in the palm adaptor (Figure 7). The palm adaptor acceleration value is the root-sum-squares of the measured acceleration values on the three mutually orthogonal axes shown in Figure 7 [refer to Formulae (3) and (6)].



Key

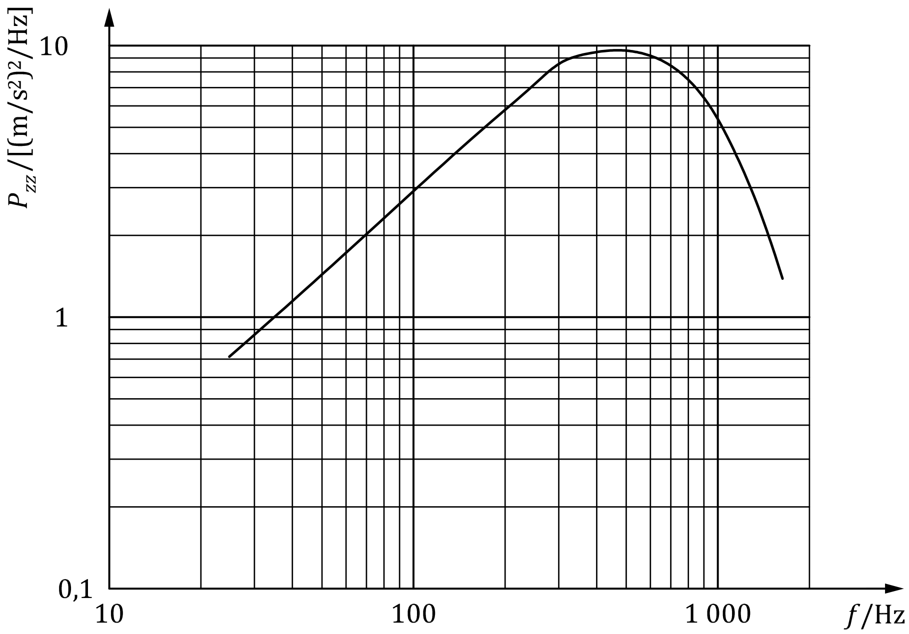
1 accelerometer location

x, *y*, *z* three mutually orthogonal measurement axes

Figure 7 — Triaxial accelerometer location in palm adaptor

6.2 Vibration signal

The vibration signal measured at the handle is a band-limited random vibration signal. The first part of the signal spectrum (from 25 Hz to 250 Hz) is a constant-velocity (0,012 8 m/s) spectrum. The second part (from 315 Hz to 1 600 Hz) is a ramp-down spectrum. The entire spectrum shall fulfil the requirements specified in Table 1 and Figure 8. The acceleration power spectral density (PSD) is expressed as mean square acceleration per unit frequency bandwidth in $(m/s^2)^2$/Hz. The corresponding one-third-octave band acceleration values of the acceleration signal are listed in Table 1 and shown in Figure 9. The frequency-weighted acceleration value of the band-limited random vibration signal is (4,82 ± 0,50) m/s^2.

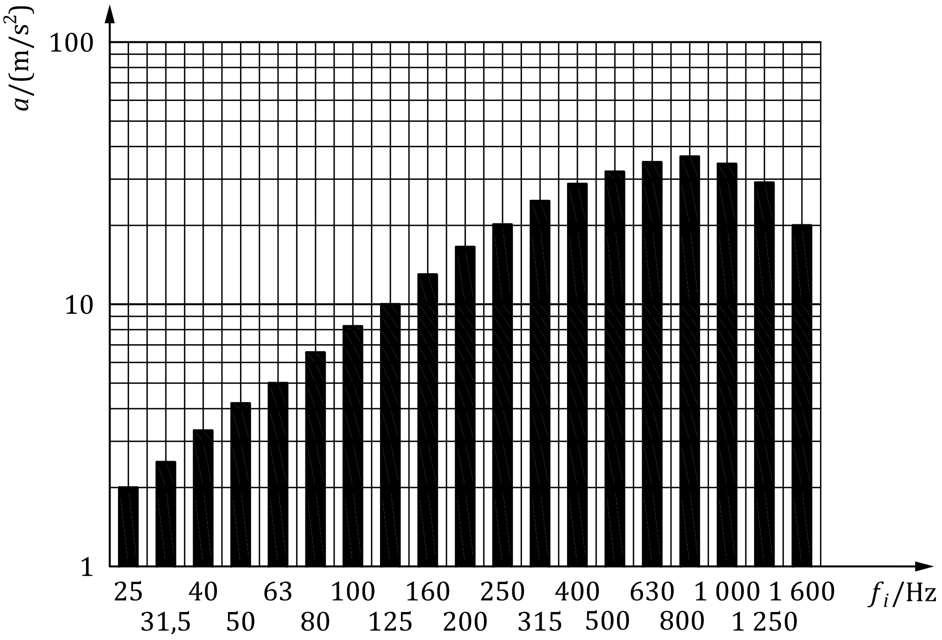


Key

P_{zz} accelerometer power spectral density

f frequency

Figure 8 — Handle acceleration power spectral density spectrum



Key

a acceleration

f_i one-third-octave-band centre frequency

Figure 9 — One-third-octave band handle acceleration values

6.3 Test procedure

6.3.1 Preparation

The following steps shall be carried out before starting the vibration measurements:

a) calibrate the accelerometers and measurement system (in accordance with ISO 8041);

b) condition the gloves as described in 6.1.3 e);

c) instruct the tests subjects with regard to the test posture in 6.1 and conduct trials so that the test subjects learn to control the feed and grip forces described in 6.1.3 a) and b);

d) check and adjust the vibration signal to achieve the vibration signal in 6.2.

