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

Part 2: Wrenches, nutrunners and screwdrivers

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

Partie 2: Clés, boulonneuses et visseuses

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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 28927-2 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 28927-2 cancels and replaces ISO 8662-7:1997, 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,

— improved definition of transducer positions and orientation, and

— all types of screwdrivers and nutrunners, excepting one-shot nutrunners, now covered.

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*

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

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

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)]

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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 wrenches and nutrunners during tightening and unfastening of threaded fasteners vary considerably in typical use. For impact and impulse machines, this is largely due to misalignment between the machine and the fastener, to worn sockets or to the use of universal joints and angle heads. Owing to the very short tightening times in real use, the response times in the vibration measurement system used also become critical for the measurement results.

In order to provide a method that gives good measurement reproducibility, this part of ISO 28927 adopts a procedure for testing impact and impulse machines using a test device based on break blocks acting on the outer diameter of a test socket, and a free running test for other machines. 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 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 either misalignment between the machine and fastener, worn sockets or the use of universal joints or angle heads. The operator's hands ought never to be in contact with rotating parts such as the sockets or the extensions used.

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 2: Wrenches, nutrunners and screwdrivers

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 wrenches, nutrunners and screwdrivers used for tightening and loosening threaded fasteners. It is a type-test procedure for establishing the magnitude of vibration in the gripping areas of a machine when operating at a specified load. The method has been tested for fastening tasks only. 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, with impact or impulse action, of shut-off, ratchet or stall type, and of all designs — straight, pistol-grip, angle or bow handle. It covers machines with 6,3 mm to 40 mm (1/4 in to 11/2 in) male or female drive output shafts, as well as other geometries. It is not applicable to nutrunners designed to be used only in torque reaction arms.

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 691:2005, *Assembly tools for screws and nuts — Wrench and socket openings — Tolerances for general use*

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

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

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

ISO 17066:2007, *Hydraulic tools — Vocabulary*

ISO 20643:2005, *Mechanical vibration — Hand-held or 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
loading device
brake device
device used to obtain a stable rotational frequency of the output shaft of the machine and to absorb the output energy of the machine

3.1.2
impact wrench
rotary machine fitted with a rotating or oscillating motor driving a hammer that periodically strikes an anvil to tighten nuts and bolts without producing any considerable reaction torque on the machine

NOTE Adapted from ISO 5391:2003, definition 3.2.1.

3.1.3
ratchet wrench
angle drive wrench that progressively rotates a socket by means of a ratchet and pawl coupling

[ISO 5391:2003, definition 3.1.2.8]

3.1.4
screwdriver
rotary, reversible or non-reversible machine that drives a spindle fitted with a screwdriver bit

[ISO 5391:2003, definition 3.1.1]

NOTE *Nutrunner* or *screwdriver* can designate the same machine fitted with a socket or screwdriver bit, respectively.

3.1.5
nutrunner
rotary, reversible or non-reversible machine incorporating a socket adapter for the tightening of nuts and bolts

NOTE 1 Adapted from ISO 5391:2003, definition 3.1.2.

NOTE 2 *Nutrunner* or *screwdriver* can designate the same machine fitted with a socket or screwdriver bit, respectively.

3.1.6
automatic shut-off nutrunner
nutrunner where the setting of the tightening torque is achieved by shutting off the motor when the set torque is achieved

NOTE Adapted from ISO 5391:2003, definition 3.1.2.5.

3.1.7
impulse nutrunner
impulse wrench
machine fitted with a motor that drives an hydraulic impulse mechanism for tightening threaded fasteners, applying torque to a fastener in discontinuous increments through a hydraulic impulse unit

NOTE Adapted from ISO 5391:2003, definition 3.3.1.

3.1.8
stall-type nutrunner
nutrunner whose tightening torque can only be set by air pressure adjustments

NOTE Adapted from ISO 5391:2003, definition 3.1.2.3.

