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ISO 7096

Third edition
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Earth-moving machinery — Laboratory evaluation of operator seat vibration

Engins de terrassement — Évaluation en laboratoire des vibrations transmises à l'opérateur par le siège

Reference number
ISO 7096:2000(E)

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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 7096 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

This third edition cancels and replaces the second edition (ISO 7096:1994), which has been technically revised.

Introduction

The operators of earth-moving machinery are often exposed to a low frequency vibration environment partly caused by the movement of the vehicles over uneven ground and the tasks carried out. 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 design of the seat and its suspension are a compromise between the requirements of reducing the effect of vibration and shock on the operator and providing him with stable support so that he can control the machine effectively.

Thus, seat vibration attenuation is a compromise of a number of factors and the selection of seat vibration parameters needs to be taken in context with the other requirements for the seat.

The performance criteria provided in this International 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 the effects of vibration and shock. They may be revised in the light of future developments and improvements in suspension design.

The test inputs included in this International Standard are based on a very large number of measurements taken *in situ* on earth-moving machinery used under severe but typical operating conditions. The test methods are based on ISO 10326-1, which is a general method applicable to seats for different types of vehicles.

Earth-moving machinery — Laboratory evaluation of operator seat vibration

1 Scope

1.1 This International Standard specifies, in accordance with ISO 10326-1, 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 earth-moving machines at frequencies between 1 Hz and 20 Hz. It also specifies acceptance criteria for application to seats on different machines.

1.2 This International Standard is applicable to operator seats used on earth-moving machines as defined in ISO 6165.

1.3 This International Standard defines the input spectral classes required for the following earth-moving machines. Each class defines a group of machines having similar vibration characteristics:

— rigid frame dumpers > 4 500 kg operating mass[1)]

— articulated frame dumpers

— scrapers without axle or frame suspension[2)]

— wheel-loaders > 4 500 kg operating mass[1)]

— graders

— wheel-dozers

— soil compactors (wheel type)

— backhoe-loaders

— crawler loaders

— crawler-dozers ⩽ 50 000 kg operating mass[1), 3)]

— compact dumpers ⩽ 4 500 kg operating mass[1)]

— compact loaders ⩽ 4 500 kg operating mass[1)]

— skid-steer loaders ⩽ 4 500 kg operating mass[1)]

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1) See ISO 6016.

2) For tractor scrapers with suspension, either a seat with no suspension may be used, or one having a suspension with high damping.

3) For crawler dozers greater than 50 000 kg, the seat performance requirements are suitably provided by a cushion type seat.

1.4 The following machines impart sufficiently low vertical vibration inputs at frequencies between 1 Hz and 20 Hz to the seat during operation that these seats do not require suspension for the attenuation of transmitted vibration:

— excavators, including walking excavators and cable excavators[4)]

— trenchers

— landfill compactors

— non-vibratory rollers

— milling machines

— pipelayers

— finishers

— vibratory rollers

1.5 The tests and criteria defined in this International Standard are intended for operator seats used in earth-moving machines of conventional design.

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

1.6 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

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

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

ISO 6016:1998, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components.*

ISO 6165:1997, *Earth-moving machinery — Basic types — Vocabulary.*

ISO 8041:1990, *Human response to vibration — Measuring instrumentation.*

ISO 10326-1:1992, *Mechanical vibration — Laboratory method for evaluating vehicle seat vibration — Part 1: Basic requirements.*

ISO 13090-1:1998, *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.*

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4) For excavators, the predominant vibration is generally in the fore and aft (X) axis.

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 2041 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
operating mass
mass of the base machine with equipment and empty attachment as specified by the manufacturer, and with the operator (75 kg), full fuel tank and all fluid systems at the levels specified by the manufacturer

[ISO 6016:1998, 3.2.1]

3.1.4
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)

3.1.5
frequency analysis
process of arriving at a quantitative description of a vibration amplitude as a function of frequency

3.1.6
measuring period
time duration in which vibration data for analysis is obtained

3.2 Symbols and abbreviations

For the purposes of this International Standard, the following symbols and abbreviations apply.

$a_P(f_r)$ Unweighted rms value of the measured vertical acceleration at the platform at the resonance frequency

a^*_{P12}, a^*_{P34} Unweighted rms value of the target vertical acceleration at the platform under the seat (see Figure 3) between frequencies f_1 and f_2, or f_3 and f_4

a_{P12}, a_{P34} Unweighted rms 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 rms value of the measured vertical acceleration at the seat disk at the resonance frequency

a^*_{wP12}, a^*_{wP34} Weighted rms 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 rms value of the measured vertical acceleration at the platform between frequencies f_1 and f_2

a_{wS12}	Weighted rms value of the measured vertical acceleration at the seat disk (see Figure 3) between frequencies f_1 and f_2
B_e	Resolution bandwidth, in hertz
f	Frequency, in hertz
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
PSD	Power Spectral Density, expressed as acceleration squared per unit bandwidth $(m/s^2)^2/Hz$
rms	root mean square
SEAT	Seat Effective Amplitude Transmissibility factor
T_s	Sampling time, in seconds

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, as measured under severe conditions.

4.2 Two criteria are used for the evaluation of seat:

a) the Seat Effective Amplitude Transmissibility (SEAT) factor according to ISO 10326-1:1992, 9.1, but with frequency weighting according to ISO 2631-1;

b) the maximum transmissibility ratio in the damping test according to ISO 10326-1:1992, 9.2.

4.3 The measuring equipment shall be in accordance with ISO 8041 (type 1 instrument) and ISO 10326-1:1992, clauses 4 and 5. The frequency weighting shall include the effects of the band limiting filters, and be in accordance with ISO 2631-1.

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

Any compliant end-stops or devices normally fitted to production versions of the seat to be tested to minimise 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 ISO 10326-1:1992, clauses 7 and 8.

5.1 Simulation of vibration

See ISO 10326-1:1992, clause 5.

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

NOTE In the case of classes EM 1 and EM 2 the vibrator should be capable of simulating sinusoidal vibration having a displacement amplitude of at least ± 7,5 cm at a frequency of 2 Hz; see 5.4.1.

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 result. 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 5 000 cycles, with measurements at 1 000 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 1 000 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 (approximately 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 International Standard specifies the input vibration in nine input spectral classes (EM 1 through EM 9) for earth-moving machinery for the purpose of determining the SEAT factor.

