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AMERICAN NATIONAL STANDARD

Mechanical Vibration and Shock – Hand-arm vibration – Method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand

A Nationally Adopted International Standard

NAIS
ANSI S2.73-2002 / ISO 10819:1996

Accredited Standards Committee S2, Mechanical Vibration and Shock

Standards Secretariat
Acoustical Society of America
35 Pinelawn Road, Suite 114 E
Melville, NY 11747-3177

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AMERICAN NATIONAL STANDARD

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

A Nationally Adopted International Standard

Secretariat

Acoustical Society of America (ASA)

Approved April 26, 2002:

American National Standards Institute, Inc. (ANSI)

Abstract

This Nationally Adopted International Standard specifies a method for the laboratory measurement, the data analysis and reporting of the vibration transmissibility of gloves in terms of vibration transmission from a handle to the palm of the hand in the frequency range from 31.5 Hz to 1250 Hz.

The standard is intended to define a screening test for the vibration transmission through gloves. It is recognized that many factors influence the transmission of vibration through gloves. Therefore the transmissibility value according to this standard is not sufficient to assess the health risk due to vibration.

The transmissibility of vibration is measured and reported for two input spectra, which are representative of the vibration of some tools, and may be reported as a function of frequency.

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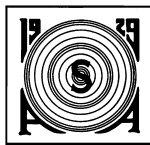
Standards Secretariat
Acoustical Society of America
35 Pinelawn Road, Suite 114 E
Melville, NY 11747-3177
USA
Telephone: 1 631 390 0215
Fax: +1 631 390 0217
E-Mail: asastds@aip.org

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Foreword

[This foreword is not part of the Nationally Adopted International Standard (NAIS), Mechanical vibration and shock – Evaluation of human exposure to whole body vibration – Part 1: General requirements, ANSI S2.73-2002 / ISO 10819:1996 (formerly ANSI S3.18-2002, ISO 10819:1996).]

This Nationally Adopted International Standard (NAIS) comprises a part of a group of definitions, standards, and specifications for use in work related to human exposure to mechanical vibration and shock. It has been adopted by the American National Standards Institute utilizing the Accredited Standards Committee Procedures, under the Secretariat of the Acoustical Society of America.

Accredited Standards Committee S3, Bioacoustics, under whose jurisdiction this NAIS was adopted, had the following scope at that time:

> *Standards, specifications, methods of measurement and test, and terminology in the fields of psychological and physiological acoustics, including aspects of general acoustics, shock, and vibration which pertain to biological safety, tolerance and comfort.*

This Standard is identical to International Standard ISO 10819:1996, Mechanical vibration and shock – Hand-arm vibration – Method for the measurement and evaluation of the vibration transmissibility of gloves at the palm of the hand, which was prepared by Technical Committee ISO/TC 108, Mechanical vibration and shock, Subcommittee SC 4, Human exposure to Mechanical vibration and shock. However, in conformance with ANSI and ISO rules, decimal points were substituted in place of the commas used in ISO documents, the words "American National Standard" replace the words "European Standard" where they appear in the ISO document, and an informational footnote has been added to page 1.

In 2004, work related to human exposure to mechanical vibration and shock was transferred to Accredited Standards Committee S2, Mechanical Vibration and Shock. Five approved S3 standards were transferred to S2 at that time and were redesignated and republished as they each came up for reaffirmation in the normal standards cycle. This redesignation of ANSI S3.40-2002/ISO 10819:1996 is taking place under this process. No substantive changes have been made to the approved 2002 text, except as noted in the preceding paragraph.

Annex A forms an integral part of this American National Standard. Annexes B, C, D and ZA are for information only.

The ANSI equivalent for an ISO standard referenced herein is given below:

- ANSI S2.1-2000/ISO 2041:1990 is an identical national adoption of ISO 2041:1990.

At the time this NAIS was submitted to Accredited Standards Committee S3, Bioacoustics, for final approval, the membership was as follows:

<div align="center">

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J. Franks, *Vice Chairman*
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Individual Experts of Accredited Standards Committee S3, Bioacoustics were:

J. Bareham	K. D. Kryter	P. D. Schomer
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A. Brammer	C. W. Nixon	D. E. Wasserman
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R. S. Gales	L. H. Royster	R. W. Young
D. Johnson		

Working Group S3-39, Human Exposure to Mechanical Vibration and Shock, which assisted Accredited Standards Committee S3, Bioacoustics, in the preparation of this Standard, had the following membership:

D.D. Reynolds, Chair

N. Alem	D. Roley
M. Cherniack	S. D. Smith
R. Dong	E. D. Sussman
T. Jetzer	D. E. Wasserman
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Suggestions for improvement of this Standard will be welcomed. They should be made in writing to the Standards Secretariat, Acoustical Society of America, 35 Pinelawn Road, Suite 114E, Melville, New York 11747-3177.

Telephone: 631-390-0215
FAX: 631-390-0217
E-mail: asastds@aip.org

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American National Standard

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

1 Scope

This American National Standard specifies a method for the laboratory measurement, the data analysis and reporting of the vibration transmissibility of gloves in terms of vibration transmission from a handle to the palm of the hand in the frequency range from 31.5 Hz to 1,250 Hz.

The standard is intended to define a screening test for the vibration transmission through gloves. It is recognised that many factors influence the transmission of vibration through gloves. Therefore the transmissibility value according to this standard is not sufficient to assess the health risk due to vibration.

