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Mobile road construction machinery — Safety

Part 4: Specific requirements for compaction machines

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National foreword

This British Standard is the UK implementation of EN 500-4:2011. It supersedes BS EN 500-4:2006+A1:2009, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/513/1, Earth moving machinery (International).

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

This document (EN 500-4:2011) has been prepared by Technical Committee CEN/TC 151 Building material construction machinery and equipment — Safety", 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of an identical text or by endorsement, at the latest by August 2011, and conflicting national standards shall be withdrawn at the latest by August 2011.

This document supersedes EN 500-4:2006+A1:2009.

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

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 EU Directive.

For relationship with EU Directive, see informative Annex ZA which is an integral part of this document.

The following changes have been introduced during the revision of EN 500-4:2006+A1:2009:

— exclusion of machines for seated ride-on operated rollers with a drum width less than nominal 0,8 m;

— addition of warnings and instructions regarding use of machines with a drum width less than nominal 1 m;

— vibrating rollers, irrespective whether they are intended for ride-on operation, pedestrian- or remote-controlled are measured on a cushion/elastic underlay;

— non-vibrating rollers, irrespective whether they are intended for ride-on operation, pedestrian- or remote-controlled are measured on a rigid reflecting plane without load and engine operating at nominal power-output;

— vibratory rammers are measured on the gravel-track;

— vibratory plates are measured on the gravel-track;

— for pragmatic reasons the deletion of explosion rammers and non-vibrating towed rollers/equipment is suggested ancillary, because today explosion-rammers cannot be found in the market any longer and non-vibrating towed rollers/equipment represent a passive attachment without any power-source and a function based on static-load only.

EN 500 "Mobile road construction machinery — Safety" comprise the following parts:

— Part 1: Common requirements;

— Part 2: Specific requirements for road-milling machines;

— Part 3: Specific requirements for soil-stabilising machines and recycling machines;

— Part 4: Specific requirements for compaction machines;

— Part 6: Specific requirements for paver-finishers.

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

Introduction

This European Standard is a type C standard as stated in EN ISO 12100.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered are indicated in the scope of this European Standard.

When provisions of this type C standard are different from those which are stated in type A or B standards, the provisions of this type C standard take precedence over the provisions of the other standards, for machines that have been designed and built according to the provisions of this type C standard.

1 Scope

This part of EN 500 specifies the safety requirements for compaction machines as defined in Clause 3 and deals with all significant hazards, hazardous situations and events relevant to compaction machines, when they are used as intended and under conditions of misuse which are reasonably foreseeable.

This document specifies additional requirements to and/or exceptions from EN 500-1 ”Common requirements”.

This part of EN 500 is not applicable for seated ride-on operated rollers with a drum width less than nominal 0,8 m.

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 500-1:2006+A1:2009, *Mobile road construction machinery — Safety — Part 1: Common requirements*

EN 954-1:1996, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005, modified)*

EN 60664 (all parts), *Insulation coordination for equipment within low-voltage systems*

EN ISO 3164:2008, *Earth-moving machinery — Laboratory evaluations of protective structures — Specifications for deflection-limiting volume (ISO 3164:1995)*

EN ISO 3450:2008, *Earth-moving machinery — Braking systems of rubber-tyred machines — Systems and performance requirements and test procedures (ISO 3450:1996)*

EN ISO 3471:2008, *Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements (ISO 3471:2008)*

EN ISO 3744:2010 *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane (ISO 3744:2010)*

EN ISO 6683:2008, *Earth-moving machinery — Seat belts and seat belt anchorages — Performance requirements and tests (ISO 6683:2005)*

EN ISO 11201:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections (ISO 11201:2010)*

EN ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction (ISO 12100:2010))*

EN ISO 20643:2008, *Mechanical vibration — Hand-held and hand-guided machinery — Principles for evaluation of vibration emission (ISO 20643:2005)*

ISO 17063:2003, *Earth-moving machinery — Braking systems of pedestrian-controlled machines — Performance requirements and test procedures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100:2010 and the following apply.

3.1
compaction machine
machine which compacts materials, e.g. rock fills, soil or asphalt surfacing, through a rolling, tamping, percussive or vibrating action of the working tool or a combination of the latter. It may be self-propelled, towed or carried as attachment to a carrying machine. A compaction machine may be controlled by direct control of an operator in physical contact with the machine (seated or standing on the machine, or walking behind operating the controls directly mounted on the machine), or indirect control without physical contact of an operator with the machine (remote controlled by wire or wireless in accordance with Annex A)

NOTE ISO 8811:2000; Clause 4 provides a methodology for a further sub-classification of vibratory and non-vibrating rollers.

Compaction machines are subdivided as follows:

3.1.1
vibratory roller
self-propelled or towed compaction machine with one or more metallic cylindrical bodies (drums), rubber tyres or a combination of the latter

NOTE The compaction of materials is performed through a rolling and directional oscillating action of the working tool.

3.1.1.1
vibratory roller for ride-on operations
self-propelled and direct controlled machine as defined in 3.1.1, where a seated or standing operator rides on the machine present at a machine integrated operator’s station

3.1.1.1.1
vibratory single-drum roller
self-propelled and direct controlled compaction machine as defined in 3.1.1.1 with one vibrating metallic cylindrical body (drum) and two rubber tyres

3.1.1.1.2
vibratory tandem roller
self-propelled and direct controlled compaction machine as defined in 3.1.1.1 with one metallic cylindrical body (drum) in the front and one in the rear

NOTE The drums can be split.

3.1.1.1.3
vibratory combined roller
self-propelled and direct controlled compaction machine as defined in 3.1.1.1 with one or more metallic cylindrical body (drum) and more than two rubber tyres

3.1.1.1.4
vibratory three-wheel roller
self-propelled and direct controlled compaction machine as defined in 3.1.1.1 with one metallic body (drum) in the front (or rear) and two in the rear (or front)

NOTE The drums can be split.

3.1.1.2
vibratory pedestrian controlled roller
self-propelled and by walking operator directly controlled or attending operator indirectly controlled machine as defined in 3.1.1

3.1.1.3
vibratory towed roller
towed and indirectly controlled machine as defined in 3.1.1 with one or more metallic cylindrical bodies (drums) or rubber tyres which do not possess an independent drive system and where the operator's station is located at the towing unit

3.1.2
non-vibrating roller
self-propelled or towed compaction machine with one or more metallic cylindrical bodies (drums), rubber tyres or a combination of the latter

NOTE The compaction of materials is performed through a rolling action of the working tool.

3.1.2.1
pneumatic-tyre roller
self-propelled compaction machine as defined in 3.1.2 with three or more tyres in the front and the rear

3.1.2.2
static towed roller
towed machine as defined in 3.1.2 with one or more metallic cylindrical bodies (drums) or rubber tyres which do neither possess an independent drive system nor an independent vibration system and where the operator's station is located at the towing unit

3.1.3
vibratory plate
compaction machine with mainly flat base-plate which is transposed into vibration and moving into a predominantly horizontal direction by directional oscillation

NOTE 1 The compaction of materials is performed through an oscillating action of the working tool.

NOTE 2 ISO 19433:2008 provides a methodology for a further sub-classification of vibratory plates.

3.1.4
vibratory rammer
compaction machine with mainly a flat foot-plate (shoe), which is made to move in a predominantly vertical direction by displacement

NOTE The compaction of materials is performed through a percussive or a tamping action of the working tool or a combination of the latter.

3.2
braking system
system affecting all machine components between the operator and the wheels and drums, which effects the machine stopping and holding (see EN ISO 3450:2008 for further definition)

4 List of significant hazards

EN 500-1:2006+A1:2009, Annex F shall apply.

5 Safety requirements and/or protective measures

5.1 Lighting, signalling and marking lights and reflex-reflector devices

EN 500-1:2006+A1:2009, 5.2 shall apply.

5.2 Operation and handling

5.2.1 Retrieval transportation and towing

EN 500-1:2006+A1:2009, 5.3.2 shall apply.

5.2.2 Pedestrian-controlled rollers

5.2.2.1 General

EN 500-1:2006+A1:2009, 5.3.3 shall apply with the following addition:

5.2.2.2 Handle bar

To prevent dangerous vertical swinging of the steering element (handle bar) of the single-drum pedestrian-controlled rollers, movement of the handle in the vertical direction shall be not less than 0,2 m and not more than 1,4 m above the ground (see Figure 1).

Dimensions in millimetres

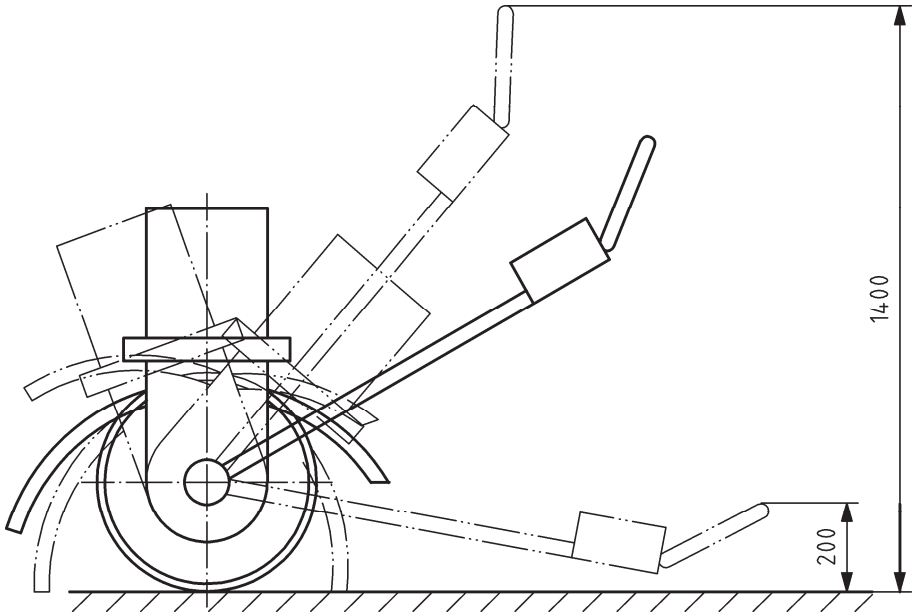


Figure 1 — Vertical swinging of single-drum walk-behind rollers

5.2.2.3 Stopping device against crushing

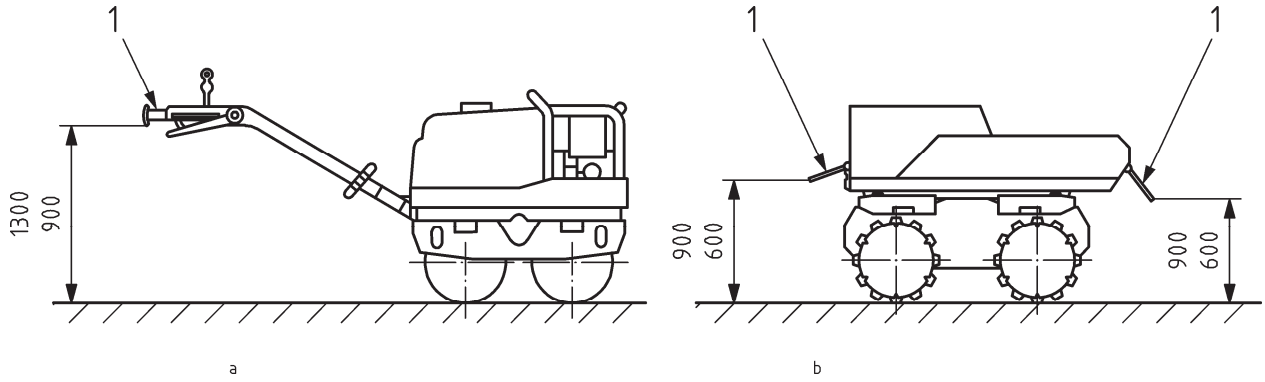
Pedestrian-controlled rollers shall be provided with a stopping device against crushing which is designed to prevent the operator from being trapped between the machine and an obstacle.

The device shall be so designed in a way to stop the machine in a distance that is less than the total operating range of the device.

This device shall have an effective operating force not exceeding 230 N.

The device shall be positioned according to Figure 2.

Dimensions in millimetres



rollers with handle bar **remote-controlled rollers**

Key
1 stopping device

Figure 2 — Position of the stopping device at pedestrian-controlled rollers

5.3 Operator's station

EN 500-1:2006+A1:2009, 5.4.1 shall apply with the following addition:

— if the operator's position is offset from the space envelope width centreline, then the internal distance from the seat centreline to the side of the enclosure shall not be less than 295 mm.

5.4 Operator's seat

EN 500-1:2006+A1:2009, 5.5 shall apply.

