INTERNATIONAL STANDARD

ISO 28927-3

First edition
2009-12-15

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

Part 3: Polishers and rotary, orbital and random orbital sanders

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

Partie 3: Polisseuses-lustreuses et ponceuses rotatives, orbitales et orbitales spéciales

Reference number
ISO 28927-3:2009(E)

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 28927-3 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 28927-3 cancels and replaces ISO 8662-8:1997, 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, and

— improved definition of transducer positions and orientation.

ISO 28927 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*

— *Part 4: Straight grinders*[3)]

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

— *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)]

---

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 polishers and all types of sanders vary considerably in typical use. The variation is largely due to variations in the unbalance of the sanding or polishing pad and to differences in the contact between the inserted tool and the surface of the work piece. Orbital and random orbital sanders are sensitive to changes in the weight of the sanding pad because the weight is counterbalanced by counterbalance weights in the machine. The vibration value also depends to a large extent 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 — chosen to give vibration values as far as possible in accordance with ISO 20643 — is described in detail and it is essential that it be followed exactly. 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 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 as estimates of 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 inserted tools, sanding pads with the wrong weight, worn backing pads 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 3: Polishers and rotary, orbital and random orbital sanders

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 polishers and rotary, orbital and random orbital sanders used for surface-finishing processes, not for material removal. It is a type-test procedure for establishing the magnitude of vibration in the gripping areas of a machine when 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. It is not applicable to straight grinders equipped with a sanding wheel or to belt sanders.

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 630:1995, *Structural steels — Plates, wide flats, bars, sections and profiles*

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 vibratio*n

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 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
polisher
machine for polishing surfaces fitted with a flexible pad and a sheepskin or felt pad

NOTE Adapted from ISO 5391:2003, definition 2.1.4.6.

3.1.2
sander
machine for sanding, equipped with a flexible pad fitted with a fibre disc or abrasive paper

NOTE Adapted from ISO 5391:2003, definition 2.1.4.

3.1.3
orbital sander
sander driving a pad in an orbital motion

NOTE Adapted from ISO 5391:2003, definition 2.1.4.2.

3.1.4
palm sander
palm-type random orbital sander
sander driving a pad with a random orbital motion or an orbital motion

3.1.5
random orbital sander
sander driving a rotating round pad in an orbital motion, allowing free rotation

[ISO 5391:2003, definition 2.1.4.3]

3.1.6
rotary sander
sander driving a circular flexible pad in a simple rotating motion

[ISO 5391:2003, definition 2.1.4.1]

3.1.7
vertical rotary sander
rotary sander with the motor straight in line with the spindle

3.1.8
angle rotary sander
rotary sander with the motor at an angle to the spindle

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/s2
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/s2
$\overline{a_{\text{hv}}}$	arithmetic mean value of a_{hv} values of runs for one operator for one hand position	m/s2
a_{h}	arithmetic mean value of $\overline{a_{\text{hv}}}$ values for all operators for one hand position	m/s2
$\overline{a_{\text{h}}}$	arithmetic mean value of a_{h} values for one hand position on several machines	m/s2
a_{hd}	declared vibration emission value	m/s2
$s_{\text{n}-1}$	standard deviation for a test series (for a sample, s)	m/s2
σ_{R}	standard deviation of reproducibility (for a population, σ)	m/s2
C_{v}	coefficient of variation for a test series	
K	uncertainty	m/s2

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 29827 applies to hand-held machines intended for surface finishing but not for material removal.

Figures 1 to 9 show examples of typical polishers and sanders covered by this part of ISO 29827.

