BRITISH STANDARD

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Mechanical vibration — Declaration and verification of vibration emission values

The European Standard EN 12096 : 1997 has the status of a British Standard

ICS 13.160; 17.160

National foreword

This British Standard is the English language version of EN 12096 : 1997.

The UK participation in its preparation was entrusted to Technical Committee GME/21/6, Mechanical vibration and shock, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Summary of pages

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Mechanical vibration — Declaration and verification of vibration emission values

Vibrations mécaniques — Déclaration et vérification des valeurs d'émission vibratoire

Mechanische Schwingungen — Angabe und Nachprüfung von Schwingungskennwerten

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European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 231, Mechanical vibration and shock, the Secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by January 1998, and conflicting national standards shall be withdrawn at the latest by January 1998.

This European Standard contains five annexes A to E which are informative.

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

Contents

Introduction

Information on vibration emission of vibrating machinery is needed by users, planners, manufacturers and authorities, for example to comply with the obligations described in the EU Machinery Directives 89/392/EEC and 91/368/EEC. This information is required for comparing the vibration emissions from different products and for assessing the vibration against vibration requirements.

In order for vibration emission values to be useful, uniform methods are necessary for the following purposes:

– measurement of the vibration values;

– determination of the declared vibration emission value;

– presentation of the declared vibration emission value;

– verification of the declared vibration emission value.

The statistical methods used for declaration and verification in this European Standard are equivalent to those used in acoustics (see EN 27574).

NOTE. This note concerns German words for 'declaration' and 'verification'.

1 Scope

This European Standard establishes the requirements for declaration and verification of vibration emission values. It applies to hand–arm and whole-body vibration values achieved by measurements according to type-B and type-C standards. It:

– gives guidance on the declaration of vibration emission values;

– describes vibration and product information to be given in technical documents supplied to users by the manufacturer;

– specifies the method for verifying the declared vibration emission values stated by the manufacturer.

The values to be used for the declaration of vibration emission are r.m.s. values of weighted acceleration measured preferably according to a vibration test code (see **3.1.5**).

2 Normative references

This European 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 European Standard only when incorporated in it by amendment or revision. Fore undated references, the latest edition of the publication referred to applies.

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)
ISO 2631-1	*Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

3 Definitions and symbols

For the purposes of this European Standard, the following definitions apply. They are grouped in two categories: general definitions and vibration-related definitions. Definitions of statistical terms are to be found in annex A.

3.1 General definitions

3.1.1 machinery

An assembly of linked parts or components, at least one of which moves, with the appropriate actuators, control and power circuits etc., joined together for a specific application, in particular for the processing, treatment, moving or packaging of material.

The term machinery also covers an assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole.

3.1.2 family of machinery

Machinery of similar design or type, intended to perform the same functions.

3.1.3 batch (lot) of machinery

A number of units of machinery intended to perform the same function, produced in quantity, manufactured to the same technical specifications and characterized by the same declared vibration emission value.

NOTE. The batch may be an entire production series or a portion thereof.

3.1.4 operating mode

A condition in which the machinery is performing its intended function, which may be artificially simulated, as specified in a relevant standard.

3.1.5 vibration test code

A type-C standard related to a specified family or sub-family or type of machinery. It gives all the information necessary to efficiently carry out the determination of the vibration emission characteristics needed for declaration and verification according to this European Standard. It ensures compatibility and allows comparison of test results.

3.2 Vibration-related definitions

3.2.1 acceleration

The r.m.s value of the vibration acceleration.

3.2.2 hand–arm weighted acceleration $a_{h,w}$

The acceleration at the measuring point determined by measurement using a weighting filter according to ENV 28041 or by calculation as specified in ENV 25349. It is expressed in m/s^2.

3.2.3 whole-body weighted acceleration a_{wx}, a_{wy}, a_{wz} and a_w

The acceleration at the measuring point determined by measurement using weighting filters according to ENV 28041 and ISO 2631-1. It is expressed in m/s^2.

3.2.4 measured vibration emission value a

The value representing the measured vibration emission value of a single machine or the mean value obtained from a reasonably big sample of a batch of machinery. It is expressed in m/s^2. The measured vibration emission value is not rounded.

NOTE. The measured vibration emission value a can be either one of the weighted values according to **3.2.2** or **3.2.3**.

3.2.5 uncertainty K

The value representing the measurement uncertainty of the measured vibration emission value a, and also, in the case of batches, production variations of machinery. It is expressed in m/s^2.

