BRITISH STANDARD

BS EN 13490:2002

Mechanical vibration — Industrial trucks — Laboratory evaluation and specification of operator seat vibration

The European Standard EN 13490:2001 has the status of a British Standard

ICS 53.060; 13.160

National foreword

This British Standard is the official English language version of EN 13490:2001.

The UK participation in its preparation was entrusted by Technical Committee GME/21, Mechanical vibration and shock, to Subcommittee GME/21/6, Human exposure to 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.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 15 January 2002

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 21 and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 38875 1

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13490

October 2001

ICS 13.160; 53.060

English version

Mechanical vibration - Industrial trucks - Laboratory evaluation and specification of operator seat vibration

Vibrations mécaniques - Chariots industriels - Evaluation en laboratoire et spécification des vibrations transmises à l'opérateur par le siège

Mechanische Schwingungen - Flurförderzeuge - Laborverfahren zur Bewertung sowie Spezifikation der Schwingungen des Maschinenführersitzes

This European Standard was approved by CEN on 20 August 2001.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 13490:2001 E

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 April 2002, and conflicting national standards shall be withdrawn at the latest by April 2002.

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 standard.

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.

Introduction

The operators of industrial trucks are often exposed to a low-frequency vibration environment mainly caused by the movement of the vehicles over uneven ground. The seat constitutes the last stage of suspension before the driver. To be efficient at attenuating the vibration, the suspension seat should be chosen according to the dynamic characteristics of the vehicle. The performance criteria provided in this European Standard have been set in accordance with what is attainable using what is at present the best design practice. They do not necessarily ensure the complete protection of the operator against effects of vibration and shock. They may be revised in the light of future developments and improvements in suspension design.

Performance criteria obtained in accordance with this European Standard may be useful to manufacturers of industrial trucks when selecting seats for possible use in their products. However, to satisfy fully the requirements of the EC Machinery Directive it is important for suppliers of mobile machinery to demonstrate that the seat supplied reduces the vibration in the specified machine to the lowest level that can be reasonably achieved.

The test inputs included in this European Standard are based on a very large number of measurements taken in situ on industrial trucks while they were used under severe but typical operating conditions. The test method is based on EN 30326-1, which is a general method applicable to seats for different types of vehicles.

1 Scope

1.1 This European Standard is applicable to operator seats used on industrial trucks as defined in ISO 5053:1987 irrespective of power supply, type of equipment, lifting mechanism and tyres. It also applies to seats for other trucks not covered by ISO 5053:1987, e.g. variable-reach trucks and low-lift order picking trucks.

1.2 This European Standard specifies, in accordance with EN 30326-1, a laboratory method for measuring and evaluating the effectiveness of the seat suspension in reducing the vertical whole-body vibration transmitted to the operator of industrial trucks at frequencies between 1 Hz and 20 Hz.

1.3 This European Standard defines the input spectral classes required for the following industrial trucks. Each class defines a group of machines having similar vibration characteristics:

– Platform trucks, trucks rider-controlled, etc. with wheel mean diameter below 200 mm and high-load non-rubber solid tyres (category 1)[1)]

– Reach trucks, articulated trucks, etc. with wheel mean diameter below 450 mm and high-load non-rubber solid tyres or cylindrical/conical base rubber solid tyres (category 2)[1)]

– Straddle trucks, trucks with wheel mean diameter below 645 mm and rubber solid or pneumatic tyres (category 3)[1)]

– Straddle trucks, trucks with wheel mean diameter between 645 mm and 900 mm and rubber solid or pneumatic tyres (category 4a)[1)]

– Straddle trucks, trucks with wheel mean diameter between 900 mm and 1200 mm and rubber solid or pneumatic tyres (category 4b)[1)]

– Trucks with wheel mean diameter between 1200 mm and 2000 mm and rubber solid or pneumatic tyres (category 5)[1)]

– All-terrain trucks (category 6)[1)].

1.4 This European Standard specifies performance criteria to be achieved by seats intended for each of the above-mentioned groups of machines.

1.5 The tests and criteria defined in this European Standard are intended for operator seats used in industrial trucks of conventional design.

NOTE Other tests may be appropriate for machines with design features that result in significantly different vibration characteristics.

1.6 This European Standard is only concerned with the vertical component of whole-body vibration. Vibration which reaches the operator other than through his seat, for example that sensed by his feet on the platform or control pedals or by his hands on the steering-wheel, is not covered.

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. For undated references, the latest edition of the publication referred to applies (including amendments).

ENV 28041, Human response to vibration – Measuring instrumentation (ISO 8041:1990)

EN 30326-1:1994, Mechanical vibration – Laboratory method for evaluating vehicle seat vibration – Part 1: Basic requirements (ISO 10326-1:1992)

EN ISO 13090-1, Mechanical vibration and shock – Guidance on safety aspects of tests and experiments with people – Part 1: Exposure to whole-body mechanical vibration and repeated shock (ISO 13090-1:1998)

---

1) See prEN 13059:1997.