The transmissibility of vibration is measured and reported for two input spectra, which are representative of the vibration of some tools, and may be reported as a function of frequency.

2 Normative References

This American National Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this American National Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 420	General requirements for gloves
ENV 25349	Mechanical vibration - Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration (ISO 5349:1986)
ENV 28041	Human response to vibration - Measuring instrumentation (ISO 8041:1990)
EN 61260	Electroacoustics - Octave-band and fractional-octave-band filters (IEC 1260:1995)
ISO 2041[1]	Vibration and shock - Vocabulary
ISO 5805	Mechanical vibration and shock affecting man - Vocabulary

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[1](U.S. footnote. This note has been added to this American National Standard only for information and is not part of ISO 10819.) ISO 2041 has been nationally adopted and is identical to ANSI S2.1-2000 / ISO 2041:1990.

3   Definitions

The terminology used in this standard is in accordance with ISO 2041, ISO 5805 and ENV 25349. Additionally for the purposes of this standard, the following definition applies:

Transmissibility: the ratio of the accelerations measured at the surface of the hand and at the reference point. Transmissibility values greater than 1 indicate that the glove amplifies the vibration. Values lower than 1 indicate that the glove attenuates the vibration.

4   Symbols and abbreviations

The following symbols and abbreviations are used:

a_w r.m.s. frequency-weighted acceleration, measured by means of a weighting filter or calculated from acceleration spectrum (see ENV 28041 and ENV 25349)

a_{ws} r.m.s. frequency-weighted acceleration for vibration spectrum s ($s = M$ or H, see clause 6.2)

R subscript used to denote measurements taken at the <u>r</u>eference point, i. e. at the handle

P subscript used to denote measurements taken at the <u>p</u>alm of the hand

b subscript used to denote measurements taken with "<u>b</u>are hand", i. e. without glove

g subscript used to denote measurements taken with "<u>g</u>loved hand", i. e. between glove and hand.

Examples of combined subscripts:

a_{wMPg} weighted acceleration for vibration spectrum M, measured at the palm of the hand with glove

TR_{sb} transmissibility for vibration spectrum s measured with bare hand $\left(TR_{sb}=a_{wsPb}/a_{wsRb}\right)$

TR_{sg} transmissibility for vibration spectrum s measured with gloved hand $\left(TR_{sg}=a_{wsPg}/a_{wsRg}\right)$

TR_s corrected vibration transmissibility of glove for vibration spectrum s $\left(TR_s=TR_{sg}/TR_{sb}\right)$

$\overline{TR}_s$ mean corrected transmissibility of glove for vibration spectrum s (see clause 7.1).

5   Measuring principle and equipment

5.1   General principle and setup

The method uses a vibration excitation system ("shaker") equipped with a special handle (see annex B) to measure the gripping force and a device for measuring the feed force. The vibration in the direction of the

excitation is measured at two points simultaneously: at the surface of the handle and—by means of an adaptor containing an accelerometer—between hand and glove, i. e. inside the glove. In order to compensate for the frequency response of the adaptor, the vibration transmissibility of the glove is calculated as the difference in vibration transmissibility from handle to hand with and without glove.

The measuring setup is shown in figure 1. The acceleration at the reference point (at the handle) and the vibration at the hand shall be measured simultaneously.

The values of the gripping force and the feed force have to be displayed continuously, to enable the operator to adjust them to the required values.
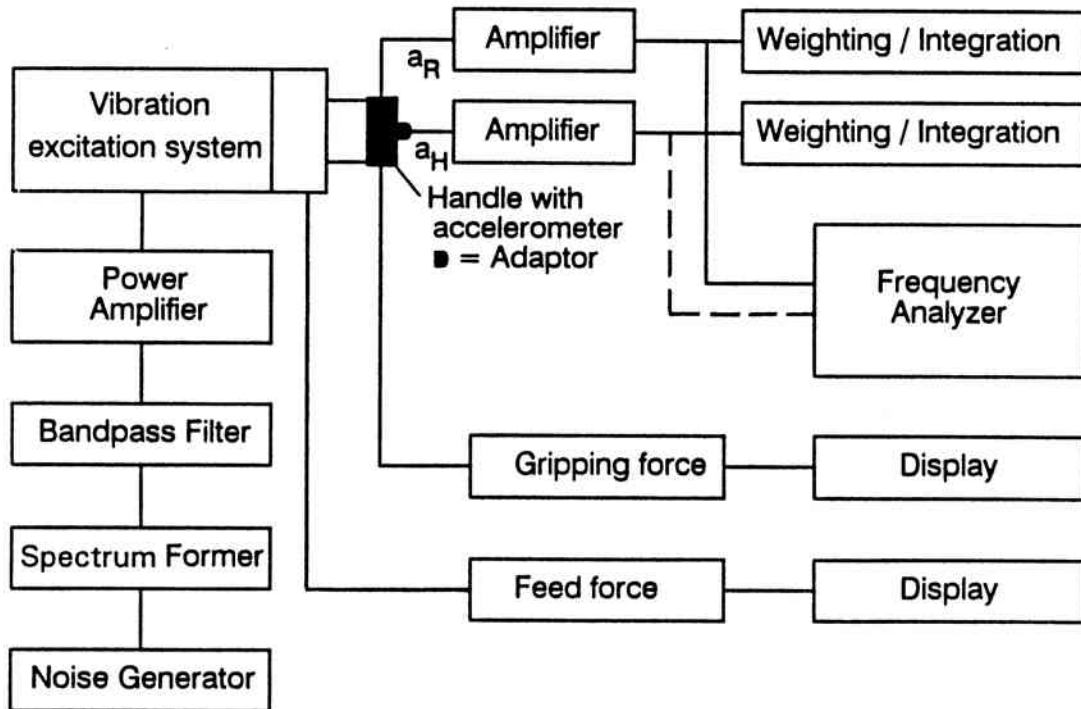

Figure 1: Schematic diagram for measurement of vibration transmissibility

5.2 Measuring equipment

5.2.1 General requirements

A frequency analyzer (narrow band or one-third octave band, preferably twin channel), two transducers and two channels of measuring equipment (including signal conditioning and weighting) are required.