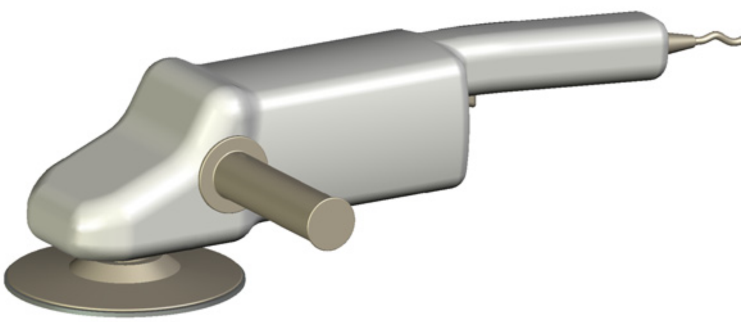


Figure 1 — Angle rotary sander/polisher with separate main handle

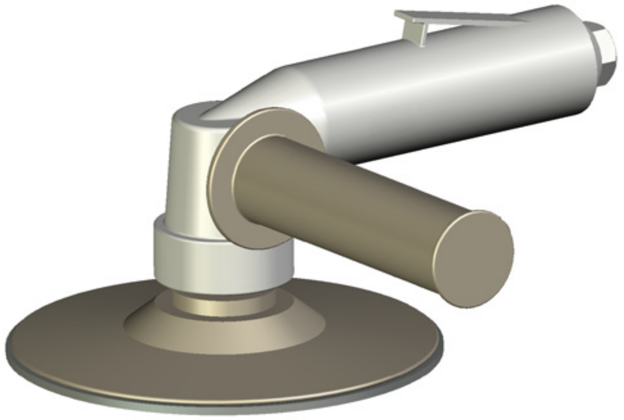


Figure 2 — Angle rotary sander/polisher where the motor serves as main handle

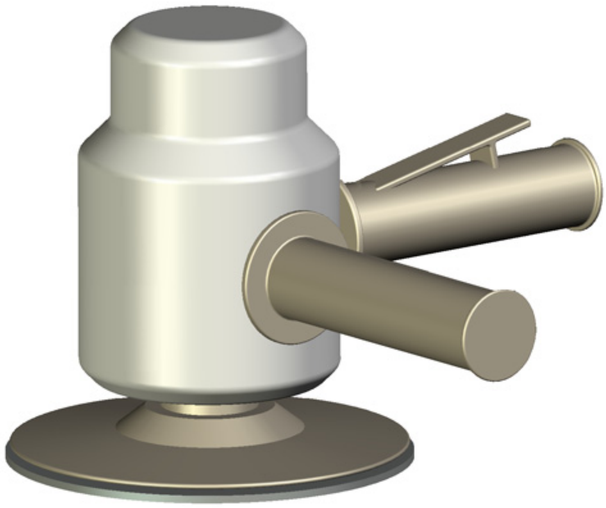


Figure 3 — Vertical sander/polisher

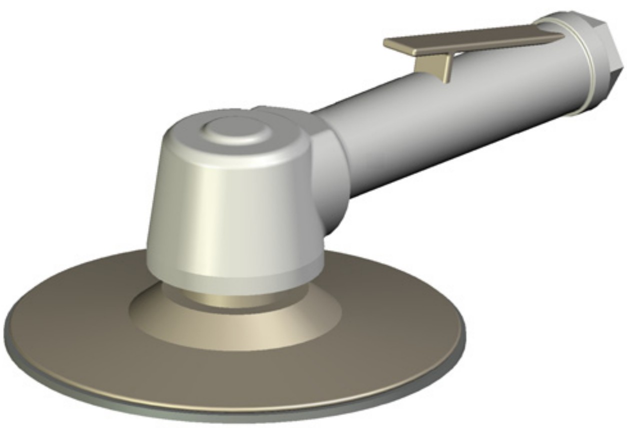


Figure 4 — Angle sander/polisher intended for one-handed operation

Figure 5 — Random orbital sander

Figure 6 — Palm sander

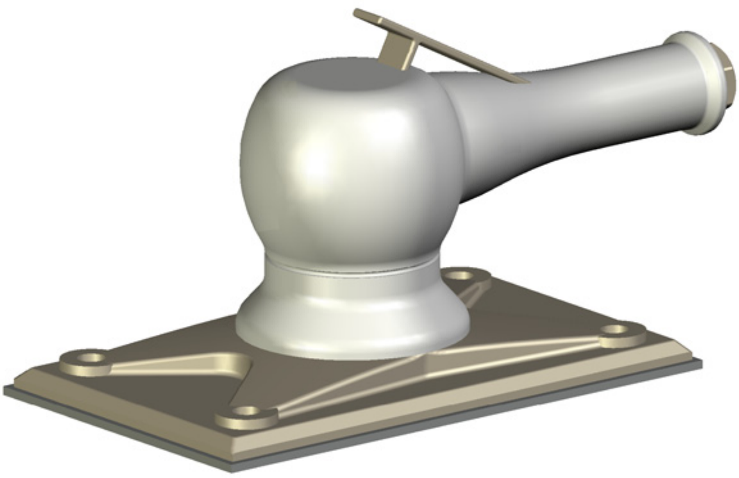


Figure 7 — Orbital sander with rectangular pad

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 8 to 14.