3.2.6 declared vibration emission value a *and* K

The measured vibration emission value a and its associated uncertainty K. The sum of a and K indicates the limit below which the vibration value of the single machine, and/or a specified large proportion of the vibration values of the batch of the machines, are stated to lie when the machines are new.

3.2.7 vibration emission declaration

The information on vibration emission of a machine, given by the manufacturer or supplier in technical documents or other literature, concerning vibration emission values. The vibration emission declaration has the form of a dual-number value.

4 Declaration of vibration emission values

The declaration of the vibration emission values a and K of machinery is the sole responsibility of the manufacturer.

The declared vibration emission values shall be determined for the machine in an operating mode according to the description in the relevant vibration test code. If no vibration test code exists the most representative operating mode should be used.

Guidelines for determination of declared vibration emission values of machinery are given in annex B. The guidelines are made in such a fashion that the declared values can be verified according to the procedures of this European Standard.

NOTE. If data required for the determination of K are unavailable from other standards applicable to the particular machine, guidance can be found in annex D.

5 Presentation of declared vibration emission values

The presentation of declared vibration emission values according to this European Standard for machinery, shall, when given in technical documents, contain the following information:

– identification of the product with sufficient detail to determine the applicability of the declared vibration emission values;

– the words ‘declared vibration emission value in accordance with EN 12096’ followed by the vibration emission value a and the uncertainty K, both in m/s^2, for the operating mode described in the relevant vibration test code;

– identification of the relevant type-C standard, or, if no type-C standard exists;

– identification of the applied operating mode and the relevant type-B standard.

The value of the measured vibration emission value a is to be given in m/s^2 and presented by using two and a half significant digits for numbers starting with 1 (e.g. 1,20 m/s^2, 14,5 m/s^2), otherwise two significant digits are sufficient (e.g. 0,93 m/s^2, 8,9 m/s^2). The value of the uncertainty K shall be presented with the same number of decimals as a.

Examples of declared vibration emission values are given in annex C.

6 Verification of declared vibration emission values

6.1 General

Verification of declared vibration emission values can be required for two different reasons:

– in order to verify the declared value of one particular machine; or

– in order to verify the declared value of a batch or production series of machinery.

Verification shall be effected by means of vibration measurements made according to the same vibration test code or basic measurement method, and under the same machinery operating mode (see **3.1.4**) as that one to which the declared vibration emission values refer.

The procedures given in **6.2** and **6.3** shall be used for verification under reproducibility conditions.

NOTE. Reproducibility conditions exist when the measurements can be repeated with similar results of the inspecting laboratory and when there are no systematic deviations between the testing laboratory and other laboratories testing the same object.

When the declaration contains only one value, the guidelines given in annex D can be used for estimating the uncertainty K.

6.2 Verification of a single machine

If one machine is evaluated, the declared vibration emission value is verified if the resulting vibration emission value is less than or equal to the value of $a + K$ as declared by the manufacturer.

NOTE. The procedure for verifying the declared vibration emission value for a single machine conforms with that one descibed in EN 27574-4 for noise.

6.3 Verification of a batch of machinery

6.3.1 *General*

This procedure shall be used to verify the declared vibration emission value of a batch (or of a production series) of machinery when more than one machine from a batch is available. For the purpose of this European Standard, a sample size of up to three machines is needed.

NOTE. The procedure for verifying the declared vibration emission value for a batch conforms with that one described in EN 27574-4 for noise.

6.3.2 *Verification method*

The verification of a batch is carried out as follows.

Derive the values A, B and C from the declared vibration emission values a and K. A, B and C are calculated based on a and K according to:

$$\begin{aligned} A &= a + 0{,}20K \\ B &= a + 1{,}13K \\ C &= a + 0{,}65K \end{aligned} \qquad (1)$$

Measure one machine, randomly selected from the batch. The resulting vibration value a_1 is compared with the values A and B:

– if $a_1 \leq A$, the declared value is verified for the batch;

– if $a_1 > B$, the declared value is not verified for the batch, the batch is rejected;

– if $A < a_1 \leq B$, measure two additional machines, randomly selected from the batch.

The mean value of the three resulting vibration values a_3 is compared to the value C:

– if $a_3 \leq C$, the declared value is verified for the batch;

– if $a_3 > C$, the declared value is not verified for the batch, the batch is rejected;

The individual machines from this batch, on which measurements have been made, are, however, verified as single machines if they fulfil the requirements of **6.2**.

NOTE. The constants used for the determination of A, B and C are derived from the procedure for verification of the declared value as described in the statistical methods for verification of sound power levels using the double sampling method described in EN 27574-4.