In accordance with ISO 10326-1:1992, 9.1.2, the SEAT factor is defined as

$$\text{SEAT} = a_{\text{wS12}} / a_{\text{wP12}}$$

The simulated input vibration used to determine the SEAT is defined in accordance with ISO 10326-1:1992, 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, $G^*_{\text{P}}(f)$, of the vertical (Z axis) acceleration of the vibrating platform, and by the unweighted rms vertical accelerations on that platform (a^*_{P12}, a^*_{P34}).

The vibration characteristics for each input spectral class EM 1 through EM 9 are shown in Figures 2 through 10, respectively. Equations for the acceleration power spectral density curves of Figures 2 to 10 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 4 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 ISO 10326-1:1992, 9.1. The effective duration of each test shall be at least 180 s.

If none of the SEAT values relating to one particular test configuration deviate 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 resolution bandwidth B_{e}, shall satisfy the following:

$$2 \times B_{\text{e}} \times T_{\text{s}} > 140$$

$$B_{\text{e}} < 0{,}5 \text{ Hz}$$

NOTE 1 Class EM 7 is also used to test agricultural wheeled tractor seats for class I tractor (see ISO 5007:1990, *Agricultural wheeled tractors — Operator's seat — Laboratory measurement of transmitted vibration*).

NOTE 2 Any means, including double integrators, analog signal generators and filters, and digital signal generators with digital-to-analog converters, may be used to produce the required PSD and rms 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 $H(f_{\text{r}})$ at resonance shall be performed according to ISO 10326-1:1992, 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's suspension.

5.5 Tolerances on input vibration

See in ISO 10326-1:1992, 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 analyzed into amplitude cells of not greater than 20 % of the total true rms acceleration, the probability density function must be within ± 20 % of the ideal Gaussian function between ± 200 % of the total true rms acceleration, and with no data exceeding ± 350 % of the total true rms acceleration. For the purposes of this requirement, the total true rms acceleration is a^*_{P12} as defined in Table 4.

5.5.2 Power spectral density and rms 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 $f_1 \leqslant f \leqslant f_2$

$$G^*_{PL}(f) \leqslant G_P(f) \leqslant G^*_{PU}(f)$$

where

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

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

$$G^*_{PL}(f) = 0$$

if $\{G^*_P(f) - 0{,}1 \times \max[G^*_P(f)]\} \leqslant 0$

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

b) $0{,}95 \times a^*_{P12} \leqslant a_{P12} \leqslant 1{,}05 \times a^*_{P12}$

c) $0{,}95 \times a^*_{P34} \leqslant a_{P34} \leqslant 1{,}05 \times a^*_{P34}$

The tolerances on $G_P(f)$ are illustrated in Figures 2 through 10. 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 4.

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 given in Table 1:

Table 1 — SEAT factors by input spectral class

Input spectral class	SEAT factors
EM 1	< 1,1
EM 2	< 0,9
EM 3	< 1,0
EM 4	< 1,1
EM 5	< 0,7
EM 6	< 0,7
EM 7	< 0,6
EM 8	< 0,8
EM 9	< 0,9

NOTE Good seats cause a slight increase of vibration at the low frequency range, whereas vibration in the higher frequency range, depending on the suspension system, are significantly reduced. The test PSD for the input spectral classes EM 1 and EM 4 are limited to the low frequency range. The low frequency range is of importance because of the shock loads which require good damping performance. This results in SEAT factors close to and slightly above 1 when performing the seat test.

6.2 Damping performance

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

1,5 for input spectral classes EM 1, EM 2, EM 3, EM 4 and EM 6,

2,0 for input spectral classes EM 5, EM 7, EM 8 and EM 9.

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. EM 1, EM 2 etc.) followed by the text: "according to ISO 7096:1999".

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 International Standard.

The results shall be compared with the acceptance criteria for a seat and recorded in the report forms given in Figures 11 and 12.

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 spectral vibration class;

g) vibration transmission to the persons with the simulated input vibration test:

— platform vibration a_{wP12},

— seat disk vibration a_{wS12},

— test person mass, in kilograms,

— SEAT factor;

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) location of marking (see clause 7).

Table 2 — Definition of input spectral classes

Spectral class of input vibrations	$G^*_P(f)$
EM 1	2,82 $(HP24)^2$ $(LP24)^2$
EM 2	2,72 $(HP24)^2$ $(LP24)^2$
EM 3	1,93 $(HP24)^2$ $(LP24)^2$
EM 4	0,60 $(HP24)^2$ $(LP24)^2$
EM 5	1,11 $(HP24)^2$ $(LP6)^2$
EM 6	0,79 $(HP12)^2$ $(LP12)^2$
EM 7	9,25 $(HP48)^2$ $(LP48)^2$
EM 8	1,45 $(HP24)^2$ $(LP12)^2$
EM 9	2,10 $(HP24)^2$ $(LP12)^2$

$(LP6) = 1/(1 + S)$

$(LP12) = 1/(1 + 1{,}414S + S^2)$

$(LP24) = 1/(1 + 2{,}613S + 3{,}414S^2 + 2{,}613S^3 + S^4)$

$(LP48) = 1/(1 + 5{,}126S + 13{,}137S^2 + 21{,}846S^3 + 25{,}688S^4 + 21{,}846S^5 + 13{,}137S^6 + 5{,}126S^7 + S^8)$

$(HP12) = S^2/(1 + 1{,}414S + S^2)$

$(HP24) = S^4/(1 + 2{,}613S + 3{,}414S^2 + 2{,}613S^3 + S^4)$

$(HP48) = S^8 /(1 + 5{,}126S + 13{,}137S^2 + 21{,}846S^3 + 25{,}688S^4 + 21{,}846S^5 + 13{,}137S^6 + 5{,}126S^7 + S^8)$

where: $S = \mathrm{j}f/f_c$; $\mathrm{j} = \sqrt{-1}$; f = frequency, in hertz.

f_c = Filter cut-off frequency, in hertz, as given in Table 3.

NOTE HP and LP designate high-pass and low-pass filters of the Butterworth type.

