INTERNATIONAL STANDARD

ISO 28927-12

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

Part 12:
Die grinders

Machines à moteur portatives — Méthodes d'essai pour l'évaluation de l'émission de vibrations —

Partie 12: Meuleuses d'outillage

Reference number
ISO 28927-12:2012(E)

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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 28927-12 was prepared by Technical Committee ISO/TC 188, *Compressors and pneumatic tools, machines and equipment*, Subcommittee SC 3, *Pneumatic tools and machines*.

This first edition of ISO 28927-12 cancels and replaces ISO 8662-13:1997, which has been technically revised. It also incorporates the Technical Corrigendum ISO 8662-13:1997/Corr.1:1998. The most important changes are

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

— new test method; a real grinding process is introduced, and

— new transducer positions, with an improved definition of the transducer positions and orientation.

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*[1)]

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

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

— *Part 4: Straight grinders*[4)]

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

— *Part 6: Rammers*[6)]

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1) Together with ISO 28927-4, replaces ISO 8662-4, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 4: Grinders*.

2) 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.

3) 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.*

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

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

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

— *Part 7: Nibblers and shears*[7)]

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

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

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

— *Part 11: Stone hammers*[11)]

— *Part 12: Die grinders*[12)]

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

8) 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*.

9) 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.*

10) Replaces ISO 8662-2 and its amendments, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 2: Chipping hammers and riveting hammers,* ISO 8662-3 and its amendments, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 3: Rock drills and rotary hammers*, and ISO 8662-5 and its amendments, *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.

11) 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*.

12) Replaces ISO 8662-13 *Hand-held portable power tools — Measurement of vibrations at the handle — Part 13: Die Grinders*.

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 (all parts) 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 (all parts) 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 IEC 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 die grinders vary considerably in typical use. This is largely due to variations in the unbalance of the inserted tool and from the contact between the inserted tool and the surface of the workpiece. The vibration value is also to a large extent dependent on the skill of the operator. This part of ISO 28927 uses a real working process for the test.

In order to provide a method that gives good measurement reproducibility, the procedure is described in detail and it is essential that the procedure be followed. The procedure is chosen to give vibration values which are, as far as possible, in accordance with ISO 20643.The values obtained according to this part of ISO 28927 are type-test values. The procedures of ISO 5349 are required whenever exposure at the workplace is to be assessed.

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 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 can 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 inserted tools, bent shafts of burrs or worn-out collets.

The vibration test codes given in ISO 28927 (all parts) supersede those given in ISO 8662 (all parts), which has 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*, can be replaced by a future part of ISO 28927.

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

Part 12: **Die 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 portable die grinders. It is a type-test procedure for establishing the magnitude of vibration in the gripping areas of the machines where operating under type test conditions. 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, equipped with a collet and intended for deburring operations using hard metal burrs or mounted points, on different materials ranging from hard steel to plastics. It is also applicable to low-speed die grinders using flap wheels or cylindrical sleeves.

NOTE 1 It is not applicable to straight grinders equipped with type 1 straight wheels, type 4 tapered wheels or different types of cylindrical plugs. For those machines, ISO 28927-4 is applicable.

NOTE 2 It is not applicable to die grinders used with wire brushes.

NOTE 3 To avoid confusion with the terms "power tool" and "inserted tool", "machine" is used hereinafter for "power tool".

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 630 (all parts), *Structural steels*

ISO 2421, *Coated abrasives — Cylindrical sleeves*

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

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

ISO 5391, *Pneumatic tools and machines — Vocabulary*

ISO 15637-1, *Holding fixtures of cylindrical abrasive sleeves — Part 1: Holding fixtures with shank for hand-held grinding machines*

ISO 17066, *Hydraulic tools — Vocabulary*

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

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

DIN 8033-1, *Hardmetal burrs — Technical requirements*

DIN 8033-2, *Hardmetal burrs — Cylindrical burrs*

3 Terms, definitions and symbols

3.1 General

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

3.2 Terms and definitions

3.2.1
die grinder
machine for deburring and light cleaning operations, the output spindle normally being fitted with a collet, making it suitable for use with mounted points and hardmetal burrs

NOTE 1 A die grinder with a burr may also be called a file.

