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Mechanical vibration — Hand-held and hand-guided machinery — Principles for evaluation of vibration emission

Vibration mécanique — Machines tenues et guidées à la main — Évaluation d'émission de vibration

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 20643 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 118, *Compressors, pneumatic tools and pneumatic machines*, Subcommittee SC 3, *Pneumatic tools and machines*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read “...this European Standard...” to mean “...this International Standard...”.

For the purposes of this International Standard, the CEN annex regarding fulfilment of European Council Directives has been removed.

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Foreword

This document (EN ISO 20643:2005) has been prepared by Technical Committee CEN/TC 231 "Mechanical vibration and shock", the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 118 "Compressors, pneumatic tools and pneumatic machines".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2005, and conflicting national standards shall be withdrawn at the latest by July 2005.

This document supersedes EN 1033:1995.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directive(s).

For relationship with EC Directive(s), see informative Annex ZA, which is an integral part of this document.

This document provides concrete rules for the application of EN 12786 in relation to vibration test codes. It is complementary to EN 12096.

New or revised vibration test codes in the standards series EN 28662/EN ISO 8662 for portable hand-held machines will be based on this document. All currently existing parts of EN 28662/EN ISO 8662, however, are based on EN 28662-1:1993. It is envisaged that EN 28662-1:1993 will be withdrawn when all parts of the series EN 28662/EN ISO 8662 have been revised in accordance with this document.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

Human exposure to mechanical vibration from hand-held or hand-guided machinery can interfere with comfort, working efficiency and, in some circumstances, health and safety. According to EN ISO 12100-2 the risks created by vibrating machinery need to be minimized and the residual risk from vibration need to be noted in the relevant instruction handbook. This, ideally, will be based on the vibration emission magnitude reported in accordance with this document or the relevant vibration test code, but additional information for use may be required (see Clause 6 in EN ISO 12100-2:2003).

It is possible that the type test method may not identify all the mechanisms that generate vibration when the machine is used in the real operational environment. Factors such as the workpiece, the process and the operator can have an important influence on the vibration magnitudes. For this reason the type test measurements cannot replace field measurements to evaluate vibration exposure at the workplace, but should be sufficiently representative to be able to be used for preliminary assessment of risk.

Vibration magnitudes in type tests shall be within the range of measurements made in the field, but with less variability. Type tests require accurate and reproducible conditions. It is essential that different laboratories obtain the same results within specified limits. This requires that the process or way in which the machine is measured is precisely defined. The operating conditions should be well defined, they should preferably be a real process, typical of that for which the machine is designed. If it is intended to be used for a variety of tasks and the vibration is affected significantly by the task, then more than one task might be used in determination of vibration emission. In some cases an artificial process may be used which is not in line with the typical use of the machine in the field but which provides equivalent data. If two machines produce significantly different magnitudes of vibration under real conditions, then the test should be capable of demonstrating this difference.

This document is intended to assist technical standardization committees responsible for specific types of machinery in preparing vibration test codes to ensure that such vibration test codes:

— enable users to make comparisons and to check the declared vibration emission values;

— are as homogeneous as possible with each individual test code having the same basic structure;

— are in full accordance with basic type-B standards on measurement of vibration emissions;

— reflect the latest technical knowledge of methods of determining the vibration emissions from the specific family of machinery under consideration.

A vibration test code for a family of machinery prepared in accordance with this document:

a) produces vibration emission data which allow the determination of the vibration state-of-the-art for a family of machinery and the identification of a machine which has significantly greater or smaller vibration emission;

b) produces vibration emission values and uncertainties suitable for comparing the emissions of machinery of the same type irrespective of the date or location of the testing;

c) produces vibration emission values and uncertainties corresponding to the upper quartile of vibration magnitudes resulting from intended uses of the machinery;

d) specifies the operating conditions of the machine during testing that are, so far as practicable, representative of normal use;

e) identifies parameters that have a significant influence on the vibration emission of the machinery;

f) specifies installation and mounting conditions of transducers, measurement positions and measurement directions;

g) prescribes equipment used during testing and

h) requires recording of the values of machinery operating parameters that may influence vibration emission.

This document can be used, in the absence of an agreed vibration test code, as a guide to determine vibration emission values and to define test parameters that may influence vibration emission to be recorded.