6.3.2 Measurements with the bare adaptor

One-third-octave band bare palm adaptor acceleration measurements shall be carried out with the palm adaptor attached to the test handle as specified in 5.2.2.2. The hand shall not be used to clasp the test handle with adaptor during these measurements. The one-third-octave band unweighted acceleration values at the handle, $a_R(f_i)$, and on the bare adaptor, $a_{h(Pb)}(f_i)$, shall be measured simultaneously and used to calculate the adaptor transmissibility between the adaptor and handle as specified in 7.2.

If the one-third-octave band bare adaptor transmissibility associated with the unweighted accelerations in any one-third-octave band between 25 Hz and 1 250 Hz is outside the range of 0,95 to 1,05, consider the measurements to be invalid.

Table 1 — Required handle acceleration values

Frequency	Acceleration PSD value	Acceleration tolerance in the one-third octave band	One-third-octave acceleration value
f_i	P_{zz}		
Hz	(m/s²)²/Hz	dB	m/s²
25	0,709	±2	1,98
31,5	0,893	±1	2,45
40	1,134	±1	3,22
50	1,417	±1	4,10
63	1,786	±1	4,85
80	2,268	±1	6,38
100	2,835	±1	8,20
125	3,543	±1	9,81
160	4,535	±1	12,53
200	5,669	±1	16,00
250	7,087	±1	20,14
315	8,521	±1	23,79
400	9,179	±1	28,19
500	9,179	±1	31,59
630	8,555	±1	33,96
800	7,069	±1	35,19
1000	4,994	±1	33,35
1250	2,905	$^{+2}_{-\infty}$	28,37
1600	1,324	$^{+3}_{-\infty}$	19,58
Unweighted acceleration			90,19
Frequency-weighted acceleration			4,82
Frequency-weighted acceleration tolerance			± 0,50

6.3.3 Measurements with gloved hand

Using the same adaptor as in 6.3.2, one-third-octave band gloved hand acceleration measurements shall be carried out with each test subject. The one-third-octave band unweighted accelerations obtained at the handle, $a_R(f_i)$, and on the adaptor, $a_{h(Pg)}(f_i)$, shall be measured simultaneously and used to calculate the gloved hand transmissibility as specified in 7.3.

6.3.4 Measurements with resilient material

If the measurement method specified in this International Standard is used to measure the vibration transmissibility of a resilient material, a piece of the material shall be wrapped around the full circumference of the handle. The resilient material shall be attached to the handle with double-sided adhesive tape or other similar adhesive material so the resilient material can be stably held on the handle. The resilient material shall be applied to the handle so as not to preload the grip force transducer in the handle. The resilient material shall then be clasped with the hand with the adaptor placed between the palm of the hand and the material.

6.3.5 Required number of tests

The required number of tests is:

a) bare palm adaptor vibration transmissibility tests: one test for the adaptor at the beginning of the test day;

b) glove vibration transmissibility tests: three separate tests for each of the five test subjects.

For each vibration transmissibility test for each test subject, there shall be a minimum 3 min rest period between each test.

If the gloved-hand vibration transmissibility tests for the five test subjects occur over multiple test sessions spread over multiple days, the bare adaptor tests shall be repeated at the beginning of each test day.

7 Evaluation of results

7.1 Calculation of transmissibility

7.1.1 General

Figure 10 is a flow diagram for the bare adaptor and glove vibration transmissibility measurements and the calculations of the mean corrected transmissibility values and related standard deviations and coefficients of variation.