NOTE 2 Adapted from ISO 5391:2003, definition 2.1.5.

3.2.2
straight die grinder
die grinder having the output spindle coaxial with the motor axis

[ISO 5391:2003, definition 2.1.5.1]

3.2.3
angle die grinder
die grinder where the output spindle is at an angle to the motor axis of the tool

[ISO 5391:2003, definition 2.1.5.2]

3.3 Symbols

For the purposes of this document, the following symbols apply.

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; is the root sum of squares of the a_{hw} values for the three measured axes of vibration	m/s^2
$\overline{a_{\mathrm{hv}}}$	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 $\overline{a_{\mathrm{hv}}}$ values for all operators for one hand position	m/s^2
$\overline{a_{\mathrm{h}}}$	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
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 and Annex B the means for determining the uncertainty, K.

5 Description of the family of machines

This part of ISO 28927 is applicable to hand-held machines, driven pneumatically or by other means, equipped with a collet and intended for deburring operations using hard metal burrs or mounted points, on different materials ranging from hard steel to plastics. It is also applicable to low-speed die grinders using flap wheels or cylindrical sleeves.

Figures 1 to 4 show examples of typical grinders covered by this part of ISO 28927.

Figure 1 — Straight die grinder — Short version

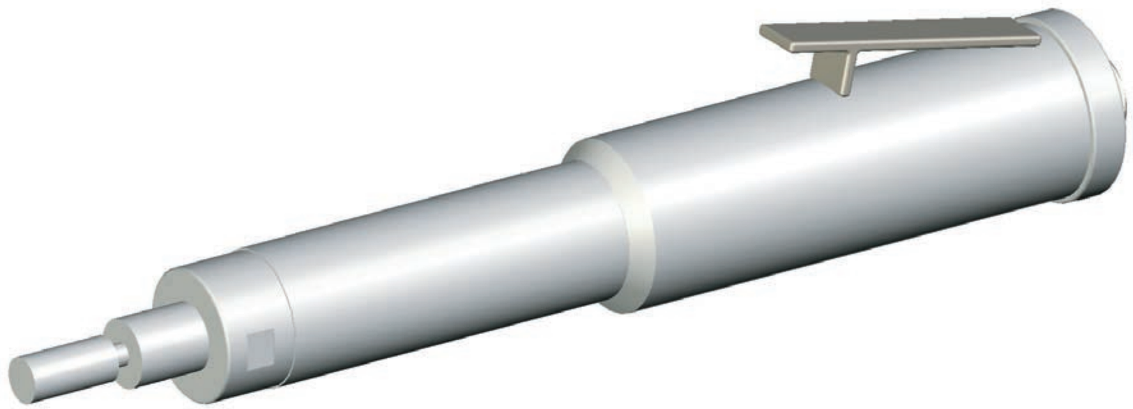


Figure 2 — Straight die grinder — Long version

Figure 3 — Angle die grinder

Figure 4 — Pencil die grinder

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 5 to 8.

6.2 Location of measurements

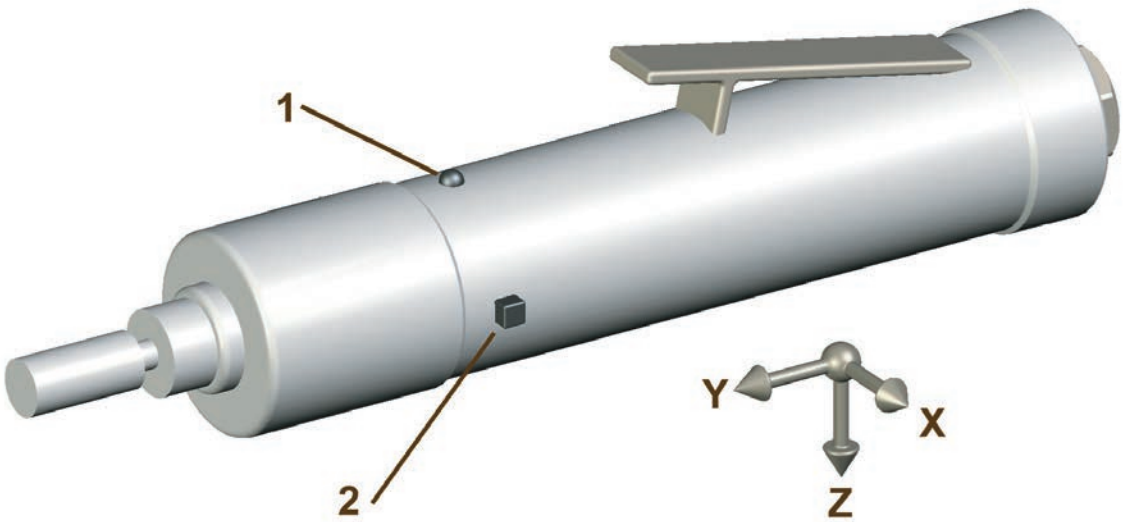
Measurement shall be carried out at the gripping zones, where the operator normally holds the machine and applies the feed force. For machines intended for one-hand operation, it is necessary to measure at only a single point.