ISO 2631-1:1997, Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 1: General requirements

ISO 5053:1987, Powered industrial trucks – Terminology

ISO 5805:1997, Mechanical vibration and shock – Human exposure – Vocabulary

ISO 8041:1990/Amd. 1:1999, Human response to vibration – Measuring instrumentation – Amendment 1

3 Terms and definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in ISO 5805:1997 and the following apply.

3.1.1
whole-body vibration
vibration transmitted to the body as a whole through the buttocks of a seated operator

3.1.2
input spectral class
machines having similar ride vibration characteristics at the seat attachment point, grouped by virtue of various mechanical characteristics

3.1.3
operator seat
that portion of the machine provided for the purpose of supporting the buttocks and back of the seated operator, including any suspension system and other mechanisms provided (for example, for adjusting the seat position)

3.1.4
frequency analysis
process of arriving at a quantitative description of a vibration amplitude as a function of frequency

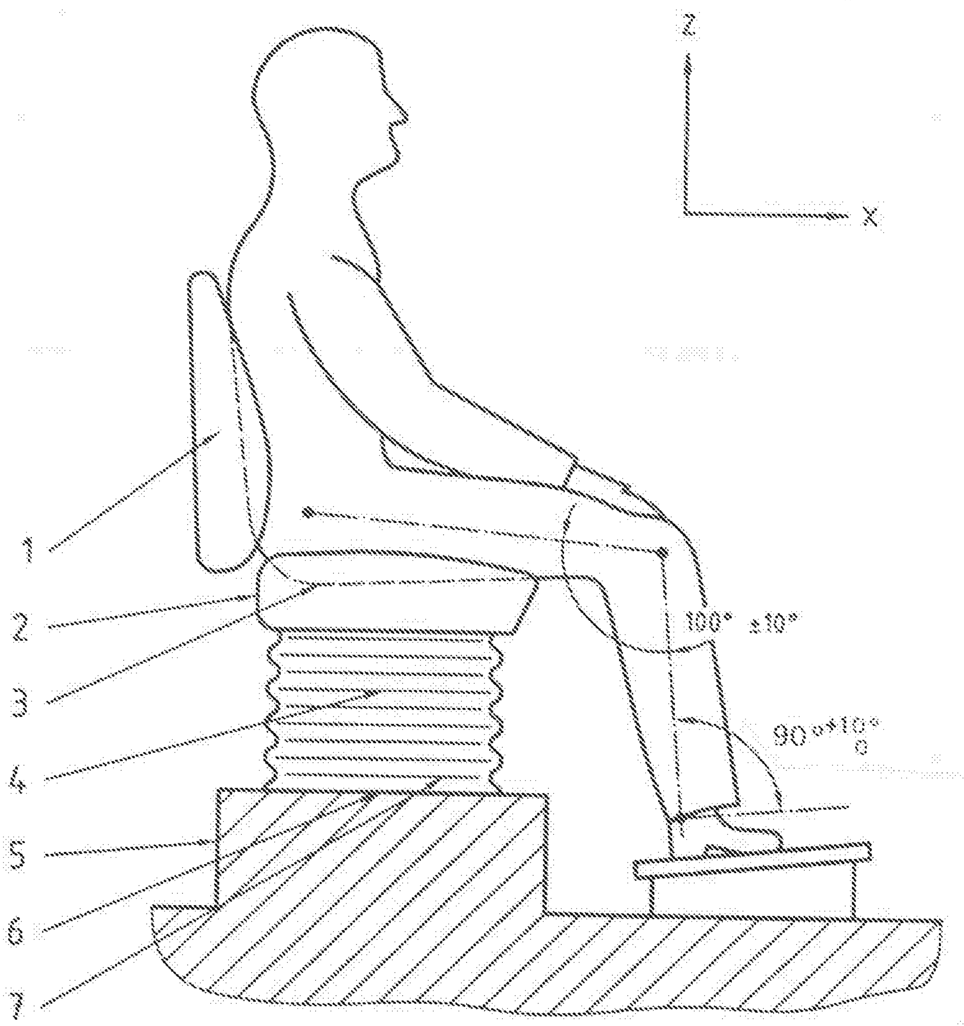
3.1.5
measuring period
time duration in which vibration data for analysis is obtained

3.2 Symbols and abbreviations

For the purposes of this European Standard, the following symbols and abbreviations apply:

