INTERNATIONAL STANDARD

ISO 28927-11

First edition
2011-02-01

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

Part 11: **Stone hammers**

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

Partie 11: Casse-pierres

Reference number
ISO 28927-11:2011(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 28927-11 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 28927-11 cancels and replaces ISO 8662-14:1996, 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 are used,

— definition of the transducer positions and orientation has been improved,

— needle scalers have been moved to a new part “Scaling hammers and needle scalers” (ISO 28927-9), and

— energy absorber has been deleted and all tools are tested on stone.

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*[3)]

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*.

— *Part 4: Straight grinders*[4)]

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

— *Part 6: Rammers*[6)]

— *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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4) Together with ISO 29827-1, 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*.

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 this part of ISO 29827, replaces ISO 8662-14, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 14: Stone-working tools and needle scalers*.

10) To be published. 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.* It also incorporates the Amendments ISO 8662-2:1992/Amd.1:1999, ISO 8662-3:1992/Amd.1:1999 and ISO 8662-5:1992/Amd.1:1999. Chipping and riveting hammers, rock drills and rotary hammers all covered.

11) Together with ISO 29827-9, replaces ISO 8662-14, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 14: Stone-working tools and needle scalers*.

12) Under preparation. Replaces ISO 8662-13, *Hand-held portable power tools — Measurement of vibrations at the handle — Part 13: Die grinders*. It also incorporates the Technical Corrigendum ISO 8662-13:1997/Cor.1:1998.

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 stone hammers vary considerably in typical use. For stone hammers, impacting action is the prime source of vibration. The variation is largely due to variations in the handling of the machine and the characteristics of the material to work on. Differences in the support of the material also cause differences in vibration. This part of ISO 28927 uses a working process where the machine is used to work on a stone surface. To improve reproducibility of the test, it is important that the material has good support and that inserted tools used are in good condition.

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 (all parts)] 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 worn inserted tools.

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*, could be replaced by a future part of ISO 28927.

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

Part 11:
Stone hammers

1 Scope

This part of ISO 28927 specifies a laboratory method for measuring hand-transmitted vibration emission at the handles of hand-held stone hammers. It is a type-test procedure for establishing the magnitude of vibration in the gripping areas of a stone hammer when operated in laboratory 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 engraving pens and stone hammers intended for use by stone masons (see Clause 5), driven pneumatically or by other means. It is not applicable to demolition hammers or to chipping hammers primarily intended for use on metal or in construction.

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

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, *Rotary and percussive pneumatic tools — Performance tests*

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

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

ISO 17066, *Hydraulic tools — Vocabulary*

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

EN 12096, *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 apply.

3.1 Terms and definitions

3.1.1
stone hammer
percussive machine for carving and chipping stone

NOTE Adapted form ISO 5391:2003, definition 2.2.6.

3.1.2
chisel
inserted tool with a straight edge, intended for carving stone

3.1.3
bush
inserted tool with teeth for levelling the surface of a stone workpiece and/or applying a pattern to the surface of the stone

3.1.4
bush hammering
mechanical process which produces textured surfaces

NOTE Textures vary from subtle to rough.

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 the a_{hw} values for the three measured axes of vibration	m/s^2
$\overline{a_{\text{hv}}}$	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 $\overline{a_{\text{hv}}}$ values for all operators for one hand position	m/s^2
$\overline{a_{\text{h}}}$	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 28927 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 applies to stone hammers, which are usually pneumatically powered straight machines although some have a “D” handle or pistol grip handle. Some are fitted with spring-loaded sleeves to reduce vibration transmitted to the operator's hand. The chisel is generally not fixed in the hammer but held by the operator. Some chisels also have sleeves, attached either to the hammer or to the chisel with spring-loading to reduce vibration.

This part of ISO 28927 is applicable to hand-held power-driven portable stone hammers.

It is not applicable to demolition hammers or to chipping hammers primarily intended for use on metal or in construction.