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 the prescribed location of the transducer cannot be used, this secondary location shall be used instead.

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

Figures 5 to 8 show the prescribed and secondary locations and measurement directions for the hand positions normally used for the different types of machines in this family.

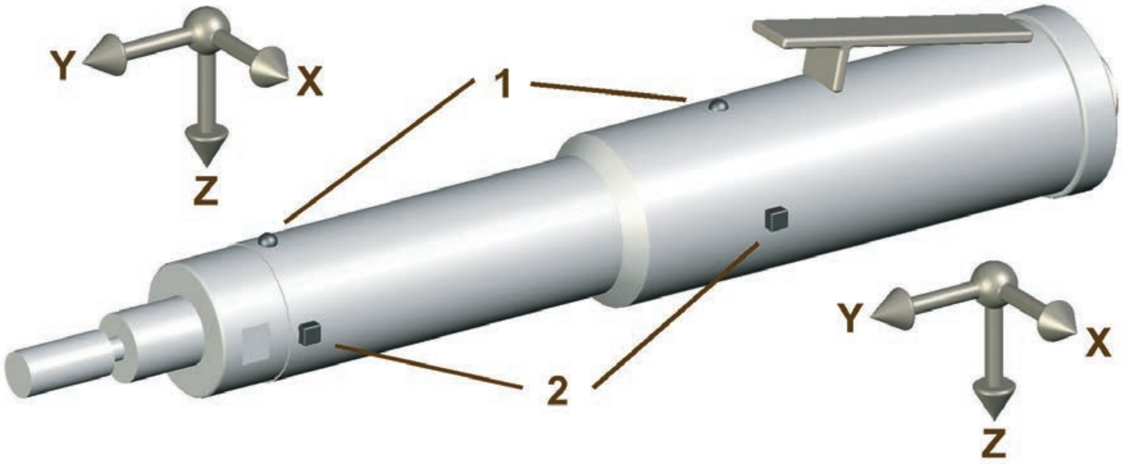


Key

1 prescribed location

2 secondary location

Figure 5 — Measurements locations — Straight die grinder — Short version

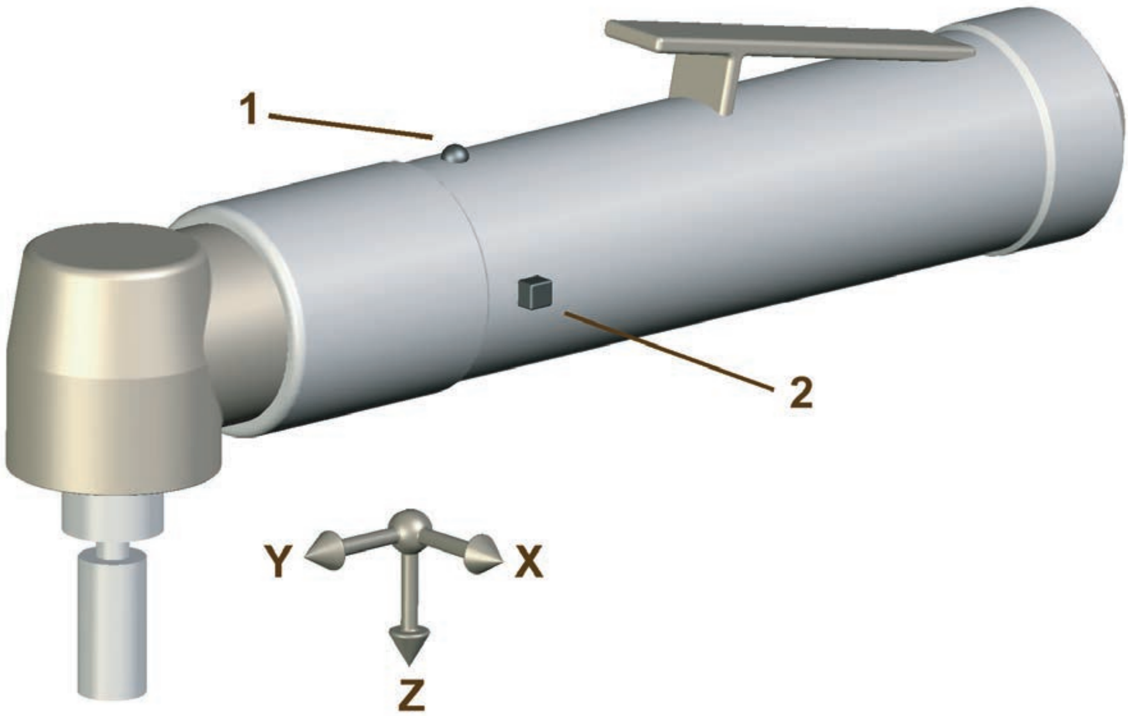