6.2 Location of measurements

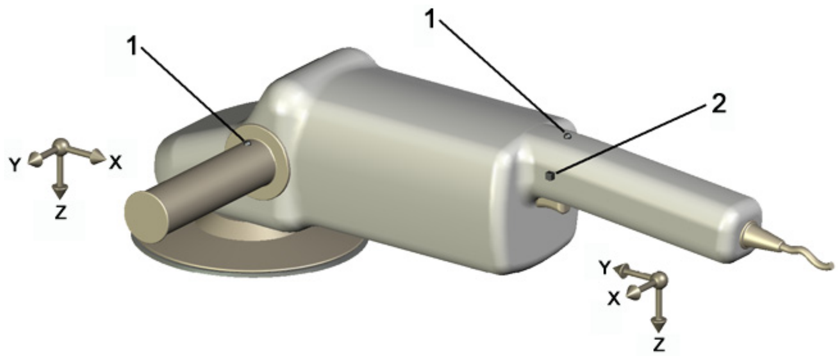
Measurements shall be made at the gripping zones, where the operator normally holds the machine and applies the feed force. For machines intended for one-handed operation, it is only necessary to measure at a single point.

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

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

Figures 8 to 14 show the prescribed and secondary locations and measurement directions for the hand positions normally used for the different types of machines in this family.

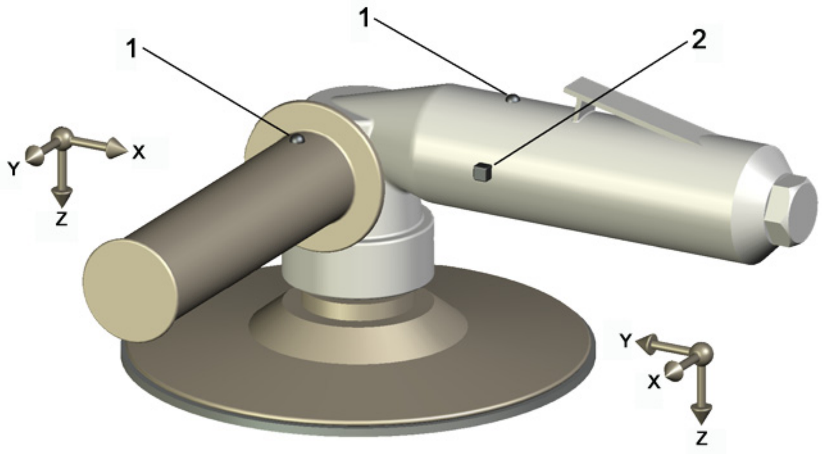


Key

1 prescribed location

2 secondary location

Figure 8 — Measurement locations — Angle rotary sander/polisher with separate main handle

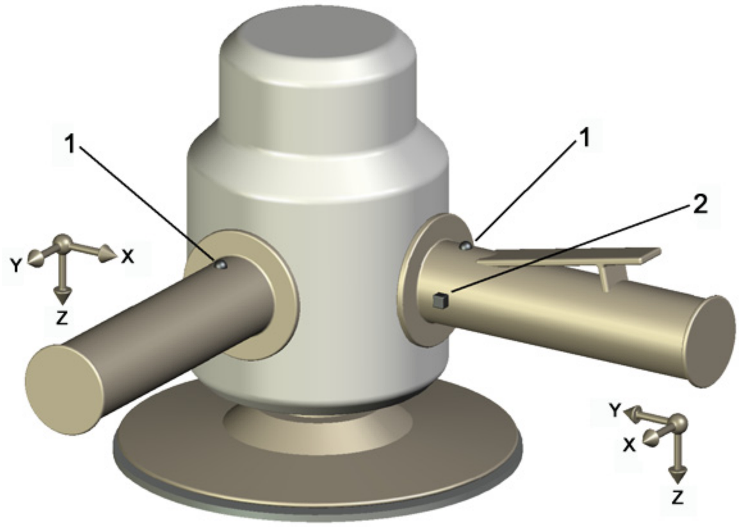


Key

1 prescribed location

2 secondary location

Figure 9 — Measurement locations — Angle rotary sander/polisher where the motor serves as main handle