$a_P(f_r)$	unweighted r.m.s. value of the measured vertical acceleration at the platform at the resonance frequency
a^*_{P12}, a^*_{P34}	unweighted r.m.s. value of the target vertical acceleration at the platform under the seat (see Figure 1) between frequencies f_1 and f_2, or f_3 and f_4
a_{P12}, a_{P34}	unweighted r.m.s. value of the measured vertical acceleration at the platform between frequencies f_1 and f_2, or f_3 and f_4
$a_S(f_r)$	unweighted r.m.s. value of the measured vertical acceleration at the seat disc at the resonance frequency

a^*_{wP12}, a^*_{wP34}	weighted r.m.s. value of the target vertical acceleration at the platform between frequencies f_1 and f_2, or f_3 and f_4
a_{wP12}	weighted r.m.s. value of the measured vertical acceleration at the platform between frequencies f_1 and f_2
a_{wS12}	weighted r.m.s. value of the measured vertical acceleration at the seat disc (see Figure 1) between frequencies f_1 and f_2
B_e	resolution bandwidth, Hz
EM	Earth-moving Machinery
f	frequency, Hz
f_r	frequency at resonance
$G_P(f)$	measured PSD of the vertical vibration at the platform (seat base)
$G^*_P(f)$	target PSD of the vertical vibration at the platform (seat base)
$G^*_{PL}(f)$	lower limit for the measured PSD of the vertical vibration at the platform (seat base)
$G^*_{PU}(f)$	upper limit for the measured PSD of the vertical vibration at the platform (seat base)
$H(f_r)$	transmissibility at resonance
HP	high-pass filter
IT	Industrial Truck
LP	low-pass filter
PSD	power spectral density expressed as acceleration squared per unit bandwidth, $(m/s^2)^2/Hz$
r.m.s.	root mean square
SEAT	Seat Effective Amplitude Transmissibility factor
T_s	sampling time, s.



Key

1 Seat backrest

2 Seat pan

3 Accelerometer disc on the seat pan (S)

4 Seat suspension

5 Platform

6 Accelerometer on the platform (P)

7 Base of the seat

Provision shall be made for adjustment of the angles of the knees, the ankles and the backrest (if possible) (see 5.2).

Figure 1 – Posture of the test person

4 General

4.1 The laboratory simulated machine vertical vibration, specified as input spectral class, is based on representative measured data from machines in severe but typical working conditions. The input spectral class is a representative envelope for the machines within the class, therefore the laboratory test is more severe than the typical vibration environment of any specific machine.

4.2 Two criteria are used for the evaluation of seat:

a) the Seat Effective Amplitude Transmissibility (SEAT) factor according to EN 30326-1:1994, 9.1, but with frequency weighting according to ISO 2631-1,

b) the maximum transmission ratio in the damping test according to EN 30326-1:1994, 9.2.

4.3 The measuring equipment shall be in accordance with ENV 28041 (type 1 instrument) and EN 30326-1:1994, clauses 4 and 5. The frequency weighting shall include the effects of the band limiting filters, and be in accordance with ISO 2631-1 (see ISO 8041:1990/Amd. 1:1999).

4.4 Safety precautions shall be in accordance with EN ISO 13090-1.

Any compliant end-stops or devices normally fitted to production versions of the seat to be tested to minimize the effect of suspension overtravel shall be in place for the dynamic tests.

5 Test conditions and test procedure

The test conditions and test procedure shall be in accordance with EN 30326-1:1994, clauses 7 and 8.

5.1 Simulation of vibration

See EN 30326-1:1994, clause 5.

A platform, the dimensions of which correspond approximately to those of the operator's platform of an industrial truck, shall be mounted on a vibrator which is capable of generating vibration along the vertical axis (see Figure 1).

5.2 Test seat

The operator seat for the test shall be representative of series-produced models, with regard to construction, static and vibration characteristics and other features which may affect the vibration test results. Before the test, the suspension seats shall be run-in under conditions stipulated by the manufacturer. If the manufacturer does not state such conditions, then the seat shall be run-in for 5000 cycles, with measurements at 1000-cycle intervals.

For this purpose, the seat shall be loaded with an inert mass of 75 kg and adjusted to the mass in accordance with the manufacturer's instructions. The seat and suspension shall be mounted on the platform of a vibrator, and a sinusoidal input vibration shall be applied to the platform at approximately the suspension natural frequency. This input vibration shall have a peak-to-peak displacement sufficient to cause movement of the seat suspension over approximately 75 % of its stroke. A platform peak-to-peak displacement of approximately 40 % of the seat suspension stroke is likely to achieve this. Care should be taken to ensure against overheating of the suspension damper during the running-in, for which forced cooling is acceptable.

The seat shall be considered to have been run-in if the value for the vertical transmissibility remains within a tolerance of ± 5 % when three successive measurements are performed under the condition described above. The time interval between two measurements shall be half an hour, or 1000 cycles (whichever is less), with the seat being constantly run-in.

The seat shall be adjusted to the weight of the test person in accordance with the manufacturer's instructions.

With seats where the suspension stroke available is **unaffected** by the adjustment for seat height or test person weight, testing shall be performed with the seat adjusted to the centre of the stroke.

With seats where the suspension stroke available is **affected** by the adjustment of the seat height or by test person weight, testing shall be performed in the lowest position which provides the full working suspension stroke as specified by the seat manufacturer.

When the inclination of the backrest is adjustable, it shall be set approximately upright, inclined slightly backwards (if possible: 10° ± 5°).

5.3 Test person and posture

The simulated input vibration test shall be performed with two persons. The light person shall have a total mass of 52 kg to 55 kg, of which not more than 5 kg may be carried in a belt around the waist. The heavy person shall have a total mass of 98 kg to 103 kg, of which not more than 8 kg may be carried in a belt around the waist.