3.2 Symbols

Symbol	Description	Unit
a_{hw}	root-mean-square (r.m.s.) single-axis acceleration value of the frequency-weighted hand-transmitted vibration	m/s^2
a_{hv}	vibration total value of frequency-weighted r.m.s. acceleration; root sum of squares of a_{hw} values for the three measured axes of vibration	m/s^2
$\overline{a_{hv}}$	arithmetic mean value of a_{hv} values of runs for one operator for one hand position	m/s^2
a_h	arithmetic mean value of $\overline{a_{hv}}$ values for all operators for one hand position	m/s^2
$\overline{a_h}$	arithmetic mean value of a_h values for one hand position on several machines	m/s^2
a_{hd}	declared vibration emission value	m/s^2
s_{n-1}	standard deviation for a test series (for a sample, s)	m/s^2
σ_R	standard deviation of reproducibility (for a population, σ)	m/s^2
C_v	coefficient of variation for a test series	
K	uncertainty	m/s^2

4 Basic standards and vibration test codes

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

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

5 Description of the family of machines

This part of ISO 29827 applies to hand-held machines intended for tightening and loosening threaded fasteners. It does not apply to one-shot type impact nutrunners, where a rotating mass is accelerated to a given rotational speed and then connected to the bolt.

Figures 1 to 10 show examples of typical wrenches, nutrunners and screwdrivers covered by this part of ISO 29827.

Figure 1 — Impact wrench/impulse nutrunner with pistol grip

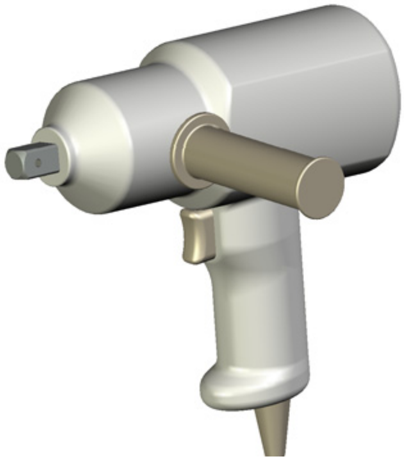


Figure 2 — Impact wrench/impulse nutrunner with pistol grip and support handle

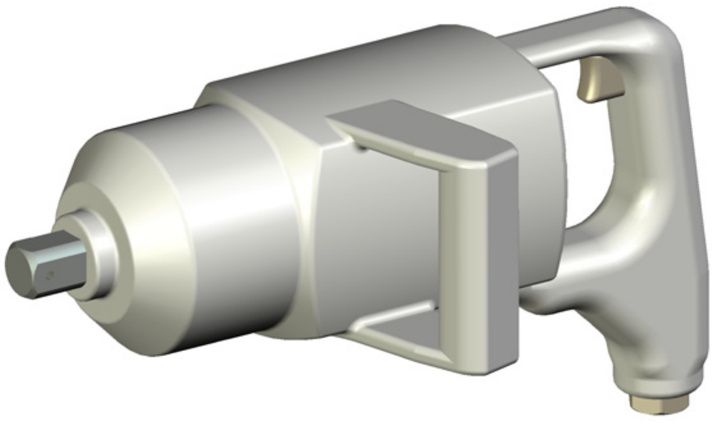


Figure 3 — Impact wrench/impulse nutrunner with bow grip and bow-shaped support handle

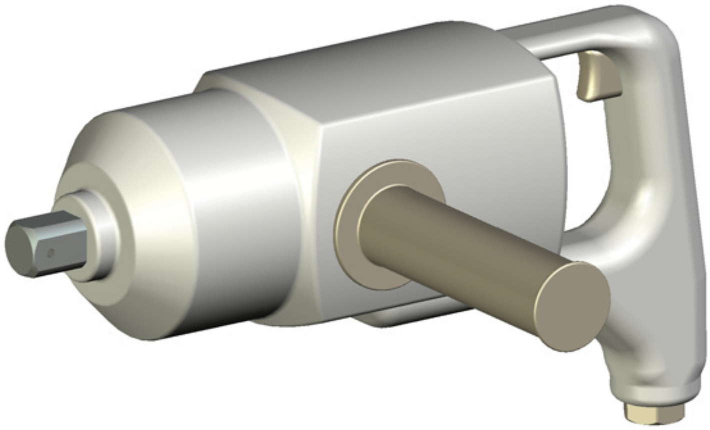


Figure 4 — Impact wrench/impulse nutrunner with bow grip and straight support handle