Key

1 prescribed location

2 secondary location

Figure 6 — Measurements locations — Straight die grinder — Long version

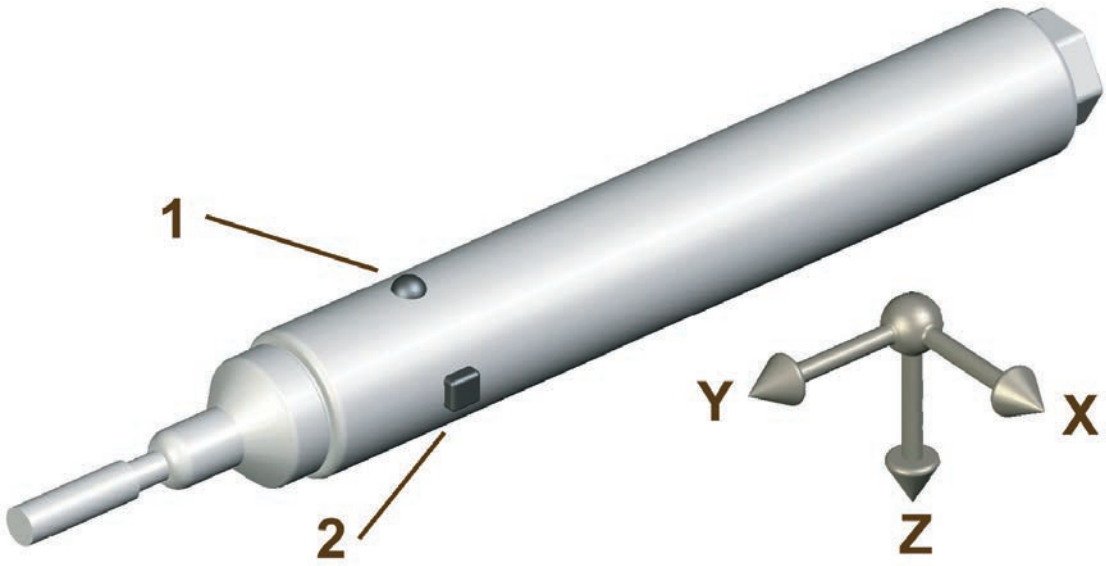


Key

1 prescribed location

2 secondary location

Figure 7 — Measurements locations — Angle die grinder



Key

1 prescribed location

2 secondary location

Figure 8 — Measurements locations — Pencil die grinder

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 whenever applicable. It is acceptable to report and carry out tests on that 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 done by one operator and five test runs.