Each person shall adopt a natural upright position on the seat and maintain this position throughout the test (see Figure 1).

Differences in the posture of the test person can cause a 10 % difference between test results. For this reason, recommended angles of knees and ankles have been specified in Figure 1.

5.4 Input vibration

5.4.1 Simulated input vibration test to evaluate the SEAT factor

This European Standard specifies the input vibration in four input spectral classes (IT 1 through IT 4) for industrial trucks for the purpose of determining the SEAT factor.

In accordance with EN 30326-1:1994, 9.1.2, the SEAT factor is defined as

$$\text{SEAT} = \frac{a_{wS12}}{a_{wP12}} \qquad (1)$$

The simulated input vibration used to determine the SEAT factor is defined in accordance with EN 30326-1:1994, 8.1, but the frequency weighting shall be in accordance with ISO 2631-1. The test input for each class is defined by a power spectral density, $G^*_P(f)$, of the vertical (z axis) acceleration of the vibrating platform, and by the unweighted r.m.s. vertical accelerations on that platform (a^*_{P12}, a^*_{P34}).

The vibration characteristics for each input spectral class IT 1 through IT 4 are shown in Figures 2 through 5. Equations for the acceleration power spectral density curves of Figures 2 to 5 are included in Table 2. The curves defined by these equations are the target values to be produced at the base of the seat for the simulated input vibration test of 5.5.2.

The input vibration shall be determined (calculated) without components at frequencies outside the frequency range defined by f_1 and f_2.

Table 3 further defines the test input values for the actual test input PSD at the base of the seat.

Three tests shall be performed for each test person and each input vibration in accordance with EN 30326-1:1994, 9.1. The effective duration of each test shall be at least 180 s.

If none of the SEAT factor values relating to one particular test configuration deviates by more than ± 5 % from the arithmetic mean, then, in terms of repeatability, the three tests mentioned above shall be deemed to be valid. If this is not the case, as many series of three tests as are necessary to satisfy this requirement shall be carried out.

The sampling time T_s and the resolution bandwidth B_e shall satisfy the following:

$$2\ B_e\ T_s > 140 \qquad (2)$$

$$B_e < 0,5\ \text{Hz}. \qquad (3)$$

NOTE 1 Classes IT 2 and IT 3 are also used to test compact loader (class EM 8) and grader (EM 4) seats (see EN ISO 7096).

NOTE 2 Any means, including double integrators, analogue signal generators and filters, and digital signal generators with digital-to-analogue converters, may be used to produce the required PSD and r.m.s. characteristics at the base of the seat for the simulated input vibration test.

5.4.2 Damping test

The seat shall be loaded with an inert mass of 75 kg and then excited by a sinusoidal vibration in the range from 0,5 to 2 times the expected resonance frequency of the suspension. The inert mass shall, if necessary, be secured to the seat in order to prevent the mass from moving on the seat or from falling off it.

To determine the resonance frequency, the frequency range shall be investigated with either a linear frequency sweep or in maximum steps of 0,05 Hz. With either method, the frequency should be varied from a lower frequency (equal to 0,5 times the expected resonance of the suspension) to an upper frequency (equal to 2 times the expected resonance frequency of the suspension) and back again to the lower frequency. The frequency sweeping shall be made over a duration of at least 80 s at a constant peak-to-peak displacement of the platform that is equal to 40 % of the total suspension travel (stroke) specified by the seat manufacturer, or 50 mm, whichever is the smaller.

The damping test and the calculation of the transmissibility $H(f_r)$ at resonance shall be performed in accordance with EN 30326-1:1994, 9.2. In all cases, the damping test itself at the resonance frequency shall be carried out with a peak-to-peak displacement of the platform of 40 % of the total suspension travel even if the 40 % value exceeds 50 mm.

Only one measurement needs to be carried out at the resonance frequency of the seat suspension.

5.5 Tolerances on input vibration

See EN 30326-1:1994, 8.1.

The input excitation for the seat as defined in 5.4.1 can only be created on a simulator in an approximate manner. In order to be valid the test input shall comply with the following requirements.

5.5.1 Distribution function

Under the condition that the acceleration on the platform shall be sampled at a minimum of 50 data points per second and analysed into amplitude cells of not greater than 20 % of the total true r.m.s. acceleration, the probability density function shall be within ± 20 % of the ideal Gaussian function between ± 200 % of the total true r.m.s. acceleration, and with no data exceeding ± 450 % of the total true r.m.s. acceleration. For the purposes of this requirement, the total true r.m.s. acceleration is a^*_{P12} as defined in Table 3.