The elements of the measuring chain shall fulfill the requirements for type 1 instrumentation according to ENV 28041.

An overload indication for the input signals shall be provided. The dynamic range shall be at least 60 dB.

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5.2.2   Transducer mounting

5.2.2.1   Mounting at the reference point in the handle

The transducer shall be rigidly mounted into the handle, close and in parallel to the excitation axis. The exact location of the transducer shall be marked on the surface of the handle.

5.2.2.2   Mounting for measurement at the hand

The transducer shall be held in the palm of the hand. Therefore, an adaptor according to the drawing in figure 2 shall be used which contains the transducer. Its mass shall not exceed 15 g including transducer.
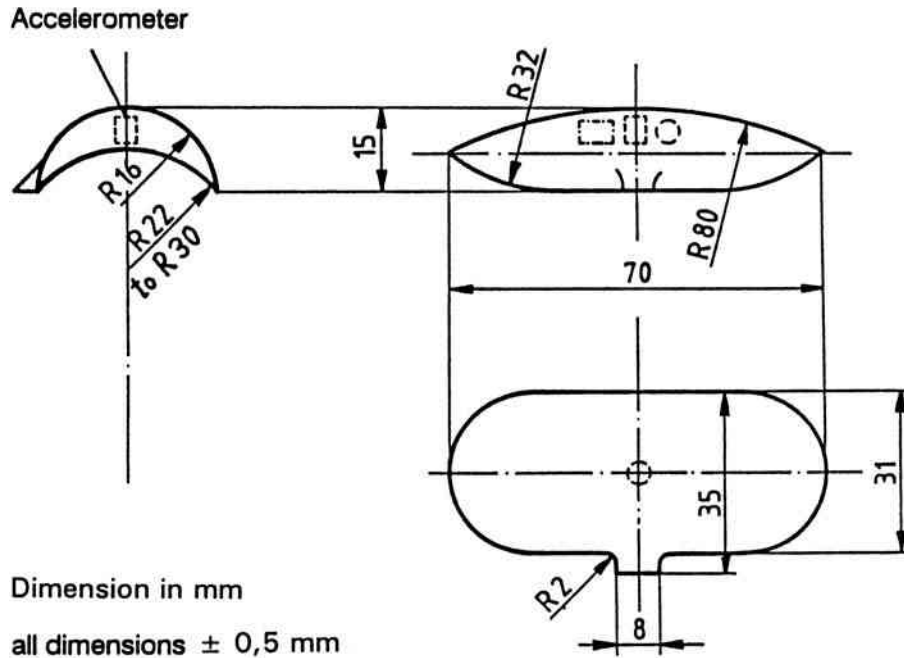

Figure 2: Adaptor for holding accelerometer in the palm of the hand

The exact value of R 22 to R 30 shall be chosen such as to apply a uniform pressure onto the glove material.

The frequency response is checked with the criterion indicated in clause 6.3.2.

5.2.3   Frequency analysis

If frequency analysis in third-octave bands is applied, the filters shall fulfill the requirements of EN 61260.

If constant bandwidth analysis is applied, the resolution for spectrum M shall be better than 1 Hz, for spectrum H better than 10 Hz.

5.2.4   Gripping force measuring system

In the context of this standard, gripping force means the force measured according to the principle shown in figure 3.

The gripping force measuring system shall fulfill the following requirements:

Dynamic range: 10 N to 50 N
Resolution: better than 2 N
Other measuring errors: less than 5 %
Integration time for display: 0.25 s

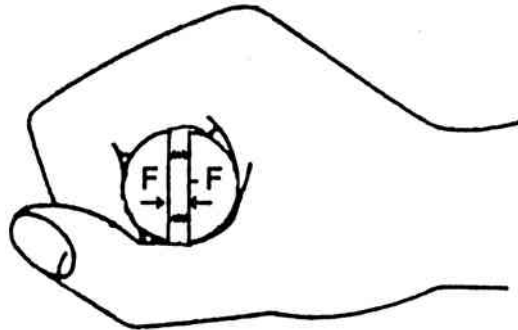An example of a technical solution based on a strain gauge built into the handle is shown in annex B.

Figure 3: Definition of gripping force to be measured (top view)

5.2.5   Feed force measuring system

In the context of this standard, feed force means the horizontal force pushing towards the vibration excitation system.

The feed force measuring system shall fulfill the following requirements:

Dynamic range: 10 N to 80 N
Resolution: better than 2 N
Other measuring errors: less than 5 % of value
Integration time for display: 0.25 s

To measure the feed force, different technical solutions are possible:

⎯   measuring the horizontal force applied to the platform by the operator (see figure 4);

⎯   direct measurement of the feed force as a part of the vibration excitation system.