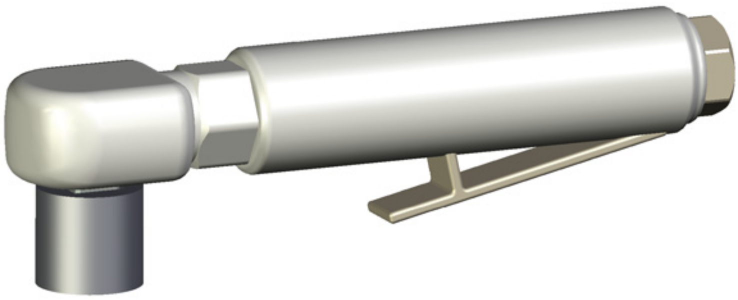


Figure 5 — Ratchet wrench

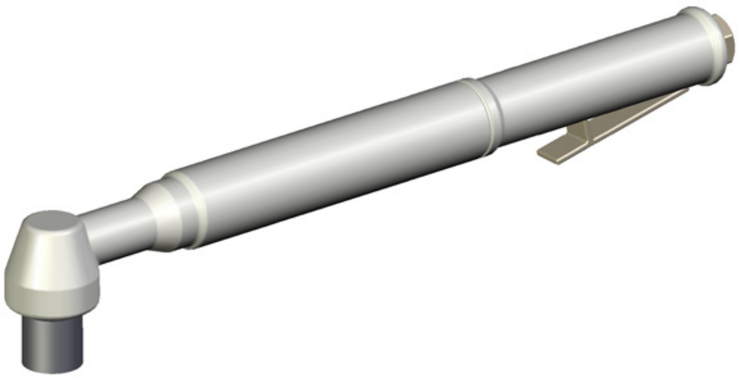


Figure 6 — Angle nutrunner

Figure 7 — Straight screwdriver

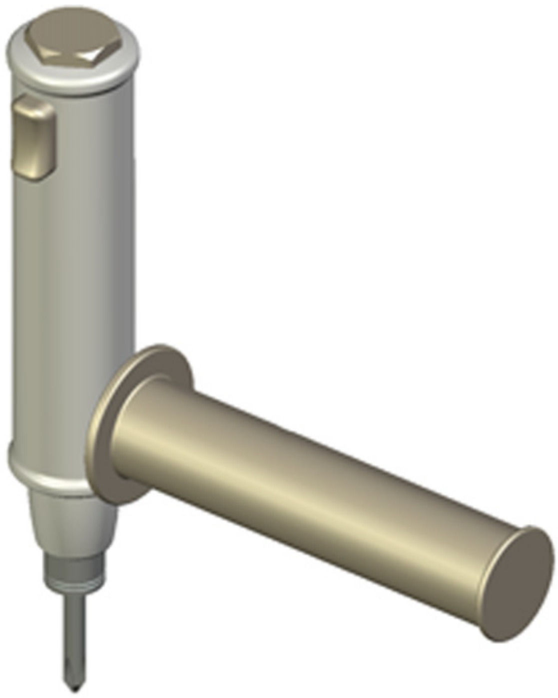


Figure 8 — Screwdriver with support handle

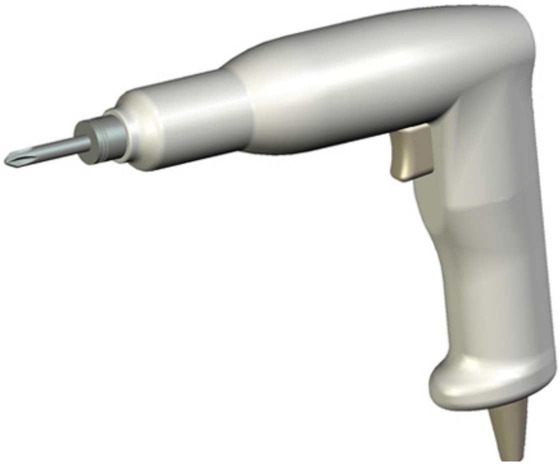


Figure 9 — Screwdriver with drill-type pistol grip

Figure 10 — Screwdriver with balanced pistol grip

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 11 to 20.