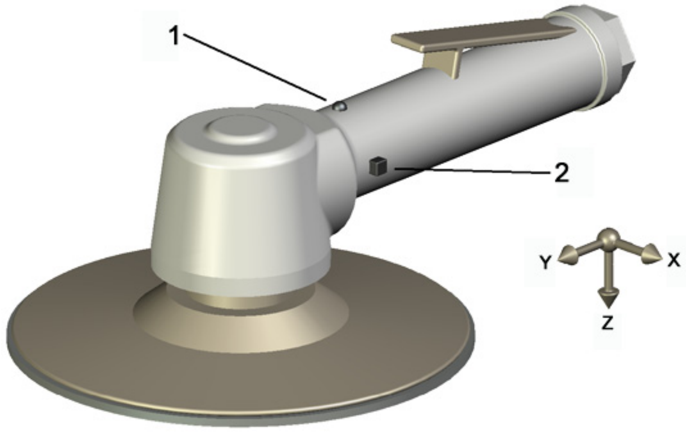


Key

1 prescribed location

2 secondary location

Figure 10 — Measurement locations — Vertical sander/polisher

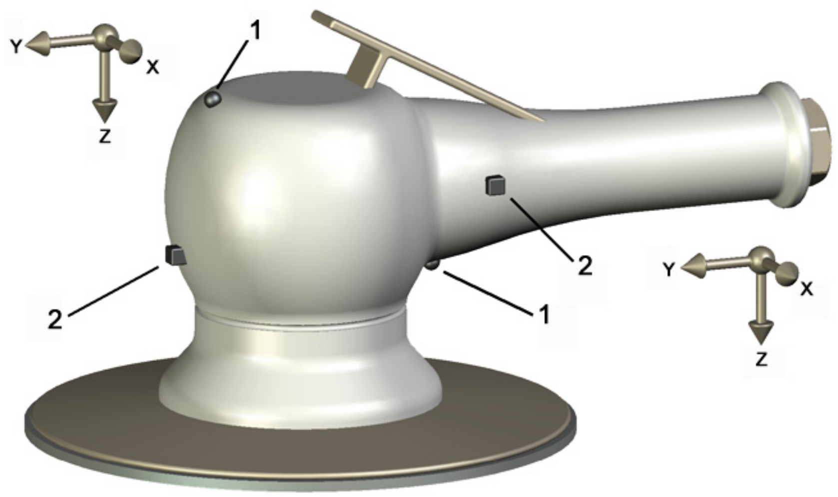


Key

1 prescribed location

2 secondary location

Figure 11 — Measurement locations — Angle sander/polisher intended for one-handed operation