5.3   Vibration excitation system

5.3.1   Geometrical characteristics

5.3.1.1   Dimensions and direction of the handle

The handle shall have a circular section of 40 mm diameter and a length of 110 mm. The direction of the handle shall be vertical.

5.3.1.2   Position of the excitation system

The axis of vibration shall be horizontal and parallel to the forearm of the standing operator (see figure 4).

The excitation system or the platform the operator is standing on shall be adjusted so, that the requirements regarding the operator's posture as defined in clause 6.1.4 are fulfilled.

5.3.2   Performance

The excitation system shall be able to produce the vibration spectra specified in clause 6.2 when a feed force and a gripping force according to clause 6.1.3 are applied.

6   Measurement conditions and procedure

6.1   Measurement conditions

6.1.1   Test subjects

Three adults with hand sizes from 7 to 9 according to EN 420 shall serve as test subjects.

6.1.2   Test gloves

Three gloves shall be tested (one for each test subject).

6.1.3   Further conditions

For the measurements, the conditions specified hereafter shall be observed.

6.1.3.1   Gripping force

The gripping force shall be displayed continuously. The operator shall maintain the gripping force at 30 N ± 5 N throughout the test period.

6.1.3.2   Feed force

The feed force shall be displayed continuously. The operator shall maintain the feed force at 50 N ± 8 N throughout the test period.

6.1.3.3   Room temperature

The measurements shall take place at a room temperature of 20 °C ± 5 °C.

6.1.3.4   Humidity

The relative humidity shall be below 70 % and shall be reported.

6.1.3.5   Conditioning of gloves

The glove to be tested shall be stored at the specified temperature for at least 30 min and worn by a subject for at least 3 min before starting the test procedure.

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6.1.3.6   Fitting of gloves

The size of the gloves shall be chosen according to EN 420.

6.1.3.7   Test period

Each test period to be evaluated shall be of at least 30 s duration for weighted measurements or third-octave band analysis, and shall allow averaging of at least 60 spectra if constant bandwidth analysis is applied.

6.1.4   Operator's posture

The operator is standing upright on a horizontal surface (floor or platform, see figure 4). The forearm is directed in the axis of vibration. The elbow forms an angle of approximately 90° ± 10°. The elbow shall not touch the body during the measurements. The wrist shall be bent from 0° (neutral) to 40° (dorsal bending) maximum (see figure 5).
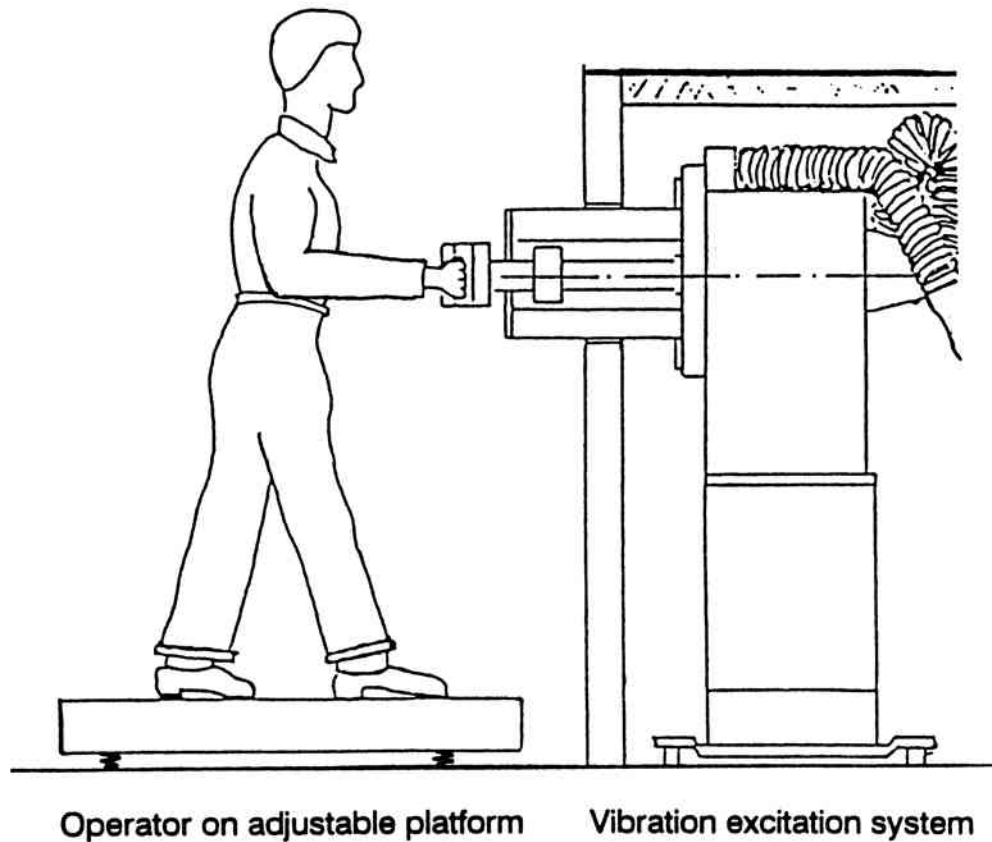