According to this European Standard $K = 1{,}5\sigma_t$ (see annex B). The value of the total standard deviation σ_t is used as the reference standard deviation σ_M, at the verification: $\sigma_M = \sigma_t$. For the double sampling method using one unit in the first sample and two units in the second sample, the following formulae and constants are used:

$$\begin{aligned} A &= a + K\left(1 - \frac{1{,}194}{1{,}5}\right) \\ B &= a + K\left(1 - \frac{-\,0{,}201}{1{,}5}\right) \\ C &= a + K\left(1 - \frac{0{,}533}{1{,}5}\right) \end{aligned} \qquad (2)$$

Annex A (informative)
Definitions of statistical terms

A.1 General

In this European Standard, the symbol μ is used for the true mean value and the symbol a for the estimated mean value and the symbol σ is used for the true standard deviation and the symbol s for the estimated standard deviation.

A.2 size of the batch (or of the population) N

Number of units (machines in the batch or vibration emission values in the population).

A.3 sample

One or more machines (or vibration emission values) randomly selected (or determined) from a batch (or population).

A.4 sample size n

Number of units in the sample.

A.5 arithmetic mean of a batch (or of a population) μ

The sum of the vibration emission values a_i in a batch (or population), divided by the size of the batch (or of the population) N:

$$\mu = \frac{1}{N} \sum_{i=1}^{N} a_i \qquad \text{(A.1)}$$

A.6 arithmetic mean of a sample $\bar{a}$

The sum of the vibration emission values a_i in a sample divided by the sample size n:

$$\bar{a} = \frac{1}{n} \sum_{i=1}^{n} a_i \qquad \text{(A.2)}$$

A.7 standard deviation of a batch (or of a population) σ

The standard deviation of vibration emission values a_i of a batch (or a population) of size N:

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (a_i - \mu)^2} \qquad \text{(A.3)}$$

A.8 standard deviation of a sample s

The standard deviation of vibration emission values a_i of a sample of the size n:

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (a_i - \bar{a})^2} \qquad \text{(A.4)}$$

A.9 standard deviation of repeatability σ_r

The standard deviation of vibration emission values obtained under repeatability conditons, i.e. the repeated application of the same vibration measurement method on the same machine within a short interval of time under the same conditions (same laboratory, same operator(s), same apparatus).

A.10 standard deviation of reproducibility σ_R

The standard deviation of vibration emission values obtained under reproducibility conditions, i.e. the repeated application of the same vibration measurement method on the same machinery at different times and under different conditions (different laboratory, different operator(s), different apparatus). The standard deviation of reproducibility, therefore, includes the standard deviation of repeatability.

σ_R is estimated by s_R:

$$s_R = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (a_i - \bar{a})^2} \qquad \text{(A.5)}$$

where a_i are the results achieved at n different laboratories and $\bar{a}$ is their mean value.

A.11 standard deviation of production σ_p

The standard deviation of vibration emission values obtained on different machinery from a batch, using the same vibration measurement method under repeatability conditions (same laboratory, same operator(s), same apparatus).

A.12 total standard deviation σ_t

The square root of the sum of the squares of the standard deviation of reproducibility and the standard deviation of production:

$$\sigma_t = \sqrt{\sigma_R^2 + \sigma_p^2} \qquad \text{(A.6)}$$

A.13 reference standard deviation σ_M

The total standard deviation of vibration emission values obtained on power driven machines which is considered typical for batches of this machinery.

A.14 reference standard deviation to mean value ratio $\sigma_{M/\mu}$

The ratio of the total standard deviation to the mean value, specified for a family of power driven machines which is considered typical for batches of this machinery.

NOTE. The use of a fixed value for $\sigma_{M/\mu}$ enables the application of a statistical method to deal with small sample sizes. If the total standard deviation σ_t is different from the reference standard deviation σ_M the manufacturer estimates his risk of rejection on the basis of both standard deviations σ_t and σ_M.

Annex B (informative)
Guidelines for declaration of vibration emission values

B.1 General

Vibration emission values a are measured for each operating mode specified in the vibration test code for the individual type of machine, or, if no vibration test code exists, for selected operating modes taken from the appropriate basic method, e.g. EN 28662-1 or EN 1033 for hand–arm vibration or from EN 1032 for whole-body vibration.

Measured values shall be of a precision consistent with the calculations to be performed in accordance with this European Standard.

The manufacturer declares the vibration emission values a and K of a single machine or the vibration emission values a and K of a production series of machines, based on measurements and the knowledge of the accuracy with which the measurements can be made. For a production series of machines, the manufacturer should take into account the standard deviation of production.