To obtain the vibration total value, a_{hv}, for each test run, the results in each direction shall be combined using Formula (1):

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

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 for the transducers 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 (covered in ISO 5349-2).

7.2.2 Fastening of transducers

The transducer or the 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 a maximum of 10 mm from the surface.

It is normally not necessary to use mechanical filters for measurements according to this part of ISO 28927.

7.3 Frequency weighting filter

Frequency weighting 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 8.4.4.

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[13)].

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 accuracy equal to or better than 3 % of the actual value.

The feed force shall be measured with an accuracy better than 1 N, for example with the operator standing on a scale.

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, properly serviced and lubricated machines. 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.

Die grinders are tested performing a real work task. Die grinding is performed on the narrow side of a piece of mild steel. The steel piece shall be rigidly fixed in a vice. Feed force shall be measured and reported while the machine is slowly moved over the steel piece. To get good reproducibility, it is important to follow in detail the test procedure described in 8.4.

Machines intended for one-handed operation shall be held with only one hand during testing. Measurements shall be carried out in one location only and for the hand position used.

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

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13) 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 operate at the rated pressure, 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 machine 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 influences 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 more than 0,2 bar below the pressure recommended by the manufacturer.

8.2.2 Hydraulic machines

During testing, the machine shall be operated 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 be operated 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 power supply: air pressure, hydraulic flow, voltage used, shall be measured and reported.

The feed force used shall be measured and reported.

8.4 Attached equipment, workpiece and task

8.4.1 Attached equipment for die grinders with shaft diameter smaller than 6 mm

Die grinders with rotational speeds of 9 000 r/min and higher are tested in a grinding operation using a hardmetal burr on a bar of mild steel. The size of the burr is chosen from Table 1. The burr shall have a cylindrical shape as style A in DIN 8033-1. The free shaft length of the burr, L_F, in Figure 9, shall be shorter than the length of the cutting part of the burr, L, in Figure 9.

Table 1 — Dimensions of hardmetal burr with shaft diameter smaller than 6 mm

Rated rotational speed kr/min	Diameter of the burr D mm	Length of burr L mm	Tooth type
70 to 100	2	10	ZYA MX
50 to 70	3	13	ZYA MX
35 to 50	4	13	ZYA MX
<35	6	16	ZYA MX

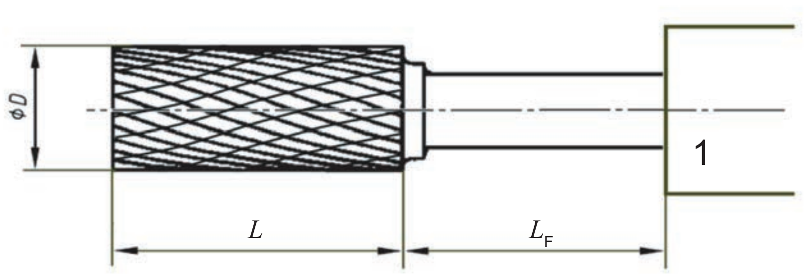
If the rated rotational speed of the die grinder is on the border between two speed ranges, the burr size in the higher speed range shall be used.

The length and diameter of the burr are dealt with in DIN 8033-2, and the shape of the helix and cut are dealt with in DIN 8033-1.

Machines for special applications that would not normally be used with a hardmetal burr as described in Table 1 should be equipped with the inserted tool normally used. The type of inserted tool should be described in the test report.

8.4.2 Attached equipment for die grinders with shaft diameter 6 mm and greater

Die grinders with rotational speeds 9 000 r/min and higher are tested in a grinding operation using a hardmetal burr on a bar of mild steel. The size of the burr is chosen from Table 2. The burr shall have a cylindrical shape as style A in DIN 8033-1. The free shaft length of the burr, L_F, in Figure 9, shall be shorter than the length of the cutting part of the burr, L, in Figure 9.