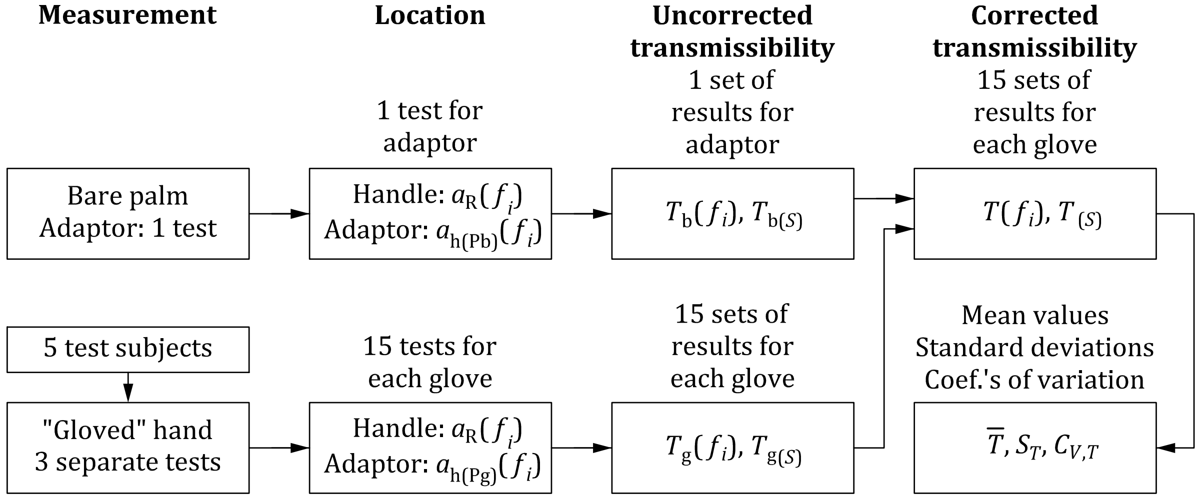


Figure 10 — Flow diagram for determining the mean corrected transmissibility values, standard deviations and coefficients of variation

7.1.2 One-third-octave frequency ranges

The range of one-third-octave centre frequencies for the vibration spectra S_M and S_H shall be:

a) vibration frequency range Δf_M: 25 Hz to 200 Hz;

b) vibration frequency range Δf_H: 200 Hz to 1 250 Hz.

7.1.3 Frequency-weighted acceleration values

The frequency-weighted acceleration value, $a_{hw(S)}(f_i)$, in the ith one-third-octave frequency band shall be obtained from:

$$a_{hw(S)}(f_i) = a_{h(S)}(f_i)\, W_{hi} \quad (1)$$

where

$a_{h(S)}(f_i)$ is the measured acceleration value in the ith one-third-octave band;

f_i is the one-third-octave centre frequency for the ith one-third-octave band;

W_{hi} is the ISO frequency weighting value specified in ISO 5349-1 for the ith one-third-octave frequency band — values for W_{hi} are given in Table 2.

NOTE For the spectrum S_M, S is substituted by M and for the spectrum S_H, S is substituted by H in Formula (1).

Table 2 — Frequency weighting factors W_{hi} for hand-transmitted vibration for conversion of one-third-octave band magnitudes to frequency-weighted magnitudes

Frequency band number	Nominal value of band centre frequency	Weighting factor
i	f_i Hz	W_{hi}
14	25	0,647
15	31,5	0,519
16	40	0,411
17	50	0,324
18	63	0,256
19	80	0,202
20	100	0,160
21	125	0,127
22	160	0,101
23	200	0,079 9
24	250	0,063 4
25	315	0,050 3
26	400	0,039 8
27	500	0,031 4
28	630	0,024 5
29	800	0,018 6
30	1 000	0,013 5
31	1 250	0,008 94

7.2 Bare palm adaptor vibration transmissibility

7.2.1 One-third-octave vibration transmissibility

The bare adaptor vibration transmissibility, $T_b(f_i)$, for the ith one-third-octave band shall be calculated from:

$$T_b(f_i) = \frac{a_{h(Pb)}(f_i)}{a_R(f_i)} \tag{2}$$

where $a_{h(Pb)}(f_i)$ and $a_R(f_i)$ are defined in 6.3.2.

If method 2 in 6.1.5.3 is used to measure $a_{h(Pb)}(f_i)$:

$$a_{h(Pb)}(f_i) = \sqrt{a^2_{h(Pbx)}(f_i) + a^2_{h(Pby)}(f_i) + a^2_{h(Pbz)}(f_i)} \tag{3}$$

where (refer to Figure 7)

$a_{h(Pbx)}(f_i)$	is the value of $a_{h(Pb)}(f_i)$ on the x-axis;
$a_{h(Pby)}(f_i)$	is the value of $a_{h(Pb)}(f_i)$ on the y-axis;
$a_{h(Pbz)}(f_i)$	is the value of $a_{h(Pb)}(f_i)$ on the z-axis.

7.2.2 Frequency-weighted vibration transmissibility

The frequency-weighted bare adaptor vibration transmissibility, $T_{b(S)}$, for the S_M and S_H vibration spectra shall be calculated from:

$$T_{b(S)} = \frac{\sqrt{\sum_{i=i_L}^{i_U} \left[a_{h(Pb)}(f_i)\, W_{hi} \right]^2}}{\sqrt{\sum_{i=i_L}^{i_U} \left[a_R(f_i) W_{hi} \right]^2}} \tag{4}$$

where

$a_{h(Pb)}(f_i)$, $a_R(f_i)$	are defined in 6.3.2;
W_{hi}	is defined in Table 2;
i_L	is 14 for $S = S_M$ and 23 for $S = S_H$ (see Table 2);
i_U	is 23 for $S = S_M$ and 31 for $S = S_H$ (see Table 2).