B.2 Determination of the declared vibration emission value for a single machine

Determine the declared vibration emission value, a and K, for the single machine from the measured vibration emission value a, using the following relation:

a is the measured vibration emission value for the machine;

$$K = 1{,}65\sigma_R \quad \text{(B.1)}$$

where σ_R is the standard deviation of reproducibility as specified by the vibration test code.

If there is no vibration test code or if the vibration test code does not specify σ_R then use as an estimation:

$$\sigma_R = \sqrt{\sigma_{op}^2 + \sigma_{rec}^2} \quad \text{(B.2)}$$

where σ_{rec} and σ_{op} are the standard deviations of the recorded values from the same operator and from the different operators, respectively.

B.3 Determination of the declared vibration emission value for a batch of machinery

Determine the declared vibration emission values a and K for the batch of machinery, where a is the estimate of the mean value and K is 1,5 times the total standard deviation:

$$K = 1{,}5\sigma_t \quad \text{(B.3)}$$

NOTE 1. This value of K is based on EN 27574-4 and results in a 5 % risk of rejection for a sample of three machines.

According to the definition in **A.12** the total standard deviation is composed of the standard deviation of reproducibility and the standard deviation of production. The standard deviation of reproducibility is given by the relevant vibration test code. The determination of the standard deviation of production shall be done by the manufacturer, based on his experience of the production variation. Guidance is given below on the estimation of σ_t.

The following procedure can be used to estimate the standard deviation of production s_p if a sample of three or more is available:

$$s_p = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(a_i - \bar{a})^2}$$

where

a_i is the measured vibration emission value of each machine in the sample; and

$\bar{a}$ is the mean value of the sample.

Calculate the total standard deviation s_t from the standard deviation of production s_p and the standard deviation of reproducibility s_R as given by the vibration test code:

$$s_t = \sqrt{s_R^2 + s_p^2}$$

NOTE 2. The value of $\bar{a}$ and s_t are estimates of the true mean value μ and the true total standard deviation σ_t of the batch.

NOTE 3. If a reasonably large sample is not available, the value of s_p may be estimated from experience.

Annex C (informative)
Examples of vibration emission declarations

C.1 Declaration when a specific vibration test code exists (e.g. for chipping hammers)

Machine model number, operating conditions and other identifying information	
Type 990, Model 12-UH, 0,6 MPa	
Declared vibration emission value in accordance with EN 12096	
Measured vibration emission value a	8,0 m/s^2
Uncertainty K	2,3 m/s^2
Values determined according to EN 28662-2.	

C.2 Declaration when a specific vibration test code does not exist

Machine model number, operating conditions and other identifying information	
Type 991, Model 14-UF, 0,6 MPa	
Declared vibration emission value in accordance with EN 12096	
Measured vibration emission value a	3,4 m/s^2
Uncertainty K	1,7 m/s^2
Specification for the used operating mode:	
(e.g. values determined when the machine was used to remove welding sparks using standard inserted tool Z.)	

Annex D (informative)
Guidelines for verification when the vibration emission value is declared without the uncertainty K

D.1 General

At the verification of a declared vibration emission value, when it is given by only one value, this value shall be considered to be the measured value a, and the uncertainty K has to be estimated.

D.2 Verification

The declared vibration emission value shall be verified according to clause **6** using the estimated uncertainty K as given in table D.1.

Table D.1 Uncertainty K for different measured values a

Measured value a		**Uncertainty K**
Hand–arm vibration	**Whole-body vibration**	
2,5 m/s^2 < a ≤ 5 m/s^2	0,5 m/s^2 < a ≤ 1 m/s^2	0,5a
a > 5 m/s^2	a > 1 m/s^2	0,4a

NOTE. Table D.1 may also be used as a guideline for the estimation of the uncertainty K if data required for the determination of K are unavailable from other standards applicable to the particular machine.

Annex E (informative)
Bibliography

EN 1032 *Mechanical vibration — Testing of mobile machinery in order to determine the whole-body vibration emission value — General*

EN 1033 *Hand–arm vibration — Laboratory measurement of vibration at the grip surface of hand-guided machinery — General*

EN 27574-2 *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 2: Methods for stated values for individual machines* (ISO 7574-2 : 1985)

EN 27574-4 *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 4: Methods for stated values for batches of machines* (ISO 7574-4 : 1985)

EN 28662-1 *Hand-held portable power tools — Measurement of vibrations at the handle — Part 1: General* (ISO 8662-1 : 1998)

EN 28662-2 *Hand-held portable power tools — Measurement of vibrations at the handle — Part 2: Chipping hammers and riveting hammers* (ISO 8662-2 : 1992)

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