5.5.2 Power spectral density and r.m.s. values

The power spectral density of the acceleration measured on the platform is considered to be representative of $G^*_P(f)$ if, and only if:

a) for $f_1 \leq f \leq f_2$

$$G^*_{PL}(f) \leq G_P(f) \leq G^*_{PU}(f) \quad (4)$$

where

$G^*_{PL}(f) = G^*_P(f) - 0,1 \max[G^*_P(f)]$ if $G^*_P(f) - 0,1 \max[G^*_P(f)] > 0$

$G^*_{PL}(f) = 0$ if $G^*_P(f) - 0,1 \max[G^*_P(f)] \leq 0$

$G^*_{PU}(f) = G^*_P(f) + 0,1 \max[G^*_P(f)]$

b) $0,9\, a^*_{P12} \leq a_{P12} \leq 1,1\, a^*_{P12}$ (5)

c) $0,9\, a^*_{P34} \leq a_{P34} \leq 1,1\, a^*_{P34}$ (6)

The tolerances on $G_P(f)$ are illustrated in Figures 2 through 5. The shape of $G^*_P(f)$ is defined by values and filters as set down in Table 2. The values for f_1, f_2, f_3, f_4, $\max[G^*_P(f)]$, a^*_{P12} and a^*_{P34} are shown in Table 3.

6 Acceptance values

6.1 SEAT (Seat Effective Amplitude Transmissibility) factor

The seat specified for a particular input spectral class shall meet the SEAT factors as given in Table 1, for both weights of operators.

Table 1 – SEAT factors by input spectral class

Input spectral class	SEAT factor
IT 1	< 0,7
IT 2	< 0,8
IT 3	< 0,9
IT 4	< 0,9

6.2 Damping performance

The transmissibility $H(f_r) = \frac{a_S(f_r)}{a_P(f_r)}$ at resonance along the vertical axis shall be less than:

2,0 for input spectral classes IT 3 and IT 4.

Seats intended for input spectral classes IT 1 and IT 2 are not subjected to this test.

7 Seat identification

The seat shall be identified by a permanent mark at a clearly visible location. The mark shall include the following information:

– manufacturer's name or logo-type,

– type denomination (e.g. part number),

– input spectral class (or classes) (e.g. IT 1, IT 2) "according to EN 13490:2001".

8 Test report

The test report shall contain all the information necessary to understand, interpret and use the results arising from the application of this European Standard.

The results shall be compared with the acceptance criteria for a seat and recorded in the report forms given in Figures 6 and 7.

The test report should contain the following:

a) Name and address of seat manufacturer;

b) model of seat, product and serial number;

c) date of test;

d) details of running-in;

e) type of measuring disc used: semi-rigid, rigid;

f) input vibration class;

g) vibration transmission to each person with the simulated input vibration test:
   - platform acceleration a_{wP12}
   - seat disc acceleration a_{wS12}
   - test person mass in kilograms
   - Seat Effective Amplitude Transmissibility, SEAT factor
   - calibration status of the measuring system used;

h) calculated transmissibility at the resonance and the resonance frequency;

i) the name of the person responsible for the test;

j) identification of test laboratory;

k) the state and traceability of calibration of the test equipment;

l) location of marking (see clause 7).

Table 2 – Definition of input spectral classes

Spectral class of input vibration	$G^*_P(f)$
IT 1	$1,66\ (HP_{24})^2\ (LP_{12})^2$
IT 2	$1,45\ (HP_{24})^2\ (LP_{12})^2$
IT 3	$0,60\ (HP_{24})^2\ (LP_{24})^2$
IT 4	$1,64\ (HP_{24})^2\ (LP_{24})^2$

$$LP_{12} = \frac{1}{1 + 1{,}414\ S + S^2}$$

$$LP_{24} = \frac{1}{1 + 2{,}613\ S + 3{,}414\ S^2 + 2{,}613\ S^3 + S^4}$$

$$HP_{24} = \frac{S^4}{1 + 2{,}613\ S + 3{,}414\ S^2 + 2{,}613\ S^3 + S^4}$$

where

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

$j = \sqrt{-1}$

f frequency in Hz

f_c filter cut-off frequency, in Hz, as given below.