This document is a type-B standard as stated in EN ISO 12100-1.

The provisions of this document may be supplemented or modified by a type-C standard. However, for machines which are covered by the scope of a type-C standard and which have been designed and built according to the provisions of that standard, the provisions of that type-C standard take precedence over the provisions of this type-B standard.

1 Scope

This document provides the basis for the drafting of vibration test codes for hand-held and hand-guided power-driven machinery. It specifies the determination of hand-transmitted vibration emission in terms of frequency-weighted root-mean-square (r.m.s.) acceleration during type testing. For machines where vibration test codes do not exist, it may also be used for determination of emission values and contains sufficient guidance for designing an appropriate test.

NOTE Vibration test codes based on this document should define measuring procedures which provide controlled, repeatable and reproducible results which are, as far as possible, in agreement with the vibration values measured at the machine-hand contact surfaces under real working conditions and for which the uncertainties of measurement are quantified.

This document is applicable to hand-held power tools (e.g. chipping hammers, sanders), hand-guided powered machines (e.g. lawn mowers, single-axle tractors, vibratory rollers) and other types of powered machines fitted with handles, guiding beams or similar means of control. It is applicable to machinery of all power sources (electrical, hydraulic, pneumatic, internal combustion engine, etc.).

It does not apply to fixed machinery in which the vibration is transmitted to the hands of the user through the workpiece.

This document is not applicable to vibration transmitted from steering wheels or control levers of mobile machinery where the operator's position is on the machine, see EN 1032.

It is restricted to translational vibration measured in three orthogonal directions at the hand-machine interface.

This document should be applied with caution to machines producing single and repetitive shocks with a frequency of occurrence lower than 5 Hz. For such machines, it is not known whether frequency-weighted root-mean-square acceleration values are related to the risks to health and additional measurements may be required. When developing vibration test codes for such machines the information in CEN ISO/TS 15694 should be considered.

This document is not applicable to vibration test codes published before the date of publication of this document by CEN and, when used as test code, to hand-held and hand-guided machinery manufactured before that date.

This document does not present limits or recommended vibration values. It does not give any guidance or recommendations for determination of human exposure to vibration at the workplace. For such information, reference is made to EN ISO 5349-1 and EN ISO 5349-2.

2 Normative references

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

EN 12096, *Mechanical vibration — Declaration and verification of vibration emission values.*

ENV 28041, *Human response to vibration — Measuring instrumentation (ISO 8041:1990).*

EN ISO 5349-1, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements (ISO 5349-1:2001).*

ISO 2041:1990, *Vibration and shock — Vocabulary.*

ISO 5347 (all parts), *Methods for the calibration of vibration and shock pick-ups.*

ISO 5805:1997, *Mechanical vibration and shock — Human exposure — Vocabulary.*

ISO 16063 (all parts), *Methods for the calibration of vibration and shock transducers.*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041:1990 and ISO 5805:1997 and the following apply.

3.1.1
family of machinery
machines of similar design to fulfil the same functions

EXAMPLE chain saws

3.1.2
hand-guided machine
machine which is guided by the operator with his hands, such that the vibration exposure is obtained through the handles, steering wheel or tiller

[EN ISO 5349-2]

EXAMPLE walk-behind cutting machine, swing grinder

3.1.3
hand-held power tool
powered tool which is held in the hand and for which a feed force is necessary to fulfil a task

EXAMPLE electric drill, pneumatic chisel, chain-saw

3.1.4
inserted tool
interchangeable or replaceable attachment which fits into or onto a hand-held power tool or hand-guided machine for performing the intended operation

EXAMPLE drill bit, chisel, saw chain, saw blade, abrasive wheel

3.1.5
equipment
specific interchangeable attachment other than an inserted tool to complete the machine

EXAMPLE guards, side handles

3.1.6
operation
identified task for which a representative vibration magnitude measurement is made; this may be for a single phase of a task or a working cycle, that means a set of tool operations which are necessary to fulfil a task

3.1.7
operator
person using a power tool

3.1.8
tool operation
any period during which a power tool is operating and the operator is being exposed to hand-transmitted vibration

[EN ISO 5349-2]

3.1.9
workpiece
item being operated upon by a power tool

[EN ISO 5349-2]

3.2 Symbols

In this document, the following symbols are used.

