BRITISH STANDARD

BS EN ISO 28927-1:2009

Hand-held portable power tools — Test methods for evaluation of vibration emission

Part 1: Angle and vertical grinders (ISO 28927-1:2009)

ICS 13.160; 25.140.01; 25.140.10

British Standards

National foreword

This British Standard is the UK implementation of EN ISO 28927-1:2009. It supersedes BS EN ISO 8662-4:1995 which will be withdrawn on publication of BS EN ISO 28927-4.

The UK participation in its preparation was entrusted to Technical Committee MCE/8/-/2, Hand-held, non-electric power tools - Safety.

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.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 28 February 2010.

ISBN 978 0 580 59888 3

Amendments/corrigenda issued since publication

Date	Comments

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 28927-1

December 2009

ICS 13.160; 25.140.10

Supersedes EN ISO 8662-4:1995

English Version

Hand-held portable power tools - Test methods for evaluation of vibration emission - Part 1: Angle and vertical grinders (ISO 28927-1:2009)

Machines à moteur portatives - Méthodes d'essai pour l'évaluation de l'émission de vibrations - Partie 1: Meuleuses verticales et meuleuses d'angles (ISO 28927-1:2009)

Handgehaltene motorbetriebene Maschinen - Messverfahren zur Ermittlung der Schwingungsemission - Teil 1: Winkelschleifer und Vertikalschleifer (ISO 28927-1:2009)

This European Standard was approved by CEN on 14 December 2009.

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

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

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, 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.

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

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN ISO 28927-1:2009: E

Foreword

This document (EN ISO 28927-1:2009) has been prepared by Technical Committee ISO/TC 118 "Compressors and pneumatic tools, machines and equipment" in collaboration with Technical Committee CEN/TC 231 “Mechanical vibration and shock” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

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 supersedes EN ISO 8662-4:1995.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directives.

For relationship with EU Directives, see informative Annex ZA and ZB, which are integral parts of this document.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, 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 the United Kingdom.

Endorsement notice

The text of ISO 28927-1:2009 has been approved by CEN as a EN ISO 28927-1:2009 without any modification.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/EC, amended by Directive 98/79/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 98/37/EC, Machinery, amended by Directive 98/79/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 corresponding Essential Requirements of that Directive, except ER 1.7.4 d) and 2.2, and associated EFTA regulations.

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

Annex ZB
(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 one means of conforming to Essential Requirements of the New Approach Directive 2006/42/EC on machinery.

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 corresponding Essential Requirement of that Directive, except ER 2.2.1.1, 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.**

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

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

ISO 28927-1 was prepared by Technical Committee ISO/TC 118, *Compressors and pneumatic tools, machines and equipment*, Subcommittee SC 3, *Pneumatic tools and machines*.

This first edition of ISO 28927-1, together with ISO 28927-4, cancels and replaces ISO 8662-4:1994, of which it constitutes a technical revision. The most important changes are

— vibration measurement in three axes and at both hand positions,

— new transducer positions,

— improved definition of transducer positions and orientation,

— straight grinders dealt with specifically by ISO 29827-4,

— rotational speed raised to no-load free running speed, and

— test wheels modified and their specification improved.

ISO 29827 consists of the following parts, under the general title *Hand-held portable power tools — Test methods for evaluation of vibration emission*:

— *Part 1: Angle and vertical grinders*

— *Part 2: Wrenches, nutrunners and screwdrivers*[1)]

— *Part 3: Polishers and rotary, orbital and random orbital sanders*[2)]

---

1) Replaces ISO 8662-7, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 7: Wrenches, screwdrivers and nut runners with impact, impulse or ratchet action*. All screwdrivers and nutrunners except for one-shot tools now covered.

2) Replaces ISO 8662-8, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 8: Polishers and rotary, orbital and random orbital sanders.*

— *Part 4: Straight grinders*[3)]

— *Part 5: Drills and impact drills*[4)]

— *Part 6: Rammers*[5)]

— *Part 7: Nibblers and shears*[6)]

— *Part 8: Saws, polishing and filing machines with reciprocating action and small saws with oscillating or rotating action*[7)]

— *Part 9: Scaling hammers and needle scalers*[8)]

— *Part 10: Percussive drills, hammers and breakers*[9)]

— *Part 11: Stone hammers*[10)]

3) Together with Part 1, replaces ISO 8662-4, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 4: Grinders*

4) Replaces ISO 8662-6, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 6: Impact drills.* Non-impacting drills now covered.

5) Replaces ISO 8662-9, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 9: Rammers.*

6) Replaces ISO 8662-10, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 10: Nibblers and shears.*

7) Replaces ISO 8662-12, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 12: Saws and files with reciprocating action and saws with oscillating or rotating action.*

8) Together with Part 11, replaces ISO 8662-14, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 14: Stone-working tools and needle scalers.*

9) Replaces ISO 8662-2, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 2: Chipping hammers and riveting hammers,* ISO 8662-3, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 3: Rock drills and rotary hammers*, and ISO 8662-5, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 5: Pavement breakers and hammers for construction work.* Chipping and riveting hammers, rock drills and rotary hammers all covered.

10) Together with Part 9, replaces ISO 8662-14, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 14: Stone-working tools and needle scalers.*

Introduction

This document is a type-C standard as stated in ISO 12100.

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

The vibration test codes for portable hand-held machines given in ISO 28927 are based on ISO 20643, which gives general specifications for the measurement of the vibration emission of hand-held and hand-guided machinery. ISO 28927 specifies the operation of the machines under type-test conditions and other requirements for the performance of type tests. The structure/numbering of its clauses follows that of ISO 20643.

The basic principle for transducer positioning first introduced in the EN 60745 series of European standards is followed, representing a deviation from ISO 20643 for reasons of consistency. The transducers are primarily positioned next to the hand in the area between the thumb and the index finger, where they give the least disturbance to the operator gripping the machine.

It has been found that vibrations generated by grinders vary considerably in typical use. This is largely due to the variances in the unbalance of the machine with the grinding wheel mounted. The unbalance also changes when the wheel is worn through operation.

In order to provide a method that gives good measurement reproducibility, the procedure adopted in this part of ISO 28927 uses a test wheel of known unbalance mounted on a machine and run under no-load conditions. The unbalance for the different types of test wheel are chosen to give vibration values that are as far as possible in accordance with ISO 20643. The procedures of ISO 5349 are required whenever exposure at the workplace is to be assessed.

Underestimation of the vibration for machines equipped with technical means to automatically reduce unbalances is taken into account by multiplying the vibration values of such machines with a correction factor of 1.3.

The values obtained are type-test values intended to be representative of the average of the upper quartile of typical vibration magnitudes in real-world use of the machines. However, the actual magnitudes will vary considerably from time to time and depend on many factors, including the operator, the task and the inserted tool or consumable. The state of maintenance of the machine itself might also be of importance. Under real working conditions the influences of the operator and process can be particularly important at low magnitudes. It is therefore not recommended that emission values below 2,5 m/s^2 be used for estimating the vibration magnitude under real working conditions. In such cases, 2,5 m/s^2 is the recommended vibration magnitude for estimating the machine vibration.

If accurate values for a specific work place are required, then measurements (according to ISO 5349) in that work situation could be necessary. Vibration values measured in real working conditions can be either higher or lower than the values obtained using this part of ISO 28927.

Higher vibration magnitudes can easily occur in real work situations, caused by the use of excessively unbalanced grinding wheels, worn flanges or bent spindles.

The vibration test codes given in ISO 28927 supersede those given in ISO 8662, whose parts have been replaced by the corresponding parts of ISO 28927 (see Foreword).

NOTE ISO 8662-11, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 11: Fastener driving tools*, and ISO 8662-13, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 13: Die grinders*, could be replaced by future parts of ISO 28927.