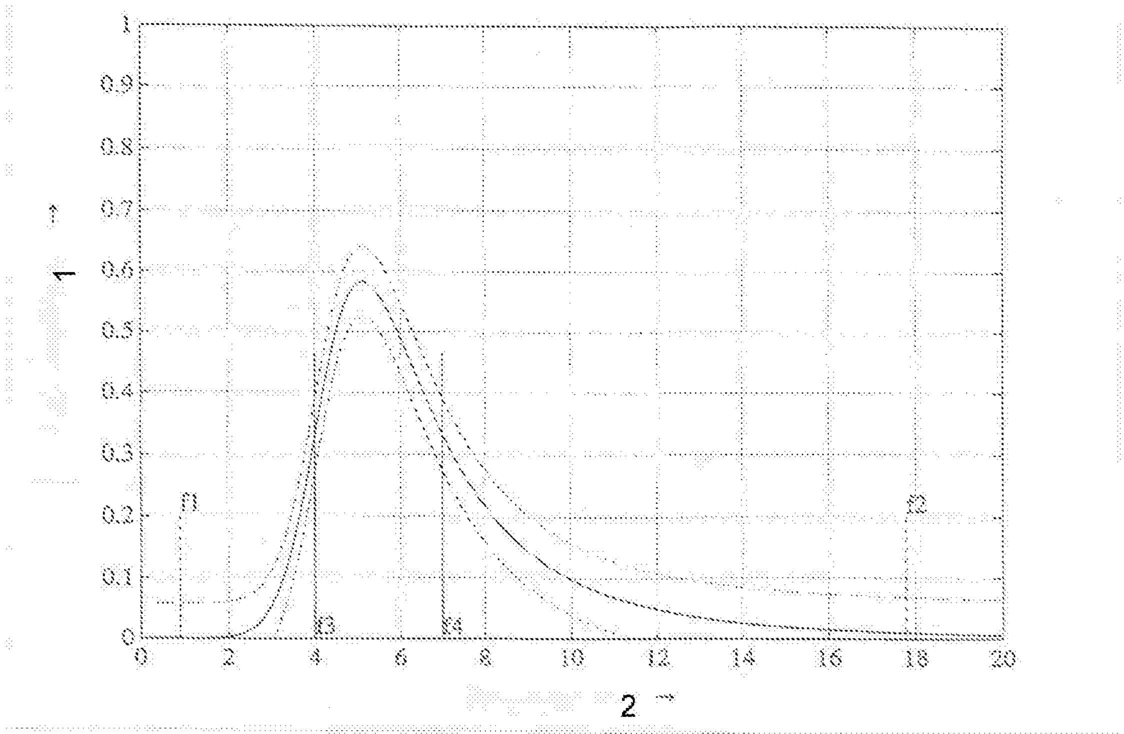
Input spectral class	LP_{12}	LP_{24}	HP_{24}
IT 1	5 Hz	–	4,5 Hz
IT 2	3 Hz	–	3 Hz
IT 3, IT 4	–	3 Hz	1,5 Hz

NOTE HP and LP designate high-pass and low-pass filters of the Butterworth type. The designations state the filter slope in decibels per octave. The table above completely defines band pass filters in terms of cut-off frequencies and slopes.

Table 3 – Characteristics of the simulated input vibration for different types of machines

Type of machine (see prEN 13059:1997)	Input spectral class	Maximum value of $G^*_P(f)$	Frequency range f_1 to f_2			Frequency range f_3 to f_4		
			f_1 and f_2	Unweighted target r.m.s. acceleration on the platform a^*_{P12}	Weighted target r.m.s. acceleration on the platform a^*_{wP12}	f_3 and f_4	Unweighted target r.m.s. acceleration on the platform a^*_{P34}	Weighted target r.m.s. acceleration on the platform a^*_{wP34}
		$(m/s^2)^2$/Hz	Hz	m/s^2	m/s^2	Hz	m/s^2	m/s^2
Categories 1, 2, 3	IT 1	0,58	f_1 = 0,89 f_2 = 17,78	1,58	1,59	f_3 = 4,00 f_4 = 7,00	1,20	1,25
Category 4a	IT 2	0,40	f_1 = 0,89 f_2 = 17,78	1,05	0,96	f_3 = 2,50 f_4 = 5,00	0,87	0,77
Categories 4b, 5	IT 3	0,53	f_1 = 0,89 f_2 = 11,22	0,96	0,63	f_3 = 1,50 f_4 = 3,00	0,82	0,49
Category 6	IT 4	1,45	f_1 = 0,89 f_2 = 17,78	1,59	1,04	f_3 = 1,50 f_4 = 3,00	1,36	0,81

NOTE The above values were calculated using Δf = 0,001 Hz and the complex analytical functions (with band limiting) given in ISO 2631-1:1997, annex A. The use of other Δf values and/or the approximate equations can give slightly different values.