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.

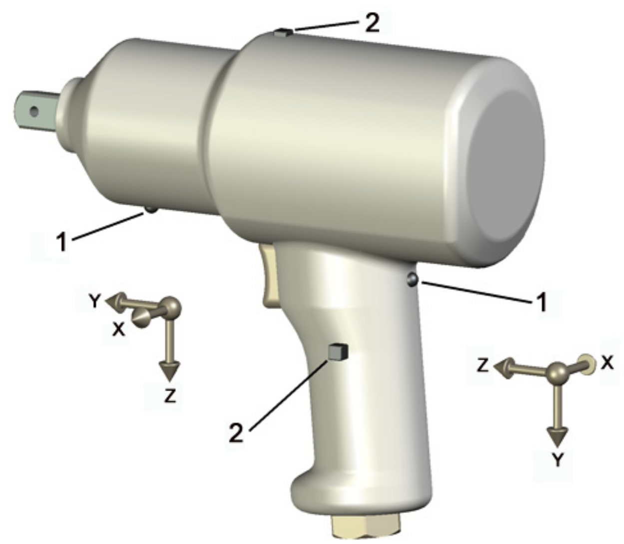
The prescribed transducer location shall be as close as possible to the hand between the thumb and index finger. This shall apply to both hand positions, with the machine held as in normal operation. Whenever possible, measurements shall be made at the prescribed locations.

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 11 to 19 show the prescribed and secondary locations and measurement directions for the hand positions normally used for the different types of machines in this family.

Impact and impulse tools with a mass less than 2 kg are normally operated using only one hand and therefore only the hand position on the trigger handle need be measured and reported. Tools of a mass of 2 kg or more are normally operated using both hands, and so measurements shall be made in two positions. For tools without a side handle, the second hand position is on the front housing, or — if that is not possible — on the motor housing (see Figure 11). For battery tools, the weight includes the standard battery.

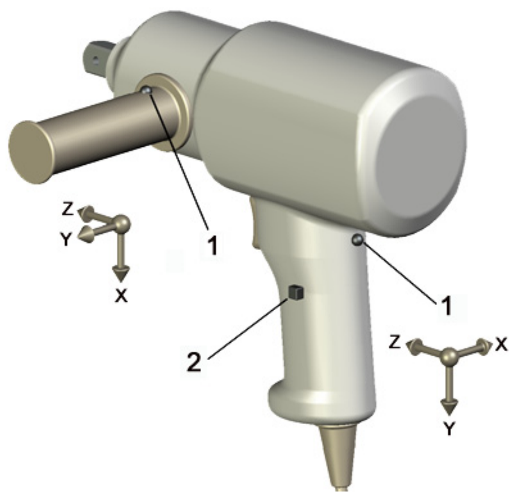


Key

1 prescribed location

2 secondary location

Figure 11 — Measurement locations — Impact wrench/impulse nutrunner with pistol grip

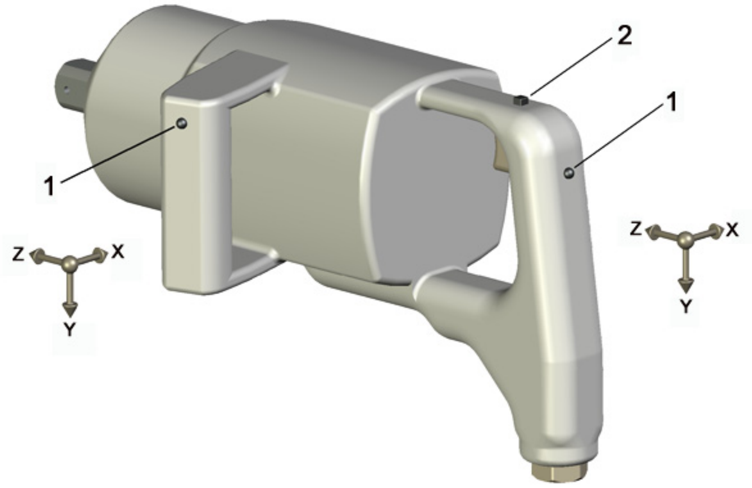


Key

1 prescribed location

2 secondary location

Figure 12 — Measurement locations — Impact wrench/impulse nutrunner with pistol grip and support handle