Operator on adjustable platform   Vibration excitation system

Figure 4: Posture of the operator during measurements

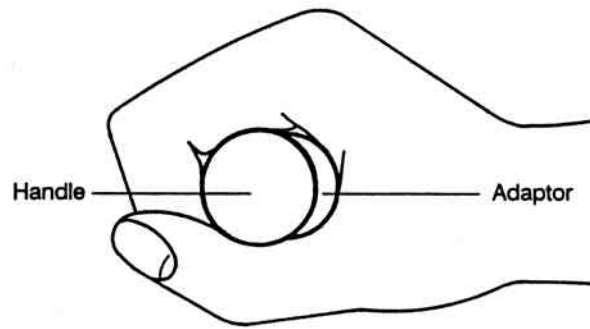© Acoustical Society of America 2002 – All rights reserved   7

Figure 5: Position of hand with handle and adaptor (top view)

6.2 Vibration signal

The two vibration spectra (M and H) as measured at the handle consist of band-limited random noise and shall fulfill the requirements according to figure 6 and table 1. The power spectral density (PSD) is expressed as mean square acceleration per unit bandwidth in $(m/s^2)^2/Hz$. The mathematical definition of these signals is to be found in annex A.

The required PSD function can be generated for example by means of a white noise generator and a bandpass filter with slopes of 12 dB/octave. Depending on the excitation system, additional spectrum forming may be necessary.

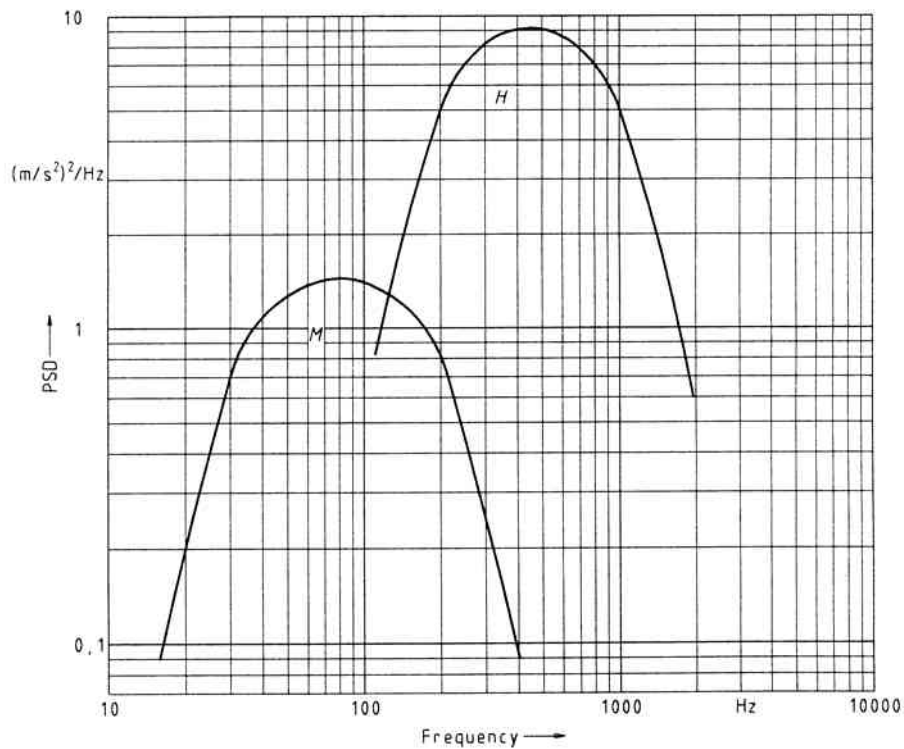Annex C gives third-octave band values of both spectra.

Figure 6: Spectra of the two vibration signals (M and H) measured on the handle

Table 1: Acceleration values and tolerances of vibration spectra M and H

Spectrum designation	Unweighted acceleration m/s^2	Weighted acceleration		Tolerances for frequency ranges (center frequencies)
		ms-value m/s^2	tolerance	
M	16.7	3.4	± 10 %	± 1 dB from 31.5 Hz to 200 Hz ± 2 dB from 16.0 Hz to 400 Hz
H	92.2	3.3	± 10 %	± 1 dB from 200 Hz to 1000 Hz ± 2 dB from 100 Hz to 1500 Hz

6.3 Procedure

6.3.1 Preparation

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

— calibration (see ENV 28041);
— conditioning of gloves;
— instruction to subjects and trials to learn control of the feed force and gripping force;
— checking (frequency analysis) and adjusting of the vibration signal.

6.3.2 Measurements with bare hand

First the measurements (spectra M and H) with bare (ungloved) hand shall be carried out with each of the test subjects. The weighted accelerations obtained at the handle (a_{wsRb}) and at the palm of the hand (a_{wsPb}) are measured simultaneously and used to calculate the weighted transmissibility (see clause 7.1).

If the transmissibility of the unweighted accelerations a_{sRb} and a_{sPb} for spectrum M or H is outside the range from 0.95 to 1.05, the measurements are to be considered not valid.

NOTE   The phase of the transfer function should also be calculated. If the phase exceeds ± 5° in the frequency range where spectra M and H are specified, the measurement should be considered not valid.

6.3.3 Measurements with gloved hand

Using the same adaptor as in clause 6.3.2, two sets of measurements (for spectra M and H) shall be carried out with each of the test subjects. From the weighted accelerations obtained at the handle (a_{wsRg}) and at the palm of the hand (a_{wsPg}) the weighted transmissibility is calculated (see clause 7.1).

NOTE   The coherence of the two unweighted signals a_{sRg} and a_{sPg}, and the transfer function should also be calculated. If the coherence in the frequency range where spectra M and H are specified is lower than 0.95 or if the transfer function is not continuous, the validity of the measurement should be considered.