$a_{hw}(t)$ instantaneous single-axis acceleration value of the frequency-weighted hand-transmitted vibration at time t, in m/s²

a_{hw} root-mean-square (r.m.s.) single-axis acceleration value of the frequency-weighted hand-transmitted vibration, in m/s²

a_{hwx}, a_{hwy}, a_{hwz} values of a_{hw} in m/s², for the axes denoted x, y and z respectively

a_{hv} vibration total value of frequency-weighted r.m.s. acceleration, in m/s²; it is the root-sum-of-squares of the a_{hw} values for the three measured axes of vibration

a_h arithmetic mean value of the measurement results of runs and operators, in m/s²; this is the result of the test

a_{hd} declared vibration value in m/s² (the quantity denoted a in EN 12096)

σ_R standard deviation of reproducibility

K uncertainty in m/s² of a_{hd} as defined in EN 12096

C_V coefficient of variation of a test series, defined as the ratio of the standard deviation of a series of measurement values and the mean value of the series:

$$C_V = \frac{s_{N-1}}{\overline{a}_{hw}}$$

where

$$s_{N-1} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(a_{\mathrm{hw}i} - \bar{a}_{\mathrm{hw}})^2}$$ is the standard deviation

$\bar{a}_{\mathrm{hw}}$ is the mean value of the series in m/s²

$a_{\mathrm{hw}i}$ is the i-th value measured in m/s²

N is the number of measured values

4 Basic standards and vibration test codes

The preparation of vibration test codes for hand-held and hand-guided machinery shall be based on the requirements of this document and, for declaration and verification, also on the requirements of EN 12096.

A vibration test code is a type-C standard relative to a specified family or sub-family or type of machinery. It shall give all the information necessary to carry out efficiently the determination, declaration and verification of the vibration emission characteristics. It shall ensure compatibility and allow comparison of test results. A summary of the requirements of this document for vibration test codes is given in Annex A.

Where no specific vibration test codes exists for a family of machines, this document shall be used as a test code. In such cases details of the measurement method and machine operation (see Clauses 6, 7 and 8) shall be fully reported.

NOTE EN 12096 gives guidance on how to declare the vibration emission values of machinery, and specifies requirements for verification of declared values.

5 Description of a family of machines

The family or type of machinery covered by the vibration test code shall be described unambiguously and in detail. In describing the configuration of the machinery, a vibration test code shall:

— identify any inserted tools used in the operation of the machine under test and which may influence the vibration emission;

— specify the selection of other equipment which may influence the vibration emission and which shall be used during the determination of vibration emission;

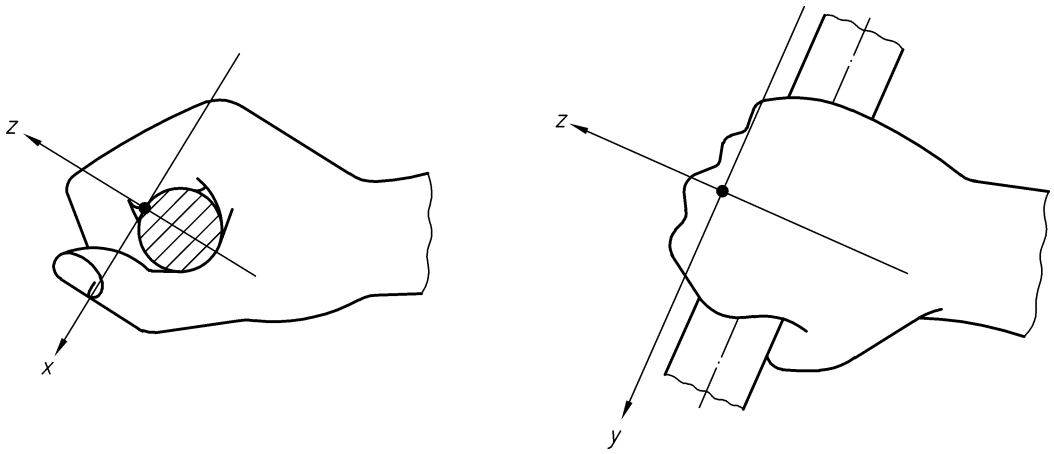
— identify the range of applications for which the vibration test code is intended.