NOTE For the spectrum S_M, S is substituted by M and for the spectrum S_H, S is substituted by H in Formula (4).

7.3 Uncorrected glove vibration transmissibility

7.3.1 One-third-octave vibration transmissibility

The uncorrected glove vibration transmissibility, $T_g(f_i)$, for the ith one-third-octave band shall be calculated from:

$$T_g(f_i) = \frac{a_{h(Pg)}(f_i)}{a_R(f_i)} \tag{5}$$

where $a_{h(Pg)}(f_i)$ and $a_R(f_i)$ are defined in 6.3.3.

If method 2 in 6.1.5.3 is used to measure $a_{h(Pg)}(f_i)$:

$$a_{h(Pg)}(f_i) = \sqrt{a_{h(Pgx)}^2(f_i) + a_{h(Pgy)}^2(f_i) + a_{h(Pgz)}^2(f_i)} \tag{6}$$

where (refer to Figure 7)

$a_{h(Pgx)}(f_i)$	is the value of $a_{h(Pg)}(f_i)$ on the x-axis;
$a_{h(Pgy)}(f_i)$	is the value of $a_{h(Pg)}(f_i)$ on the y-axis;
$a_{h(Pgz)}(f_i)$	is the value of $a_{h(Pg)}(f_i)$ on the z-axis.

7.3.2 Frequency-weighted vibration transmissibility

The frequency-weighted uncorrected glove vibration transmissibility, $T_{g(S)}$, for the S_M and S_H vibration spectra shall be calculated from:

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

where

$a_{h(Pg)}(f_i)$, $a_R(f_i)$	are defined in 6.3.3;
W_{hi}	is defined in Table 2;
i_L	is 14 for $S = S_M$ and 23 for $S = S_H$ (see Table 2);
i_U	is 23 for $S = S_M$ and 31 for $S = S_H$ (see Table 2).

NOTE For the spectrum S_M, S is substituted by M and for the spectrum S_H, S is substituted by H in Formula (7).

7.4 Corrected glove vibration transmissibility

7.4.1 One-third-octave vibration transmissibility

The corrected glove vibration transmissibility, $T(f_i)$, for the ith one-third-octave band shall be calculated from:

$$T(f_i) = \frac{T_g(f_i)}{T_b(f_i)} \tag{8}$$

7.4.2 Frequency-weighted vibration transmissibility

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

$$T_{(S)} = \frac{T_{g(S)}}{T_{b(S)}} \tag{9}$$

NOTE For the spectrum S_M, S is substituted by M and for the spectrum S_H, S is substituted by H in Formula (9). The associated frequency ranges are given in 7.1.2.

8 Calculation of statistical values

8.1 General

The statistical values presented in this clause shall be calculated and reported for all vibration transmissibility tests for each individual test subject (three tests each) and for all five test subjects (15 tests in total).

8.2 One-third-octave vibration transmissibility

The mean value, $\bar{T}(f_i)$, for each corrected one-third-octave vibration transmissibility value is given by:

$$\bar{T}(f_i) = \frac{1}{N}\sum_{j=1}^{N} T_j(f_i) \tag{10}$$

where

$N = 3$ (three tests for each test subject); or

$N = 15$ (five test subjects with three tests each);

$T_j(f_i)$ are the corrected one-third-octave glove vibration transmissibility values for each individual test.

The standard deviation, $s_T(f_i)$, for the one-third-octave vibration transmissibility values is given by:

$$s_T(f_i) = \sqrt{\frac{1}{N-1}\sum_{j=1}^{N}\left[T_j(f_i) - \bar{T}(f_i)\right]^2} \tag{11}$$

The coefficient of variation, $C_{V,T}(f_i)$, for the one-third-octave vibration transmissibility values is given by:

$$C_{V,T}(f_i) = \frac{s_T(f_i)}{\bar{T}(f_i)} \tag{12}$$

The mean values, standard deviations and coefficients of variation shall be reported

a) for each individual test subject ($N = 3$); and

b) for all five test subjects combined ($N = 15$)

for the one-third-octave bands with centre frequencies from 25 Hz to 1 250 Hz.

8.3 Frequency-weighted vibration transmissibility

The mean value, $\overline{T}_{(S)}$, for the corrected frequency-weighted glove vibration transmissibility values is given by:

$$\overline{T}_{(S)} = \frac{1}{N}\sum_{j=1}^{N} T_{(S)j} \tag{13}$$

where

$N = 3$ (three tests for each test subject); or

$N = 15$ (five test subjects with three tests each);

$T_{(S)j}$ are the corrected frequency-weighted glove vibration transmissibility values for each individual test.

NOTE For the spectrum S_M, S is substituted by M and for the spectrum S_H, S is substituted by H in Formula (13). The associated frequency ranges are given in 7.1.2.