Table 3 — Filter cut-off frequencies

Input spectral class	Filter cut-off frequencies, f_c, Hz						
	Filter designations						
	(LP6)	(LP12)	(LP24)	(LP48)	(HP12)	(HP24)	(HP48)
EM 1	—	—	2,5 Hz	—	—	1,5 Hz	—
EM 2, EM 3, EM 4	—	—	3,0 Hz	—	—	1,5 Hz	—
EM 5	3,5 Hz	—	—	—	—	1,5 Hz	—
EM 6	—	9,0 Hz	—	—	6,5 Hz	—	—
EM 7	—	—	—	3,5 Hz	—	—	3,0 Hz
EM 8	—	3,0 Hz	—	—	—	3,0 Hz	—
EM 9	—	4,0 Hz	—	—	—	3,5 Hz	—

NOTE HP and LP designate high-pass and low-pass filters of the Butterworth type. The subordinated numbers 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 4 — Characteristics of the simulated input vibration for different types of machines.

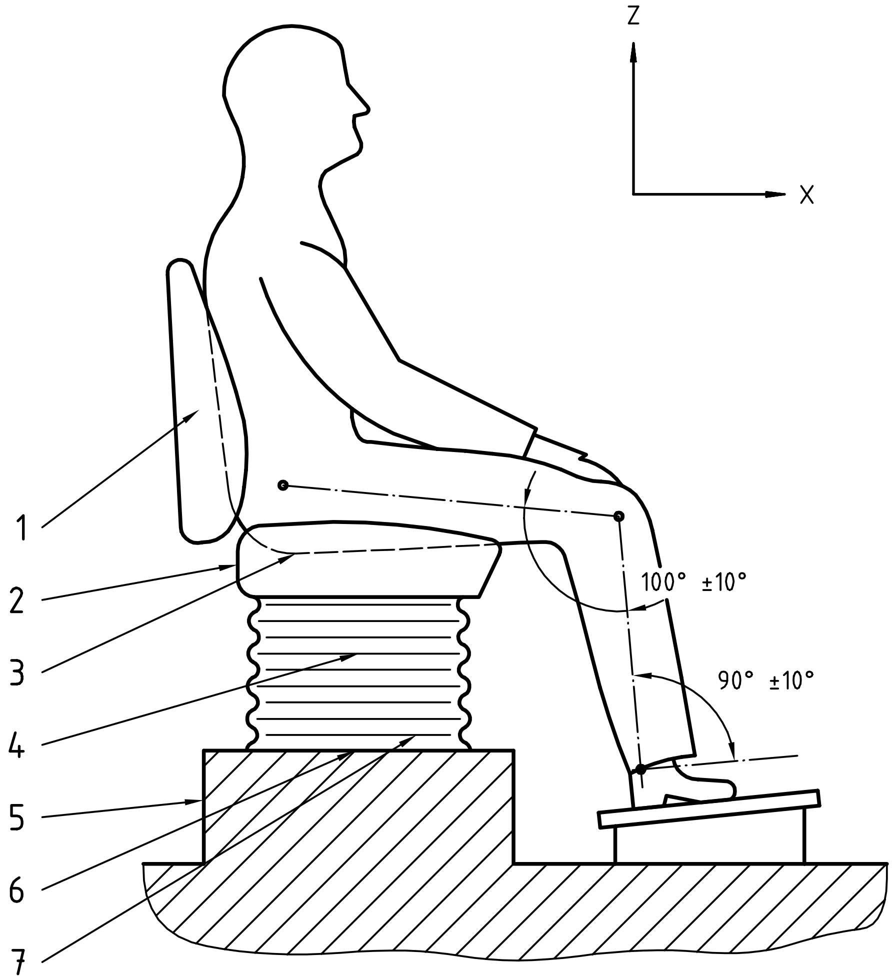
Type of machine	Input spectral class	Target PSD of vertical vibration at the platform $G^*_P(f)$ (m/s²)²/Hz max.	Frequency range f_1 to f_2			Frequency range f_3 to f_4		
			f_1 and f_2 Hz	Unweighted target rms acceleration on the platform a^*_{P12} m/s²	Weighted target rms acceleration on the platform a^*_{wP12} m/s²	f_3 and f_4 Hz	Unweighted target rms acceleration on the platform a^*_{P34} m/s²	Weighted target rms acceleration on the platform a^*_{wP34} m/s²
Articulated or rigid frame dumper > 4 500 kg[a]	EM 1	2,21	f_1 = 0,89 f_2 = 11,22	1,71	1,02	f_3 = 1,50 f_4 = 2,50	1,39	0,75
Scraper without axis or frame suspension[b]	EM 2	2,41	f_1 = 0,89 f_2 = 11,22	2,05	1,34	f_3 = 1,50 f_4 = 3,00	1,75	1,04
Wheel loader > 4 500 kg[a]	EM 3	1,71	f_1 = 0,89 f_2 = 11,22	1,73	1,13	f_3 = 1,50 f_4 = 3,00	1,48	0,87
Grader	EM 4	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
Wheel dozer Soil compactor on wheels Backhoe loader	EM 5	0,77	f_1 = 0,89 f_2 = 17,78	1,94	1,68	f_3 = 1,50 f_4 = 5,00	1,42	1,11
Crawler loader Crawler dozer[c] ⩽ 50 000 kg[a]	EM 6	0,34	f_1 = 0,89 f_2 = 17,78	1,65	1,61	f_3 = 5,00 f_4 = 12,00	1,39	1,42
Compact dumper ⩽ 4 500 kg[a]	EM 7	5,55	f_1 = 0,89 f_2 = 11,22	2,26	1,89	f_3 = 2,90 f_4 = 3,60	1,82	1,51
Compact loader ⩽ 4 500 kg[a]	EM 8	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
Skid steer loader ⩽ 4 500 kg[a]	EM 9	0,78	f_1 = 0,89 f_2 = 17,78	1,63	1,59	f_3 = 3,00 f_4 = 6,00	1,33	1,31

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 D. The use of other Δf values and/or the approximate equations can give slightly different values.

a Operating mass (see ISO 6016).

b For scrapers with suspension, either a seat with no suspension or having a suspension with high damping, may be used.

c For crawler dozers greater than 50 000 kg, the seat performance requirements are suitably provided by a cushion type seat.



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 and the ankles.