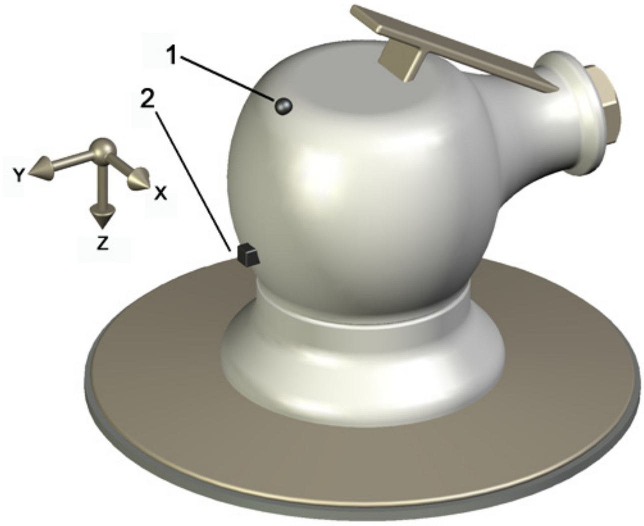


Key

1 prescribed location

2 secondary location

Figure 12 — Measurement locations — Random orbital sander

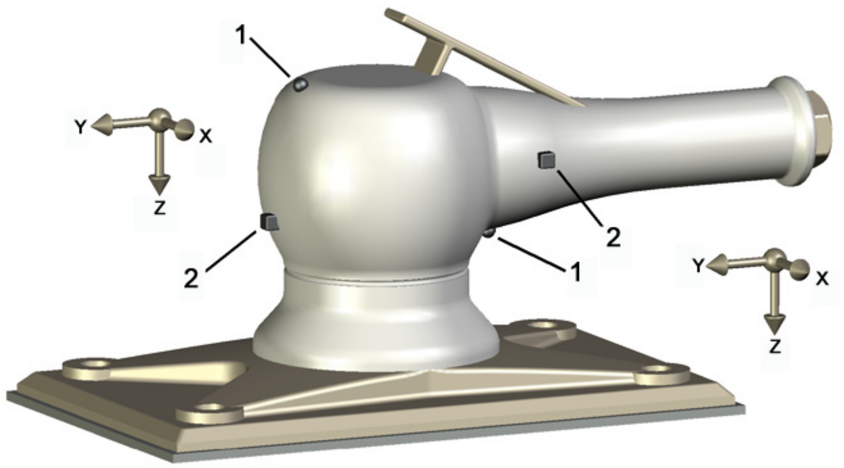


Key

1 prescribed location

2 secondary location

Figure 13 — Measurement locations — Palm sander



Key

1 prescribed location

2 secondary location

Figure 14 — Measurement locations — Orbital sander with rectangular pad

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 on 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, a_{hv}, for each test run, the results in each direction shall be combined using Equation (1):

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

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 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 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.

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

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. During testing, the machines shall be equipped and held in a manner similar to that used when sanding and polishing. 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 polishers and sanders are tested performing a real work task, with sanding or polishing performed on a horizontal steel surface. Feed force shall be measured and reported while the machine is moved in a figure-of-eight pattern. In order to obtain good reproducibility, it is important to follow exactly the test procedure specified in 8.4.

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 rated conditions, as specified by the manufacturer. The operation shall be stable.

8.2 Operating conditions

8.2.1 Pneumatic machines

During testing, the machine shall be operated at the rated air 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 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 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 feed force used shall be measured and reported.

8.4 Attached equipment, work piece and task

8.4.1 Attached equipment

Polishers shall be tested with a polishing pad as recommended by the manufacturer.

Orbital and random orbital sanders shall be tested using the backing pad recommended by the manufacturer for use on steel. The abrasive material shall be suitable for steel, have a grain size of 180, and as recommended by the manufacturer. For machines normally not used with grain size 180, the grain size shall be the most common for that machine type. The material shall be new, but shall be worn in for approximately 1 min before starting the measurements. The paper shall be replaced when it shows signs of being worn out.

Rotary sanders shall be tested with a backing pad as recommended by the manufacturer for use on steel. The abrasive material shall be suitable for steel and of the grain size normally used for the particular type of sander tested.

For sanders designed for a specific task only, measurements shall be made during that specific task. The task used shall be reported.

8.4.2 The work piece

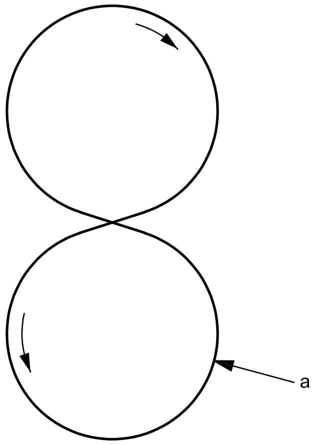
The work piece shall be a mild steel plate similar to type E235 in accordance with ISO 630, mounted horizontally on a stable foundation. The dimensions of the steel plate shall be at least 400 mm × 300 mm × 20 mm.

For orbital and random orbital sanders, the surface of the plate to which the machine is to be applied shall have a finish, Ra, less than or equal to 8,0 μm. This surface will normally be achieved during preliminary testing and will be maintained by the test procedure.