6 Characterization of vibration

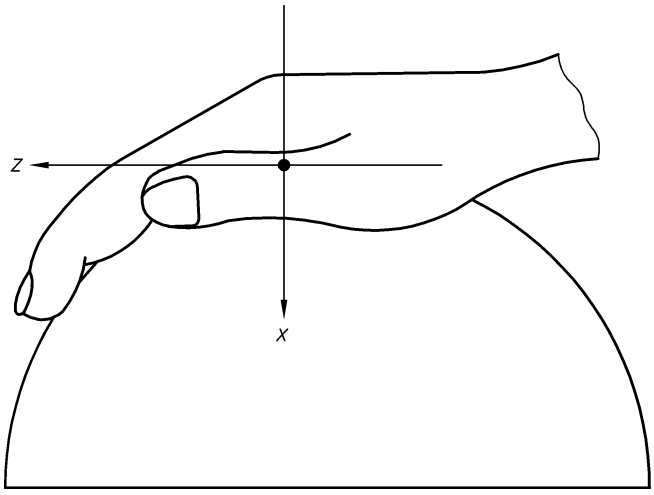
6.1 Direction of measurement

Translational vibration transmitted to the hand is related to the x, y or z directions shown in Figure 1. For a family of machinery, these directions of vibration measurement shall be defined in the vibration test code.

NOTE Other directions of vibration (e.g. rotational motion) are not dealt with in this document.



a) "Handgrip" position
(In this position, the hand grips a cylindrical hand grip)



b) "Flat palm" position
(In this position, the hand presses down onto a spherical hand grip)

Figure 1 — Directions of vibration measurement

6.2 Location of measurement

As a basic rule, measurements shall be made simultaneously in three directions for each hand position.

If, in some cases, it is not possible to make vibration measurements in three axes, the vibration test code may specify that measurements are made only in one or two axes, but the axis of greatest vibration shall be included (where this can be identified).

Sequential measurement in the three directions is undesirable, and is more time consuming. However, it is permissible where the total size or mass of three transducers prevents correct operation of the machine or is likely to affect the measurement (see 7.2.1).

Measurements shall be carried out as close as possible to a point on the grip surface half-way along the length of the grips or at such places where an operator normally holds the machine during a typical operation. If the placing of the switch actuator makes this impossible then the accelerometer shall be placed as close as possible to the hand between the thumb and the index finger.

It is possible to get differences between vibration measurements across the width of the hand position, particularly for hand-held power tools with side handles such as angle grinders, and especially where these handles are

flexibly mounted. In these cases, two accelerometer positions shall be used, located at either side of the hand position and the mean value of the magnitudes measured at the two positions shall be calculated.

The specification of measurement positions shall be given in the vibration test code.

When machines are operated with two hand grips, the vibration at both hand positions shall be measured and recorded. If it can be shown that the vibration magnitude at one grip is dominant the vibration test code may specify that measurements are made only at that gripping zone. Where inserted tools must be held by the operator (e.g. chipping hammer chisels) this is likely to be the hand position of greatest vibration and should be included in the evaluation of vibration emission.

6.3 Magnitude of vibration

The quantity used to describe the magnitude of vibration shall be the frequency-weighted acceleration a_{hw} in m/s².

The frequency weighting to be used is defined in 7.3.

The r.m.s. value a_{hw} in accordance with this document is defined as the r.m.s. value of the frequency-weighted acceleration signal $a_{hw}(t)$:

$$a_{hw} = \left[\frac{1}{T} \int_0^T a_{hw}^2(t)\, \mathrm{d}t \right]^{1/2} \tag{1}$$

Requirements for the integration time T are given in 7.4.

NOTE Frequency analysis is recommended in order to check the validity of the measurements and to provide additional information.

6.4 Combination of vibration directions

The vibration total value a_{hv} is determined from

$$a_{\mathrm{hv}} = \left[a_{\mathrm{hwx}}^2 + a_{\mathrm{hwy}}^2 + a_{\mathrm{hwz}}^2 \right]^{1/2} \tag{2}$$

where

a_{hwx}, a_{hwy}, a_{hwz} are the r.m.s. values of the frequency-weighted acceleration in the x-, y- and z-direction, respectively

If measurements are not made in all three directions, the value a_{hv} shall be estimated using the measured value(s) available and a carefully considered multiplying factor. The vibration magnitude in the axis of greatest vibration requires a multiplying factor in the range 1,0 to 1,7 to give the vibration total value (for further advice, see EN ISO 5349-2). Where a multiplying factor is used to estimate the vibration total value, it shall be justified in the vibration test code.