5.5 Controls and indicators

5.5.1 General

EN 500-1:2006+A1:2009, 5.6 shall apply with the following addition:

5.5.2 Travel control of pedestrian-controlled machines with handle bar

The machine-travel control of pedestrian-controlled rollers shall be of the hold-to-run type.

5.5.3 Controls for towed machines

For towed vibratory-rollers, it shall be possible to control the on/off operate of the vibration from the operator's station on the towing unit.

5.5.4 Remote control of pedestrian-controlled rollers

5.5.4.1 Infrared remote control

Infrared remote-controlled pedestrian-controlled rollers shall conform to Annex A.

5.5.4.2 Cable remote control

The stretched cable length shall not be more than 4 m.

5.6 Starting

EN 500-1:2006+A1:2009, 5.7.1 shall apply with the following exception:

— the requirement for a neutral start function does not apply to vibratory plates and vibratory rammers if they are furnished with a centrifugal clutch in their driving system.

5.7 Stopping

5.7.1 General

EN 500-1:2006+A1:2009, 5.7 shall apply with the following exceptions:

— hold-to-run control for forward and reverse function is not required for vibratory plates and vibratory rammers;

— an emergency stop is not required for vibratory plates and vibratory rammers.

5.7.2 Stopping device

An automatic stopping device is not required for vibratory plates and vibratory rammers equipped with a centrifugal force clutch.

5.7.3 Braking systems

5.7.3.1 Braking systems for rollers with ride-on operators

Rollers with ride-on operators shall be fitted with the following braking systems:

— a service brake system;

— a secondary brake system;

— a parking brake system.

The following applies for the service and secondary brake systems:

— the brake systems shall apply to all power-driven drums and wheels;

— in case of split drums, every drum part shall have the same brake torque;

— the brake systems of single-drum rollers and combined rollers shall apply to all wheels and to the drum.

If a hydrostatic drive is provided, it shall be interrupted when activating the secondary brake.

The performance of the braking systems shall meet the requirements of EN ISO 3450:2008.

All brake systems shall be controlled from the operator's station.

5.7.3.2 Braking systems for pedestrian-controlled rollers

ISO 17063 shall apply.

5.8 Access system to operator's station and to maintenance points

EN 500-1:2006+A1:2009, 5.9 shall apply with the following exception:

— on machines with articulated steering system and in the full articulated steering position, a minimum clearance of 150 mm shall be provided in the path of the access systems to the operator's station as illustrated in Figure 3.

Dimensions in millimetres

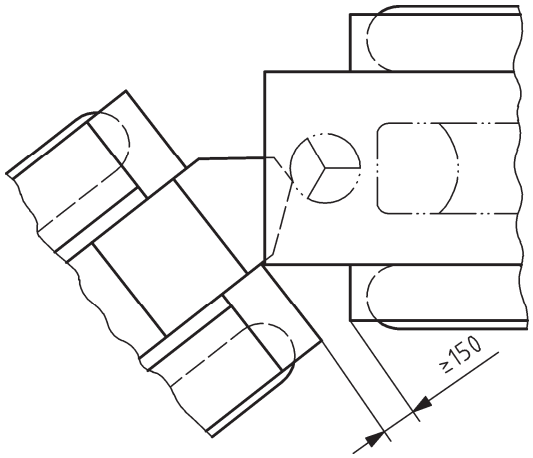


Figure 3 — Minimum clearance of lower limbs at access to the operator's station on machines with articulated steering

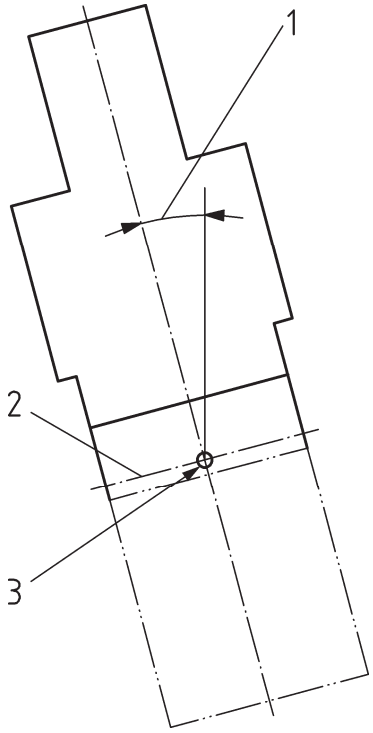
5.9 Roll-over protective structure (ROPS)

Rollers for ride-on operators shall be equipped with a roll-over protective structure (ROPS) meeting the requirements of EN ISO 3471.

If the driver's position is not at the longitudinal centre line of the machine, the test procedure of EN ISO 3471 is modified as follows:

— the proportion of deflection-limiting volume (DLV) above the LA (SIP) line according to EN ISO 3164 is allowed to deviate (lean) up to 15° laterally as shown in Figure 4 when the minimum energy requirement is met. The portion below the LA (SIP) line of DLV can be disregarded.

The driver's seat shall be provided with a restrain system according to EN ISO 6683. The seat belts shall not hinder the operation of the roller, nor shall they interfere with the suspension system of the seat.



Key

1 angle up to 15°
2 locating axis, LA
3 seat index point SIP

Figure 4 — Deflection-limiting volume, front view, side view

5.10 Noise and vibration

5.10.1 Noise measurement of vibratory plates and vibratory rammers

EN 500-1:2006+A1:2009, 5.18.2 and 5.18.3 shall apply with the following additions:

— the noise emission of vibratory plates and vibratory rammers shall be determined according to Annex B.

5.10.2 Noise measurement of rollers

EN 500-1:2006+A1:2009, 5.18.2 and 5.18.3 shall apply with the following additions:

— the noise emission of vibratory rollers shall be determined according to Annex D;

— the noise emission of non-vibrating rollers shall be determined according to Annex E.

5.10.3 Vibration measurement of hand-guided machines

EN 500-1:2006+A1:2009, 5.18.4 and 5.18.5 shall apply with the following additions:

— the hand-arm vibration of hand-guided machines shall be determined according to Annex C.

6 Verification of safety requirements and/or protective measures

EN 500-1:2006+A1:2009, Clause 6 shall apply.

7 Information for the user

7.1 Warning signals and devices

EN 500-1:2006+A1:2009, Annex E shall apply.

For rollers with a drum width less than nominal 1 m a warning decal (see Figure 5) shall be affixed visible from the operator´s station.

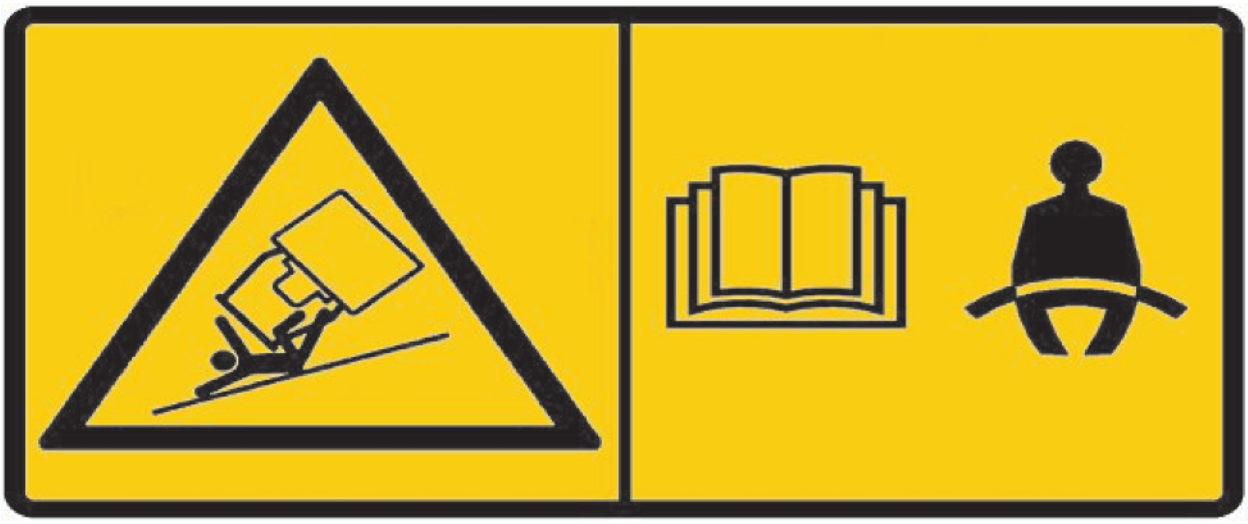


Figure 5 — Warning decal

7.2 Instruction handbook

EN 500-1:2006+A1:2009, 7.2 shall apply with the following addition:

— hand-/arm vibration as specified in 5.10.3;

— stopping device for pedestrian-controlled compaction machines;

— remote control;

— safety precaution for starting and stopping pedestrian-controlled machines;

— access systems;

— instructions for the proper use including cleaning and maintenance of the water sprinkler system;

— additional information concerning the stability of the machine (permissible slope, tipping angle etc.);

— for rollers with a drum width less than nominal 1 m the tipping angle and the applicable circumstances on the job-site which have a negative impact on the stability (e.g. height of kerbstone, dynamic influence);

— for rollers with a drum width less than nominal 1 m additional risk arises while driving close to edges (e.g. edges of kerbstones, bank, trenches, pothole) by exceeding the edge.

7.3 Marking

EN 500-1:2006+A1:2009, 7.3 shall apply.

Annex A
(normative)

Remote infrared controls for rollers with attending operator

A.1 General

This annex will be replaced by a relevant type B standard when available.

A.2 Scope

This annex deals with the mode of construction and components of remote infrared controls which ensure the safe operation of rollers with attending operator.

A.3 Terms and definitions

For the purposes of this annex, the following terms and definitions apply.

A.3.1
remote control
portable transmitter and a receiver permanently mounted on the roller

A.3.2
transmitter
steering element with the necessary controls for issuing commands and the transmission element including the part for modulation

A.3.3
receiver
receiving element including the part for demodulation, the evaluation unit as well as the command-output element

A.3.4
safety distance
minimum distance between the roller and operating personnel necessary to prevent injury

A.4 Safety requirements and measures

A.4.1 All travel movements shall be switched off automatically by the receiver if:

a) the maximum range exceeds 20 m;

b) the distance of the machine to the operator is closer than 2 m;

c) a break in communications between the remote controls and machinery lasting longer than 3 s occurs;

d) the power supply to the transmitter or receiver is interrupted;

e) the travel controls are released.

NOTE If there is an insufficient state of charge concerning the battery of the transmitter, this state should be indicated (e.g. acoustically or optically) before the function of the equipment is affected in any way (e.g. alteration of the transmission of control commands).

A.4.2 When a return of power occurs after a power cut affecting the transmitter or receiver, the roller shall not automatically start to move.

A.4.3 Transmitters and receivers shall be assigned to each other, e.g. on the basis of a code.

NOTE Measures should be taken to ensure that interference with the process of wireless transmission due to external signals or a combination of several remote control systems with the same transmission frequency does not cause hazardous movements.

A.4.4 No hazardous movements shall be caused on connection of transmitter or receiver to a power source.

A.4.5 Remote controls shall be constructed to be capable of withstanding any operation stresses and external influences which may reasonably be expected.

Operating stresses are, for example:

— actuation frequencies;

— electrical load.

External influences are, for example:

— continuous vibration, impacts, shocks;

— dampness;

— external optical, magnetic, electromagnetic, electrostatic fields;

— extraneous light, e.g. interrupted alternating illumination caused by pulsating light sources or gas-discharge lamps;

— solar influence;

— ambient temperatures;

— interference in power supply as well as variations in voltage and frequency;

— effects on connecting cables, linking components of the receiver and the control system of the roller, which are located in separate casings, due to which a short circuit of any two conductors of such cables or an interruption of a conductor could be caused which could in turn could lead to a cancellation of the cut-out.

A.4.6 The beam angle of the transmission element shall not exceed 60°.

NOTE It is intended that this measure limits the possibility of a command being unintentionally issued due to reflecting walls or obstacles.

A.4.7 The number of the transmitted commands shall be higher than the executed commands because of data safety.

A.4.8 Due to safety requirements the steering telegrams shall consist of several independent telegrams.

A.4.9 The remote control shall be realised by stateful dependent logic.

A.5 Components and equipment

A.5.1 Switching equipment with an automatic reset shall be provided on the drive system. It shall not be possible to restart the machine unintentionally if the roller stops due to the release of such switching equipment.

A.5.2 The controls for the drive system shall be designed in such a way that, when the roller is working, the controls can be actuated from the operator's station to give the desired effect.

It shall also be possible to operate the controls safely while wearing protective gloves.

A.5.3 If programming is used in the process of transmitting commands in conjunction with the remote controls, it shall only be possible to alter the programme with a special tool.