Hand-held portable power tools — Test methods for evaluation of vibration emission —

Part 1:
Angle and vertical grinders

1 Scope

This part of ISO 28927 specifies a laboratory method for measuring hand-transmitted vibration emission at the handles of hand-held power-driven angle and vertical grinders. It is a type-test procedure for establishing the magnitude of vibration in the gripping areas of a machine fitted with a specified test wheel and run under no-load conditions. The method has been established for surface grinding tasks only. Cutting and sanding generally create lower vibrations. It is intended that the results be used to compare different models of the same type of machine.

This part of ISO 28927 is applicable to hand-held machines (see Clause 5), driven pneumatically or by other means, intended for grinding, cutting-off and rough sanding, with bonded, coated and super-abrasive products for use on all kinds of materials. It is not applicable to grinders used with wire brushes, nor is it applicable to die or straight grinders.

NOTE To avoid confusion with the terms "power tool" and "inserted tool", *machine* is used for the former throughout this document.

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.

ISO 2787:1984, *Rotary and percussive pneumatic tools — Performance tests*

ISO 5349:2001 (all parts), *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration*

ISO 5391:2003, *Pneumatic tools and machines — Vocabulary*

ISO 17066:2007, *Hydraulic tools — Vocabulary*

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

EN 755-2:2008, *Aluminium and aluminium alloys — Extruded rod/bar, tube and profiles — Part 2: Mechanical properties*

EN 12096:1997, *Mechanical vibration — Declaration and verification of vibration emission values*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in ISO 5391, ISO 17066 and ISO 20643, and the following terms, definitions and symbols, apply.

3.1 Terms and definitions

3.1.1
grinder
machine driving a rotary output spindle adapted to carry an abrasive wheel/device for material removal

NOTE Adapted from ISO 5391:2003, definition 2.1.3.

3.1.2
angle grinder
grinder where the output spindle is at a given angle (usually a right angle) to the motor axis

[ISO 5391:2003, definition 2.1.3.3]

3.1.3
vertical grinder
grinder where the handle or handles are at an angle to the coaxially aligned motor and output spindle axis

[ISO 5391:2003, definition 2.1.3.2]

3.1.4
test wheel
aluminium wheel geometrically similar to a real grinding wheel, with holes on specified radii to give defined unbalances

3.2 Symbols

Symbol	Description	Unit
a_{hw}	root-mean-square (r.m.s.) single-axis acceleration value of the frequency-weighted hand-transmitted vibration	m/s^2
a_{hv}	vibration total value of frequency-weighted r.m.s. acceleration; root sum of squares of a_{hw} values for the three measured axes of vibration	m/s^2
a_{hvmeas}	a_{hv} as measured during testing	m/s^2
a_{hvrat}	a_{hv} at rated no-load speed	m/s^2
$\overline{a_{hv}}$	arithmetic mean value of a_{hv} values of runs for one operator for one hand position	m/s^2
a_h	arithmetic mean value of $\overline{a_{hv}}$ values for all operators for one hand position	m/s^2
$\overline{a_h}$	arithmetic mean value of a_h values for one hand position on several machines	m/s^2
a_{hd}	declared vibration emission value	m/s^2
n_{meas}	measured no-load speed during testing with the test wheel mounted	r/min
n_{rat}	rated no-load speed: maximum rotational-speed of the machine according to the speed marking of the machine	r/min
s_{n-1}	standard deviation for a test series (for a sample, s)	m/s^2
σ_R	standard deviation of reproducibility (for a population, σ)	m/s^2
C_V	coefficient of variation for a test series	
K	uncertainty	m/s^2

4 Basic standards and vibration test codes

This part of ISO 28297 is based on the requirements of ISO 20643 and corresponds to its structure in respect of clause subjects and numbering except for the annexes.

Annex A presents a model test report, Annex B the means for determining the uncertainty, K, and Annex C specifies test wheel design.

5 Description of the family of machines

This part of ISO 28297 applies to hand-held machines fitted with guards, which are intended for grinding, cutting-off and rough sanding, with bonded, coated and super abrasive products for use on all kinds of materials.

For sanders without guards, see ISO 28927-3.

For applicable wheel types, as defined in ISO 603-14 and ISO 603-16, see Table 1.

The family of machines covered by this part of ISO 28297 comprises the following machines:

— angle and vertical grinders with type 27 wheels of diameters 80 to 300 mm; when the same guard is also used for type 41 cutting-off wheels then only the vibration value for the type 27 test wheel need be declared (see 8.4.1 for test wheel specifications);

— angle and vertical grinders with special guards for type 41 cut off wheels; the test shall be carried out using a type 27 test wheel (see 8.4.1 for test wheel specifications);

— angle and vertical grinders with special guards for stone cutting wheels; the test shall be carried out using the most appropriate wheel from the types described in Table 2;

— angle and vertical grinders for types 6 and 11 cup wheels with diameters 100 to 180 mm;

— angle and vertical grinders, as well as sanders, for fibre discs and flap wheels with diameters 80 to 300 mm.

Figures 1 to 6 show examples of typical grinders covered by this part of ISO 28927.