Key

1 collet

D diameter

L_F free shaft length

L length of burr

Figure 9 — Hardmetal burr shape

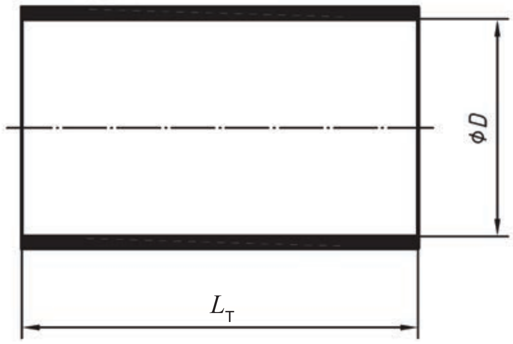
Table 2 — Dimensions of hardmetal burr with a shaft diameter 6 mm **and greater**

Rated rotational speed kr/min	**Diameter of the burr** D mm	**Length of burr** L mm	**Tooth type**
70 to 100	2	10	ZYA MX
50 to 70	3	13	ZYA MX
35 to 50	4	13	ZYA MX
25 to 35	6	16	ZYA MX
19 to 24	8	20	ZYA MX
15 to 19	10	20	ZYA MX
12 to 15	12	25	ZYA MX
9 to 12	16	25	ZYA MX

If the rated rotational speed of the die grinder is on the border between two speed ranges, the burr size in the higher speed range shall be used.

The length and diameter of the burr are dealt with in DIN 8033-2, and the shape of the helix and cut is dealt with in DIN 8033-1.

Machines with rotational speeds of lower than 9 000 r/min are tested in a grinding operation using a cylindrical sleeve 120 grit suitable for working on steel in accordance with ISO 2421 mounted on a holding fixture in accordance with ISO 15637-1. The free shaft length of the holding fixture, L_F, in Figure 11, shall be shorter than the length of the cylindrical sleeve, L_T, in Figure 10 (see Table 3).

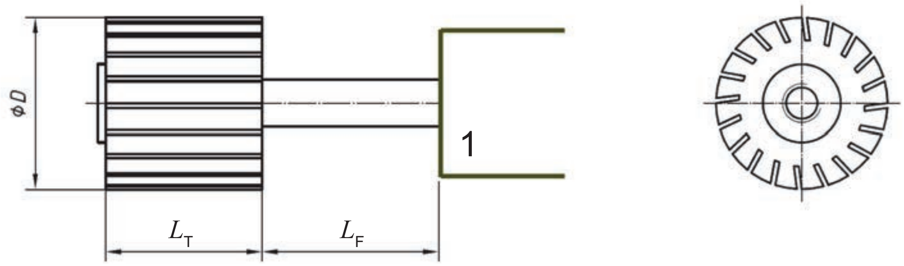


Key

D diameter

L_T length of cylindrical sleeve

Figure 10 — Cylindrical sleeve



Key

1 collet

D diameter

L_F free shaft length

L_T length of cylindrical sleeve

Figure 11 — Holding fixture

Table 3 — Dimensions of cylindrical sleeve and holding device with a shaft diameter of 6 mm **and greater**

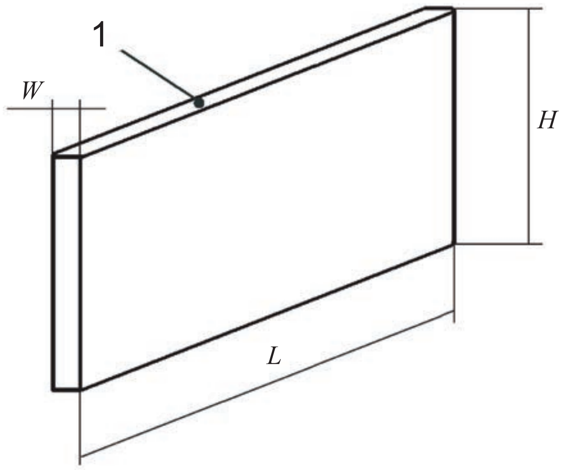
Rated rotational speed r/min	**Diameter,** D mm	**Length,** L_T mm
7 500 to 9 000	60	30
5 000 to 7 500	75	30
<5 000	100	40

If the rated rotational speed of the die grinder is on the border between two speed ranges, the cylindrical sleeve size in the higher speed range shall be used.

Machines for special applications that are not normally used with a hardmetal burr or cylindrical sleeve, as described in Table 2 or 3, should be equipped with the inserted tool normally used. The type of inserted tool should be described in the test report.