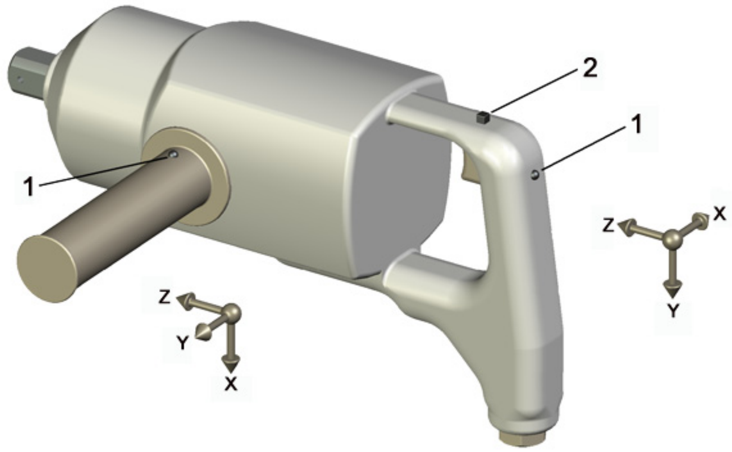


Key

1 prescribed location

2 secondary location

Figure 13 — Measurement locations — Impact wrench/impulse nutrunner with bow grip and bow shaped support handle

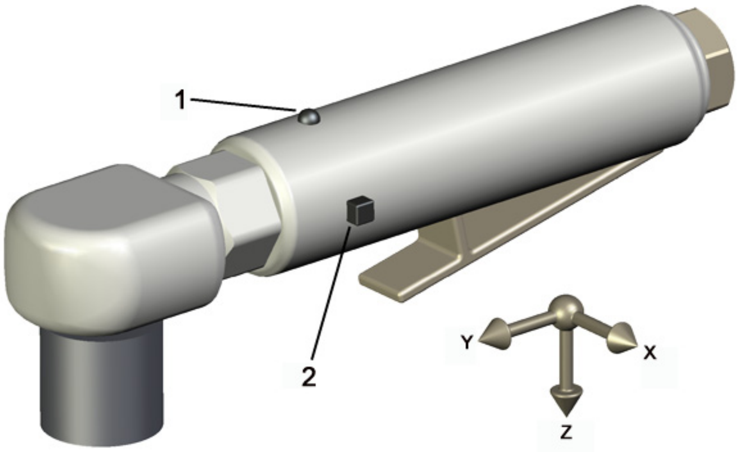


Key

1 prescribed location

2 secondary location

Figure 14 — Measurement locations — Impact wrench/impulse nutrunner with bow grip and straight support handle