A.5.4 The power supply of the receiver shall have its own separate fuses.

A.5.5 Insulation and current-carrying of peripheral conductors and cables for power supply, receiving elements and actuators shall correspond with EN 60204-1. The current carrying of conductors on printed boards in remote controls shall be laid out for a maximum temperature increase of 10 °C.

A.5.6 The requirements laid down in EN 60664 shall apply to the measurement of safety distances.

A.5.7 The remote control shall bear legibly and indelibly the following minimum information:

— name and address of the manufacturer;

— type;

— year of manufacture;

— product identification number.

The description of type shall clearly indicate the relationship between transmitter and receiver.

The following message shall be legibly and durably shown on the transmitter (either by text or by an appropriate pictogram):

CLEAN THE TRANSMITTER ELEMENTS BEFORE USE

A.5.8 The safety-related parts of the control system of remote infrared controllers shall be in accordance with category 2 of EN 954-1:1996 (corresponds to IEC 61508, SIL 1).

A.5.9 Remote-control units shall be supplied with operating instructions containing all technical and safety information required for utilising the controls in accordance with the regulations, e.g.:

— data on performance and operating limits;

— instructions on actuation;

— a description of the actuation equipment;

— the instruction handbook shall contain information regarding the assigned operator's location, and it shall specify if the actuation of controls from the operator's place/station which is on the opposite side does not correspond with the intended/expected direction of the roller movement;

— instructions concerning safe operation (changing the battery, cleaning, reflections, encoding etc.);

— instructions on action in the event of the occurrence of faults;

— instructions in accordance with A.5.2 and accompanying note;

— the minimum distance between machine and operator shall be 2 m.

Annex B
(normative)

Noise-test-code for vibratory plates and vibratory rammers

B.1 Scope

This noise test code specifies all the information necessary to carry out efficiently and under standardised conditions the determination, declaration and verification of the noise emission characteristics of vibratory plates and vibratory rammers.

Noise emission characteristics include emission sound pressure levels at workstations and the sound power level. The determination of those quantities is necessary for:

— manufacturers to declare the noise emitted;

— comparing the noise emitted by machines in the family concerned;

— purposes of noise control at the source at the design stage.

The use of this noise test code ensures reproducibility of the determination of the noise emission characteristics within specified limits determined by the grade of accuracy of the basic noise-measurement method used. Noise-measurement methods allowed by this European Standard are engineering methods (grade 2).

Operating and mounting conditions for the determination of noise emission (according to this annex) and hand-arm vibration (according to Annex C) are identical. It is therefore possible to record the noise emission and the hand-arm vibration simultaneously during one measurement. The measuring effort is thereby reduced.

Noise emission of machines exceeding a working width of 1 m shall be determined according to Annex D.

NOTE 1 Tests conducted with machines exceeding a working width of 1 m according to this Annex lead to irreproducible results due to reflection by the apron of the test course.

NOTE 2 The noise evaluation procedures as laid down in this European Standard aim at ensuring the reproducibility of the measurements of the noise emission of the machine. This determination does not necessarily reflect the noise emission during operation on construction sites.

NOTE 3 The sound pressure spectra may be registered at microphone position 10 in accordance with EN ISO 3744:2010, 8.7.

NOTE 4 The sound pressure level may be recorded as a function of time at microphone position 10.

B.2 Determination of the A-weighted sound power level

B.2.1 General

This annex specifies additional requirements for the determination of the A-weighted sound power level according to EN ISO 3744:2010.

For all measurements carried out under free field over a reflecting plane conditions according to EN ISO 3744:2010 the environmental correction factor K_{2A} shall be set to 0.

B.2.2 Measurement surface

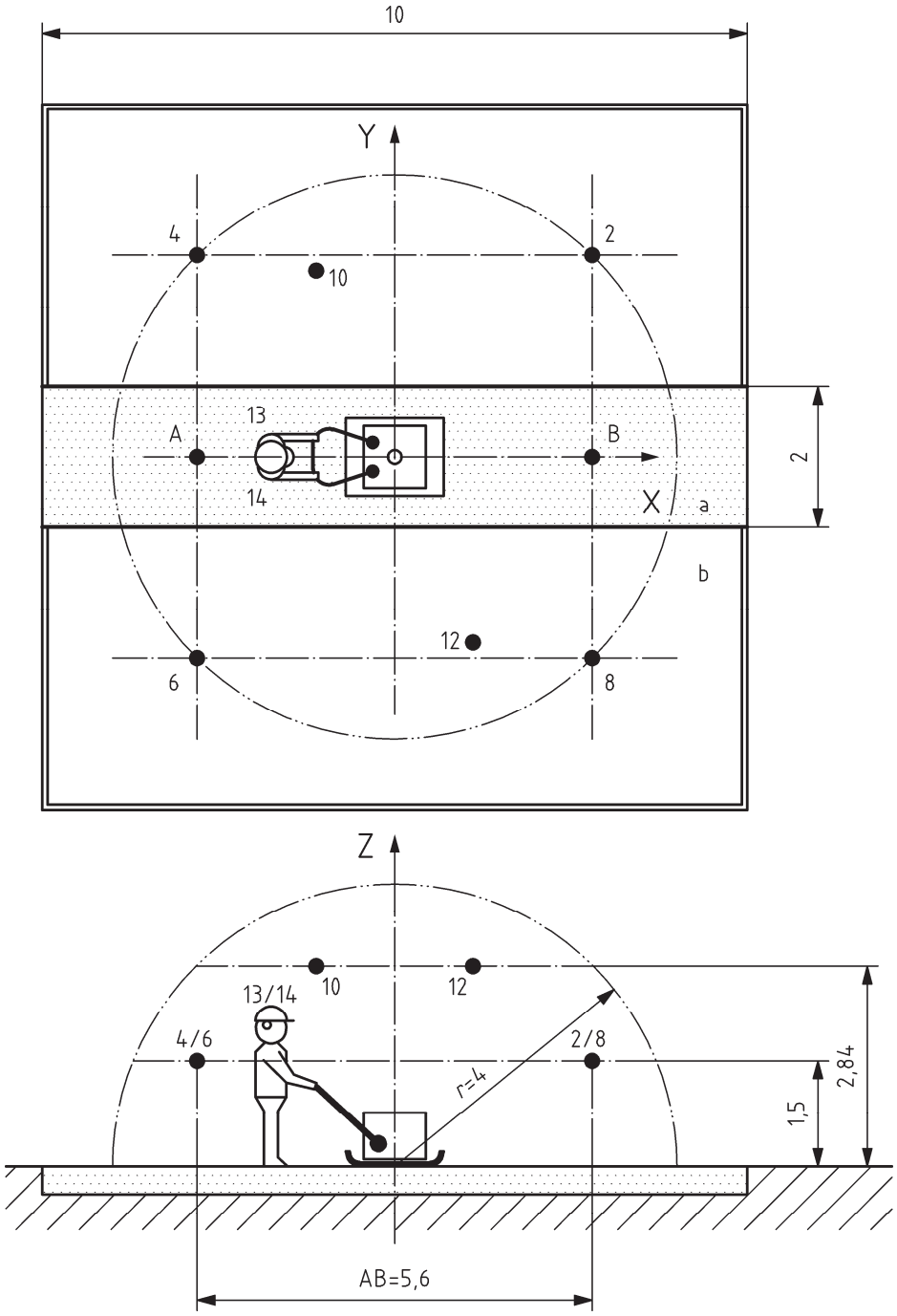
B.2.2.1 Shape and size of the measurement surface

The measurement surface for determining the A-weighted sound power level shall be a hemisphere of radius r = 4 m that is bounded by the plane sound-reflecting surface (see Figures B.1 and B.2).

B.2.2.2 Microphone positions

Six microphone positions are specified on the hemisphere (see Figures B.1, B.2 and Table B.1).

Dimensions in meters



Key

AB	measuring length *(*AB = 5,60 m)
a	gravel-test course (depth = 0,50 m)
b	hard reflecting plane = 10 m × 10 m
2, 4, 6, 8, 10, 12	microphone positions for sound power level determination (see Table B.1)
13, 14	microphone positions for emission sound pressure level determination

Figure B.1 — Arrangement of test positions for hand-guided vibratory plates and hand-guided vibratory rammers

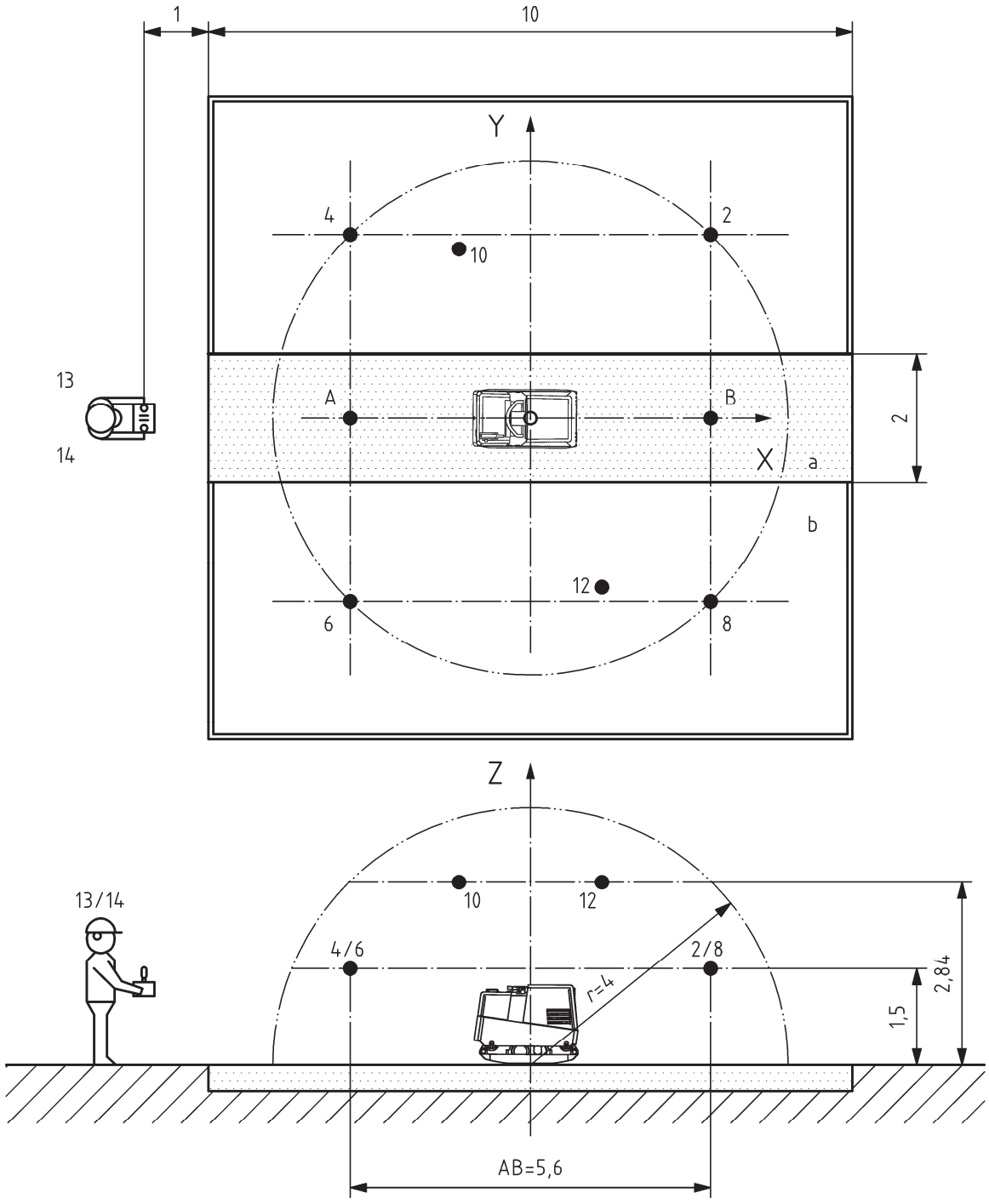
measuring travel time in seconds:

$$t_{\mathrm{F}} = \frac{AB}{v_{\mathrm{F}}}$$

where v_{F} = working speed in m/s

t_F (measuring travel time) = measuring time t_M

Dimensions in metres



Key

AB	measuring length (AB = 5,60 m)
a	gravel-test course (depth = 0,50 m)
b	hard reflecting plane = 10 m × 10 m
2, 4, 6, 8, 10, 12	microphone positions for sound power level determination (see Table B.1)
13, 14	microphone positions for emission sound pressure level determination

Figure B.2 — Arrangement of test positions for remote controlled vibratory plates

Table B.1 — Coordinates of microphones

Measuring point	Coordinates in m		
	x	y	z
2	2,8	2,8	1,5
4	- 2,8	2,8	1,5
6	- 2,8	- 2,8	1,5
8	2,8	- 2,8	1,5
10	- 1,08	2,6	2,84
12	1,08	- 2,6	2,84

B.2.3 Test procedure

The machine shall be moved along the centre line of the test course as in usual operation.