Figure 1 — Posture of the test person

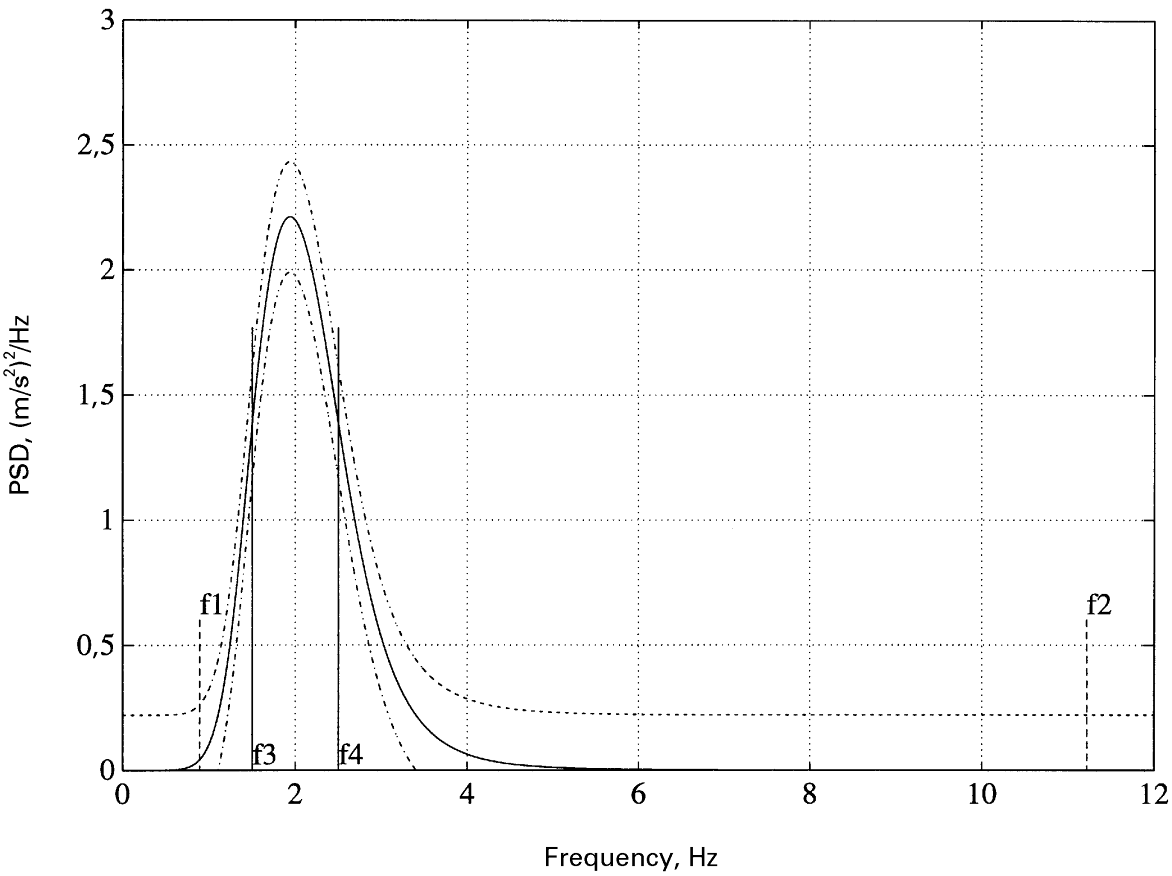


Figure 2 — PSD for input spectral class EM 1 (articulated or rigid frame dumper > 4 500 kg)

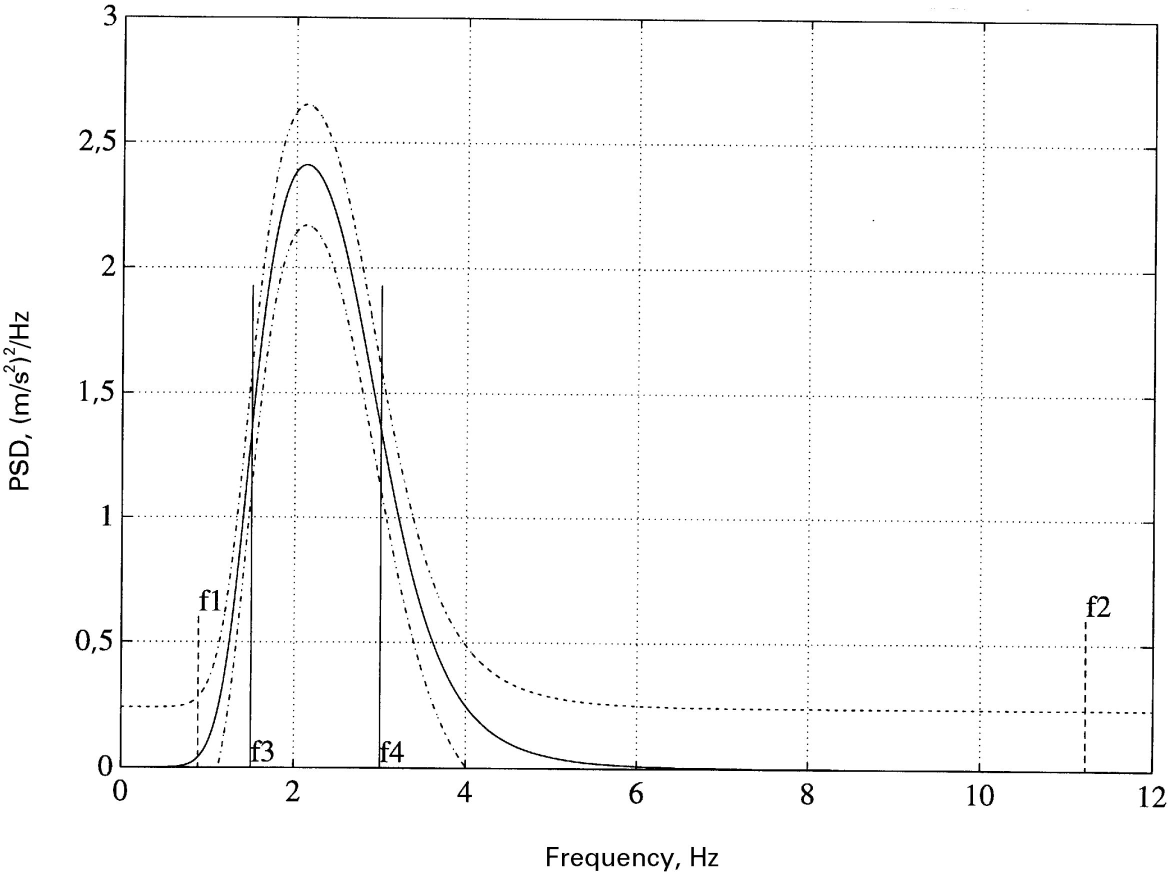


Figure 3 — PSD for input spectral class EM 2 (scraper without axle or frame suspension)