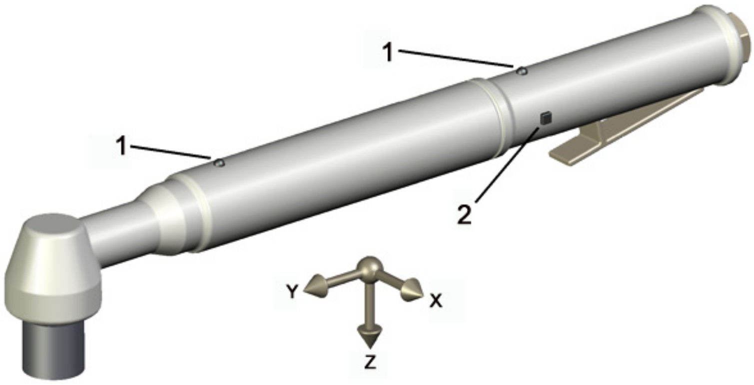


Key

1 prescribed location

2 secondary location

Figure 15 — Measurement locations — Ratchet wrench

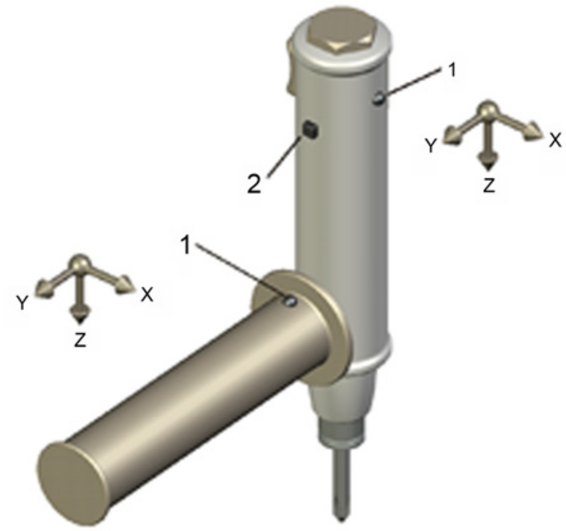


Key

1 prescribed location

2 secondary location

Figure 16 — Measurement locations — Angle nutrunner

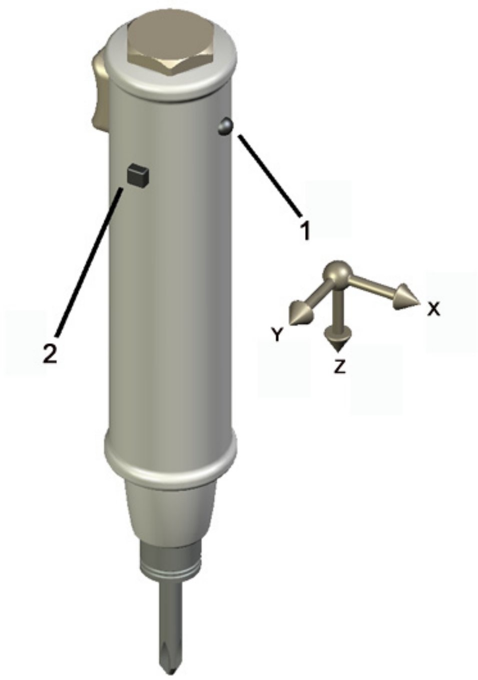


Key

1 prescribed location

2 secondary location

Figure 17 — Measurement locations — Straight screwdriver with support handle

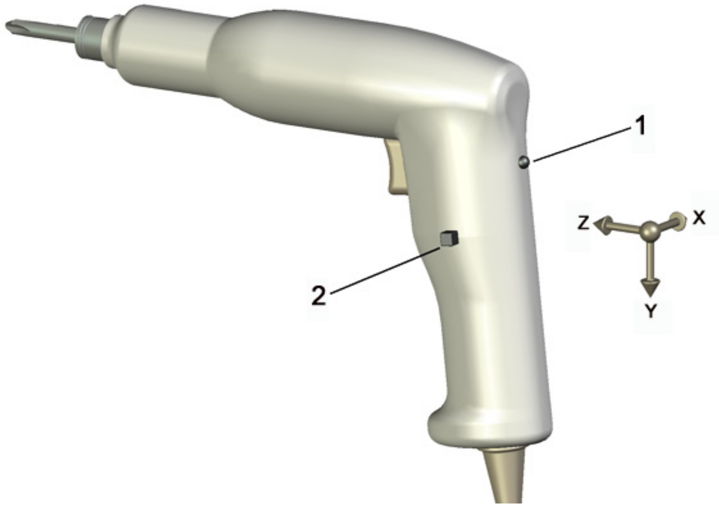


Key

1 prescribed location

2 secondary location

Figure 18 — Measurement locations — Straight screwdriver

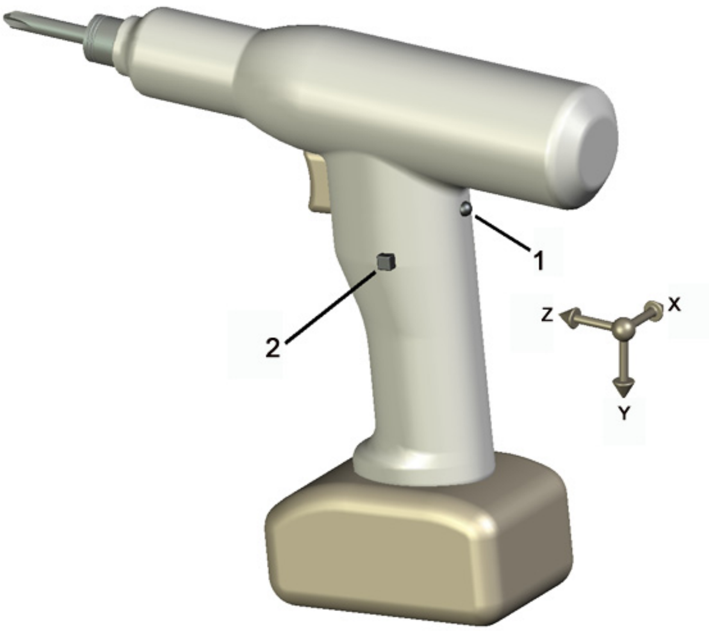


Key

1 prescribed location

2 secondary location

Figure 19 — Measurement locations — Screwdriver with drill-type pistol grip



Key

1 prescribed location

2 secondary location

Figure 20 — Measurement locations — Screwdriver with balanced pistol grip

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 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):

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

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.

It is strongly recommended that mechanical filters be used for measurements performed on impact wrenches.

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 8.4.4. The exception to this are impulse machines, which shall be run for at least 5 s, to avoid overheating of the impulse mechanism.

7.5 Auxiliary equipment

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

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

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

The rotational speed of nutrunners and screwdrivers without impact, impulse or ratchet mechanisms, tested under no-load conditions, shall be measured and reported with accuracy better than 5 % of the actual value, using either a tachometer or frequency analysis of the measured vibration signal. When a tachometer transducer is placed on the machine, it should be small enough not to influence the vibration of the machine.

The blow frequency of machines tested in the brake shall be determined, using the signal from the vibration transducer or other suitable means. The accuracy shall be better than ± 1 Hz.

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 tightening and loosening threaded fasteners. 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.