Figures 1 to 3 show examples of stone hammers as specified in this part of ISO 28927. Figure 4 is an example of a sleeved chisel intended to be used when the chisel needs to be guided using the left hand.

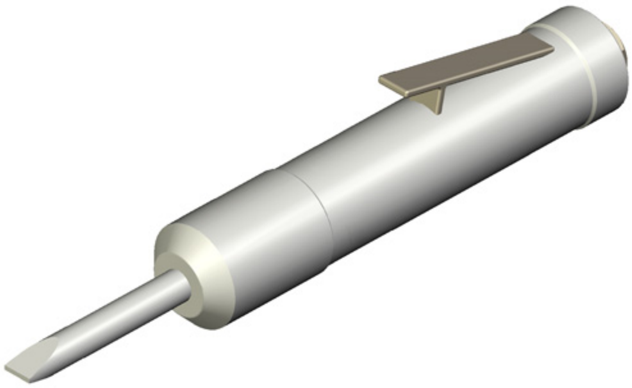


Figure 1 — Straight hammer

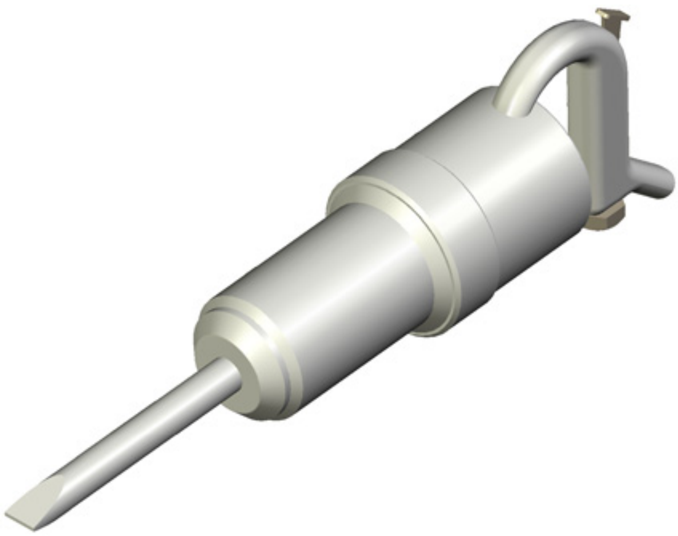


Figure 2 — Hammer with open or closed bow grip

Figure 3 — Pistol grip hammer

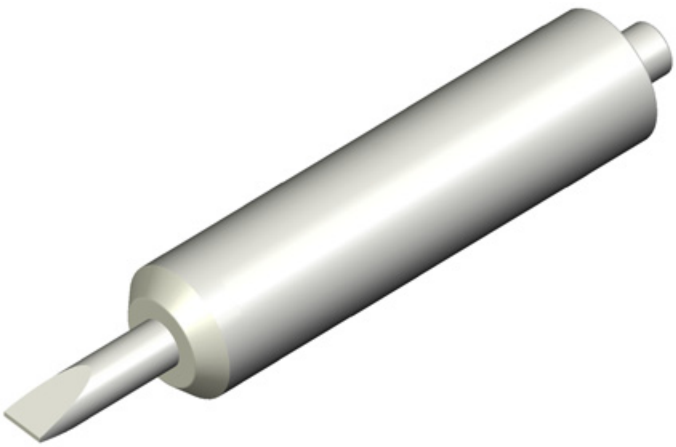


Figure 4 — Sleeved chisel

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

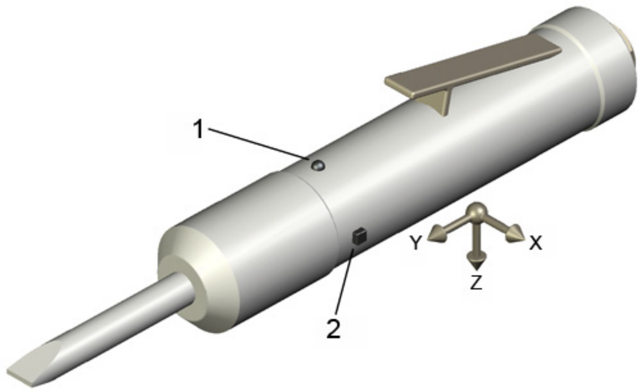
Measurements shall be made at the gripping zones, where the operator normally holds the machine and applies the feed force. For machines intended for one-handed operation, it is only necessary to measure at a single point.