7 Instrumentation requirements

7.1 General

The vibration measurement system shall be in accordance with ENV 28041.

Instrumentation for measuring other parameters (e.g. for controlling the working conditions), whose characteristics are not covered by ENV 28041, shall be specified in the vibration test code. The justification for use of such instrumentation shall be given, together with a detailed specification of the instrumentation.

7.2 Mounting of transducers

7.2.1 Specification of transducer

The vibration values as specified in 6.3 shall be measured using transducers and other appropriate measurement equipment conforming to ENV 28041.

The total mass of the vibration transducer and its mounting shall be small enough, compared with that of the tool, handle, etc., on which it is mounted, not to influence the measurement result.

NOTE This is particularly important for light-weight plastic handles (see EN ISO 5349-2 for further information).

Factors such as the transverse sensitivity (less than 10 %), the ambient temperature range, the typical temperature transient sensitivity and the maximum shock acceleration shall be considered in the selection of transducers.

7.2.2 Fastening of transducer

The transducer and the mechanical filter, if used, shall be rigidly attached to the vibrating surface. Guidance on mounting of transducers is given in EN ISO 5349-2.

Mechanical filters or other appropriate means may be needed to minimize measurement errors likely to occur when measuring vibration containing impulsive elements, such as occur in percussive tools.

NOTE High acceleration in the high-frequency components of the vibration can cause the accelerometer to generate false signals (e.g. dc shift) in the frequency range of interest because of excitation of the resonance of the transducer itself.

7.3 Frequency weighting filter

Frequency weighting in accordance with EN ISO 5349-1 shall be used.

7.4 Integration time

An integrating device equipped with linear integration facilities shall be used in order to obtain r.m.s. values.

The integration time for measurements shall be as long as reasonably possible and normally not less than 8 s for hand-transmitted vibration measurements.

The integration time shall be defined in relevant vibration test codes to be consistent with the duration of the test according to 8.1.

7.5 Auxiliary equipment

The test code may also require the measurement of quantities other than acceleration (e.g. feed force, cutting speed, hydraulic pressure). In such cases the test code shall specify the device or instrument to be used.

7.6 Calibration of the measurement chain

The whole measurement chain shall be checked both before and after a sequence of measurements by using a calibrator which produces known acceleration at a known frequency.

The transducers shall be calibrated in accordance with ISO 5347 and ISO 16063. The whole measurement chain shall be checked according to the requirements in ENV 28041.

8 Testing and operating conditions of the machinery

8.1 General

A vibration test code shall specify precisely the machine and its equipment and the operating parameters that have a significant influence on the vibration emitted by the machinery.

The operating conditions and working procedure shall be specified in as much detail as necessary to achieve appropriate reproducibility (see Annex C). Working procedures based on a typical real working situation are preferred. The vibration test may simulate a single phase of a task or a working cycle, that means a set of operations where the operator is being exposed to vibration.

If the machinery is supplied with a feature, which may reduce the vibration emission in comparable operating conditions, this should be used, in accordance with the manufacturer’s instructions, during vibration testing. If this requires a deviation from the type test method, this should be reported and explained.

NOTE When possible, the vibration test code should be designed to reflect the efficiency and quality of the machine's performance when performing the defined tasks.

If for reasons of better reproducibility an artificial procedure is defined, the vibration source should produce approximately the same magnitude of vibration as that in a typical working situation.

8.2 Operating conditions

Measurements shall be carried out using a properly serviced and lubricated machine under stable running conditions. The machine shall be operated in normal working conditions and working modes according to the manufacturer's specifications, which shall be maintained for the duration of the test. The operating conditions used shall be representative of the highest vibration values likely to occur at typical and normal use of the machine under test (see Annex C).

8.3 Other quantities to be specified

The vibration test code shall stipulate requirements for any operating parameters which can influence the vibration emission of the machine (such as feed force or guiding force) or which may affect the accuracy and reproducibility of measurements.