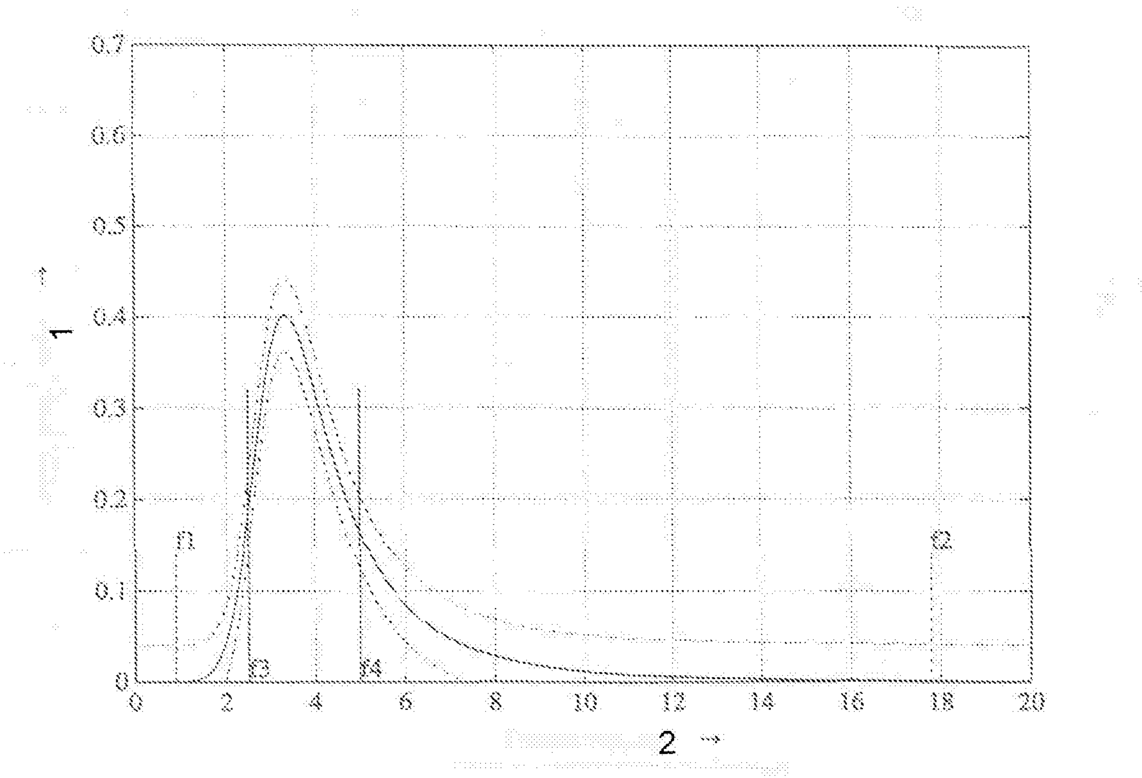


Key

1 PSD (m/s²)/Hz

2 Frequency, Hz

Figure 2 – PSD for input spectral class IT 1 (categories 1, 2 and 3 according to prEN 13059:1997)

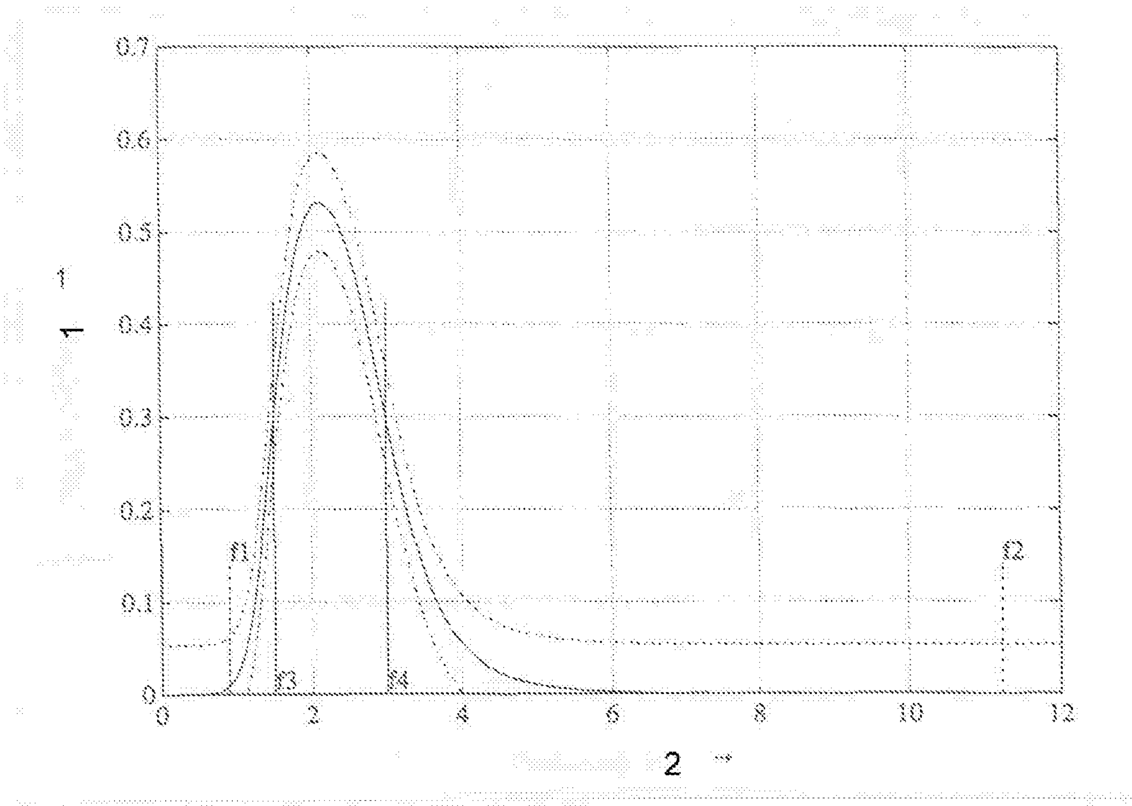


Key

1 PSD $(m/s^2)/Hz$

2 Frequency, Hz

Figure 3 – PSD for input spectral class IT 2 (category 4a according to prEN 13059:1997)