For the measurements, the machine shall be in accordance with the manufacturer's specifications (e.g. if the extension plates of a vibratory plate are attached on delivery, then they shall remain screwed on during the measurement).

The drawbar if any shall be freely movable between the upper and lower stops.

Simultaneous measurement at all microphone positions is preferred (consecutive measurements are also possible and allowed).

For each machine, three measuring cycles shall be carried out.

The compacted material of the test surface shall be loosened before starting of the whole test procedure.

The compacted material of the test surface shall not be loosened between the three measuring cycles.

For the measurement duration $t_{M,}$ the surface of the test track AB = 5,60 m is compacted by the machine in forward operation. Subsequently the machine is moved back to the starting point.

Before starting the measurement, the operating temperature shall be reached.

The measurement shall start when the middle of the machine is in line with point A and stops at point B of the measuring stretch (see Figure B.1). In all cases the compaction shall go on along the whole stretch of gravel. Therefore it shall be ensured that the machine works with the full compaction power within the measuring distance.

The r.m.s. values of the sound pressure levels shall be taken for each measurement over the measurement duration (see Figure B.1).

B.2.4 Repetition of the test and calculation of the sound power level

The A-weighted sound power level shall be determined at least three times. If at least two of the determined values do not differ by more than 1 dB, further measurements will not be necessary. Otherwise the measurements shall be continued until two values differing by no more than 1 dB are obtained. The A-weighted sound power level to be used for calculating the sound power level to be declared is the arithmetic mean of both highest values that do not differ by more than 1 dB.

B.3 Determination of the A-weighted emission sound pressure level at the operator's position

B.3.1 General

This annex specifies additional requirements for the determination of the A-weighted emission sound pressure level of vibratory plates and vibratory rammers according to EN ISO 11201:2010.

B.3.2 Operator's position

For hand-guided machines, the position of the operator shall be as specified in Figure B.1.

For remote-controlled machines, the position of the operator shall be as specified in Figure B.2.

B.3.3 Test procedure

Since the sound pressure level varies greatly in relation to the operator's tallness, the operator's height shall be 1,8 m ± 5 cm.

NOTE Tests conducted for the purpose of this annex proved that a difference in operator's heights of 0,20 m leads to a difference in the A-weighted emission sound pressure level at the operator's ear of approximately 1,3 dB.

The test shall be carried out according to B.2.3.

During the whole test, the machine shall be operated by the same person. The person shall be skilled in handling and operating the machine.

The machine shall be guided with both hands during measurement. Gripping-, feed-, and guiding-forces appropriate to usual operation shall be applied.

The test track for remote-controlled machines shall be identical to that of hand-guided machines (see Figure B.1).

B.3.4 Repetition of the test and calculation of the emission sound pressure level

The sound pressure level shall be measured at least three times at each microphone position. If at least two of the measured values do not differ by more than 1 dB, further measurements will not be necessary. Otherwise the measurements shall be continued until two values differing by no more than 1 dB are obtained. The A-weighted emission sound pressure level to be used is the arithmetic mean of the two highest values that do not differ by more than 1 dB.

B.3.5 Determination of emission sound pressure spectra

If required, sound pressure spectra at the work station can be registered in accordance with EN ISO 11201:2010 at microphone position 14 (right ear, see Figures B.1 and B.2).

B.3.6 Sound pressure level as a function of time

If required, the sound pressure level can be recorded as a function of time at microphone position 14 (right ear).

B.4 Installation and mounting conditions

B.4.1 General

The machines shall be tested during actual operation on a course of gravel according to B.4.2. Testing may be carried out outdoors or in a room fulfilling the requirements on test environment of EN ISO 3744.

B.4.2 Design of the test surface

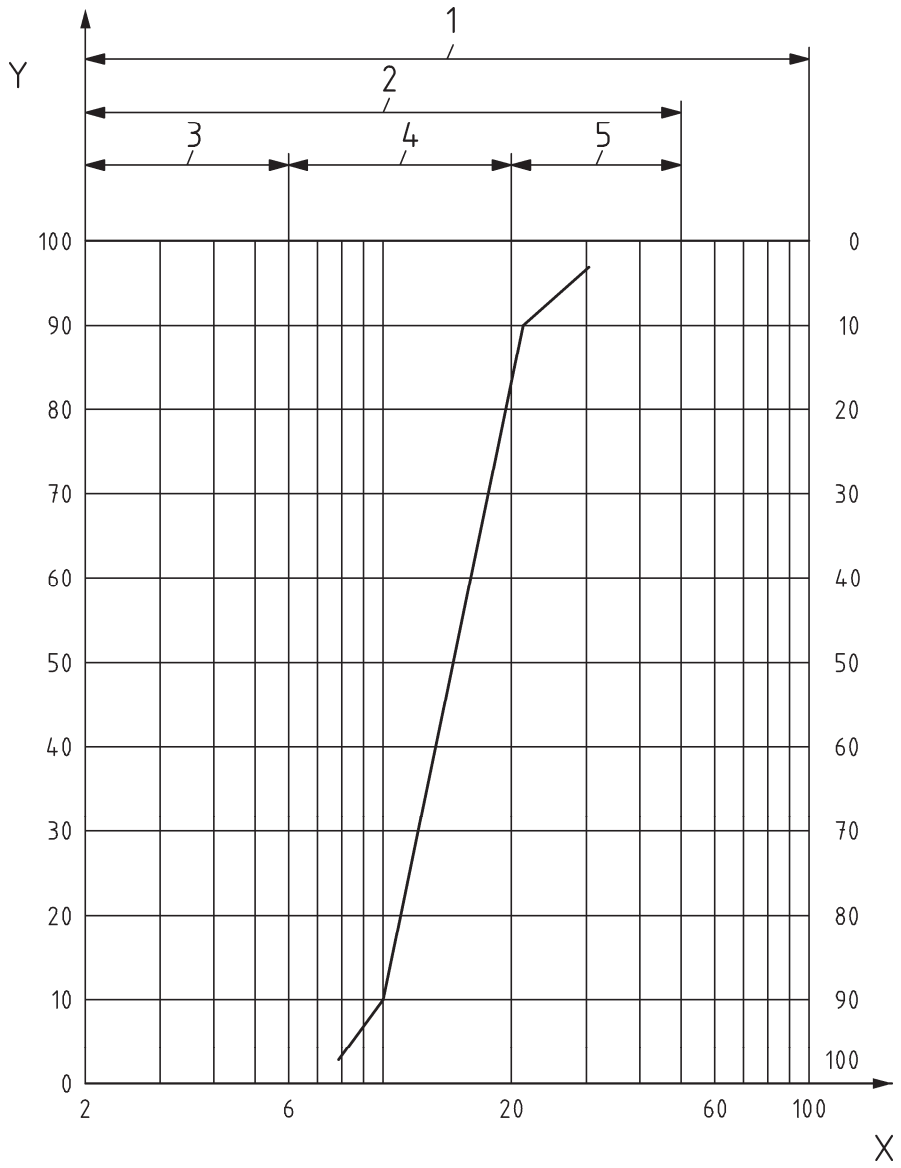
The compression ground shall have the following characteristics:

— dry gravel with sufficient hardness of a mean gravel diameter of 16 mm (particle size 10 mm to 22 mm), see grading curve in Figure B.3;

— the gravel shall be replaced if the mean gravel diameter has decreased by 30 % or more;

— the dumping height of the gravel shall be at least 0,50 m due to the depth effect of the compacting machines;

— the test course of gravel shall have the same horizontal level as the sound-reflecting surface being rammed in order to prevent the gravel from creeping.



Key

Y	percentage of mass of the total volume	3	fine grain
X	grain size	4	middle grain
1	screening gravel	5	coarse grain
2	gravel size		

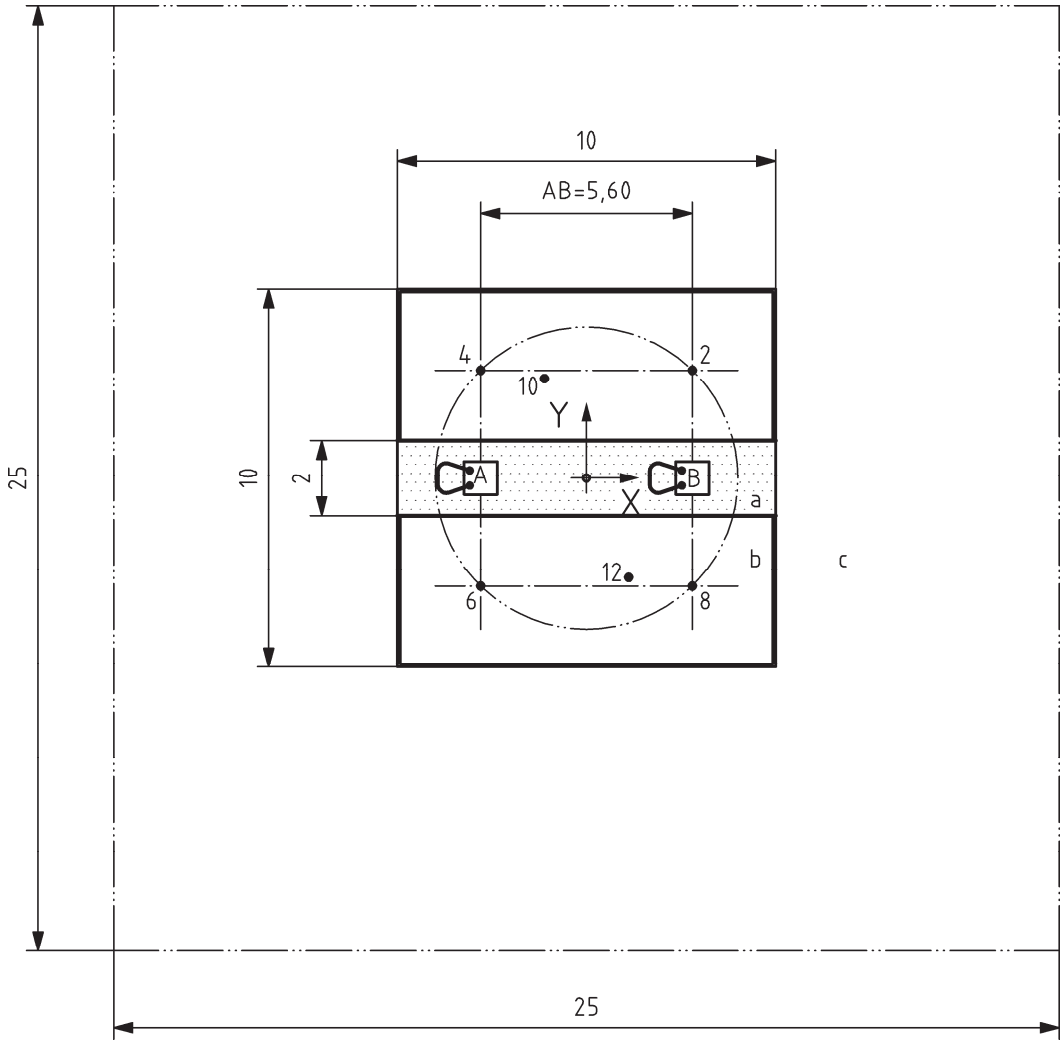
Figure B.3 — Grading-size diagram of the material to be compacted (gravel)

B.4.3 Design of the test site

The test course of gravel shall be designed according to Figure B.4.

A sound-reflecting material (e.g. concrete, closed-pore asphalt or steel plates) of at least 10 m × 10 m and a zone with no reflecting obstacles of at least 25 m × 25 m are required around the course of gravel.

Dimensions in metres



Key

AB measuring length
A start
B end
a gravel-test course (depth = 0,50 m)
b hard sound-reflecting plane 10 m × 10 m
c plane without reflecting obstacles 25 m × 25 m
2, 4, 6, 8, 10, 12 microphone positions for sound power level determination

Figure B.4 — Test site and arrangement with test track

B.5 Operating conditions

Operating conditions are specified in Table B.2.

Table B.2 — Operating conditions

Reservoir of sprinkler-system:	Reservoirs, if any, shall be half-filled with water. The sprinkler facility shall not be switched on.
Fuel tank:	The fuel tank shall be half-filled.
Warm-up period:	The machine shall be warmed up under normal operation before measurement.
Engine speed:	The engine shall be at the rated speed ± 5 % as specified by the manufacturer.
Centrifugal force and stroke:	Where the centrifugal force is adjustable, the maximum setting shall be selected. Rammers shall be operated at maximum piston stroke.
Forward-working speed:	The maximum forward-working speed shall be selected.