8.4 Attached equipment, workpiece and task

The attached equipment or inserted tools to be used with the machine, the workpiece and the task shall be specified in the vibration test code. The specified attached equipment or inserted tools shall be appropriate for the workpiece and task, as specified in the manufacturer’s information for use.

NOTE 1 It should be noted that even small differences in size, shape, material, wear, unbalance, etc. of the attached equipment can alter the vibration magnitude considerably.

NOTE 2 Care should be taken that the location of the workpiece on its support does not affect the results of the test.

8.5 Operator

The vibration of the machine is influenced by the operator. The operator shall therefore be skilled and able to operate the machine properly, that means he shall be experienced in the use of the tool. The measurements shall be made with at least three operators. If it can be shown that the vibration is not affected by operator characteristics, it is acceptable to perform measurements with one operator only.

The vibration test code shall give the number and qualification of operators.

9 Measurement procedure and validity

9.1 Reported vibration value

Unless otherwise specified in the vibration test code (see 8.5) three series of five consecutive tests are to be carried out using a different operator for each series.

If measurements are made in three axes the results of each direction shall be combined using equation (2) to obtain the vibration total value a_{hv}.

If the coefficient of variation C_V of the five vibration total values a_{hv} recorded for each series is less than 0,15 or the standard deviation s_{N-1} is less than 0,3 m/s², the measuring procedure is accepted, otherwise it shall be checked for errors (see Annex B which provides information on possible sources of errors of measurement).

The measurement result a_h shall be determined as the arithmetic mean of vibration total values over all runs and operators.

If values have been obtained for different hand positions, the greatest value shall be the basis for the declaration.

9.2 Declaration and verification of the vibration emission value

The result a_h is the basis for the declared value a_{hd} (for declaration, see EN 12096).

To determine the uncertainty K of the declared value according to EN 12096, the vibration test code shall give information concerning the standard deviation of reproducibility, σ_R.

NOTE Verification of the declared value is discussed in EN 12096.

10 Measurement report

A vibration test code shall specify all the items to be included in the measurement report. The report shall, as a minimum, include the following information:

a) reference to the relevant vibration test code (where no vibration test code exists, reference shall be made to this document);

b) specification of the machine tested (i.e. manufacturer, type and serial number of the machine, etc.);

c) attached equipment and/or inserted tools;

d) operating and testing conditions (pressure, voltage, feed force, speed, duration and number of test runs, etc.);

e) measuring institution (e.g. laboratory, manufacturer);

f) date of measurement and name of the person responsible for the test;

g) instrumentation (accelerometer mass, filters, integrators, recording system, etc.);

h) position and fastening of transducers, measuring directions and individual vibration values when relevant (e.g. recorded by photos);

i) the arithmetic mean value of the frequency-weighted r.m.s. vibration a_h characterizing the vibration emission value a_{hd};

j) the uncertainty, K, of the vibration emission value a_{hd}.

It is good practice to report all the measured values (i.e. for all axes of vibration, runs and operators) as well as the overall result a_{hd}.

Vibration test codes may add further demands on information in the measurement report.

Any deviations from the vibration test code or from the basic standard(s) upon which it is based are to be reported together with the technical justification for such deviations.

Annex A
(normative)

Summary of information to be given in the vibration test code

This annex constitutes a minimum list of items that shall be dealt with in vibration test codes, in accordance with the requirements of this document.

a) The family of machinery and range of application to which the test code applies (see Clause 5).

b) Measuring directions (see Clause 6):
   - Definition of the reference axes;
   - Indication of the dominant axis, if any exists.

c) Instrumentation requirements (see 7.1):
   - Specific details of the instrumentation, if not covered by ENV 28041.

d) Transducers (see 7.2):
   - Specific transducer mounting conditions;
   - Description of mechanical filters if used;
   - Location of transducers;
   - Tolerance on the location of the transducers;
   - Mass of accelerometers and fixing system or adaptors for measurements on the handles.

e) Frequency weighting (see 7.3):
   - Frequency range to be used.

f) Integration time (see 7.4):
   - Integration time to be used.

g) Testing and operating conditions (see Clause 8):
   - Operating conditions during which the vibration values shall be determined;
   - If relevant, simulated and/or simplified operating conditions;
   - Specification of test rig, if used;
   - Values required for each of the operating parameters influencing the vibration emitted by the machinery;
   - Tool and workpiece or material, if relevant;
   - Work cycle and number of work cycles, if applicable;
   - Number and qualification of operators.

h) Vibration measurement and analysis (see Clause 9);
   - Number of measurements required to determine the vibration emission value;
   - Expected standard deviation of reproducibility for declaration to derive the uncertainty K.

i) Measurement report (see Clause 10):

— Specification of the items to be included in the measurement report.