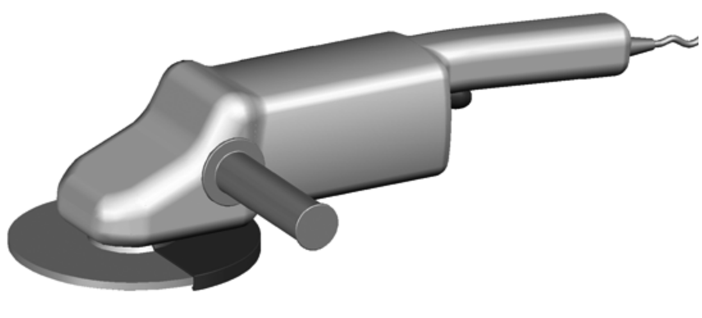


Figure 1 — Electrical angle grinder with separate main handle

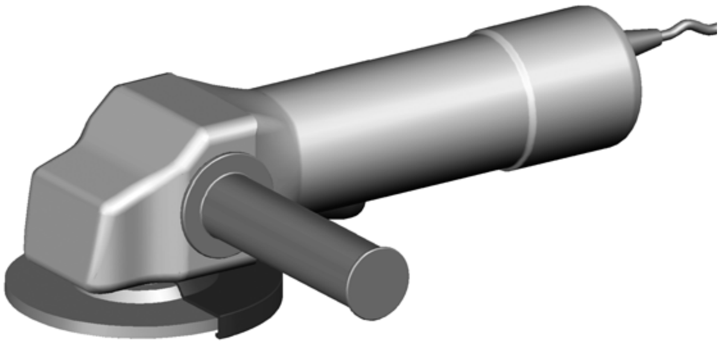


Figure 2 — Electrical angle grinder whose motor serves as main handle

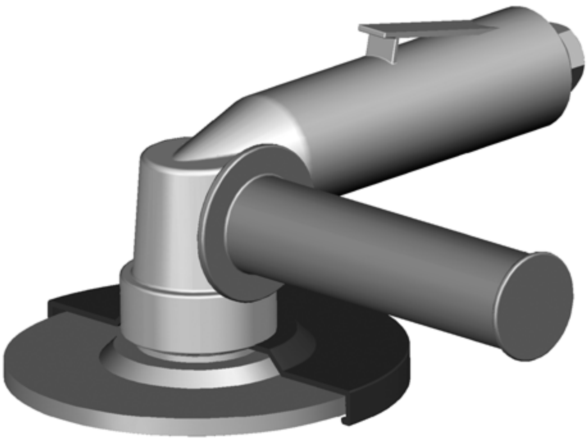


Figure 3 — Pneumatic angle grinder whose motor serves as main handle

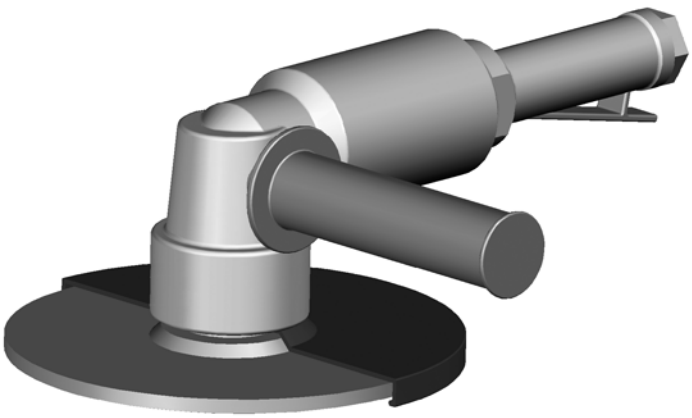


Figure 4 — Pneumatic angle grinder with separate main handle

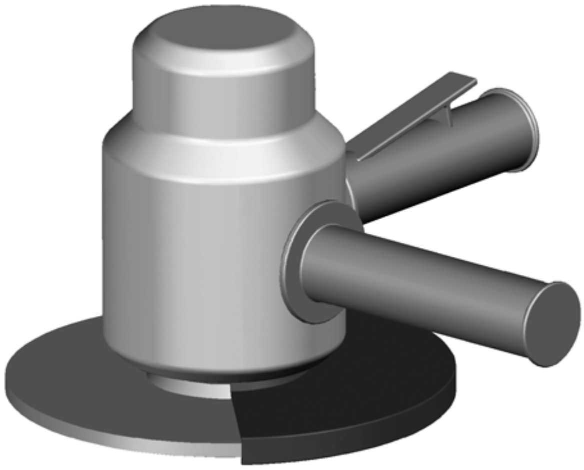


Figure 5 — Pneumatic vertical grinder

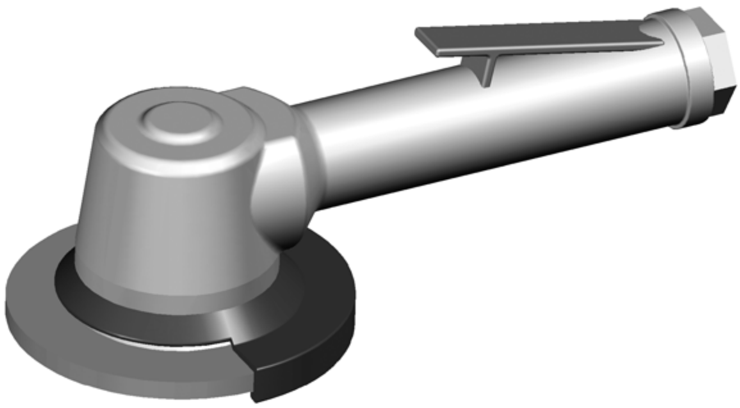


Figure 6 — Angle grinder intended for one-handed operation

6 Characterization of vibration

6.1 Direction of measurement

The vibration transmitted to the hand shall be measured and reported for three directions of an orthogonal coordinate system. At each hand position, the vibration shall be measured simultaneously in the three directions shown in Figures 7 to 12.

6.2 Location of measurements

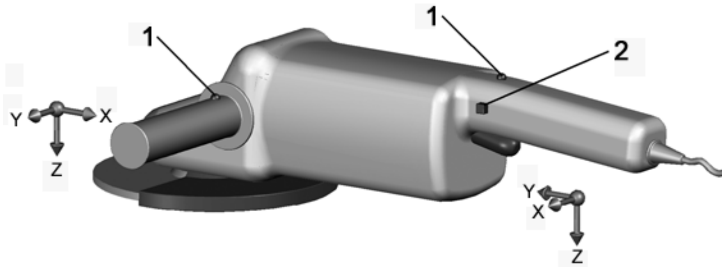
Measurements shall be made at the gripping zones, where the operator normally holds the machine and applies the feed force. For machines intended for one-handed operation, it is only necessary to measure at a single point.

The prescribed transducer location shall be as close as possible to the hand between the thumb and index finger. This shall apply to both hand positions, with the machine held as in normal operation. Whenever possible, measurements shall be made at the prescribed locations.

A secondary location is defined as being on the side of, and as close as possible to, the inner end of the handle where the prescribed location is found. If a prescribed location of the transducer cannot be used, this secondary location shall be used instead.

The prescribed or secondary locations shall also be used on anti-vibration handles.

Figures 7 to 12 show the prescribed and secondary locations and measurement directions for the hand positions normally used for the different types of machines in this family.

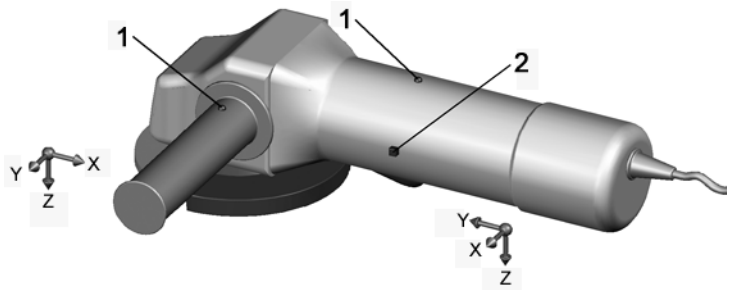


Key

1 prescribed location

2 secondary location

Figure 7 — Measurement locations — Electrical angle grinder with separate main handle

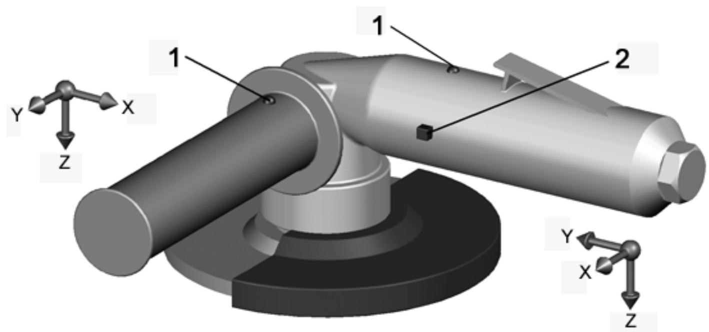


Key

1 prescribed location

2 secondary location

Figure 8 — Measurement locations — Electrical angle grinder whose motor serves as main handle

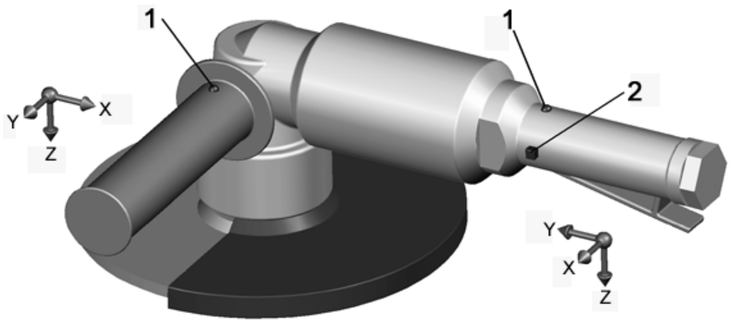


Key

1 prescribed location

2 secondary location

Figure 9 — Measurement locations — Pneumatic angle grinder whose motor serves as main handle