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 locations 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.

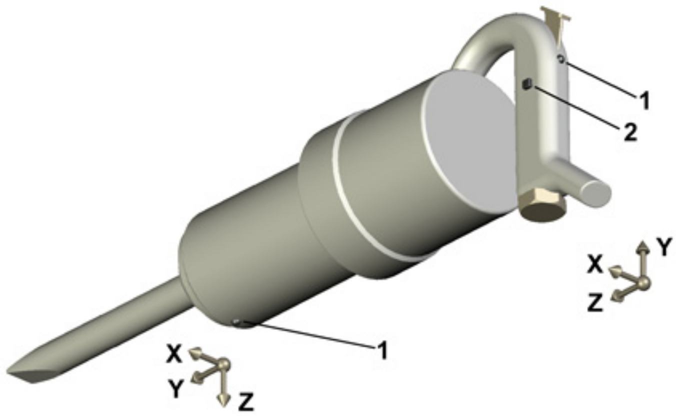


Key

1 prescribed location

2 secondary location

Figure 5 — Straight hammer

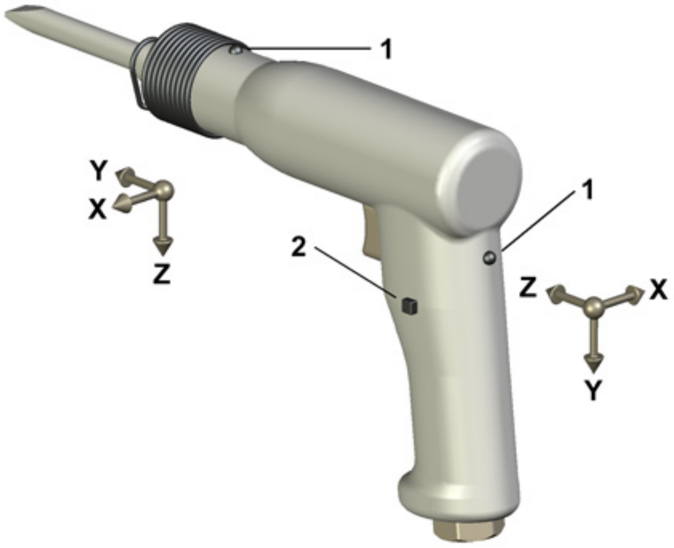


Key

1 prescribed location

2 secondary location

Figure 6 — Hammer with open or closed bow grip

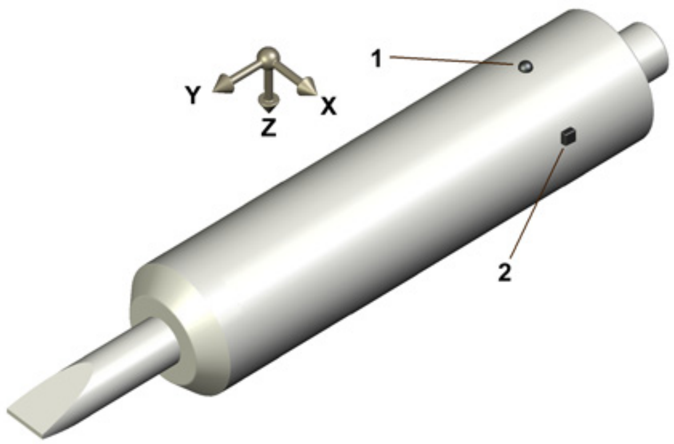


Key

1 prescribed location

2 secondary location

Figure 7 — Pistol grip hammer



Key

1 prescribed location

2 secondary location

Figure 8 — Sleeved chisel

6.3 Magnitude of vibration

The magnitude of vibration shall be in accordance with ISO 20643:2005, 6.3.