7 Evaluation of results

7.1 Calculation of transmissibility

The calculation of the mean corrected transmissibility consists of the following steps (see figure 7):

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Measurement (3 persons)	Location transducer	Evaluation	Results for each spectrum

Bare hand (once) — handle a_{wsRb}, hand a_{wsPb} } transmissibility TR_{sb}

With glove (twice) — handle a_{wsRg}, hand a_{wsPg} } transmissibility TR_{sg}

} six times corrected transmissibility ↓ mean corrected transmissibility
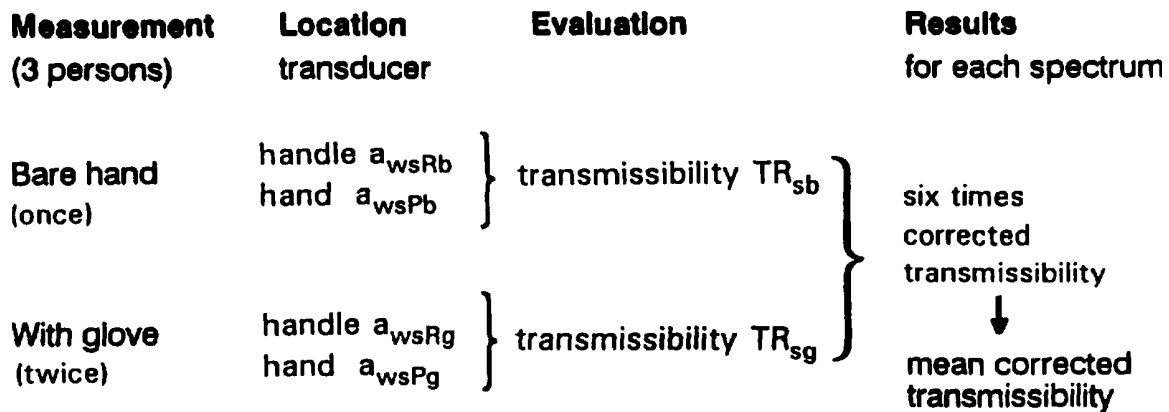
Figure 7: Principle of determination of mean corrected transmissibility

From the results obtained with bare hand, calculate the weighted transmissibility for each vibration spectrum: $TR_{sb} = a_{wsPb} / a_{wsRb}$

From the results obtained with gloved hand, calculate the weighted transmissibility (two values) for each vibration spectrum: $TR_{sg} = a_{wsPg} / a_{wsRg}$

The corrected transmissibilities of the glove are calculated for each vibration spectrum as follows: $TR_s = TR_{sg} / TR_{sb}$

The mean corrected transmissibility $\overline{TR}_S$ for each of the spectra (M and H) is equal to the arithmetic mean value of the six results (two measurements for each of the three subjects). Furthermore, the standard deviation and the coefficient of variation shall be calculated.

7.2   Criteria for antivibration gloves

A glove shall not be considered as "antivibration glove" according to this standard if it does not fulfill both of the following criteria:

$$\overline{TR}_M < 1.0 \quad \text{and} \quad \overline{TR}_H < 0.6$$

NOTE   The fulfilment of these criteria does not imply that the use of such gloves removes the hazard of vibration exposure.

Moreover, a glove shall only be considered as "antivibration glove" according to this standard if the fingers of the glove have the same properties (materials and thickness) as the part of the glove covering the palm of the hand.

NOTE   However, if such gloves fulfill the requirements regarding vibration transmissibility, they may have a beneficial effect when used in situations involving no contact between fingers and vibrating surface.

7.3   Transmissibility as a function of frequency

7.3.1   General

It is recommended to determine the transmissibility as a function of frequency. This will allow the effect of the glove on frequency-weighted vibration to be estimated, in situations where the vibration spectrum is

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known. The principle of calculation is identical to the one described in clause 7.1 for the weighted transmissibilities.

7.3.2 Transmissibility in third-octave bands

If transmissibility as a function of frequency is reported in third-octave bands, the results shall be given for third-octave bands with centre frequencies

from	31.5	Hz to	200	Hz:	based on results obtained with vibration spectrum M
from	200	Hz to	1250	Hz:	based on results obtained with vibration spectrum H.

7.3.3 Transmissibility in narrow band analysis

If transmissibility measured by means of narrow band analysis is reported, the results obtained with the two vibration spectra shall be used as follows:

from	32.0	Hz to	200	Hz:	based on results obtained with vibration spectrum M
from	200	Hz to	1250	Hz:	based on results obtained with vibration spectrum H.

8 Test report

The test report shall contain the following:

a) name and address of glove manufacturer;
b) model/type and state (new or used) of glove;
c) description of tested samples (size, weight, left/right, colour);
d) date of test;
e) description of testing equipment;
f) measuring conditions;
g) vibration attenuation results:
    mean corrected transmissibility, standard deviation and coefficient of variation for vibration spectra M and H.
    If possible: Transmissibility as a function of frequency (see clause 7.3);
h) test carried out by (institute, laboratory, responsible).

Annex A

(normative)

Mathematical definition of vibration test signals

Equations for the power spectral densities (PSD):

$$PSD = c \cdot (HP_{12})^2 \cdot (LP_{12})^2$$

where

$$LP_{12} = \frac{1}{1 + 1.414\,s + s^2}$$

and

$$HP_{12} = \frac{s^2}{1 + 1.414\,s + s^2}$$

with

$$s = \frac{jf}{f_c}$$

$$j = \sqrt{-1}$$

f frequency, Hz

The filter cut-off frequencies f_c and the constant factors c are given in the table below.