The standard deviation, $s_{T(S)}$, for the frequency-weighted transmissibility values is given by:

$$s_{T(S)} = \sqrt{\frac{1}{N-1}\sum_{j=1}^{N}\left[T_{(S)j} - \overline{T}_{(S)}\right]^2} \tag{14}$$

The coefficient of variation, $C_{V,T(S)}$, for the frequency-weighted transmissibility values is given by:

$$C_{V,T(S)} = \frac{s_{T(S)}}{\overline{T}_{(S)}} \tag{15}$$

The mean values, standard deviations and coefficients of variation shall be reported:

a) for each individual test subject ($N = 3$); and

b) for all five test subjects combined ($N = 15$)

for $T_{(M)}$ and $T_{(H)}$.

9 Criteria for designating gloves as antivibration gloves

9.1 General

To be designated as an *antivibration glove* according to this International Standard, all the requirements specified in 9.2 and 9.3 shall be fulfilled.

9.2 Vibration transmissibility of the gloves

The gloved hand mean values $\overline{T}_{(H)}$ and $\overline{T}_{(M)}$ shall meet the requirements:

$$\overline{T}_{(H)} \le 0{,}60$$

and

$$\overline{T}_{(M)} \le 0{,}90$$

9.3 Construction of the gloves

9.3.1 Glove vibration-reducing material thickness

9.3.1.1 Glove vibration-reducing material thickness in the palm

The thickness of vibration-reducing material placed in the palm section of the glove should not be greater than 8 mm.

NOTE The use of a glove with an embedded vibration-reducing material generally reduces the hand grip strength associated with gripping a machine handle. This requires a greater grip effort to achieve the same level of machine control as is achieved with bare hand operation of the machine. Increased hand-transmitted vibration reduction can often be achieved with thicker vibration-reducing materials. However, a trade-off needs to be made between this increased vibration reduction and the potential negative effects of the thicker materials associated with increased grip effort, reduced finger dexterity and hand comfort, and reduced control while operating a machine.

9.3.1.2 Glove vibration-reducing material in the thumb and fingers

The same vibration-reducing material shall be placed in the palm section and the finger and thumb sections of the glove. The vibration-reducing material shall cover the complete palm area of the hand and shall cover the three phalanges of each finger and the two phalanges of the thumb. The thickness of vibration-reducing material placed in the fingers and thumb sections of the glove shall be equal to or greater than 0,55 times the thickness of the vibration-reducing material placed in the palm section of the glove.

NOTE An antivibration glove that meets the vibration transmissibility requirements of this International Standard can also potentially be too stiff, bulky, and uncomfortable to wear and use if the same thickness of vibration-reducing material is used in the palm section and the finger and thumb sections of the glove. Using a thinner vibration-reducing material of the same type used in the palm section in the finger and thumb sections of a glove increases finger dexterity and hand comfort associated with the use of the glove. The potential negative effects of the thinner material with respect to vibration transmitted to the fingers is minimal and is offset by the increased dexterity and comfort experienced when wearing and using the glove.

9.3.2 Measurement of the thickness of the glove vibration-reducing material

9.3.2.1 General

The thickness of the vibration-reducing material in the palm and finger sections of a glove shall be measured as follows.

9.3.2.2 Measurement setup

The measurement setup for measuring the thickness of the glove vibration-reducing material is shown in Figure 11. The thickness measurement should be made on a flat bench top. Place a (6 ± 0,6) mm thick sheet of polymethylmethacrylate (PMMA) or other similar material on the surface of the bench top. This is the measurement surface. Machine a uniform cylindrical measurement mass which shall have the following specifications:

a) material: aluminium (density 2 700 kg/m^3);

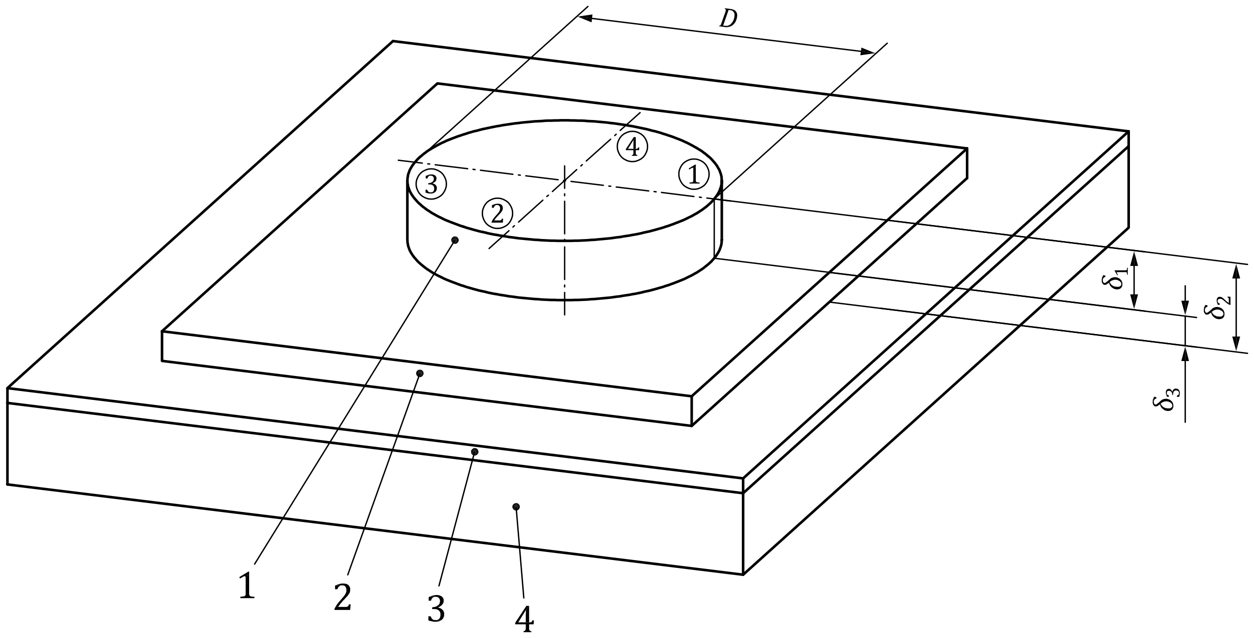
b) diameter, D: (80 ± 4) mm;