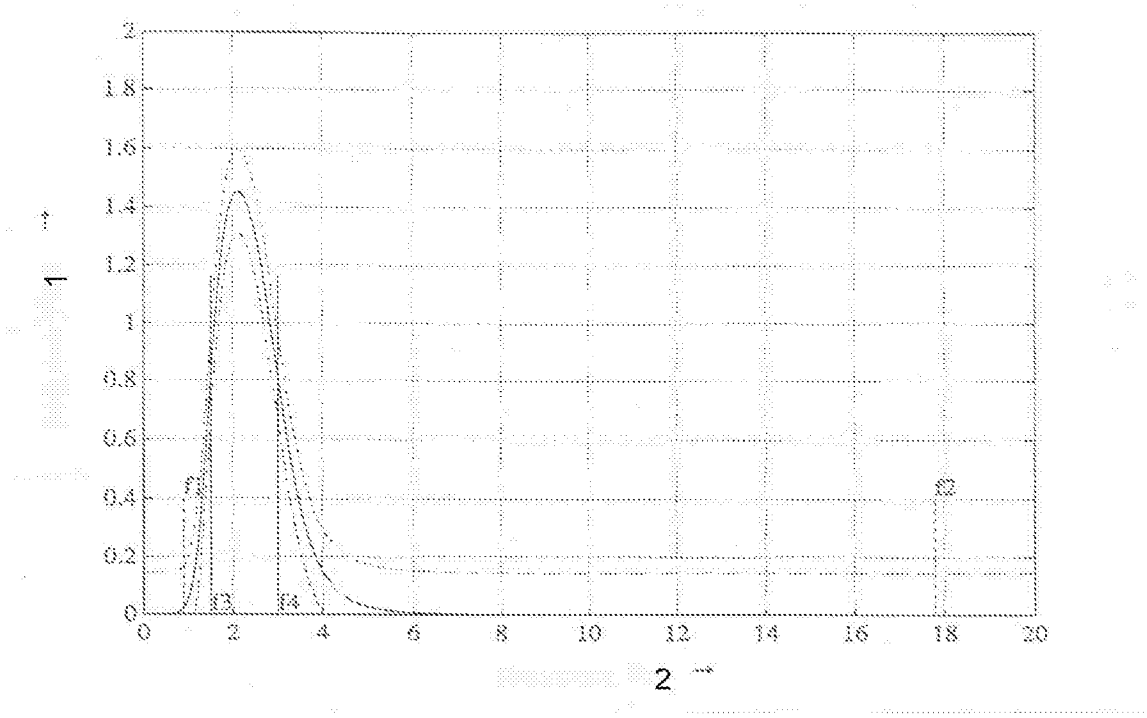


Key

1 PSD $(m/s^2)^2/Hz$

2 Frequency, Hz

Figure 4 – PSD for input spectral class IT 3 (categories 4b and 5 according to prEN 13059:1997)



Key
1 PSD $(m/s^2)^2/Hz$
2 Frequency, Hz

Figure 5 – PSD for input spectral class IT 4 (category 6 according to prEN 13059:1997)

Seat on test: . . . .
Input spectral class: . . . .
a^*_{P12} = ... m/s^2
a^*_{wP12} = ... m/s^2

		a_{P12} m/s^2	a_{wP12} m/s^2	a_{wS12} m/s^2	SEAT factor
Light operator . . . . kg Added mass . . . . kg	1st test				
	2nd test				
	3rd test				
	Arithmetic mean value				
Heavy operator . . . . kg Added mass . . . . kg	1st test				
	2nd test				
	3rd test				
	Arithmetic mean value				
SEAT factor requirement (see 6.1) for input spectral class is fulfilled: Yes/No*					

* Delete as appropriate

Figure 6 – Report form for the simulated input vibration test to evaluate the SEAT factor (vertical axis)

Seat on test: ....

Peak-to-peak displacement of platform: .... mm

f_r = ... Hz

$a_P(f_r)$ = ... m/s^2

$a_S(f_r)$ = ... m/s^2

$$H(f_r) = \frac{a_S(f_r)}{a_P(f_r)} = \text{..}$$

Calculated transmissibility $H(f_r)$ less than	Input spectral class
– 2,0	IT 1, IT 2 IT 3, IT 4

NOTE The test report may be improved by including the graph of the transfer function.

Figure 7 – Report form for the evaluation of the calculated transmissibility $H(f_r)$ (damping test, vertical axis)

Annex ZA
(informative)

Relationship of this document with EC 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 EC Directive:

Machinery Directive 98/37/EC, amended by Directive 98/79/EC.

Compliance with this standard provides one means of conforming with the specific essential requirements of the Directive concerned.

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

Bibliography

EN ISO 7096, Earth-moving machinery – Laboratory evaluation of operator seat vibration (ISO 7096:2000)

prEN 13059 :1997, Safety of industrial trucks – Test method for measuring vibration

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

Details and advice can be obtained from the Copyright & Licensing Manager. Tel: +44 (0)20 8996 7070. Fax: +44 (0)20 8996 7553. Email: copyright@bsi-global.com.

BSI
389 Chiswick High Road
London
W4 4AL