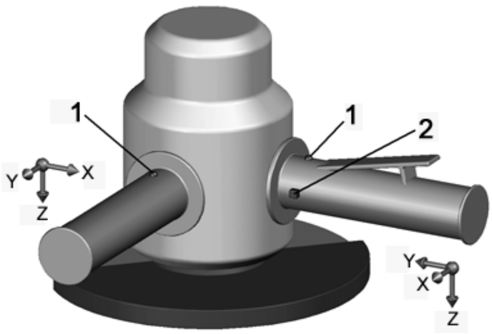


Key

1 prescribed location

2 secondary location

Figure 10 — Measurement locations — Pneumatic angle grinder with separate main handle

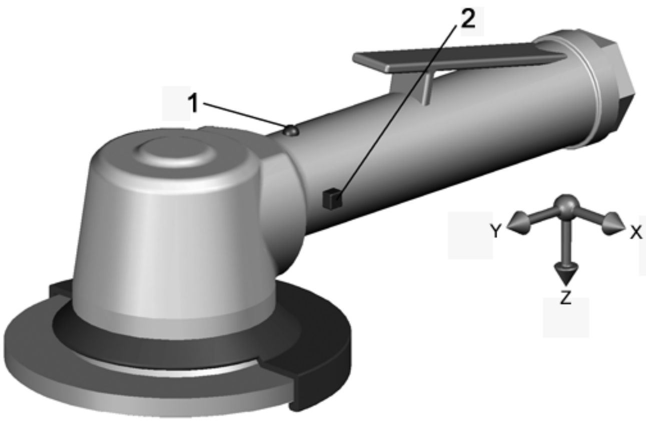


Key

1 prescribed location

2 secondary location

Figure 11 — Measurement locations — Pneumatic vertical grinder



Key

1 prescribed location

2 secondary location

Figure 12 — Measurement locations — Angle grinder intended for one-handed operation

6.3 Magnitude of vibration

The definitions for the magnitude of vibration given in ISO 20643:2005, 6.3, apply.

6.4 Combination of vibration directions

The vibration total value defined in ISO 20643:2005, 6.4, shall be reported for both hand positions when applicable. It is acceptable to report and carry out tests on the hand position having the highest reading. The vibration total value at that hand position shall be at least 30 % higher than the other. This result may be obtained during a preliminary test carried out by a single operator during five test runs.

To obtain the vibration total value of the frequency-weighed acceleration, a_{hvmeas}, at the measured no-load speed for each test run, the result in each direction shall be combined using Equation (1):

$$a_{\text{hvmeas}} = \sqrt{a_{\text{hwx}}{}^2 + a_{\text{hwy}}{}^2 + a_{\text{hwz}}{}^2} \qquad (1)$$

The a_{hvmeas} value for each test run is corrected to the frequency-weighed acceleration, a_{hvrat}, at the rated no-load speed using Equation (2):

$$a_{\text{hvrat}} = a_{\text{hvmeas}} \frac{n_{\text{rat}}}{n_{\text{meas}}} \qquad (2)$$

where

n_{rat} is the rated no-load speed i.e. the maximum rotational speed of the machine as marked on the machine;

n_{meas} is the measured no-load speed during testing.

7 Instrumentation requirements

7.1 General

The instrumentation shall be in accordance with ISO 20643:2005, 7.1.

7.2 Mounting of transducers

7.2.1 Specification of transducer

The specification of the transducer given in ISO 20643:2005, 7.2.1, applies.

The total mass of the transducers and mounting device shall be small enough, compared with that of the machine, handle, etc., so as not to influence the measurement result.

This is particularly important for low-mass plastic handles (see ISO 5349-2).

7.2.2 Fastening of transducers

The transducer or mounting block used shall be rigidly attached to the surface of the handle.

If three single-axis transducers are used, these shall be attached to three sides of a suitable mounting block.

For the two axes aligned parallel to the vibrating surface, the measurement axes of the two transducers — or the two transducer elements in a triaxial transducer — shall be at a maximum of 10 mm from the surface.

NOTE It is normally not necessary that mechanical filters be used for the measurements.

7.3 Frequency weighting filter

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

7.4 Integration time

The integration time shall be in accordance with ISO 20643:2005, 7.4. The integration time for each test run shall be at least 16 s, so as to be consistent with the duration of machine operation defined in 8.4.3.

7.5 Auxiliary equipment

For pneumatic machines, the air pressure shall be measured using a pressure gauge with an accuracy equal to or better than 0,1 bar[11)].

For hydraulic machines, the flow shall be measured using a flow meter with an accuracy equal to or better than 0,25 l/min.

For electrical machines, the voltage shall be measured using a volt meter with an accuracy equal to or better than 3 % of the actual value.

The rotational speed shall be measured and reported with an accuracy better than 5 % of the actual value, using either a tachometer or frequency analysis of the measured vibration signal. When a tachometer transducer is placed on the machine, it should be small enough not to influence the vibration of the machine.

The feed force shall be measured with an accuracy equal to or better than 5 % of the actual value.

7.6 Calibration

The specifications for calibration given in ISO 20643:2005, 7.6, apply.

8 Testing and operating conditions of the machinery

8.1 General

Measurements shall be carried out on new, and properly serviced and lubricated machines. During testing, the machine shall be equipped and held in a manner similar to that when grinding (see Figure 13). If, for some types of machines, a warming-up period is specified by the manufacturer, this shall be undertaken prior to the start of the test.

The grinders shall be run under no-load conditions, equipped with the appropriate test wheel according to Table 2.

Machines intended for one-handed operation shall be held with only one hand during testing. Measurements shall be made in one location only and for the hand position used. During measurement, a support handle shall not be mounted.

During testing, the energy supply to the machine shall be at the rated conditions, as specified by the manufacturer. The operation shall be stable.

11) 1 bar = 0,1 MPa = 0,1 N/mm^2 = 10^5 N/m^2.

8.2 Operating conditions

8.2.1 Pneumatic machines

During testing, the machine shall be operated at the rated air pressure, and shall be used in accordance with the manufacturer's specifications. The operation shall be stable and smooth. The air pressure shall be measured and reported.

Air shall be supplied to the machines by means of a hose of the diameter recommended by the machine manufacturer. The test hose shall be attached to the machine via a threaded hose connector, preferably the one supplied with the machine. The length of the test hose shall be 3 m. The test hose shall be secured with a hose clip. Quick-couplings shall not be used, since their mass will influence the vibration magnitude.

The air pressure of pneumatically powered machines shall be measured in accordance with ISO 2787 and maintained as specified by the manufacturer. During testing, the air pressure measured immediately before the test hose shall not drop by more than 0,2 bar below the pressure recommended by the manufacturer.

8.2.2 Hydraulic machines

During testing, the machine shall operate at the rated power supply, i.e. the rated flow, and shall be used in accordance with the manufacturer's specifications. The operation shall be stable and smooth. A warming up period of about 10 min should be allowed before starting the measurements. The flow shall be measured and reported.

8.2.3 Electrical machines

During testing, the machine shall operate at the rated voltage and shall be used in accordance with the manufacturer's specifications. The operation shall be stable and smooth. The voltage shall be measured and reported.

8.3 Other quantities to be specified

The rotational speed of the spindle with test wheel mounted shall be measured and reported for each tool used in the test.

The feed force used shall be reported.

8.4 Attached equipment, work piece and task

8.4.1 Test wheel

The dimensions and the production methods for the different test wheels used in this test code are specified in Annex C.

Type 27 test wheels shall be mounted on the grinder in five orientations with a 72° rotation about the spindle from the preceding position. Reference lines shall be drawn on the wheel and on the spindle to mark these positions.