B.6 Uncertainty

The measurement uncertainty and, in the case of series machines, the uncertainty due to production variations shall be considered when determining the value of the A-weighted sound power level and that of the A-weighted emission sound pressure level at the operator's position.

Current experience shows that the total uncertainty (measurement plus production) K_{WA} for the A-weighted sound power levels and K_{pA} = for the A-weighted emission sound pressure level of vibratory plates and vibratory rammers is less than the values given in Table B.3.

Table B.3 — Uncertainties applicable to gravel course

	K_{WA} in dB(A)	K_{pA} in dB(A)
Vibratory rammers	1,5 to 2,5	2,5 to 3,5
Vibratory plates	1,5 to 2,5	2,5 to 3,0

B.7 Information to be recorded

EN ISO 3744:2010 and EN ISO 11201:2010 shall apply with the following additions:

— type and engine rating;

— engine speed;

— centrifugal force and piston-stroke;

— working speed during measurement;

— measurement duration t_M for each measurement;

— tallness of the operating personnel;

— grading curve of the gravel;

— description of the test environment;

— A-weighted sound power level from each of the at least three measurements and the resulting sound power level as emission value;

— A-weighted sound pressure levels from each of the at least three measurements at the operator's position and the resulting emission sound pressure level;

— sound pressure spectra, where appropriate;

— sound pressure level as a function of time, where appropriate;

— place, date of measurement, test laboratory and person responsible.

B.8 Information to be reported

EN ISO 3744:2010 and EN ISO 11201:2010 shall apply with the following additions:

— type and engine rating;

— engine speed;

— centrifugal force and piston-stroke;

— working speed during measurement;

— measurement duration t_M for each measurement;

— tallness of the operating personnel;

— grading curve of the gravel;

— description of the test environment;

— A-weighted sound power level from each of the at least three measurements and the resulting sound power level as emission value;

— A-weighted sound pressure levels at the operator's position from the at least three measurements and the resulting emission sound pressure level;

— sound pressure spectra, where appropriate;

— sound pressure level as a function of time, where appropriate;

— place, date of measurement, test laboratory and person responsible.

The test report shall include the statement that the sound power level and the emission sound pressure level at the operator's position have been determined entirely in accordance with the specifications of this annex. The reported A-weighted sound power level of the machine under test and A-weighted emission sound

pressure level at the operator's position shall be rounded down or up to the nearest integral value in dB (< 0,5 round down, ≥ 0,5 round up).

B.9 Declaration and verification of noise emission values

The declared A-weighted sound power level shall be the sum of the arithmetic mean of the sound power levels of the measured series machines and the associated uncertainty K_{wA} (see B.6).

NOTE The declared value of the A-weighted sound power level is identical to the guaranteed sound power level according to Directive 2000/14/EC.

The declared A-weighted emission sound pressure level at the operator's position shall be the sum of the arithmetic mean of the emission sound pressure levels at the operator positions of the measured series machines and the associated uncertainty K_{pA} (see B.6).

The declared A-weighted sound power level and the declared A-weighted emission sound pressure level at the operator's position shall be rounded down or up to the nearest integral value in dB (< 0,5 round down, ≥ 0,5 round up).

The noise declaration shall explicitly state that the noise emission values have been obtained according to this noise test code.

Any verification shall be done using this noise test code. If the value measured during verification is less than or equal to the declared value, the declared value is verified.

Annex C
(normative)

Measurement of the hand-arm vibration of hand-guided vibratory ground compaction machines

C.1 General

In this annex, specifications are laid down for machines as a supplement to EN ISO 20643 for hand-guided vibratory ground compaction machines (vibratory rollers for manual operation, vibratory plates, vibratory rammers). Those specifications serve to determine the characteristic vibration amplitudes under practical conditions. The machines are characterised by their possessing a module for producing vibration, so as to cause compacting of the undersurface.

This annex contains the same conditions for operation and arrangement for all hand-guided vibratory machines as they apply to the determination of sound power level for those hand-guided vibratory machines as described in Annex B.

C.2 Terminology

See ISO 5805 for terminology.

C.3 Quantities to be measured

C.3.1 R.m.s. value of the weighted acceleration

The quantities to be measured are the r.m.s. values of the weighted vibration accelerations $a_{xhw,i}$, $a_{yhw,i}$ and $a_{zhw,i}$ of the i = 1 to 3 measurements of a test run in accordance with EN ISO 20643. Those are formed according to

$$\bar{a}_{xhw} = \frac{1}{3}\sum_{i=1}^{3} a_{xhw,i} \; ; \; \bar{a}_{yhw} = \frac{1}{3}\sum_{i=1}^{3} a_{yhw,i} \; ; \; \bar{a}_{zhw} = \frac{1}{3}\sum_{i=1}^{3} a_{zhw,i} \qquad \text{(C.1)}$$

for each co-ordinate into the result of the test run. Since in the case of the machines under investigation, the vibration accelerations in the x-, y- and z-co-ordinates often produce values of the same magnitude, the acceleration sum of the test run is also formed according to

$$a_{vhw} = \sqrt{\bar{a}_{xhw}^{\,2} + \bar{a}_{yhw}^{\,2} + \bar{a}_{zhw}^{\,2}} \qquad \text{(C.2)}$$

C.3.2 Frequency analysis

If required, frequency analyses from the acceleration time signals can be determined for one measurement direction (x-axis) or for all directions of measurement. The analyses shall not be weighted with the hand-arm filter.

C.3.3 Time records

If required, the variations of the signals with time can be recorded for one measurement direction (x-axis) or for all three measurement directions.

C.3.4 Other quantities to be measured

a) speed of engine (see Table B.2).

b) measurement duration t_M (see Annex B, Figure B.1).

C.4 Measuring equipment

C.4.1 Requirements for the acceleration transducers

Shall be according to EN ISO 20643:2008, 7.2.1.

In another variant, the total mass of the three acceleration transducers (or of the triaxial transducer) should be less than 60 g. The mass of the coupling device for the acceleration transducers should be kept as low as possible (maximum 60 g).

C.4.2 Fastening of the acceleration transducers

Measurement is carried out in three directions of measurement with three single or one triaxial acceleration transducer(s). The three acceleration transducers are fastened to a coupling device on the drawbar (according to Figures C.1 a) and C.1 b)). The coupling device shall be adapted to the diameter of the respective drawbar. The three acceleration transducers (or one triaxial transducer) are attached (screwed or glued) to the coupling device.

The axes of the acceleration transducers shall be directed in accordance with C.5.1.

If the drawbar has a resilient cover in the region to which the coupling device is to be attached (see Figure C.2), then care shall be taken during the measurements. The resilient cover can form a „spring-mass system“ together with the coupling device and the acceleration transducer(s), resulting in natural vibration. In addition, the results of measurement are difficult to reproduce. It is therefore advisable to remove the resilient cover for the measurements.

In the test report, it shall be recorded whether a vibration-damping cover was present and whether this was removed for the measurements.

C.4.3 Frequency weighting filter

Shall be according to EN ISO 20643:2008, 7.3.

C.4.4 R.m.s. detector

Shall be according to EN ISO 20643:2008, 6.3.

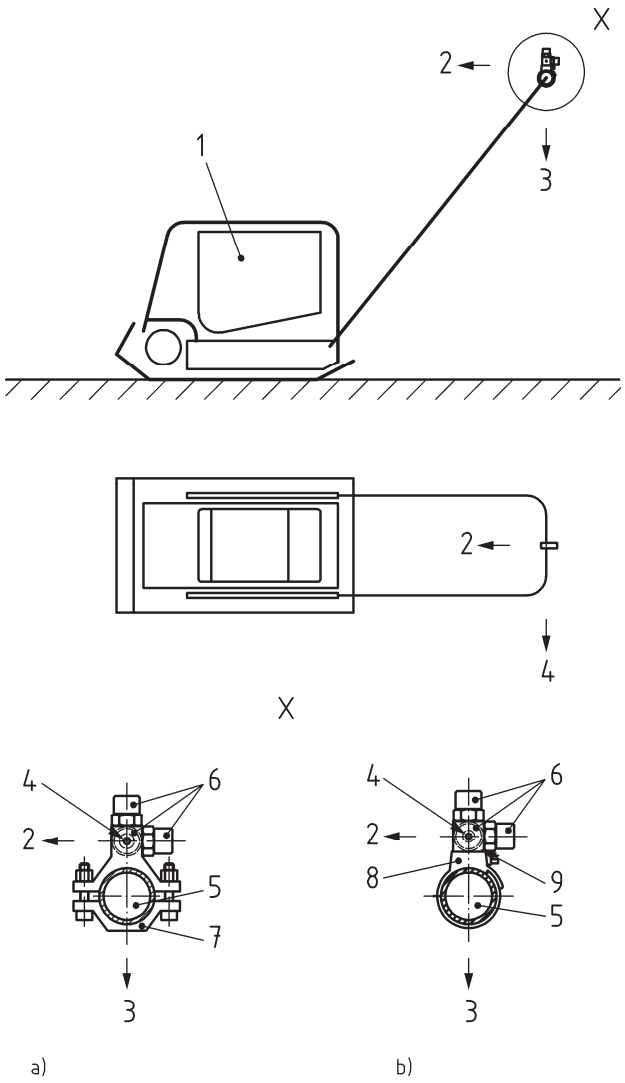
C.4.5 Calibration

Shall be according to EN ISO 20643:2008, 7.6.

C.5 Measurement direction and measurement location

C.5.1 Measurement direction

The directions of measurement are given in Figure C.1. The coupling device shall be directed, depending on the size of the operator, in such a manner that the z-axis runs parallel to the ground during the measurements.



Key

1 engine
2 z-axis
3 x-axis
4 y-axis
5 pole tube
6 acceleration transducer
7 aluminium clamp
8 steel clamp
9 steel block approximately 10 mm × 10 mm × 10 mm soldered

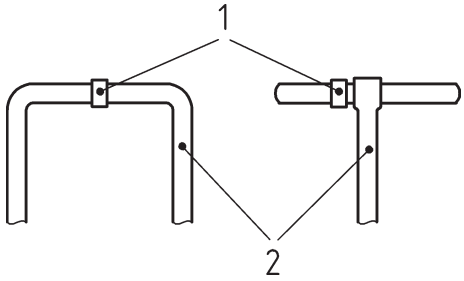
a) aluminium clamp to be adjusted to the guidance pole tube

b) steel clamp with soldered block carrying the acceleration transducer

Figure C.1 — Directions of measurement and examples for attachment of the acceleration transducer

C.5.2 Measurement location

Depending on the design of the drawbar, the coupling device shall be arranged according to Figure C.2.



Key

1 coupling device

2 drawbar

Figure C.2 — Arrangement of the coupling device on the drawbar

C.6 Specification of working procedure

C.6.1 Operator

The operator shall be skilled in handling and operating the machine.

C.6.2 Other quantities to be determined (forces)

The acceleration values measured at the drawbars can be influenced by the operating forces (gripping, feed and guiding forces) exerted by the operator. Therefore:

— a gripping force at the drawbar appropriate to typical operation shall be applied;

— a feed force at the drawbar appropriate to typical operation shall be applied;

— a guiding force at the drawbar appropriate to typical operation shall be applied.

NOTE The three named forces cannot be measured yet by simple means according to the present state of the art.

The machine shall be guided with both hands during measurement.

C.6.3 Operating conditions

According to B.5.

C.6.4 Requirements for the test site

According to B.2.2.

Unless simultaneous sound measurements are carried out, there are no requirements for the test site and background outside the gravel frame.

C.6.5 Measurement procedure

According to B.2.3.

The acceleration signals are frequency-weighted according to C.4.3 and their r.m.s. average is taken over the time period of the measurement. In the process, the signals in all three directions of measurement shall be recorded simultaneously.

The acceleration transducer cables are pulled along by the machine or by the operator during each measurement (if noise-level measurements are not to be carried out simultaneously, the cables may also be pulled along by a second person). Therefore, the cables shall in addition be attached to the machine, so that no tensile force develops at the acceleration transducers.

C.7 Test report

C.7.1 Reference

It shall be noted in the test report that the measuring procedure was in conformity with EN ISO 20643:2008, Clause 10 and Annex C of this European Standard.

C.7.2 Description of the object to be measured

According to B.7.

C.7.3 List of measuring equipment

Shall be according to EN ISO 20643:2008, Clause 7.

C.7.4 Fastening of the acceleration transducers

Shall be according to EN ISO 20643:2008, 7.2.

C.7.5 Operating conditions

Shall be according to EN ISO 20643:2008, 8.2.