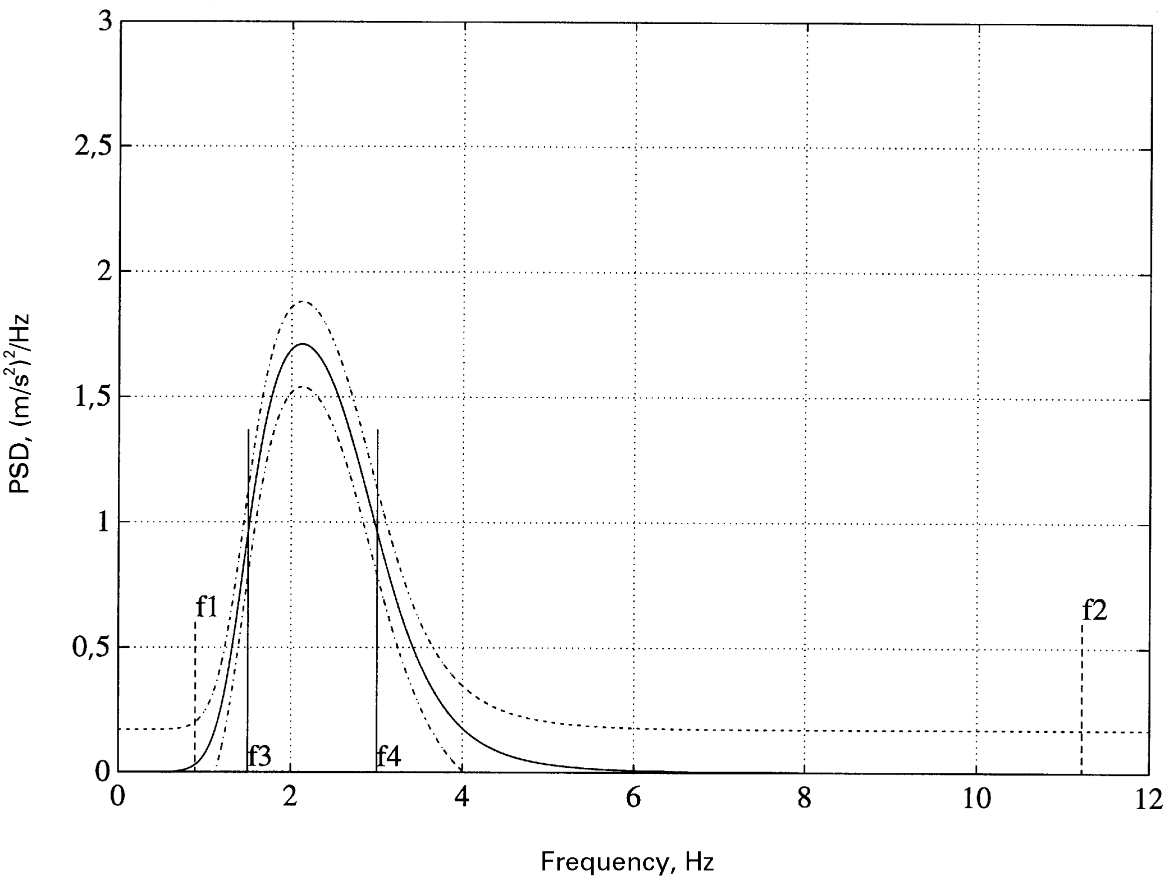


Figure 4 — PSD for input spectral class EM 3 (wheel loader > 4 500 kg)

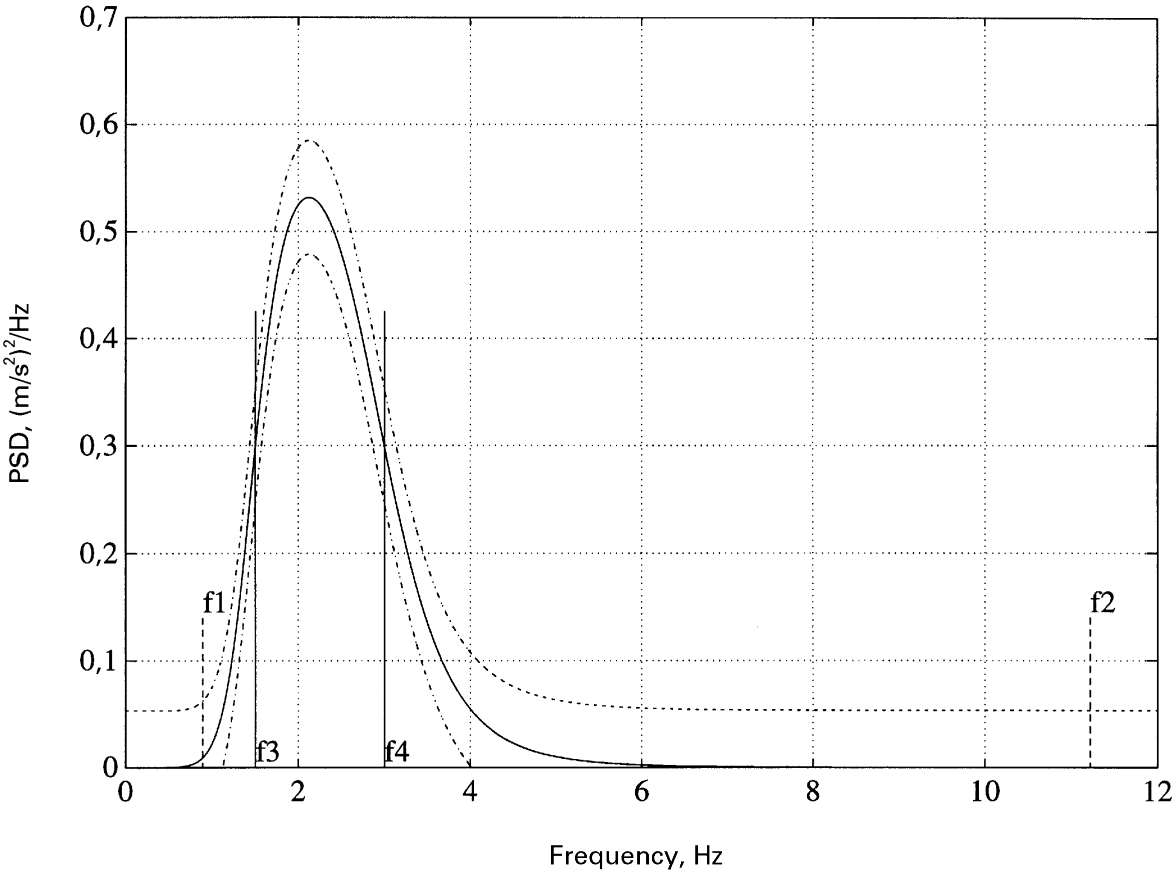


Figure 5 — PSD for input spectral class EM 4 (grader)