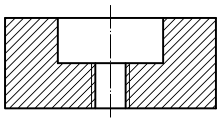
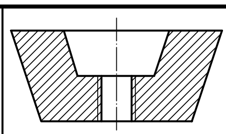
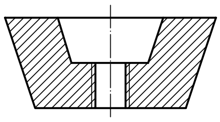
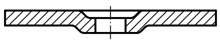
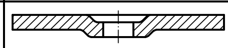
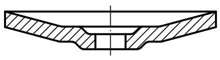
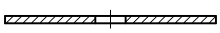
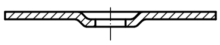
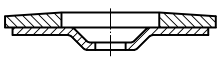
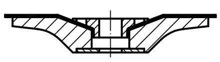
The test wheel shall be mounted as a normal grinding wheel, with flanges as recommended by the manufacturer. It shall be mounted concentrically with the grinder spindle and with zero play. To achieve this, a concentric adaptor bushing as specified in Annex C shall be used.

Type 11 test wheels have mounting threads. These wheels cannot be rotated to five different positions. Instead, the wheel shall be remounted five times for each of the three operators performing the test (see 8.4.3). The test wheel shall be mounted on the machine using the flanges and the mounting torque recommended by the manufacturer.

Test wheels for the different types of machines shall be chosen in accordance with Table 1.

All combinations of machines and guards shall be tested separately. In those cases where more than one type of grinding wheel can be used in one specific guard, the test wheel specified for the heaviest possible grinding wheel shall be used.

Table 1 — Wheel types and corresponding test wheels

Grinding wheel type and designation according to ISO 603-14, ISO 603-16 et al		**Grinding wheel diameter** mm	**Designation of test wheel used**	**Test wheel description**		**Diameter of test wheel** mm	**Unbalance** gmm
Type 6 Straight cup wheel		100 125 150	11:100 11:125 11:150	Type 11 tapered cup test wheel		100 125 150 180	85 140 200 390
Type 11 tapered cup wheel		100 125 150 180	11:100 11:125 11:150 11:180				
Type 27 depressed centre wheel		80 100 115 125 150 180 230 300	27:80 27:100 27:115 27:125 27:150 27:180 27:230 27:300	Type 27 depressed centre test wheel		80 100 115 125 150 180 230 300	37 58 76 90 130 190 305 520
Type 28 depressed centre wheel, cone shaped							
Type 41 straight cutting wheel							
Type 42 depressed centre cutting off wheel							
Type D1 flap disc							
Type D3 fibre disc							

8.4.2 Feed force

During testing, the machine shall be held in the same way as when grinding on a horizontal surface. A force (to simulate the feed force) shall be applied to the handles during testing. The feed force and the mass of the machine shall be counterbalanced by an upward force equal to the sum of the feed force given in Table 2 and the mass of the machine.

For angle grinders, the upward force should be applied using the threaded holes for the support handle. For machines where the support handle can be mounted on either side, a short bolt should be inserted in the empty hole and a short sling of cord should be attached between this bolt and the inner part of the support handle.

For vertical grinders, the sling should be attached to the two handles as close as possible to the motor housing.

For machines with anti-vibration handles, the sling shall be attached between the machine body and the handle and acting on the machine body. Check that the action of the resilient mounting of the handle is not restrained.

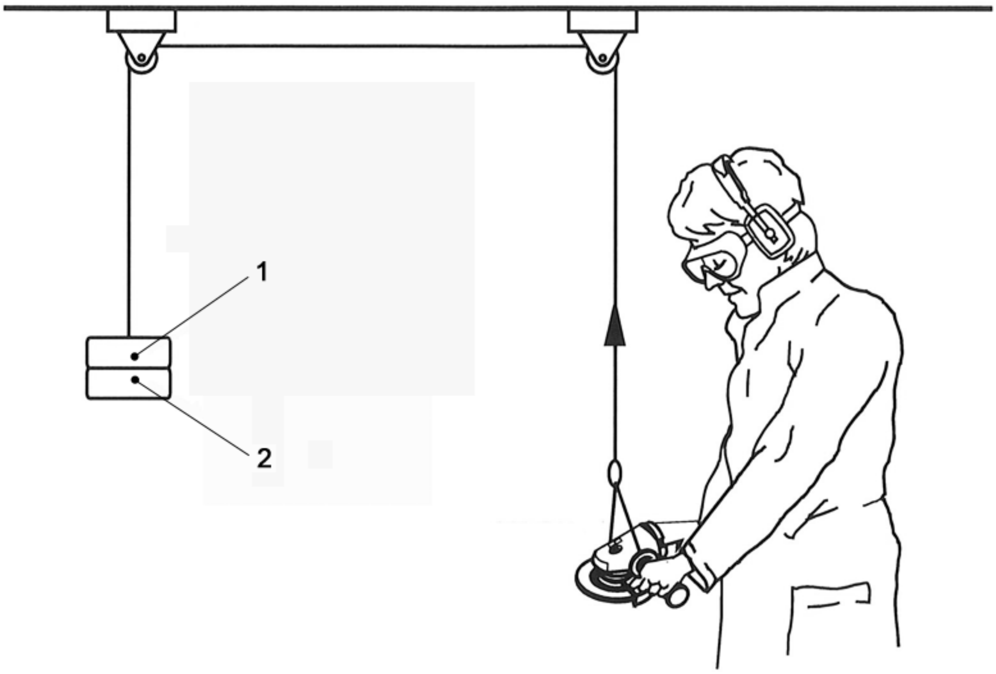
The upward force shall be applied through a cord attached to the sling. The friction between the sling and the cord should be kept low enough as to not restrict the movement of the machine. The force may be applied using a mass and pulley arrangement as shown in Figure 13. Alternatively, a dynamometer may be attached to the cord. The application of the force shall be achieved with minimum adaptation of the grinder.

The forces and torques applied to the handles influence the vibration. It is therefore important that the force and torque distribution between the handles be comparable to that under real work conditions. The machine shall be held with the main handle lifted to give an angle of attack of approximately 20° to the horizontal plane.

NOTE Any mass added to the machine, e.g. fixing devices for the upward force, will alter the inertia of the machine and thereby alter the vibration magnitude.

Table 2 — Feed forces

Diameter of wheel, mm	80	100	115	125	150	180	200	230	300
Feed force, N ± 5 N	15	30	30	30	30	45	45	45	50



Key

1 mass of grinder

2 feed force mass

Figure 13 — Working position of operator and application of feed force using sling

8.4.3 Test procedure

Using a test wheel chosen in accordance with 8.4.1, perform the test as follows.

— For machines tested with type 27 test wheels, each operator (see 8.5) shall carry out a series of five consecutive measurements, one in each orientation, by unfastening and refastening the test wheel. The sequence of measurements shall be 0°, 72°, 144°, 216° and 288°.

— For machines tested with type 11 threaded test wheels, each operator (see 8.5) shall each carry out a series of five consecutive measurements. Between each test, the test wheel shall be unfastened and re-fastened. Due to the design of the wheel, repositioning of the wheel is not possible.

A complete test sequence is set out in the model test report given in Annex A.

Each test run shall be such that the measurements can be carried out for not less than 16 s, when stable operation has been established.

8.5 Operators

Three different operators shall operate the machine during testing. The vibration of the machine is influenced by the operators. They shall therefore be skilled enough to be able to hold and operate the machine correctly.

9 Measurement procedure and validity

9.1 Reported vibration values

Three series of five consecutive tests shall be carried out on each machine tested, using a different operator for each series.

The values (see also 6.4) should be reported for each machine as in Annex A.

The coefficient of variation, C_V, and the standard deviation, s_{n-1}, shall be calculated for each hand position for each of the three operators. The C_V of a test series is defined as the ratio of s_{n-1} to the mean value of the series:

$$C_V = \frac{s_{n-1}}{\overline{a_{hv}}} \tag{3}$$

where the standard deviation of the i^{th} value, a_{hvrati}, measured and corrected using Equation (2) and expressed in m/s^2, is

$$s_{n-1} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(a_{hvrati} - \overline{a_{hv}}\right)^2} \tag{4}$$

where

$\overline{a_{hv}}$ is the mean value of the series in m/s^2;

n is equal to five, the number of measured values.