The drawbar height (from the ground) that is maintained during the measurement shall be entered in the test report.

The duration of the measurement (travel time) t_M shall be recorded for each measurement.

C.7.6 Further specifications

Shall be according to EN ISO 20643:2005, 8.3.

Moreover:

— description of the physical characteristics of the material to be compacted;

— did the drawbar have a resilient cover, and was the latter removed for the measurement?

— grading curve according to Figure B.3.

C.7.7 Results

— the arithmetic average value of weighted acceleration of each of the three measuring directions;

— vector sum for each test cycle, formed from the arithmetic mean values of the individual accelerations in the three directions of measurement (see C.3.1);

— acceleration spectra, if appropriate;

— time records, if appropriate;

— place, date of measurement, executing institution and person responsible.

C.8 Report of results

The report shall include the statement that the vibration accelerations given fully comply with the requirements of Annex C. The vibration accelerations shall be rounded up or down to the nearest integral acceleration value in m/s^2 (< 0,5 round down, ≥ 0,5 round up).

C.9 Measurement uncertainty

When applying this test procedure, one should allow for a measurement uncertainty of 3 m/s^2 in the determination of the arithmetic mean values of the three vibration accelerations. The same applies to the sum of accelerations.

Annex D
(normative)

Noise test code for vibratory rollers

D.1 Scope

This noise test code specifies all the information necessary to carry out efficiently and under standardised conditions the determination, declaration and verification of the noise emission characteristics of vibratory rollers.

Towed vibratory rollers without own power source are excluded from the scope of this annex.

Noise emission characteristics include emission sound pressure levels at workstations and the sound power level. The determination of those quantities is necessary for:

— manufacturers to declare the noise emitted;

— comparing the noise emitted by machines in the family concerned;

— purposes of noise control at the source at the design stage.

The use of this noise test code ensures reproducibility of the determination of the noise emission characteristics within specified limits determined by the grade of accuracy of the basic noise-measurement method used. Noise-measurement methods allowed by this European Standard are engineering methods (grade 2).

NOTE The noise evaluation procedures as laid down in this European Standard aim at ensuring the reproducibility of the measurements of the noise emission of the machine. This determination does not necessarily reflect the noise emission during operation on construction sites.

D.2 Determination of the A-weighted sound power level

D.2.1 General

This annex specifies additional requirements for the determination of the A-weighted sound power level according to EN ISO 3744:2010.

For all measurements carried out under free field over a reflecting plane conditions according to EN ISO 3744:2010 the environmental correction factor K_{2A} shall be set to 0.

D.2.2 Measurement surface

A hemispherical test area on a plane sound-reflecting hard surface shall be used for measurement.

D.2.2.1 Size of the measurement surface

The radius shall be calculated from the basic length *L* of the machine (see Figure D.1):

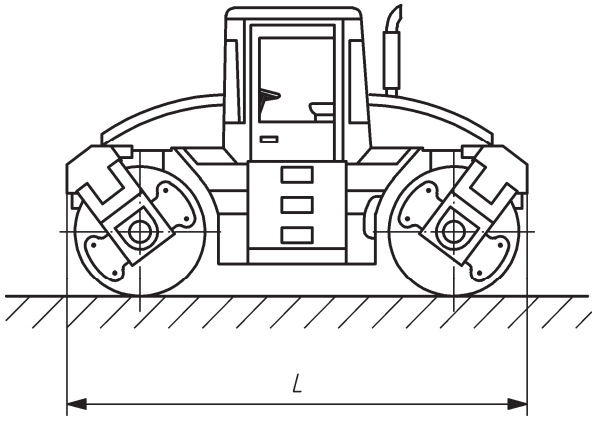


Figure D.1 — Basic length *L*

The radius r shall be:

— 4 m when the basic length *L* of the machine to be tested is less than or equal to 1,5 m;

— 10 m when the basic length *L* of the machine to be tested is greater than 1,5 m but less than or equal to 4 m;

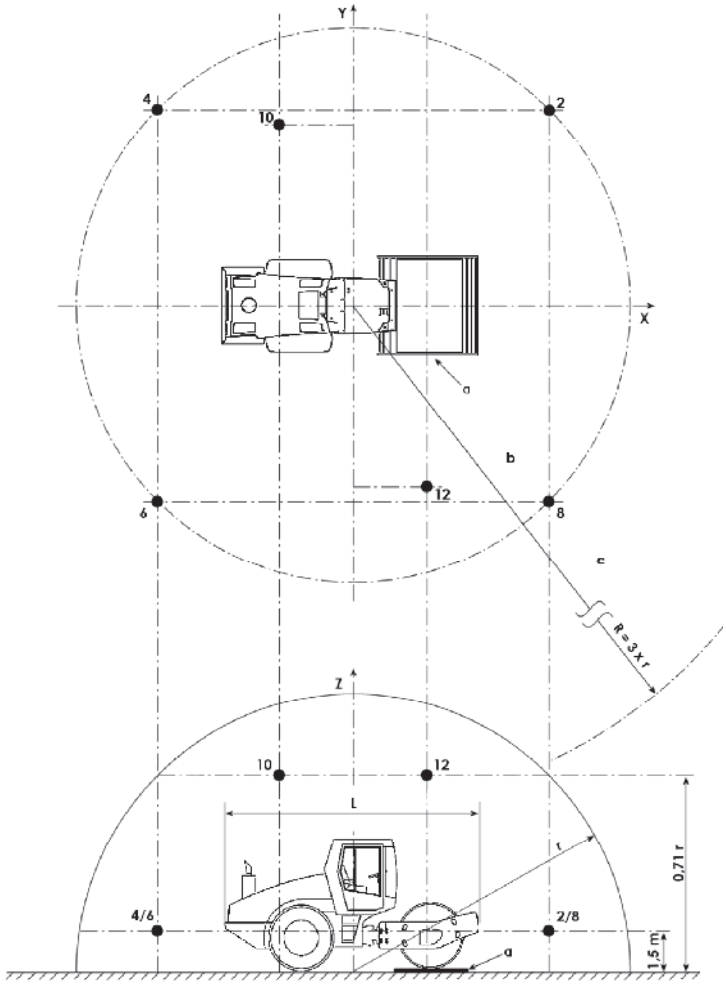
— 16 m when the basic length *L* of the machine to be tested is greater than 4 m.

Table D.1 — Coordinates of microphone positions

Microphone position	x/r	y/r	z
2	0,7	0,7	1,5m
4	-0,7	0,7	1,5m
6	-0,7	-0,7	1,5m
8	0,7	-0,7	1,5m
10	-0,27	0,65	0,71r
12	0,27	-0,65	0,71r

D.2.2.2 Microphone positions

Six microphone positions (i.e. positions 2, 4, 6, 8, 10 and 12) shall be arranged according to Figure D.2.



Key

L	basic length of machine
a	elastic material
b	hard reflecting area bordered by the microphones
c	area without reflecting obstacles
r	radius of the hemisphere, with r = r(L)
R	radius of area without reflecting obstacles
2, 4, 6, 8, 10, 12	microphone positions for sound power determination

Figure D.2 — Arrangement of test positions for ride-on vibratory rollers

D.2.3 Positioning of the machine

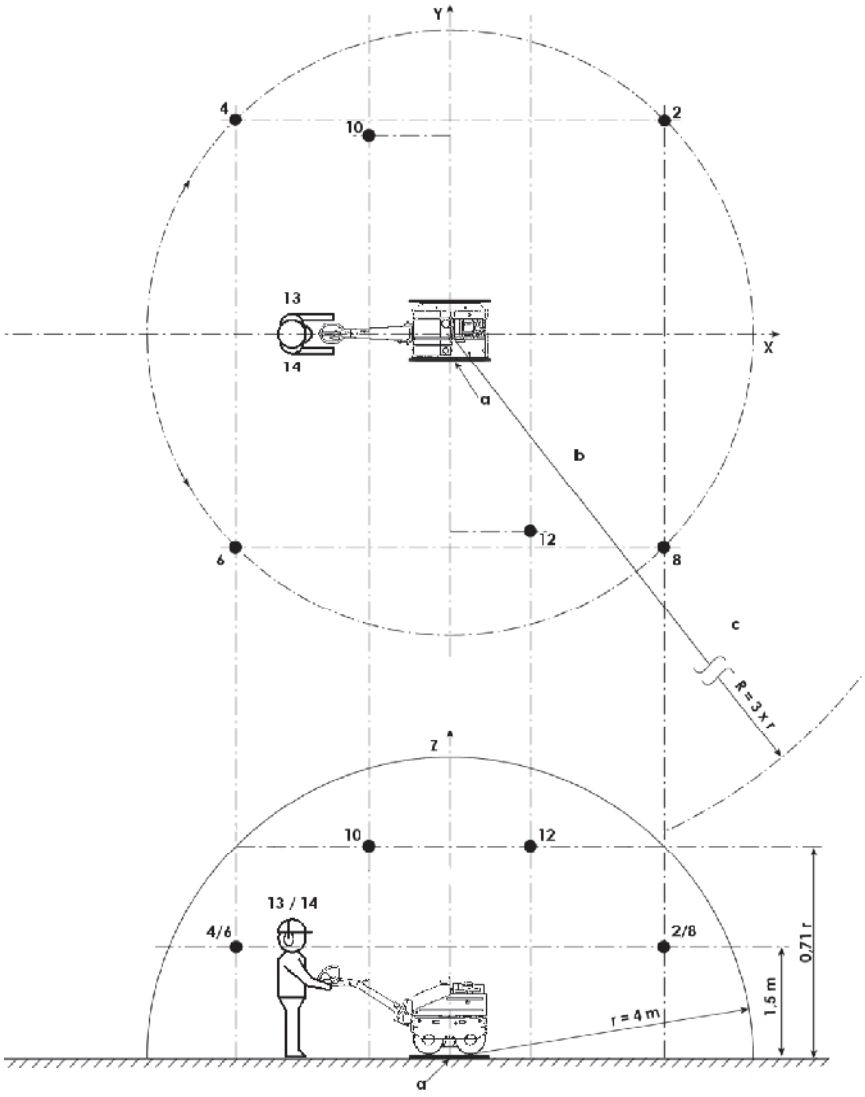
The centre of the machine shall coincide with the centre of the hemisphere which is the intersecting point of the x-axis and y-axis. The front (direction of travelling) of the machine shall point towards the microphone positions 2 and 8. For positioning the machine, the middle of the basic length L shall be regarded as the central point.

For ride-on operated machines, the positioning shall be as in Figure D.2.

For hand-guided machines, the positioning shall be as specified in Figure D.3.

For remote-controlled machines, the positioning shall be as specified in Figure D.4.

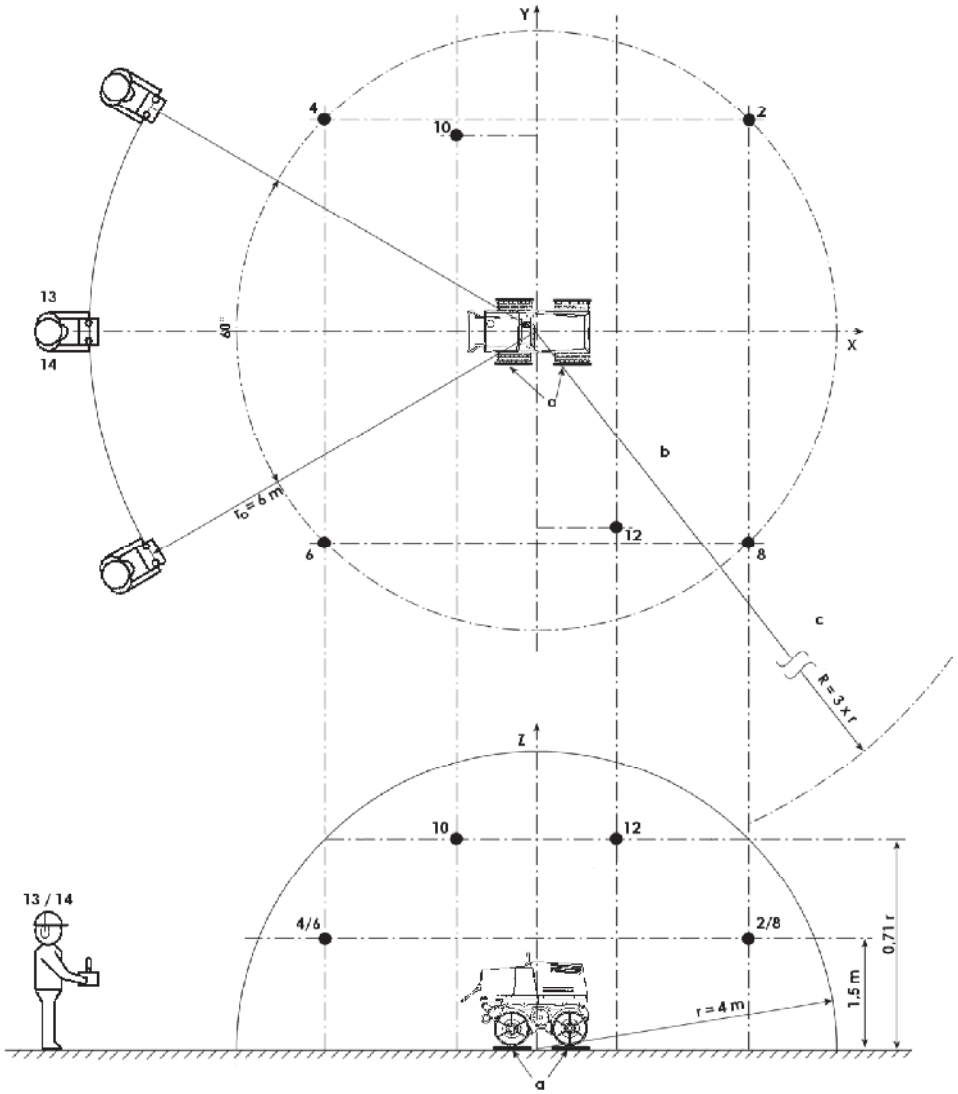
For towed machines, the positioning shall be as specified in Figure D.5.