The mounted work piece shall have no resonances within the frequency range for the hand–arm vibration that could influence the test results.

8.4.3 Test procedure

A sanding or polishing task is used for testing. The machine shall be moved at a constant speed over the surface of the work piece in a figure-of-eight pattern, as described in Figure 15. Each figure-of-eight pattern shall take approximately 4 s. The total test time shall be long enough to allow for 16 s integration time when steady operation is achieved.



[a] Approximate radius: 50 mm.

Figure 15 — Pattern of movement of machine

The vertical feed force, in addition to the weight of the machine, shall ensure that the machine operates at its normal level of performance and in a stable manner. The magnitude of the vertical feed force, in addition to the mass of the machine, shall be in accordance with Table 1. The feed force shall be applied and controlled by the operator — for example, by standing on a scale during the test — and its value displayed to the operator. The feed force shall be measured and reported.

Table 1 — Values of the feed force, in addition to the machine mass

Machine mass kg	**Feed force** N
$< 1,5$	30 ± 5
$\geqslant 1,5$	50 ± 5

A feed force specified in Table 1 or, alternatively, the force necessary to obtain rated output shall be used, whichever is the lower.

The height of the work piece shall be adjusted to allow the operator to perform the task in a normal posture.

Figure 16 — Working position of operator

Polishers and orbital and random orbital sanders with two handles shall be held by both handles.

Machines with only one handle shall be held with one hand on the handle and the other on the machine housing (or knob-handle).

Polishers and sanders without a handle shall be held with one hand on the machine housing.

Machines intended to be used with only one hand holding a handle shall be held in that fashion during testing.

For polishers and sanders with two handles, the feed force shall be applied on the handles, perpendicular to the working surface and parallel to the rotation axis of the pad.

For polishers and sanders with one handle or without a handle, intended to be used with one hand on the housing, the feed force shall be applied on the housing of the machine, perpendicular to the working surface, close to the rotation axis of the pad.

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 experienced under real working conditions.

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 as in Annex A.

The coefficient of variation, C_{v}, and the standard deviation, $s_{\mathrm{n-1}}$, 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 $s_{\mathrm{n-1}}$ to the mean value of the series:

$$C_{\mathrm{v}} = \frac{s_{\mathrm{n-1}}}{\overline{a_{\mathrm{hv}}}} \qquad (2)$$

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

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

where

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

n is equal to 5, the number of measured values.

If C_{v}, is greater than 0,15 or $s_{\mathrm{n-1}}$ is greater than 0,3 m/s^2, then 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 into 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 a precision determined in accordance with EN 12096. The value of a_{hd} is to be given in m/s^2 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 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 28927-3);

b) name of the measuring laboratory;

c) date of measurement and name of the person 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 and other quantities to be specified according to 8.2 and 8.3;

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

l) weight pad for orbital and random orbital sanders.

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 polishers and sanders

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 28927-3, *Hand-held portable power tools — Test method for evaluation of vibration emission — Part 3: Polishers and rotary, orbital and random orbital sanders*	
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 uncertainty K:
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 (types and mass of pad and/or abrasive material, work piece, hand position, photos):	
Measured feed force:	Power supply (air pressure, hydraulic flow, voltage):
Any other quantities to report:	

Table A.2 — Measurement results for one machine

Date			Machine type:							Serial number:						
			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 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 only a single machine, 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 by

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

or

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

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

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

$$s_{recj}^2 = \frac{1}{n-1}\sum_{i=1}^{n}(a_{hvji} - \overline{a_{hvj}})^2$$

where

n is 5, the number of measured values;

a_{hvij} is the vibration total value for the i^{th} test with the j^{th} operator;

$\overline{a_{hvj}}$ is the average vibration total value of measurements on the j^{th} 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 3, i.e. the number of operators;

$\overline{a_{hvj}}$ is the average vibration value from the j^{th} 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 there is currently 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) $s_t = 0{,}06 a_{hd} + 0{,}3$,

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 l^{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 the two hand positions;

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

Bibliography

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

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

ICS 13.160; 25.140.10

Price based on 22 pages