If C_V is greater than 0,15, or s_{n-1} is greater than 0,3 m/s^2, then the measurements shall be checked for error before the data are accepted.

9.2 Declaration and verification of the vibration emission value

The $\overline{a_{hv}}$ value for each operator shall be calculated as the arithmetic mean of a_{hvrat} values for the five test runs.

For each hand position, the result from the three operators should be combined into one value, a_h, using the arithmetic mean of the three $\overline{a_{hv}}$ values.

For tests using only one machine, the declared value, a_{hd}, is the highest of the a_h values reported for the two hand positions.

For tests using three or more machines, $\overline{a_h}$ values for each hand position shall be calculated as the arithmetic mean of the a_h values for the different machines on that hand position. The declared value, a_{hd}, is the highest of the $\overline{a_h}$ values reported for the two hand positions.

Both a_{hd} and the uncertainty, K, shall be presented with a precision determined in accordance with EN 12096. The value of a_{hd} is to be given in m/s^2 and presented using two and a half significant digits for numbers starting with 1 (e.g. 1,20 m/s^2, 14,5 m/s^2); otherwise, two significant digits are sufficient (e.g. 0,93 m/s^2, 8,9 m/s^2). The value of K shall be presented with the same number of decimals as a_{hd}.

K shall be determined in accordance with EN 12096, based on the standard deviation of reproducibility, σ_R. The value of K shall be calculated in accordance with Annex B.

Underestimation of the vibration for machines equipped with technical means for automatically reducing unbalances shall be taken into account by multiplying the declared vibration values of such machines with a correction factor of 1,3 before the values are reported.

10 Measurement report

The following information shall be given in the test report:

a) reference to this part of ISO 28927 (i.e. ISO 28927-1);

b) name of the measuring laboratory;

c) date of measurement and name of the persons responsible for the test;

d) specification of the hand-held machine (manufacturer, type, serial number etc.);

e) declared emission value a_{hd} and uncertainty K, as well as information on any correction applied;

f) attached or inserted tools;

g) energy supply (air pressure/input voltage etc., as applicable);

h) instrumentation (accelerometer, recording system, hardware, software, etc.);

i) position and fastening of transducers, measuring directions and individual vibration value;

j) operating conditions and other quantities to be specified according to 8.2 and 8.3;

k) detailed results of the test (see Annex A).

If transducer positions or measurements other than those specified in this part of ISO 29827 are used, they shall be clearly defined and an *explanation of the reason* for the change in the position of the transducer shall be inserted in the test report.

Annex A
(informative)

Model test report for vibration emission of angle and vertical grinders

See Tables A.1 and A.2.

Table A.1 — General information and reported results

The test has been carried out in accordance with ISO 28927-1, *Hand-held portable power tools — Test method for evaluation of vibration emission — Part 1: Angle and vertical grinders*	
Tester:	
Measured by: (Company/Laboratory)	Tested by: Reported by: Date:
Test object and declared value:	
Machine tested (power supply and machine type, manufacturer, machine model and name):	Declared vibration emission value (a_{hd} and K, and correction if applied):
Measuring equipment:	
Transducers (manufacturer, type, positioning, fastening method, photos, mechanical filters if used):	
Vibration instrumentation:	Auxiliary equipment:
Operating and test conditions and results:	
Test conditions (test wheel used, location of upward force, operator posture and hand position, photos):	
	Power supply (air pressure, hydraulic flow, voltage):
Feed force:	Any other quantities:

Table A.2 — Measurement results for one machine

Date:			Machine type:						Serial number:					Measured speed:				
			Main handle (hand position 1)								Support handle (hand position 2)							
Test	Operator	Wheel mounting[a]	a_{hwx}	a_{hwy}	a_{hwz}	a_{hvmeas}	a_{hvrat}	Statistics for operator			a_{hwx}	a_{hwy}	a_{hwz}	a_{hvmeas}	a_{hvrat}	Statistics for operator		
								$\overline{a_{hv}}$	s_{n-1}	C_v						$\overline{a_{hv}}$	s_{n-1}	C_v
1	1	1																
2	1	2																
3	1	3																
4	1	4																
5	1	5																
6	2	1																
7	2	2																
8	2	3																
9	2	4																
10	2	5																
11	3	1																
12	3	2																
13	3	3																
14	3	4																
15	3	5																
			a_h for hand position 1:								a_h for hand position 2:							
			s_R for hand position 1:								s_R for hand position 2:							

NOTE The a_{hvrat} and $\overline{a_{hv}}$ values are calculated according to 6.4 and 9.2, s_{n-1} and C_v are calculated according to 9.1, and s_R is calculated according to Annex B.

[a] For unthreaded test wheels, 1 to 5 equals mounting angles 0°, 72°, 144°, 216°, 288°. For threaded test wheels, a remount shall be done for each test.

Annex B
(normative)

Determination of uncertainty

B.1 General

The uncertainty value, K, represents the uncertainty of the declared vibration emission value, a_{hd}, and, in the case of batches, production variations of machinery. It is expressed in m/s^2.

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

B.2 Tests on single machines

For tests made on a single machine only, K shall be given as

$$K = 1,65\sigma_R$$

where σ_R is the standard deviation of reproducibility, estimated by the value, s_R, given as

$$s_R = 0,2a_h$$

For the hand position having the highest $a_h$value, a_{hd} is equal to a_h:

$$K = 0,33a_{hd}$$

NOTE The value of the standard deviation of reproducibility, s_R, is based on a round-robin test made on grinders (see ISO/TR 27609): s_R was found to vary with the measured vibration magnitude and could be estimated to be 0,2a_h.

B.3 Tests on batches of machines

For tests on three or more machines, K shall be given as:

$$K = 1,5\sigma_t$$

where σ_t is estimated by s_t:

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

The calculations are performed on the hand position having the highest a_{hd} value and where

$$s_R = 0,2a_{hd}$$

s_b is the standard deviation of the test results for individual machines, i.e.

$$s_b{}^2 = \frac{1}{n-1}\sum_{i=1}^{n}(a_{hi} - \overline{a_h})^2$$

where

a_{hi} is the single-machine emission for the i^{th} machine;

$\overline{a_h}$ is the mean value of the single-machine emissions for one hand position;

a_{hd} is the highest of the $\overline{a_h}$ values reported for two hand positions;

n is the number of machines tested ($\geqslant 3$).

Annex C
(normative)

Design of test wheel

C.1 General

The test wheel shall have machined holes on specified radii to give defined unbalances. Aluminium of type EN AW 2014 (AlCu4SiMg), as specified in EN 755-2, or an equivalent material, shall be used.

The density should be within 2 700 kg/m^3 to 2 800 kg/m^3.

Test wheels shall be manufactured in accordance with Figures C.1 to C.4. They shall be measured and adjusted to the given unbalance with an accuracy higher than 5 % of the actual unbalance.