c) thickness, δ_1: (25 ± 2) mm;

d) mass: (350 ± 35) g.

The circumferential position of the measurement locations can be conveniently selected based on the location of the measurement mass on the vibration-reducing material.

The purpose of the sheet of PMMA or other similar material is to provide on a typical bench top a smooth flat surface on which to perform the measurements specified in 9.3.2. If the measurements are performed on a smooth flat granite, slate or other similar surface, this sheet may not be necessary. When placed on the palm or fingers of a glove, the disc may extend beyond the boundaries of the palm or fingers of the glove.



Key

1	measurement mass	①, ②, ③, ④	measurement locations around the top of the measurement mass
2	vibration-reducing material	D	diameter of the measurement mass
3	polymethylmethylacrylate sheet	δ_1	measurement mass thickness
4	flat bench top	δ_2	$\delta_2 = \delta_1 + \delta_3$
		δ_3	vibration-reducing material thickness

Figure 11 — Example of a measurement setup for measuring the glove vibration-reducing material thickness

9.3.2.3 Measurement procedure

The thickness of the glove vibration-reducing material in the palm and finger sections shall be measured as follows.

a) If the vibration-reducing material is an insert placed into the glove, remove the vibration-reducing material from the glove or use a sample of the vibration-reducing material that has been received from the glove manufacturer or supplier.

b) If the vibration-reducing material is integrated into the covering of the palm, finger and thumb sections on the palm-side of the glove, the thickness measurement shall include the entire integrated material from the palm side of the glove.

c) Place the glove vibration-reducing material on the surface of the sheet of PMMA or other similar material and the measurement mass on top of the centre of the palm section or on top of a minimum of three finger elements of the finger section of the vibration-reducing material.

d) Measure the distance between the top of the measurement mass and the surface of the sheet of PMMA or other similar material, δ_2, at four locations around the top of the measurement mass that shall be separated by angles of 90° ± 5° to within ±0,1 mm (see Figure 11).

e) Calculate the thickness of the vibration-reducing material, δ3, at the four measurement locations, using Formula (16):

$$\delta_{3i} = \delta_{2i} - \delta_1 \quad (16)$$

where i = 1, 2, 3, 4.

f) Calculate the average thickness of the vibration-reducing material, using Formula ((17):

$$\bar{\delta}_3 = \frac{1}{4}\sum_{i=1}^{4}\delta_{3i} \quad (17)$$

$\bar{\delta}_3$ shall be the reported thickness of the vibration-reducing material in the palm and finger sections.

g) It may be difficult to use the measurement setup in Figure 11 to measure the thickness of the thumb element of the glove vibration-reducing material. When this is the case, the thumb element shall be visually inspected to verify that its thickness is similar to the thickness of the four finger elements.

9.3.3 Lacks (gap) between the palm and thumb sections of glove vibration-reducing material

9.3.3.1 General

Antivibration gloves may be fabricated in which the vibration-reducing material placed in the thumb section of the gloves is not directly connected to the adjacent vibration-reducing material placed in the palm section. When this is the case, the following requirements shall be met.

9.3.3.2 Vibration-reducing material covering in the palm area between the index finger and thumb

The area of the palm directly between the index finger and the thumb shall be covered by vibration-reducing material that is part of the vibration-reducing material in the palm section of the gloves.

9.3.3.3 Lacks (gap) between the thumb and palm vibration-reducing material

The lacks (gap) between the thumb section and adjacent palm section vibration-reducing material should not be greater than the thickness of the palm section vibration-reducing material along the length of the lacks.

9.3.3.4 Securing of the vibration-reducing material in the thumb

The thumb section vibration-reducing material shall be secured in the thumb section of the gloves so that the material does not slip or move out of position during normal use of the gloves.