6.4 Combination of vibration directions

The vibration total value in accordance with ISO 20643:2005, 6.4, shall be reported for both hand positions, as 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 at 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):

$$a_{hv} = \sqrt{a_{hwx}{}^2 + a_{hwy}{}^2 + a_{hwz}{}^2} \tag{1}$$

The a_{hv} value for each operator shall be calculated as the arithmetic mean of the a_{hv} values for the five tests.

For each hand position, the results from the three operators should be combined to one value, a_h, using the arithmetic mean of the three a_{hv} values.

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 (covered in 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.

It is normally necessary to use mechanical filters for measurements in accordance with this part of ISO 28927 to prevent d.c. shifts. At the time of publication of this part of ISO 28927, it is still good practice to use three accelerometers, one for each direction, mounted on a block, each with its own mechanical filter. However, some triaxial accelerometers may be suitable. It is also good practice to be observant of low-frequency components in the measurement signal below the blow frequency. Such components are often early signs of d.c. shifts or instrument overload in the high-frequency region.

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 8 s, so as to be consistent with the duration of machine operation defined in Clause 8.

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 an accuracy equal to or better than 3 % 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, 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.

Machines intended for one-handed operation shall be held using 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.

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 by 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.

13) 1 bar = 0,1 MPa = 0,1 N/mm^2 = 10^5 N/m^2.

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 and voltage used shall be measured and reported.

8.4 Attached equipment, workpiece and task

The hammer shall be fitted with an inserted tool of the type that is most commonly used with that hammer. For larger hammers, this may be a bush machine; for smaller hammers, it may be a flat chisel. Where more than one type of inserted tool is commonly used with the hammer, the lightest one shall be selected.

If the hammer is intended for use with a conventional chisel or bush (without a sleeve) and this is in contact with the operator's hand in intended use, it is not usually practicable to measure the vibration on the chisel or bush. However, it is likely that the vibration at this hand position would be much greater than that measured on the hammer. In such cases, a vibration emission value of “greater than 30 m/s^2” shall be declared (see Clause 9) and measurement is not required.

The hammer shall be operated on stone with an apparent specific weight ranging from 25,0 kN/m^3 to 32,5 kN/m^3 (apparent density 2 500 kg/m^3 to 3 200 kg/m^3), such as granite, marble and hard limestone. The workpiece shall be a block of stone with a flat upper surface. The minimum dimensions shall be 500 mm (length), 250 mm (width) and 250 mm (height). The workpiece shall be mounted on a rigid heavy base with no resonances below 1 kHz. The height of the workpiece shall be such that the operator can adopt a comfortable, upright posture to carve a groove in the upper surface of the stone. For example, for an operator measuring 1,70 m in height, a workpiece height of approximately 1,20 m may be suitable.

In each test run, the operator shall carve a groove along the upper surface of the workpiece. The operation of the hammer shall be stable and smooth and shall allow a measurement period of least 8 s. The angle between the main axis of the machine and the stone surface shall be appropriate for the operation and similar to that used in real work. (For bush machines this is approximately 90°.)

The feed force applied shall be appropriate for normal, efficient operation of the hammer, and for machines with spring-loaded sleeves or suspension systems; it shall allow such systems to operate correctly, as recommended by the manufacturer.

NOTE The test in the previous test code, ISO 8662-14:1996, used an artificial operation with an energy absorber. The vibration was measured only on the hammer and only in one direction. This did not allow measurement at the chisel hand position, which is generally the position of greater vibration.