C.2 Basic geometry of aluminium test wheels

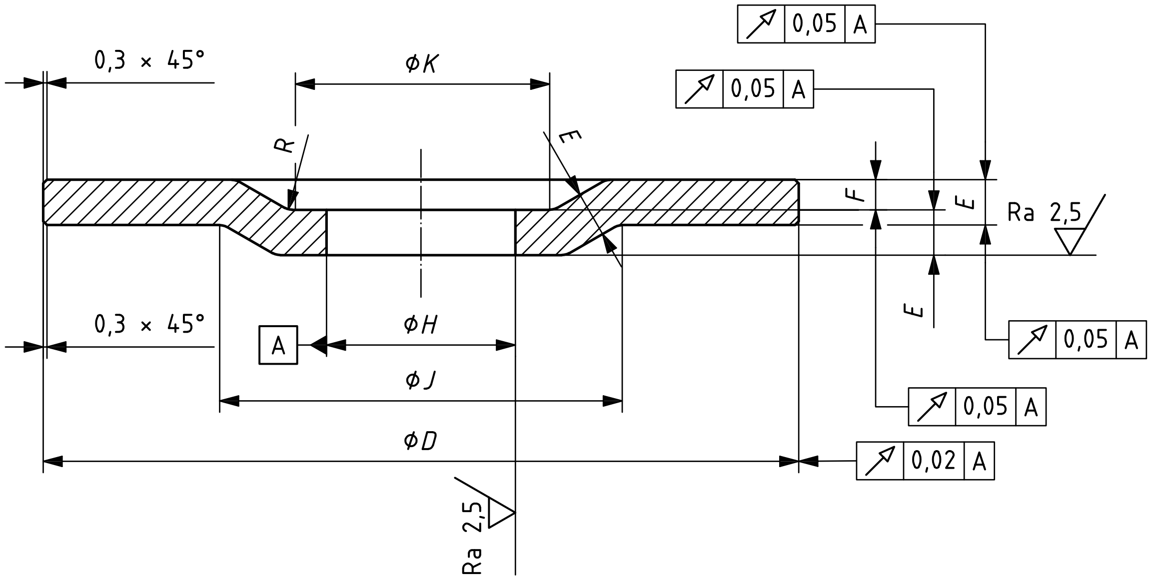
C.2.1 Type 27 depressed centre test wheels

Figure C.1 and Table C.1 give the required geometrical dimensions and machining tolerances for type 27 depressed centre test wheels. The information on how to machine the unbalance holes and the bushings required for assembly on the machines are given in separate clauses.

Table C.1 — Dimensions and tolerances of type 27 test wheels

Dimensions in millimetres

Designation of test wheel	Outside diameter *D* ± 0,02 mm	Thickness *E* ± 0,05 mm	Bore diameter *H* g7	Internal diameter of recess *K* ± 0,5 mm	Depth of recess *F* ± 0,1 mm	Corner radius of recess *R*	Diameter of the depressed centre *J* ± 0,5 mm
27:80	80	6	16	23	4	2	42
27:100	100	6	25	35,5	4	2	54,5
27:115	115	6	28	45	4,6	2	64
27:125	125	6	28	45	4,6	2	64
27:150	150	6	28	45	4,6	2	64
27:180	180	6	28	45	4,6	2	64
27:230	230	6	28	45	4,6	2	64
27:300	300	6	28	45	4,6	2	64



Key

D outside diameter

E thickness

F depth of recess

H bore diameter

J diameter of depressed centre

R corner radius of recess

K internal diameter of recess

Figure C.1 — Geometrical dimensions and machining tolerances for type 27 test wheels

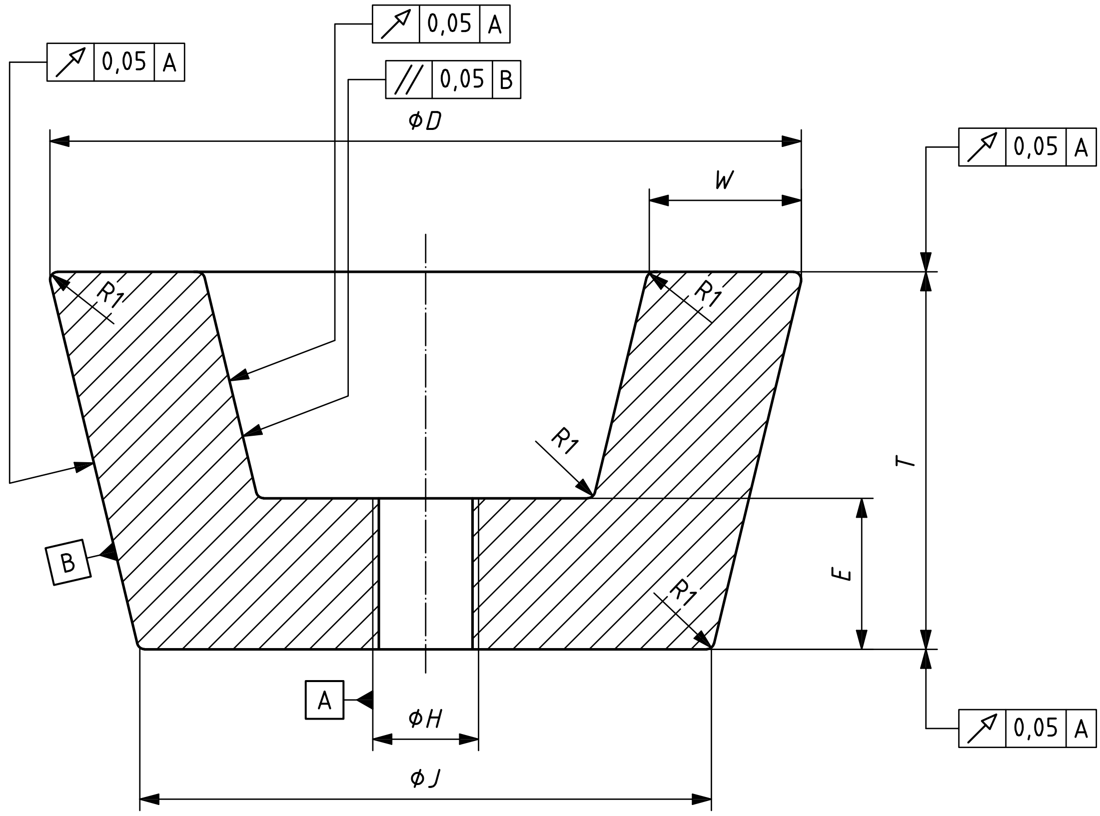
C.2.2 Type 11 tapered cup test wheels

Figure C.2 and Table C.2 give the required geometrical dimensions and machining tolerances for type 11 tapered cup test wheels.

Table C.2 — Dimensions and tolerances of type 11 test wheels

Dimensions in millimetres

Designation of test wheel	Outside diameter *D* ± 0,2 mm	Thickness *T* ± 0,2 mm	Thread *H*	Smallest diameter *J* ± 0,2 mm	Rim width *W* ± 0,1 mm	Thickness at threaded bore *E* ± 0,2 mm
11:100	100	50	M14 or UNC 5/8"	76	20	20
11:125	125	50	M14 or UNC 5/8"	94	25	20
11:150	150	50	M14 or UNC 5/8"	120	30	20
11:180	180	80	M14 or UNC 5/8"	120	41	25



Key

D outside diameter

E thickness at threaded bore

H thread

J smallest diameter of tapered wheel

T thickness

W rim width

Figure C.2 — Geometrical dimensions and machining tolerances for type 11 test wheels

C.3 Unbalance holes

C.3.1 Type 27 depressed centre test wheels

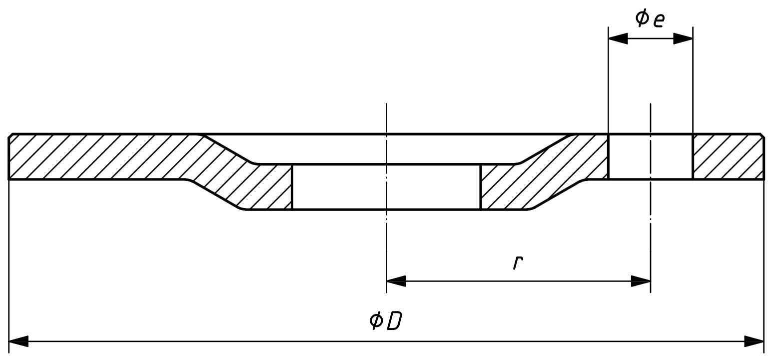
The unbalance is generated by machining a hole in the aluminium wheel. First, machine the hole to a bore smaller than needed to reach the defined unbalance. Measure the unbalance and increase the bore until the defined unbalance is reached.