9.3.4 Requirements within the European Union

Gloves that are designated as antivibration gloves according to this International Standard that will be used in workplace environments in the European Union are also required to meet the minimal requirements for mechanical risks specified in EN 388.

10 Test report

The glove manufacturer or supplier shall provide the following information, which shall be included in the test report.

— Description of glove material(s) or fabric(s) used in the palm, finger and thumb sections of the glove that comes into contact with the handles and other parts of a vibrating machine or the surface of a vibrating work piece.

— Description of material(s) or fabric(s) used on the dorsal sections of the glove.

— Description of the vibration-reducing material placed in the glove [include trademark(s) and brand name(s) associated with the vibration-reducing material, if used].

— A picture (in jpeg, tiff or other accepted electronic picture format) of the vibration-reducing material used in the glove.

— Thicknesses of the vibration-reducing material used in the palm, finger and thumb sections of the glove.

— A sample of the glove vibration-reducing material (or permission to disassemble one of the gloves sent for testing) so the thickness measurements specified in 9.3.2 can be made.

— Description of other relevant properties of materials or fabrics used in the glove (e.g. outer glove materials or fabrics that are resistant to cutting and slashing, are flame resistant, have improved wear and durability properties). Identify by name the types of these materials [with trademark(s) or brand name(s)].

The test report shall contain at least the following information:

a) the details of theinstitute, laboratory or other responsible organization which carried out the test;

b) the date of the test;

c) the name and address of the glove manufacturer;

d) the model or type and condition (new or used) of the glove;

e) a description of the samples tested (size, mass, left or right, colour);

f) a description of the testing equipment;

g) the method 1 or 2 in 6.1.5.2 or 6.1.5.3 that was used for the vibration transmissibility tests;

h) the measuring conditions (temperature and relative humidity in the test area);

i) vibration attenuation results:

   1) corrected gloved hand frequency-weighted arithmetic mean vibration transmissibility, standard deviation and coefficient of variation values for the Δf_M and Δf_H frequency ranges for each individual test subject and for all five test subjects combined,

   2) corrected gloved hand arithmetic mean vibration transmissibility, standard deviation and coefficient of variation values for the one-third-octave bands with centre frequencies of 25 Hz to 1 250 Hz for each individual test subject and for all five test subjects combined.

NOTE Standard deviation and coefficient of variation values for $T_{(M)}$ and $T_{(H)}$ are calculated and reported as required in 8.3. Currently there is no clear guidance as to what constitutes acceptable values for these terms. Standard deviation and coefficient of variation values obtained from glove vibration transmissibility tests conducted in accordance with the requirements of this International Standard will be collected and evaluated. It is anticipated that the results of this evaluation will give guidance as to how to more appropriately select test subjects for glove vibration transmissibility tests conducted in accordance with the requirements of this International Standard.

Annex A
(informative)

Examples of handles with force and acceleration measuring systems

Two examples of test handles with force and acceleration measuring systems are shown in Figures A.1 and A.2. Figure A.1 shows a grip force measuring system while Figure A.2 includes both a feed force and a grip force measuring system.

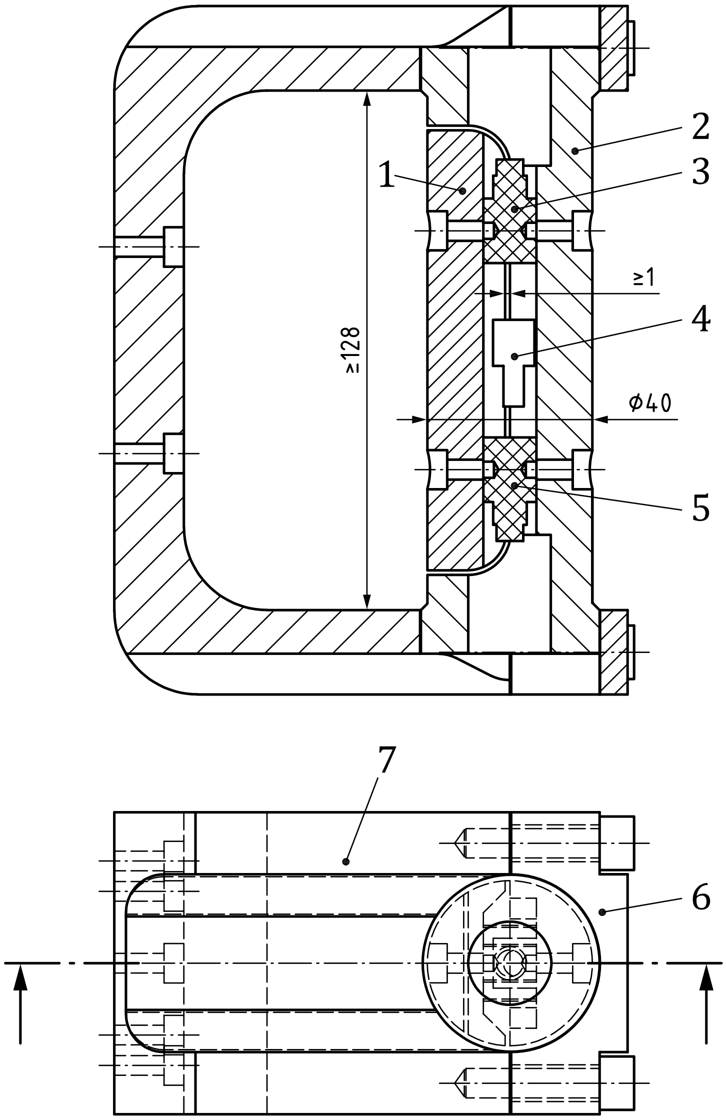
The first resonance frequency of these handles is usually in the range of 1,6 kHz to 2,1 kHz depending on the cap material and the tightness of the screws that hold the handle together.