8.4.3 The workpiece

The workpiece shall be a bar of mild steel to type E235 in accordance with ISO 630 (all parts) mounted in a rigid foundation like e.g. a vice. The dimensions of the steel plate shall be according to Figure 12 and Table 4.



Key

1 surface A

Figure 12 — Dimensions of the workpiece

Table 4 — Dimensions of the workpiece

Rated rotational speed kr/min	**Length,** L mm	**Height,** H mm	**Width**, W mm
Above 50	200	30	1,5
Up to 50	250	30	4

The mounted workpiece shall not have any resonances within the frequency range for the hand-arm vibration that could influence the test results.

8.4.4 Test procedure

Grinding is carried out on surface A in Figure 12 of a bar of mild steel similar to type E235 in accordance with ISO 630 (all parts) with dimensions according to Table 4. The bar shall be rigidly fixed, e.g. in a vice with the surface A horizontal. Feed force shall be measured and reported while the machine is moved slowly over the surface. It is preferable to move the machine back and forth, but repeated movement in only one direction is allowed to avoid problems with chattering. During grinding, the shaft of the die grinder shall be kept horizontal and at 90° to the line of the top edge of the workpiece (see Figure 13). The test run shall simulate a deburring operation. Feed force should therefore be kept rather low, just enough to ensure smooth operation. During the grinding with the hardmetal burr, the surface tends to get uneven. To ensure smooth operation, the surface shall therefore be flattened at least between operators. This can be done by milling or by grinding with an angle grinder equipped with a depressed centre wheel. During the test, the main handle (tool body) shall be held with one hand. Check and clean the groves in the burr between operators. The front part of machines intended for one-hand operation is guided with a light grip using the thumb and index finger. Machines intended for two-hand operation shall be gripped also around the front part. Machines intended for one-hand operation shall be measured only in one position, while machines intended for two-hand operation shall be measured in both hand positions.

8.4.5 Feed force

The vertical feed force, in addition to the mass of the machine, shall ensure that the machine operates smoothly. Chattering can give substantially higher vibrations and should always be avoided also in normal work with the machine. During the test, chattering shall be avoided. It is not regarded to be part of a normal work situation.

A feed force of between 5 N and 15 N is normal. In the test, the feed force should be chosen to ensure that the machine operates smoothly also if that feed force is outside the range of 5 N to15 N. The feed force shall be applied and controlled by the operator (e.g. by standing on a scale during the test), and its value displayed to the operator. The feed force shall be measured and reported.

The height of the workpiece shall be adjusted to allow the operator to perform the task using a normal posture.

Figure 13 — Working position of operator

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.

8.5 Operator

Three different operators shall operate the machine during the test. The vibration of the machine is influenced by the operators. The operators 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 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 coefficient of variation of a test series is defined as the ratio of s_{n-1} to the mean value of the series:

$$C_V = \frac{s_{n-1}}{\overline{a_{\mathrm{hv}}}} \quad (2)$$

with s_{n-1} identical to s_{rec} (see Annex B) and where the standard deviation of the ith value, $a_{\mathrm{hv}i}$, is given as:

$$s_{n-1} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(a_{\mathrm{hv}i} - \overline{a_{\mathrm{hv}}}\right)^2} \quad (3)$$

where

$\overline{a_{\mathrm{hv}}}$ is the mean value of the series, in metres per square second (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, the measurements shall be checked for error before data are accepted.

9.2 Declaration and verification of the vibration emission value

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

For each hand position, the result from the three operators should be combined to one value, a_{h}, using the arithmetic mean of the three $\overline{a_{\mathrm{hv}}}$ 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, $\overline{a_{\mathrm{h}}}$ 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 $\overline{a_{\mathrm{h}}}$ values reported for the two hand positions.