The defined unbalance is chosen to be in the area of 40 % of the maximum allowed unbalance according to ISO 6103.

For type 27 depressed centre test wheels the unbalances, the diameter of the drilled hole and the radius for the centre of the hole shall be in accordance with Table C.3 and Figure C.3. The holes shall be drilled through.

Table C.3 — Unbalance hole dimensions for type 27 test wheels

Designation of test wheel	Wheel diameter *D* mm	Unbalance gmm ± 5 %	Hole diameter *e* mm	Radius to centre of hole *r* mm ± 0,1 mm
27:80	80	37	9,8	30
27:100	100	58	11,3	35
27:115	115	76	12,1	40
27:125	125	90	12,4	45
27:150	150	130	12,9	60
27:180	180	190	14,0	75
27:230	230	305	15,4	100
27:300	300	520	17,3	135



Key

D wheel diameter

e hole diameter

r radius to centre of hole

Figure C.3 — Unbalance hole dimensions for type 27 test wheels

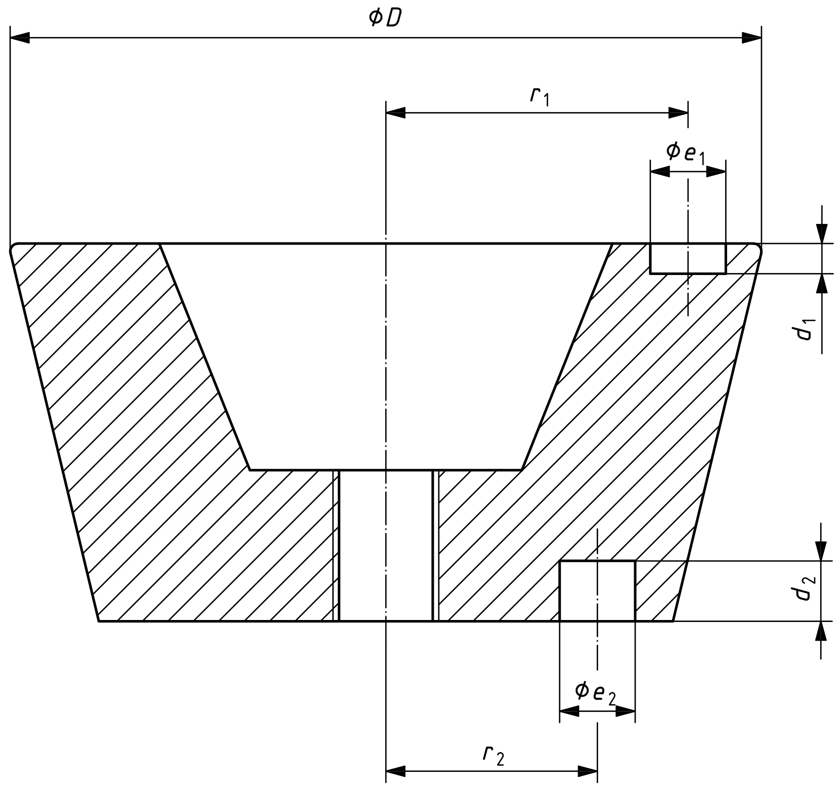
C.3.2 Type 11 taper cup test wheel

For type 11 test wheels, the unbalance is created by drilling two holes, one from the front and one from the rear. The holes shall have a flat bottom and be positioned in the same plane. The direction is parallel to the centre hole. Two holes are needed in order to realistically distribute the unbalance over the thickness of the test wheel. The diameters of the drilled holes and the radius for the centre of the holes shall be in accordance with Table C.4 and Figure C.4.

Machine the holes on the rear side to the depth given and machine the holes on the front side to a smaller depth. Measure the unbalance and increase depth or diameter until the defined unbalance is reached.

Table C.4 — Unbalance hole dimensions for type 11 test wheels

Designation of test wheel	Wheel diameter D mm	Unbalance gmm ± 5 %	Front hole diameter e_1 mm	Radius to centre of front hole r_1 mm ± 0,1 mm	Front hole depth d_1 mm	Rear hole diameter e_2 mm ± 0,05 mm	Radius to centre of rear hole r_2 mm ± 0,1 mm	Rear hole depth d_2 mm ± 0,05 mm
11:100	100	85	10	40	4	10	28	8
11:125	125	140	10	50	5,5	10	37	9,7
11:150	150	200	10	60	7,7	10	50	9
11:180	180	390	10	70	13,4	10	50	16,7
The front and rear holes are located in the same plane and should have a flat bottom and surface.								



Key

D wheel diameter
d_1 front hole depth
d_2 rear hole depth
e_1 front hole diameter
e_2 rear hole diameter
r_1 radius to centre of front hole
r_1 radius to centre of front hole

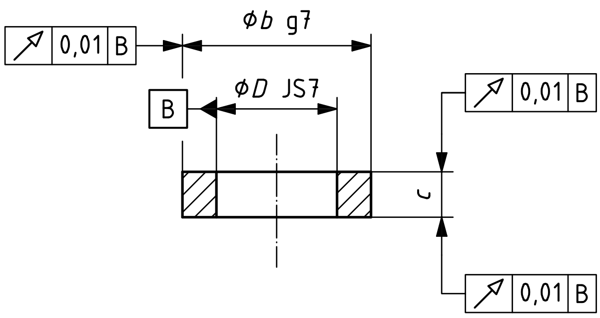
Figure C.4 — Unbalance hole dimensions for type 11 test wheels

C.4 Bushings for type 27 test wheels

The test wheel shall be mounted with zero play. When mounting, choose the bushing with the best fit to the spindle, in accordance with Table C.5. Other inner diameters may be used if found to give a better fit to the spindle. See Figure C.5 for a description of the dimensions. The material is mild steel, similar to type E235 according to ISO 630.

Table C.5 — Dimension of bushings to be used with type 27 test wheels

Diameter *b*	**Thickness** *C*	**Bore diameter** *D*
	mm	
g7	– 0,1 mm – 0,2 mm	JS7
16	6	10 10,04 10,08 10,12
25	6	16 16,04 16,08 16,12
28	6	22,00 22,04 22,08 22,12 22,16 22,20



Key

b diameter
c thickness
D bore

Figure C.5 — Geometrical dimensions and machining tolerances for mounting bushings

Bibliography

[1] ISO 603-14, *Bonded abrasive products — Dimensions — Part 14: Grinding wheels for deburring and fettling/snagging on an angle grinder*

[2] ISO 603-16, *Bonded abrasive products — Dimensions — Part 16: Grinding wheels for cutting-off on hand held power tools*

[3] ISO 5429, *Coated abrasives — Flap wheels with incorporated flanges or separate flanges*

[4] ISO 6103, *Bonded abrasive products — Permissible unbalances of grinding wheels as delivered — Static testing*

[5] ISO 12100, *Safety of machinery — General principles for design, risk assessment and risk reduction*

[6] ISO/TR 27609, *Vibration in hand-held tools — Vibration measurement methods for grinders — Evaluation of round-robin test*

[7] IEC 60745 (all parts), *Hand-held motor-operated electric tools — Safety*

BSI - British Standards Institution

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

Revisions

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

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

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

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001 Email: orders@bsigroup.com You may also buy directly using a debit/credit card from the BSI Shop on the Website http://www.bsigroup.com/shop

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

Information on standards

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

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

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsigroup.com/BSOL

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

BSI Group Headquarters 389 Chiswick High Road, London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/standards