**Table A.1: Cut-off frequencies f_c and constant factors c for vibration spectra
(filter slopes of 12 dB/octave, Butterworth characteristics)**

Spectrum	f_c (HP$_{12}$) Hz	f_c (LP$_{12}$) Hz	c (m/s^2)^2/Hz	Comment
L	8	31.5	0.82	see note
M	31.5	200	1.52	—
H	200	1,000	10.0	—
NOTE According to the current state of knowledge gloves do not provide significant vibration attenuation below 150 Hz. If it is necessary to check the vibration transmissibility at low frequencies - e. g. for the testing of gloves purported to provide vibration attenuation in this frequency range - then spectrum L should be used in addition to M and H.				

Annex B

(informative)

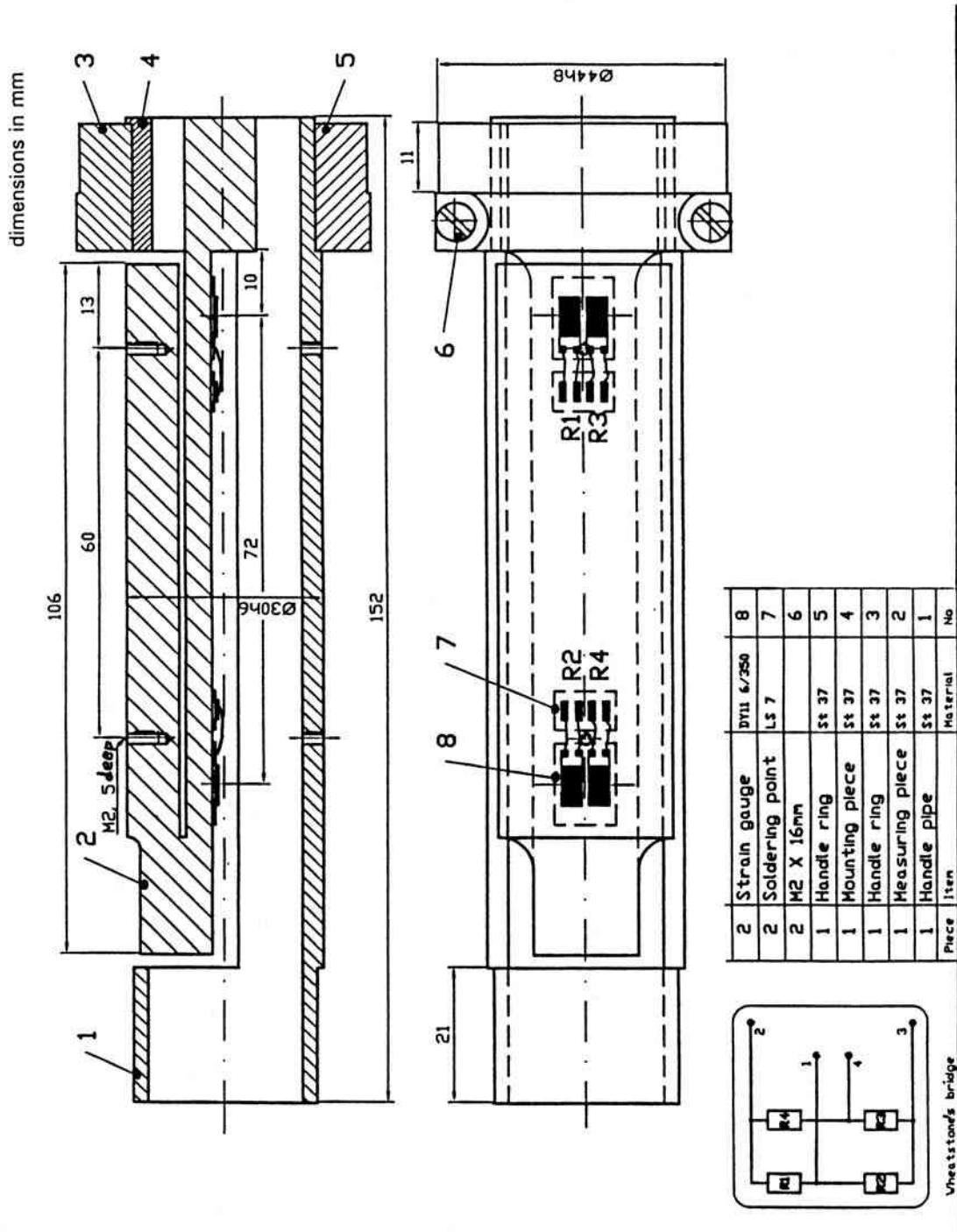## Example of handle with gripping force measuring system

Figure B.1: Example of handle with gripping force measuring system

Annex C

(informative)

Third-octave band spectra of vibration test signals

When analysed in third-octave bands, the vibration test signals M and H described in clause 6.2 and annex A give the acceleration values listed below.