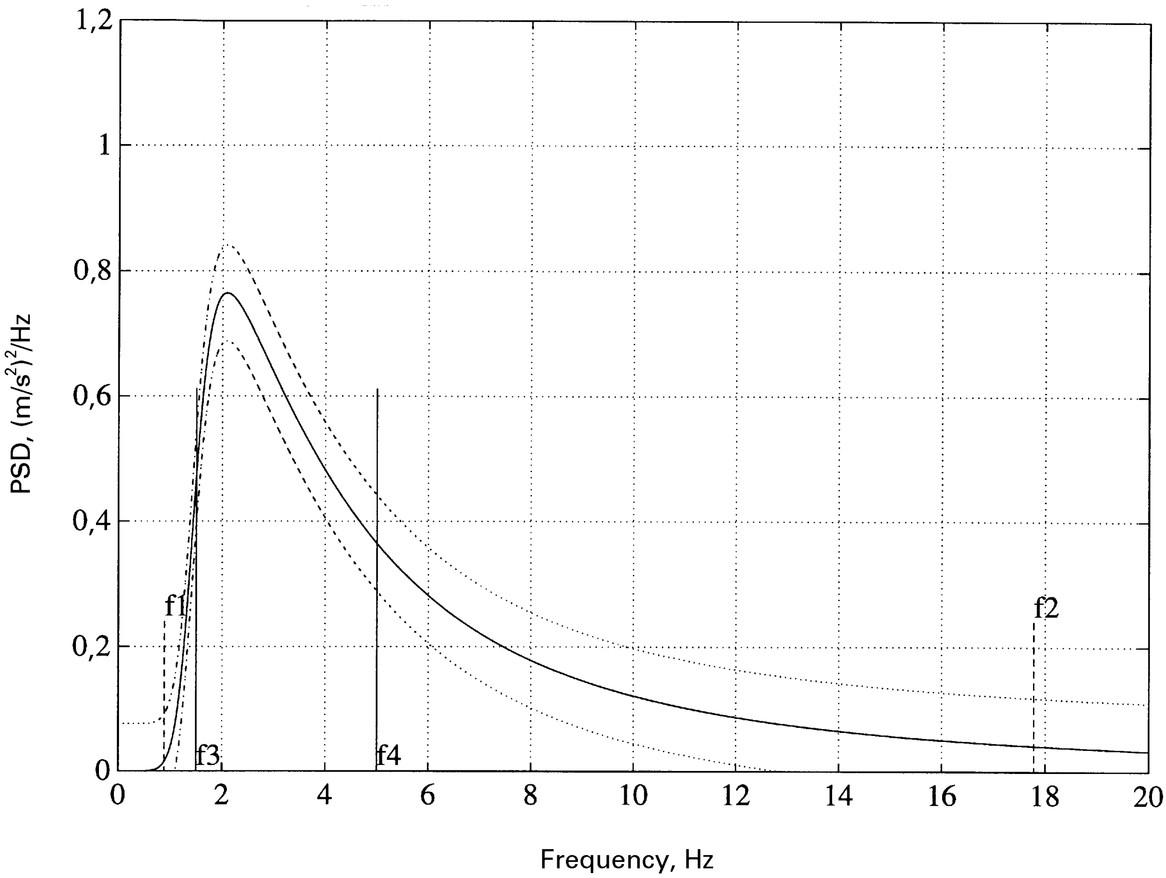


Figure 6 — PSD for input spectral class EM 5 [wheel dozer, soil compactor (wheel type), backhoe loader]