Key

a	elastic material
b	hard reflecting area bordered by the microphones
c	area without reflecting obstacles
r	radius of the hemisphere, with r = r(L)
R	radius of area without reflecting obstacles
2, 4, 6, 8, 10, 12	microphone positions for sound power level determination (see Table D.1)
13, 14	microphone positions for emission sound pressure level determination

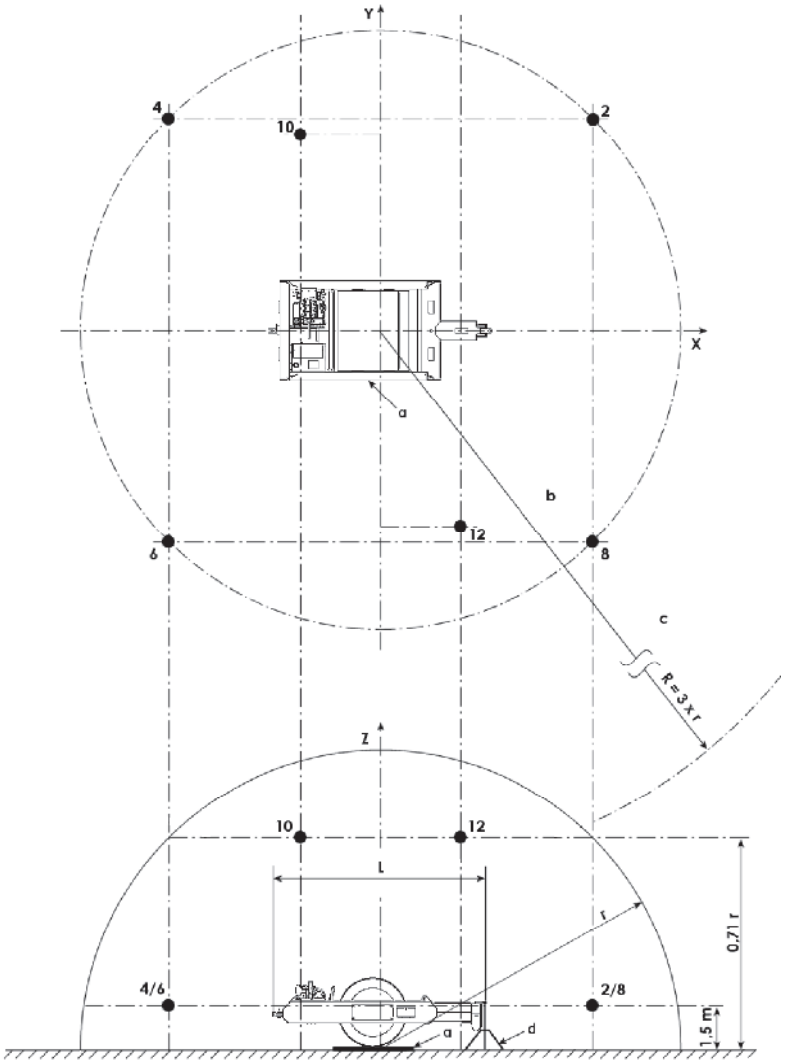
Figure D.3 — Arrangement of test positions for hand-guided vibratory rollers



Key

a	elastic material
b	hard reflecting area bordered by the microphones
c	area without reflecting obstacles
r	radius of the hemisphere, with r = r(L)
R	radius of area without reflecting obstacles
r_o	radius of operators position
2, 4, 6, 8, 10, 12	microphone positions for sound power level determination (see Table D.1)
13, 14	microphone positions for emission sound pressure level determination

Figure D.4 — Arrangement of test positions for remote controlled vibratory rollers



Key

a	elastic material
b	hard reflecting area bordered by the microphones
c	area without reflecting obstacles
d	supporting jack to the drawbar
r	radius of the hemisphere, with r = r(L)
R	radius of area without reflecting obstacles
2, 4, 6, 8, 10, 12	microphone positions for sound power level determination (see Table D.1)
13, 14	microphone positions for emission sound pressure level determination

Figure D.5 — Arrangement of test positions for towed vibratory rollers

D.2.4 Repetition of the test

The A-weighted sound power level shall be determined at least three times. If at least two of the determined values do not differ by more than 1 dB, further measurements will not be necessary. Otherwise the measurements shall be continued until two values differing by no more than 1 dB are obtained. The A-weighted sound power level to be used for calculating the sound power level to be declared is the arithmetic mean of both highest values that do not differ by more than 1 dB. The total duration t_M of each measurement at each microphone position shall be at least 15 s.

D.3 Determination of the A-weighted emission sound pressure level at the operators positions for vibratory rollers

D.3.1 General

This annex specifies additional requirements for the determination of the A-weighted emission sound pressure level at the operators positions according to EN ISO 11201:2010. The operator shall be present during the test at those positions applicable according to D.3.2.

D.3.2 Operator's positions

For ride-on operated machines, the position of the operator shall be as specified in D (E).3.3, D (E).3.5 and the operator shall be seated on operators seat while machine is positioned as illustrated in Figure D (E).2.

The operator position for towed vibratory rollers is located on the towing machine. Therefore the A-weighted emission sound pressure level determination shall be carried out by the manufacturer of the towing machine in accordance with the noise test code for the towing machine.

For hand-guided machines, the position of the operator shall be as specified in Figure D.3.

For remote-controlled machines, the position of the operator shall be as specified in Figure D.4. The position of the operator in the 60° sector shall be in accordance to the manufacturer specification.

D.3.3 Enclosed operator's positions

When equipped with a cabin, all doors and windows shall be closed during measurement. Air-conditioning and/or pressurized ventilating system shall be set to mid-position.

D.3.4 Quantities to be determined

If more than one operator's station is provided, the emission sound pressure level at the operator's station is the highest emission value determined at the operator's stations.

D.3.5 Microphone position(s)

Should more than one operator’s position be provided, measurement shall be carried out for all positions.

D.3.6 Test procedure

Since the sound pressure level varies greatly in relation to the operator’s tallness, the operator's height shall be 1,8 m ± 5 cm.

The test shall be carried out according to D.4.

During the whole test, the machine shall be operated by the same person. The person shall be skilled in handling and operating the machine.

Hand-guided machines shall be guided with both hands during measurement. Gripping-, feed-, and guiding-forces appropriate to usual operation shall be applied.

D.3.7 Repetition of the test

The sound pressure level shall be measured at least three times at each microphone position. If at least two of the measured values do not differ by more than 1 dB, further measurements will not be necessary. Otherwise the measurements shall be continued until two values differing by no more than 1 dB are obtained. The A-weighted emission sound pressure level to be used is the arithmetic mean of the two highest values that do not differ by more than 1 dB.

The duration t_M of each measurement at each microphone position shall be at least 15 s.

D.4 Test conditions

D.4.1 Installation and mounting conditions

A flat reflecting surface of concrete or non-porous asphalt shall be used for the tests.

The vibrating roller shall be installed on one ore more appropriate elastic materials such as air-cushion(s). Those air-cushions shall be made of a supple material (elastomer or similar) and shall be inflated to a pressure insuring that the machine is elevated by at least 5 cm; resonance effects shall be avoided. The dimension of the cushion(s) shall be such that the stability of the machine under test is insured.

D.4.2 Operating conditions

The engine (driving device and, if installed, vibratory system) and hydraulic system of the equipment shall be warmed up in accordance with the instructions of the manufacturer.

The machine shall be tested in a stationary position with the engine at the rated speed (stated by the manufacturer) and the moving mechanism(s) disconnected. The compaction mechanisms shall be operated using the maximum compaction power corresponding to the combination of the highest frequency and the highest possible amplitude for the frequency as declared by the manufacturer.

D.5 Uncertainty

The measurement uncertainty and, in the case of series machines, the uncertainty due to production variations shall be considered when determining the value of the A-weighted sound power level and that of the A-weighted emission sound pressure level at the operator's position.

Current experience shows that the total uncertainty (measurement plus production) K_{WA} for the A-weighted sound power levels and K_{pA} for the A-weighted emission sound pressure level of rollers is less than the values given in Table D.2.

Table D.2 — Uncertainties applicable to cushion mounted machines

	K_{WA} in dB (A)	K_{pA} in dB (A)
Vibratory Rollers	1,0 to 1,5	2,0 to 3,0

D.6 Information to be recorded

EN ISO 3744:2010 and EN ISO 11201 shall apply with the following additions:

— type and output of engine;

— engine speed;

— frequency and amplitude of vibratory system;

— measurement duration t_M for each measurement;

— description of the test environment;

— for remote controlled machines the position of the operator on the perimeter;

— A-weighted sound power level from each of the at least three measurements and the resulting sound power level as emission value;

— A-weighted sound pressure levels at the operator's position from the at least three measurements and the resulting emission sound pressure level for rollers;

— sound pressure spectra, where appropriate;

— sound pressure level as a function of time, where appropriate;

— place, date of measurement, test laboratory and person responsible.

D.7 Information to be reported

EN ISO 3744:2010 and EN ISO 11201 shall apply with the following addition:

— type and output of engine;

— engine speed;

— frequency and amplitude of vibratory system;

— measurement duration t_M for each measurement;

— description of the test environment;

— for remote controlled machines the position of the operator on the perimeter;

— A-weighted sound power level from each of the at least three measurements and the resulting sound power level as emission value;

— A-weighted sound pressure levels at the operator's position from the at least three measurements and the resulting emission sound pressure level;

— sound pressure spectra, where appropriate;

— sound pressure level as a function of time, where appropriate;

— place, date of measurement, test laboratory and person responsible.

The test report shall include the statement that the sound power level and the emission sound pressure level at the operator's position have been determined entirely in accordance with the specifications of this annex. The reported A-weighted sound power level of the machine under test and A-weighted emission sound pressure level at the operator's position shall be rounded down or up to the nearest integral value in dB (< 0,5 round down, ≥ 0,5 round up).

D.8 Declaration and verification of noise emission values

The declared A-weighted sound power level shall be the sum of the arithmetic mean of the sound power levels of the measured series machines and the associated uncertainty K_{WA} (see D.5).

NOTE The declared value of the A-weighted sound power level is identical to the guaranteed sound power level according to 2000/14/EC.

The declared A-weighted emission sound pressure level at the operator's position shall be the sum of the arithmetic mean of the sound pressure levels at the operator positions of the measured series machines and the associated uncertainty K_{pA} (see D.5). The declared A-weighted sound power level and the declared A-weighted emission sound pressure level at the operator's position shall be rounded down or up to the nearest integral value in dB (< 0,5 round down, ≥ 0,5 round up).

The noise declaration shall explicitly state that the noise emission values have been obtained according to this noise test code.

Any verification shall be done using this noise test code. If the value measured during verification is less than or equal to the declared value, the declared value is verified.

Annex E
(normative)

Noise test code for non-vibrating rollers

E.1 Scope

This noise test code specifies all the information necessary to carry out efficiently and under standardised conditions the determination, declaration and verification of the noise emission characteristics of rollers.

Noise emission characteristics include emission sound pressure levels at workstations and the sound power level. The determination of those quantities is necessary for:

— manufacturers to declare the noise emitted;

— comparing the noise emitted by machines in the family concerned;

— purposes of noise control at the source at the design stage.