NOTE 1 Only one charge amplifier is required for the two piezoelectric force transducers because their signals can be input to the same amplifier for the total grip force measurement.

NOTE 2 Because any piezoelectric force transducer has some zero-drift during its use, a reset of the charge amplifier before each test is recommended to ensure the accuracy of the force measurement.

NOTE 3 The accelerometer can be firmly attached to the handle base using a hard adhesive.

Dimensions in millimetres



Key

1 measurement cap, aluminium or magnesium

2 handle base, aluminium

3 force transducer

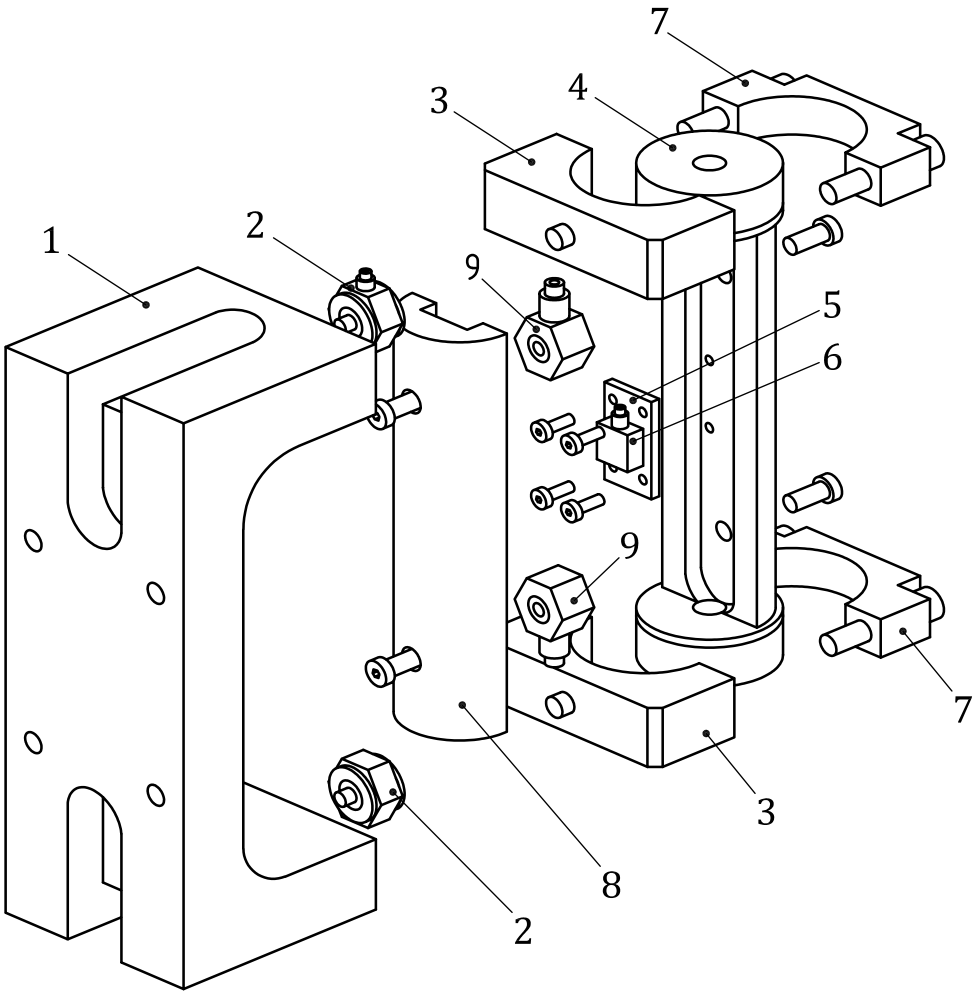
4 accelerometer attached to base using cyanoacrylate glue or stud

5 force transducer

6 fixture clamp, aluminium

7 handle fixture, aluminium

Figure A.1 — Example 1 of a handle with grip force measuring system



Key

1	base, aluminium		4	handle Ø 40 mm		7	front bracket
2	feed force transducer		5	accelerometer base		8	handle cover Ø 40 mm
3	rear bracket		6	accelerometer		9	grip force transducer

Figure A.2 — Example 2 of a handle with feed and grip force measuring systems

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