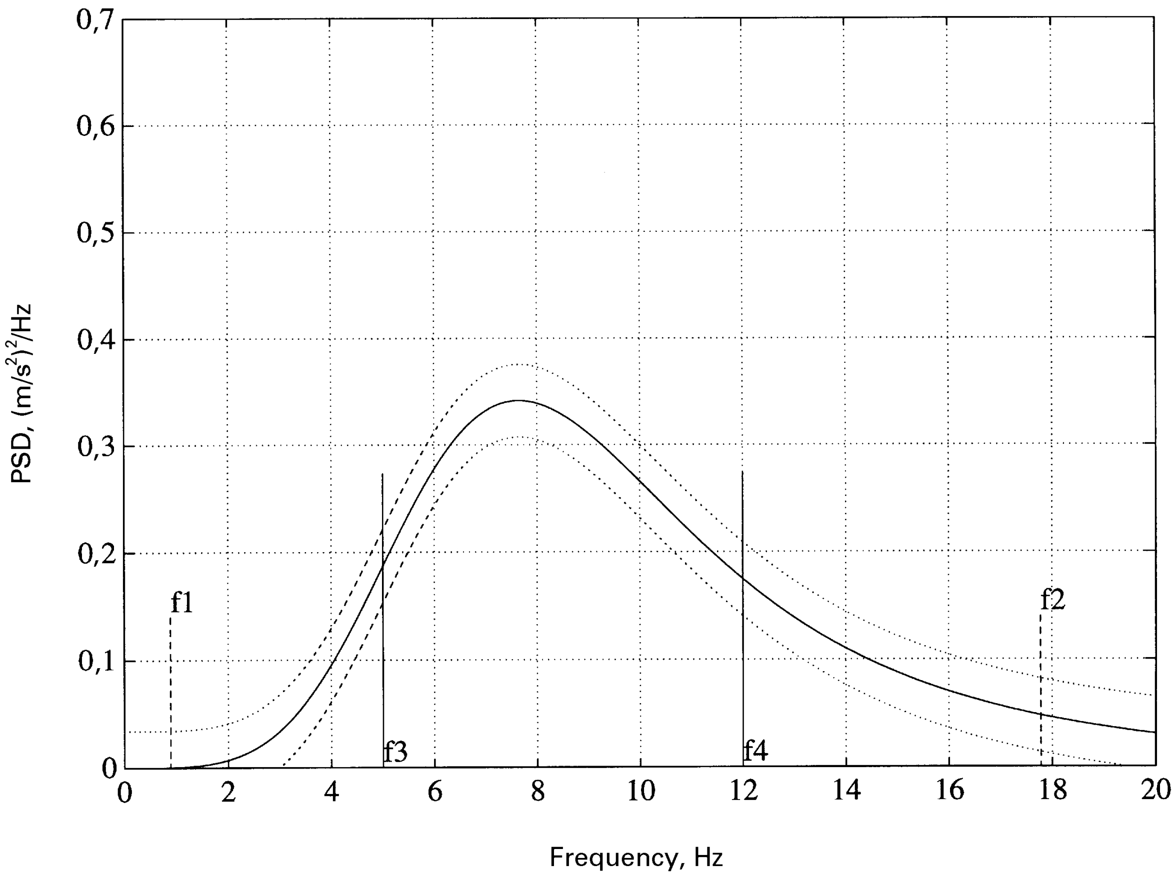


Figure 7 — PSD for input spectral class EM 6, (crawler dumper, crawler dozer, crawler loader ⩽ 50 000 kg)

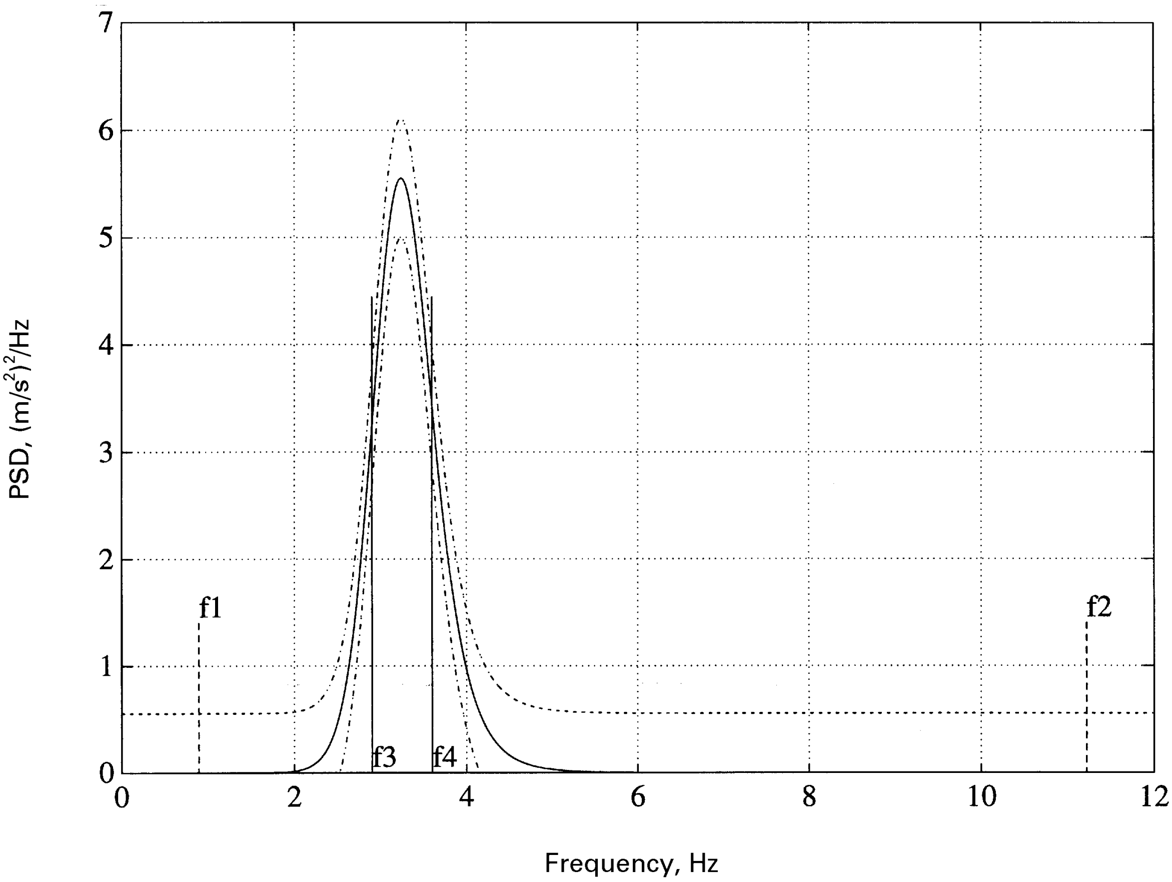


Figure 8 — PSD for input spectral class EM 7 (compact dumper ⩽ 4 500 kg)