The use of this noise test code ensures reproducibility of the determination of the noise emission characteristics within specified limits determined by the grade of accuracy of the basic noise-measurement method used. Noise-measurement methods allowed by this European Standard are engineering methods (grade 2).

NOTE The noise evaluation procedures as laid down in this European Standard aim at ensuring the reproducibility of the measurements of the noise emission of the machine. This determination does not necessarily reflect the noise emission during operation on construction sites.

E.2 Determination of the A-weighted sound power level

E.2.1 General

This annex specifies additional requirements for the determination of the A-weighted sound power level according to EN ISO 3744:2010.

For all measurements carried out under free field over a reflecting plane conditions according to EN ISO 3744:2010 the environmental correction factor K_{2A} shall be set to 0.

E.2.2 Measurement surface

A hemispherical test area on a plane sound-reflecting hard surface shall be used for measurement.

E.2.2.1 Size of the measurement surface

The radius shall be calculated from the basic length *L* of the machine (see Figure E.1):

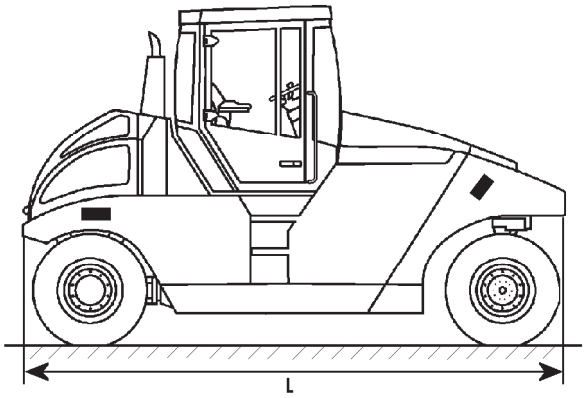


Figure E.1 — Basic length *L*

The radius r shall be:

— 4 m when the basic length *L* of the machine to be tested is less than or equal to 1,5 m;

— 10 m when the basic length *L* of the machine to be tested is greater than 1,5 m but less than or equal to 4 m;

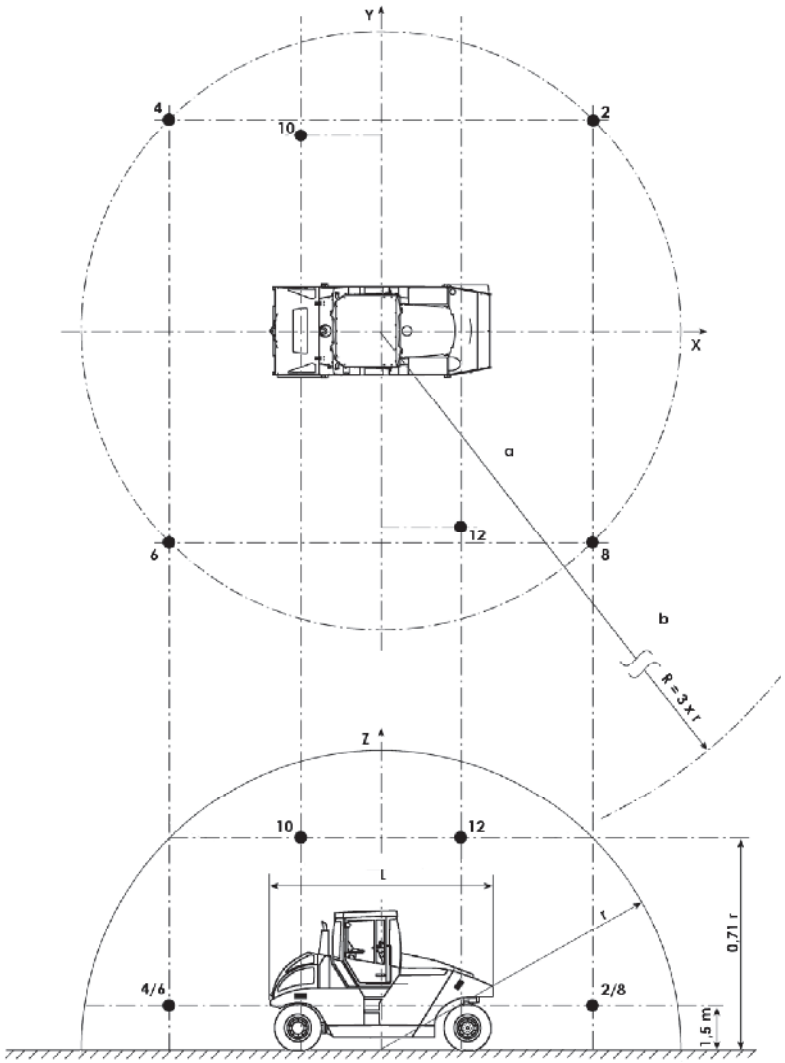
— 16 m when the basic length *L* of the machine to be tested is greater than 4 m.

Table E.1 — Coordinates of microphone positions

Microphone position	x/r	y/r	z
2	0,7	0,7	1,5m
4	-0,7	0,7	1,5m
6	-0,7	-0,7	1,5m
8	0,7	-0,7	1,5m
10	-0,27	0,65	0,71r
12	0,27	-0,65	0,71r

E.2.2.2 Microphone positions

Six microphone positions (i.e. positions 2, 4, 6, 8, 10 and 12) shall be arranged according to Figure E.2.



Key

L	basic length of machine
a	hard reflecting area bordered by the microphones
b	area without reflecting obstacles
r	radius of the hemisphere, with r = r(L)
R	radius of area without reflecting obstacles
2, 4, 6, 8, 10, 12	microphone positions for sound power determination

Figure E.2 — Microphone positions

E.2.3 Positioning of the machine

The centre of the machine shall coincide with the centre of the hemisphere which is the intersecting point of the x-axis and y-axis (see Figure E.2). The front (direction of travelling) of the machine shall point towards the microphone positions 2 and 8. For positioning the machine, the middle of the basic length *L* shall be regarded as the central point. For positioning of other machinery than seat-operated machines analogously Figures D.3 to D.5 are applicable with the restriction for this annex, that machines shall be operated without elastic material.

E.2.4 Repetition of the test

The A-weighted sound power level shall be determined at least three times. If at least two of the determined values do not differ by more than 1 dB, further measurements will not be necessary. Otherwise the measurements shall be continued until two values differing by no more than 1 dB are obtained. The A-weighted sound power level to be used for calculating the sound power level to be declared is the arithmetic mean of both highest values that do not differ by more than 1 dB. The total duration t_M of each measurement at each microphone position shall be at least 15 s.

E.3 Determination of the A-weighted emission sound pressure level at operator's positions for non-vibrating rollers

E.3.1 General

This annex specifies additional requirements for the determination of the A-weighted emission sound pressure level at the operators positions according to EN ISO 11201:2010. The operator shall be present during the test at those positions applicable according to E.3.2.

E.3.2 Operators positions

For ride-on operated machines, the position of the operator shall be as specified in E.3.3, E.3.5 and Figure E.2.

For hand-guided machines, the position of the operator shall be as specified in Figure D.3.

For remote-controlled machines, the position of the operator shall be as specified in Figure D.4. The position of the operator in the 60° sector shall be in accordance to the manufacturer specification.

Deviating from figure D.3 and D.4 measurements on non-vibrating-rollers are carried out without the use of elastic material (see key a).

NOTE Towed non-vibrating rollers are considered as non-powered attachment and as such do not fall under the scope of this annex.

E.3.3 Enclosed operator's positions

When equipped with a cabin, all doors and windows shall be closed during measurement. Air-conditioning and/or pressurized ventilating system shall be set to mid-position.

E.3.4 Quantities to be determined

If more than one operator's station is provided, the emission sound pressure level at the operator's station is the highest emission value determined at the operator's stations.

E.3.5 Microphone position(s)

Should more than one operator’s position be provided, measurement shall be carried out for all positions.

E.3.6 Test procedure

Since the sound pressure level varies greatly in relation to the operator’s tallness, the operator's height shall be 1,8 m ± 5 cm.

The test shall be carried out according to E.4.

During the whole test, the machine shall be operated by the same person. The person shall be skilled in handling and operating the machine.

Hand-guided machines shall be guided with both hands during measurement. Gripping-, feed-, and guiding-forces appropriate to usual operation shall be applied.

E.3.7 Repetition of the test

The sound pressure level shall be measured at least three times at each microphone position. If at least two of the measured values do not differ by more than 1 dB, further measurements will not be necessary. Otherwise the measurements shall be continued until two values differing by no more than 1 dB are obtained. The A-weighted emission sound pressure level to be used is the arithmetic mean of the two highest values that do not differ by more than 1 dB.

The duration t_M of each measurement at each microphone position shall be at least 15 s.

E.4 Test conditions

E.4.1 Installation and mounting conditions

The non-vibrating roller shall be installed on a flat sound-reflecting hard surface of concrete or non-porous asphalt.

E.4.2 Operating conditions

The engine (driving device) and hydraulic system of the equipment shall be warmed up in accordance with the instructions of the manufacturer.

The machine shall be tested in a stationary position. The engine shall be operated at the rated high idle at no less than the rated speed corresponding to the net power as stated by the manufacturer of the machine. The moving mechanism(s) and driving devices shall be disconnected.

E.5 Uncertainty

The measurement uncertainty and, in the case of series machines, the uncertainty due to production variations shall be considered when determining the value of the A-weighted sound power level and that of the A-weighted emission sound pressure level at the operator's position.

Current experience shows that the total uncertainty (measurement plus production) K_{WA} for the A-weighted sound power levels and K_{pA} for the A-weighted emission sound pressure level of rollers is less than the values given in Table E.2.

Table E.2 — Uncertainties

	K_{WA} in dB (A)	K_{pA} in dB (A)
Non-vibrating rollers	1,0 to 1,5	2,0 to 3,0

E.6 Information to be recorded

EN ISO 3744:2010 and EN ISO 11201 shall apply with the following additions:

— type and output of engine;

— engine speed;

— measurement duration t_M for each measurement;

— description of the test environment;

— for remote controlled machines the position of the operator on the perimeter;

— A-weighted sound power level from each of the at least three measurements and the resulting sound power level as emission value;

— A-weighted sound pressure levels at the operator's position from the at least three measurements and the resulting emission sound pressure level;

— sound pressure spectra, where appropriate;

— sound pressure level as a function of time, where appropriate;

— place, date of measurement, test laboratory and person responsible.

E.7 Information to be reported

EN ISO 3744:2010 and EN ISO 11201 shall apply with the following addition:

— type and output of engine;

— engine speed;

— measurement duration t_M for each measurement;

— description of the test environment;

— for remote controlled machines the position of the operator on the perimeter;

— A-weighted sound power level from each of the at least three measurements and the resulting sound power level as emission value;

— A-weighted sound pressure levels at the operator's position from the at least three measurements and the resulting emission sound pressure level;

— sound pressure spectra, where appropriate;

— sound pressure level as a function of time, where appropriate;

— place, date of measurement, test laboratory and person responsible.

The test report shall include the statement that the sound power level and the emission sound pressure level at the operator's position have been determined entirely in accordance with the specifications of this annex. The reported A-weighted sound power level of the machine under test and A-weighted emission sound

pressure level at the operator's position shall be rounded down or up to the nearest integral value in dB (< 0,5 round down, ≥ 0,5 round up).

E.8 Declaration and verification of noise emission values

The declared A-weighted sound power level shall be the sum of the arithmetic mean of the sound power levels of the measured series machines and the associated uncertainty K_{WA} (see E.5).

NOTE The declared value of the A-weighted sound power level is identical to the guaranteed sound power level according to Directive 2000/14/EC.

The declared A-weighted sound power level and the declared A-weighted emission sound pressure level at the operator's position shall be rounded down or up to the nearest integral value in dB (< 0,5 round down, ≥ 0,5 round up). The declared A-weighted emission sound pressure level at the operator's position shall be the sum of the arithmetic mean of the sound pressure levels at the operator positions of the measured series machines and the associated uncertainty K_{pA} (see E.5).

The noise declaration shall explicitly state that the noise emission values have been obtained according to this noise test code.

Any verification shall be done using this noise test code. If the value measured during verification is less than or equal to the declared value, the declared value is verified.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive Machinery 2006/42/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] ISO 5805, *Mechanical vibration and shock — Human exposure — Vocabulary*

[2] ISO 8811:2000, *Earth-moving machinery — Rollers and compactors — Terminology and commercial specifications*

[3] ISO 9248:1992, *Earth-moving machinery — Units for dimensions, performance and capacities, and their measurement accuracies*

[4] ISO 19433:2008, *Building construction machinery and equipment — Pedestrian-controlled vibratory plates — Terminology and commercial specifications*

[5] IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

[6] Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors

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