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Table C.1: Spectrum M

Band Hz	a_{rms} m/s^2	Tolerance
16	0.18	± 2 dB
20	0.40	± 2 dB
25	0.90	± 2 dB
31.5	2.36	± 1 dB
40	3.18	± 1 dB
50	3.88	± 1 dB
63	4.54	± 1 dB
80	5.16	± 1 dB
100	5.71	± 1 dB
125	6.14	± 1 dB
160	6.28	± 1 dB
200	5.89	± 1 dB
250	5.04	± 2 dB
315	3.94	± 2 dB
400	2.89	± 2 dB

Table C.2: Spectrum H

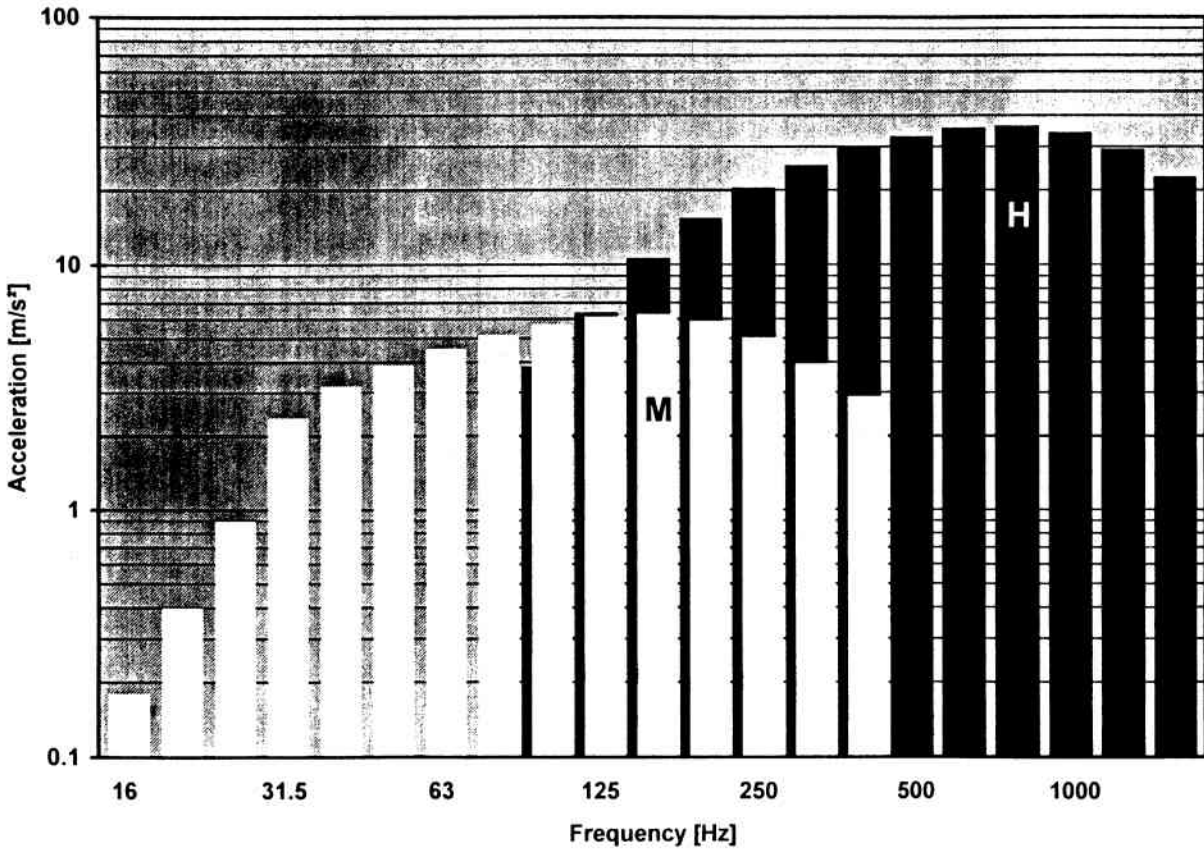| Band Hz	a_{rms} m/s^2	Tolerance
100	3.77	± 2 dB
125	6.29	± 2 dB
160	10.47	± 2 dB
200	15.24	± 1 dB
250	20.20	± 1 dB
315	24.86	± 1 dB
400	29.07	± 1 dB
500	32.48	± 1 dB
630	35.15	± 1 dB
800	35.95	± 1 dB
1000	33.79	± 1 dB
1250	28.91	± 2 dB
1600	22.40	± 2 dB

</div>

Figure C.1: Spectra M and H

Annex D

(informative)

Bibliography

EN 388   Protective gloves against mechanical risks

EN ISO 13753 Mechanical vibration and shock – Hand-arm vibration – Method for the measurement of the vibration transmissibility of resilient materials when loaded by the hand-arm system[1],

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[1] At present under preparation

Annex ZA

(informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of the EU Directive 89/686/EEC "Personal Protective Equipment".

WARNING: Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

The following clauses of this standard are likely to support requirements of the Directive 89/686/EEC:

1
6.1
6.2
7.2
8.

Compliance with the clauses of this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

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MEMBERSHIP OF THE ASA COMMITTEE ON STANDARDS (ASACOS)

P. D. Schomer, *Chair and ASA Standards Director*

Schomer & Associates
2117 Robert Drive
Champaign, IL 61821

Tel: +1 217 359 6602
Fax: +1 217 359 3303
E-mail: schomer@SchomerAndAssociates.com

S. B. Blaeser, *Standards Manager*

Standards Secretariat
Acoustical Society of America
35 Pinelawn Rd.,
Suite 114E
Melville, NY 11747

Tel: +1 631 390 0215
Fax: +1 631 390 0217
E-mail: asastds@aip.org

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