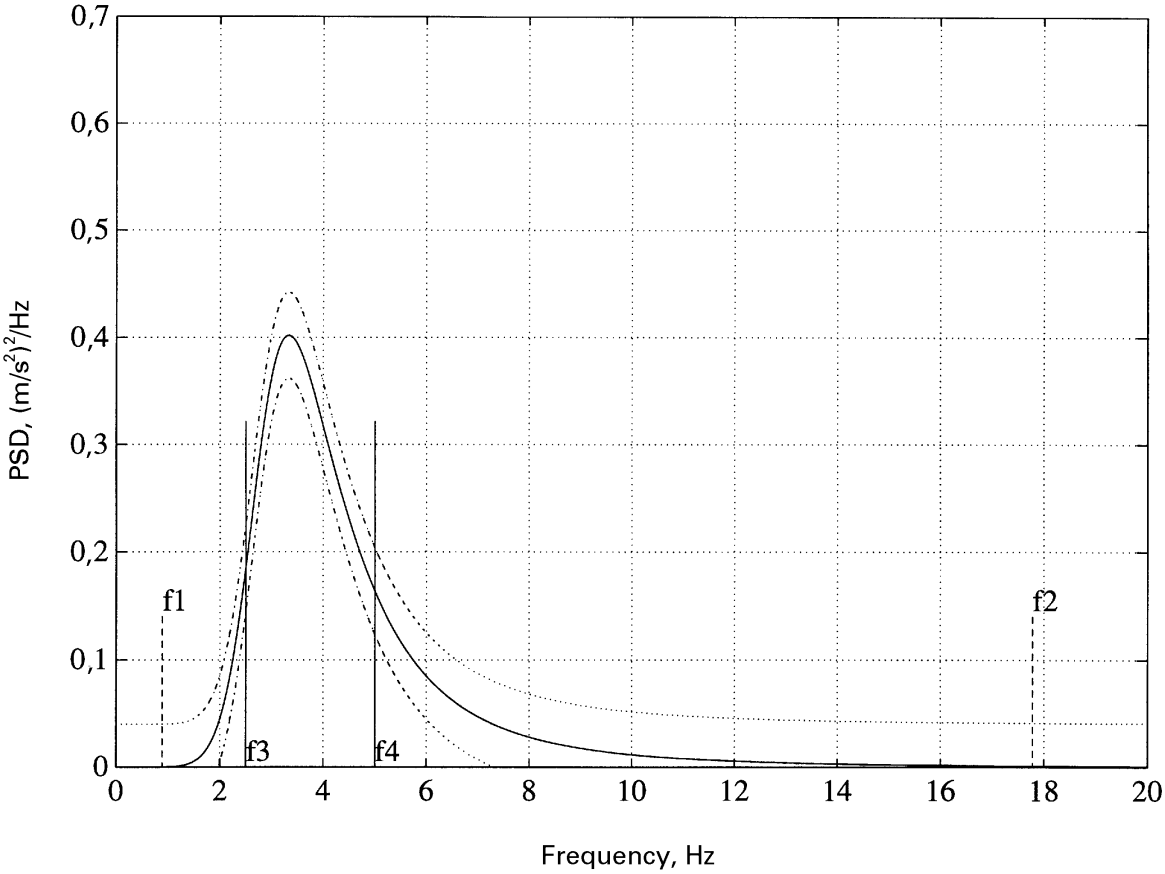


Figure 9 — PSD for input spectral class EM 8 (compact loader ⩽ 4 500 kg)

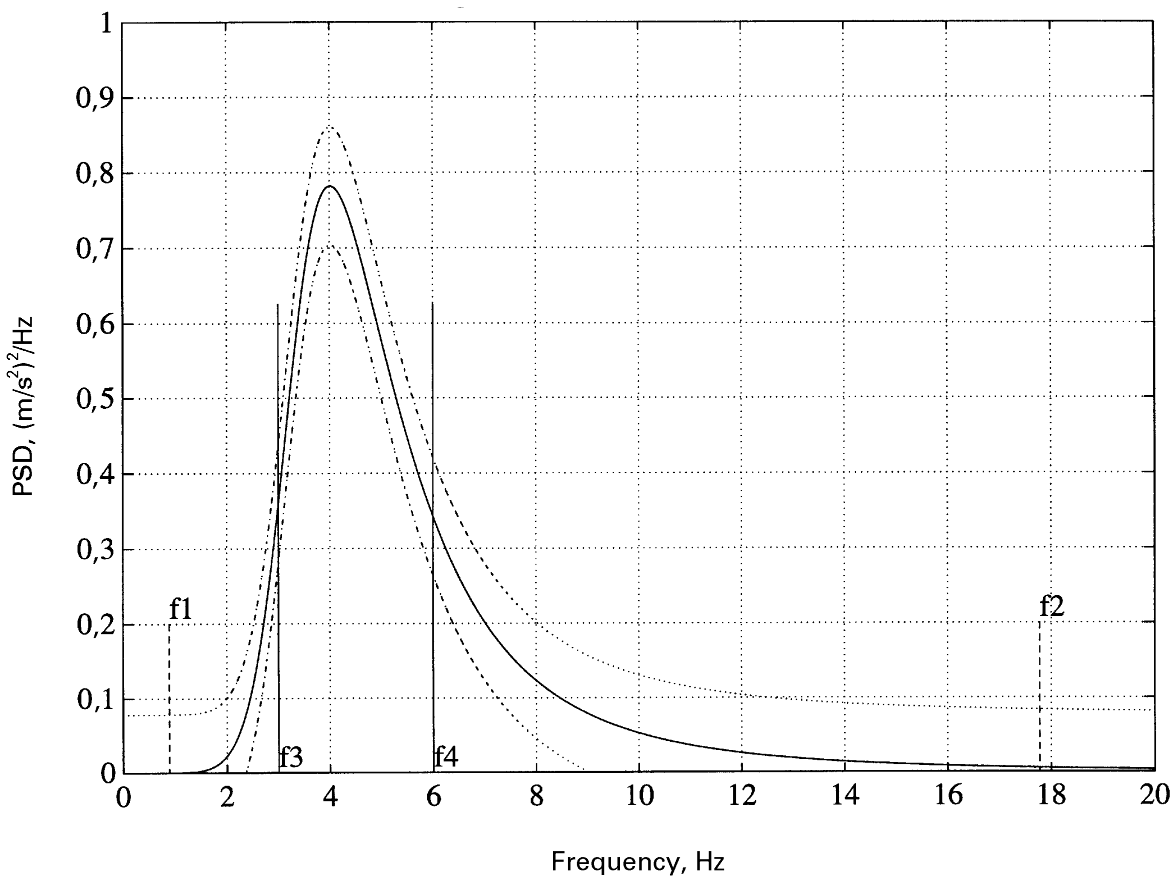


Figure 10 — PSD for input spectral class EM 9 (skid steer loader ⩽ 4 500 kg)

Seat on test:					
Input spectral class:					
a^*_{P12} = ... m/s²					
a^*_{wP12} = ... m/s²					
Designation		a_{P12} m/s²	a_{wP12} m/s²	a_{wS12} m/s²	SEAT
Light operator	1st test				
.... kg	2nd test				
Added mass	3rd test				
.... kg	Arithmetic mean value				
Heavy operator	1st test				
.... kg	2nd test				
Added mass	3rd test				
.... kg	Arithmetic mean value				
SEAT for input spectral class ... is fulfilled: Yes / No					

Figure 11 — 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/s²	
$a_S(f_r)$ = ... m/s²	
$H(f_r) = a_S(f_r)/a_P(f_r)$	
Calculated transmissibility $H(f_r)$, less than	Input spectral class
1,5	EM 1, EM 2, EM 3, EM 4, EM 6
2,0	EM 5, EM 7, EM 8, EM 9
NOTE The test report may be improved by including the graph of the transfer function.	

Figure 12 — Report form for the evaluation of the calculated transmissibility $H(f_r)$ (damping test, vertical axis)

ICS 13.160; 53.100

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