Annex B
(informative)

Possible sources of errors during vibration measurements

This annex does not constitute an exhaustive list of possible sources of errors. It should only be considered as a guide to avoid the main errors in measurement:

a) unsuitable mounting or fastening of accelerometers;

b) inadequate fastening of cables;

c) lack or misadjustment of band-pass filter;

d) not nulling output of amplifiers after mounting of transducers;

e) misalignment of directions of transducers, or inappropriate or varying position of the transducers;

f) inappropriate signal conditioning (band-pass, signal-to-noise ratio, overload, etc.);

g) too short duration of measurement;

h) lack of calibration before and after measurement;

i) inappropriate definition of operational conditions;

j) unexperienced operators using inappropriate grip forces;

k) unstable operating conditions, such as fluctuating feed forces and varying motor speed.

Further practical advice on measurement errors is given in EN ISO 5349-2.

Annex C
(normative)

Procedure for developing a vibration test code for a specific category of hand-held or hand-guided machinery

The following procedure shall be followed, as appropriate, to develop a vibration test code for a specific category of machinery.

The approach requires:

— Categorize the family of machines and their applications;

— Determine the exact location of the axes of measurement and where to fix the accelerometers.

Determination of the conditions of test:

— Collect information on vibration at the gripping zones measured under real conditions when the machines are under operation;

— Collect information on typical tasks under real conditions and type of products processed;

— Collect information on the inserted or attached tools generally used and their effect on vibration emission;

— Establish an acceleration at the gripping zone which is representative of the upper quartile of the range of values obtained under typical working conditions of the machine measured in accordance with EN ISO 5349-1;

— Choose a representative type of task to be used. The test task should be as short as possible but long enough to enable vibration analysis and to get an acceptable repeatability of results. The task may be either the machine doing an usual operation under controlled conditions or free running (e.g. grinders with an artificial unbalance wheel) or operating under artificial conditions (e.g. percussive tools tested with an energy absorber);

— Use a number of representative machines to compare the vibration acceleration magnitude measured using the test task;

— Assess the effect of different operators;

NOTE In order to avoid exposure of a test person to vibration and for improving the reproducibility of the test results, it is desirable to establish specific test rigs for future vibration test codes. However, such a test rig should under no circumstances affect the ability of the test to reflect the vibration emission in real use.

— Identify causes of variability in order to study the possibility of minimizing their effects;

— Quantify the repeatability errors which can be best achieved. Organize comparison tests between measuring institutions to determine the reproducibility of the type test;

— Minimize the number of tests required to the smallest number consistent with the achieved accuracy of the overall method.

Validation of the vibration test code:

— Compare the results of the test on a representative sample of machines with measurements on the same machines in real use.

Bibliography

[1] EN 1032, *Mechanical vibration — Testing of mobile machinery in order to determine the vibration emission value.*

[2] EN 12786, *Safety of machinery — Guidance for the drafting of the vibration clauses of safety standards.*

[3] EN ISO 5349-2, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 2: Practical guidance for measurement at the workplace (ISO 5349-2:2001).*

[4] EN ISO 12100-1, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003).*

[5] EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003).*

[6] CEN ISO/TS 15694, *Mechanical vibration and shock — Measurement and evaluation of single shocks transmitted from hand-held and hand-guided machines to the hand-arm system (ISO/TS 15694:2004).*

[7] Kinne, J.; Schenk, Th., and Knoll, P.: Automatic test stand for the measurement of the vibration emission of hand held machines. 8th International Conference on Hand-Arm Vibration, Proceedings, Umeå 1998, Arbetslivsrapport No. 2000:4, pp. 51–57

[8] Schenk, Th., and Gillmeister, F.: Investigation on the accuracy of vibration measurements for the declaration of emission values for hand-held machines. 8th International Conference on Hand-Arm Vibration, Proceedings, Umeå 1998, Arbetslivsrapport No. 2000:4, pp. 281–288.

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