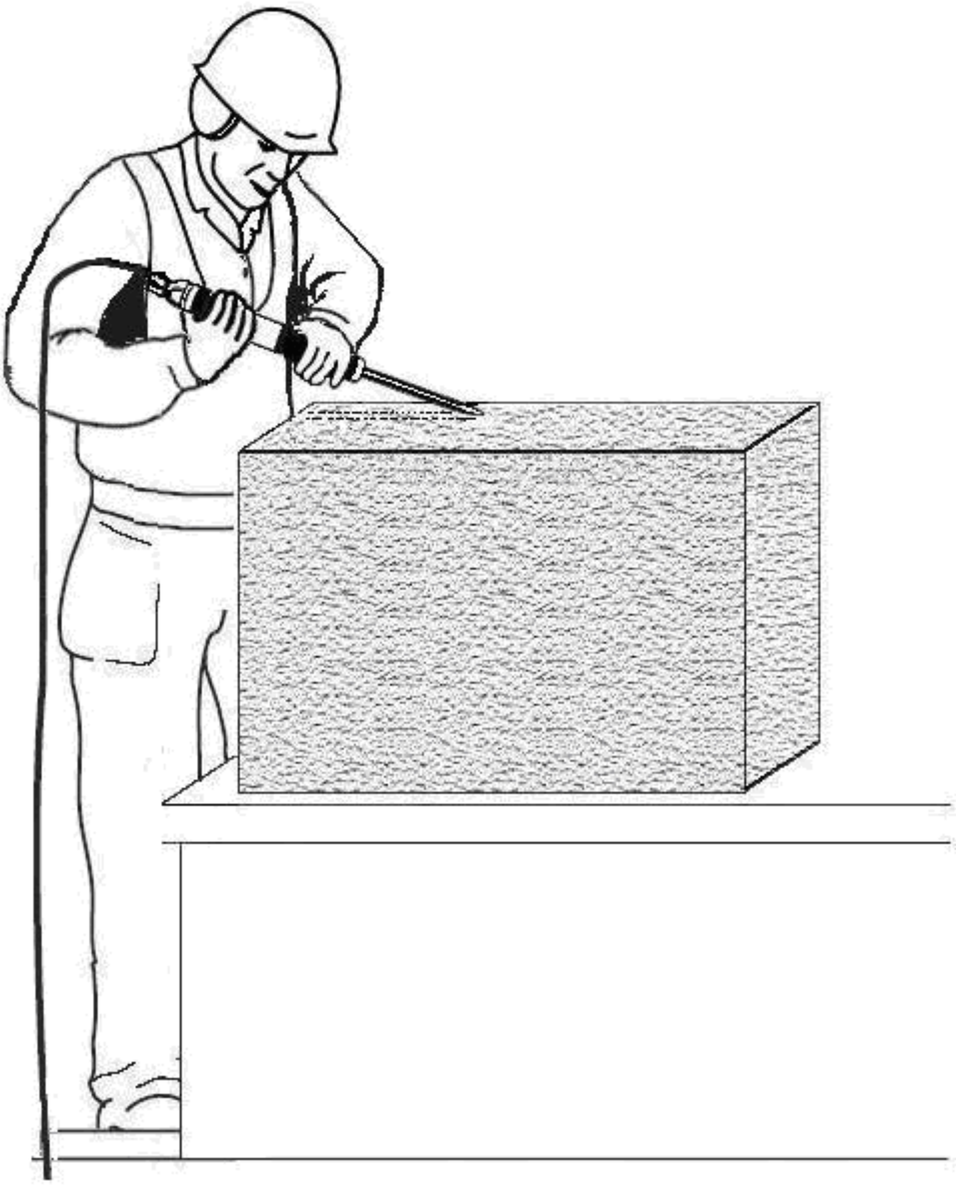


Figure 9 — Working position of operator — Stone hammer

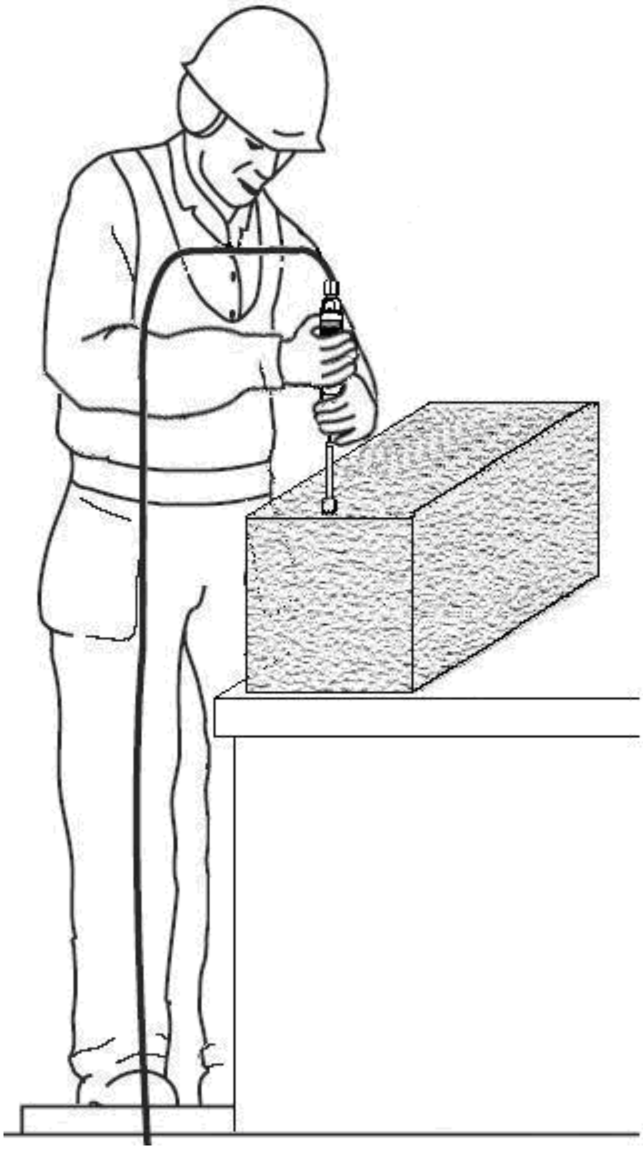


Figure 10 — Working position of operator — Bush hammer

8.5 Operator

Three different operators shall operate the machine during testing. The vibration of the machine is influenced by the operators. They shall, therefore, be skilled stone masons who are 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 using the model test report shown 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:

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

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 Equation (3):

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

where

$\overline{a_\mathrm{hv}}$ is the mean value of the series, in metres per square second;

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 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 the 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 the declared value, a_hd, and the uncertainty, K, shall be presented with the precision determined in EN 12096. The value 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 the information given in Annex B.

10 Test report

The following information shall be given in the test report:

a) reference to this part of ISO 28927, i.e. ISO 28927-11:2010;

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 mass, integrators, 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 28927 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 stone hammers

See Tables A.1 and A.2.

Table A.1 — General information

The test has been carried out in accordance with ISO 28927-11: *Hand-held portable power tools — Test methods for evaluation of vibration emission — Part 11: Stone hammers*	
Tester:	
Measured by (company/labortatory):	Tested by: Reported by: Date:
Test object and declared value:	
Machine tested (power supply and machine type, manufacturer, machine model and name, mass):	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 (see 8.2 to 8.4; material used, workpiece, operator posture and hand position):	
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 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 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 Equation 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 9.1, 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 equal to five, the number of measured values;

a_{hvji} is the vibration total value for the ith test with the jth operator;

$\overline{a_{hvj}}$ 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 equal to 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 28927, 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*

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