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

10 Measurement report

The following information shall be given in the test report:

a) reference to this part of ISO 28927 (i.e. ISO 28927-12);

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;

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 values;

j) operating conditions as specified in 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 die 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 28927-12: *Hand-held portable power tools — Test method for evaluation of vibration emission — Part 12: Die 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, rated no-load speed):	Declared vibration emission value: (a_{hd} and K)
Measuring equipment:	
Transducers (manufacturer, type, positioning, fastening method, photographs, mechanical filters, if used):	
Vibration instrumentation:	Auxiliary equipment:
Operating and test conditions and results:	
Test conditions (see 8.2 to 8.4; type and dimensions of inserted tool used, material, workpiece, photograph of hand position):	
Power supply (air pressure, hydraulic flow, voltage):	Measured feed force:
Any other quantities to report:	

Table A.2 — Measurement result for one machine

Date			Machine type:				Serial number:						Measured rotational speed:			
			Main handle (hand position 1)							Support handle (hand position 2)						
							Statistics for operator							Statistics for operator		
Test	Operator	Test run	a_{hwx}	a_{hwy}	a_{hwz}	a_{hv}	$\overline{a_{hv}}$	s_{n-1}	C_V	a_{hwx}	a_{hwy}	a_{hwz}	a_{hv}	$\overline{a_{hv}}$	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_{hv} 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.

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 metres per square second.

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 whenever the machines are new.

B.2 Tests on single machines

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

$$K = 1{,}65\sigma_{\mathrm{R}}$$

where σ_{R} is the standard deviation of reproducibility, estimated by the value s_{R}, given by

a) $s_{\mathrm{R}} = \sqrt{\overline{s_{\mathrm{rec}}}^2 + s_{\mathrm{op}}^2}$

or

b) $s_{\mathrm{R}} = 0{,}06a_{\mathrm{hd}} + 0{,}3$,

whichever is the greater.

NOTE 1 Formula b) is empirical, based on experience giving a lower limit for s_{R}.

The calculations are performed on the hand position giving the highest value of a_{h} where

$\overline{s_{\mathrm{rec}}}^2$ is the arithmetic mean value of the standard deviation from the results of five tests, $s_{\mathrm{rec}j}$, for operator j, identical to s_{n-1} according to 9.2, and with the $s_{\mathrm{rec}j}{}^2$ value for each operator calculated using:

$$s_{\mathrm{rec}j}{}^2 = \frac{1}{n-1}\sum_{i=1}^{n}(a_{\mathrm{hv}ji} - \overline{a_{\mathrm{hv}j}})^2$$

where

n is five, the number of measured values;

$a_{\mathrm{hv}ji}$ is the vibration total value for the ith test with the jth operator;

$\overline{a_{\mathrm{hv}j}}$ is the average vibration total value of measurements on the jth operator;

s_{op} is the standard deviation of the results from the three operators, i.e.

$$s_{op}{}^2 = \frac{1}{m-1}\sum_{j=1}^{m}(\overline{a_{hvj}} - a_h)^2$$

where

m	is three, i.e. the number of operators;
$\overline{a_{hvj}}$	is the average vibration value from the jth operator (average of five tests);
a_h	is the average vibration value from all three operators;
a_{hd}	is the highest of the a_h values reported for the two hand positions.

NOTE 2 The value of s_R is an estimate of the standard deviation of reproducibility of testing performed at different test centres. Since, at the time of publication, there is no information on reproducibility for the tests defined in this part of ISO 29827, the value for s_R is based on the repeatability of the test for individual test subjects and across the different test subjects, according to EN 12096.

B.3 Tests on batches of machines

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

$$K = 1{,}5\sigma_t$$

where σ_t is estimated by the value s_t, given by

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

or

b) $s_t = 0{,}06a_{hd} + 0{,}3$,

whichever is the greater.

The calculations are performed on the hand position giving the highest value of $\overline{a_h}$ and where

$\overline{s_R{}^2}$	is the mean value of $s_R{}^2$ for the different machines in the batch, with the s_R value for each machine calculated using B.2 a), above;
s_b	is the standard deviation of the test results for individual machines, i.e.

$$s_b{}^2 = \frac{1}{p-1}\sum_{l=1}^{p}(a_{hl} - \overline{a_h})^2$$

where

a_{hl}	is the single-machine emission for one hand position on the lth 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 the two hand positions;
p	is the number of machines tested (≥ 3).

Bibliography

[1] ISO 7755-1, *Hardmetal burrs — Part 1: General specifications*

[2] ISO 7755-2, *Hardmetal burrs — Part 2: Cylindrical burrs (style A)*

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

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

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