Wrenches, nutrunners and screwdrivers with an impact or impulse mechanism shall be measured while operating in right-hand rotation on the loading device. It is permissible to operate the wrench, nutrunner or screwdriver in left-hand rotation in cases where shut-off mechanisms, etc. make continuous operation in right-hand rotation impossible.

Nutrunners and screwdrivers without an impact or impulse mechanism, as well as ratchet wrenches, shall be measured while operating in right-hand rotation under no-load conditions. During testing, the machines shall be equipped with a socket or toolbit of standard type with a size typical for the machine tested.

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.

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

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

8.2 Operating conditions

8.2.1 Pneumatic machines

During testing on a braking device, the machine shall be operated at the maximum rated torque setting 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 rotational speed of the wrench or nutrunner tested under no-load conditions shall be measured and reported for each tool tested.

The blow frequency of machines tested on a brake device shall be measured and reported for each tool tested.

8.4 Attached equipment, work piece and task

8.4.1 Loading device for wrenches, nutrunners and screwdrivers with impact or impulse mechanism

During measurement, the machine shall be operated against a loading device (i.e. a brake device). The rotational frequency of the output shaft shall not exceed 10 min^{-1}. Examples of the design of suitable brake devices are given in Annex C.

8.4.2 Selection of size of brake block and socket

The brake device shall, as well as applying a frictional torque to the machine, provide a realistic inertial loading on the output shaft through the use of realistic sizes of sockets for different sizes of machine.

Only brake block and socket combinations for the most common square-drive sizes are specified in Annex C:

- *Brake device, small* refers to machines with 6,3 mm, 10 mm, 12,5 mm and 16 mm (1/4 in, 3/8 in, 1/2 in and 5/8 in) square output shaft drives and for machines with 1/4 in hex female drives;

- *Brake device, large* refers to machines with 20 mm, 25 mm and 40 mm (3/4 in, 1 in and 11/2 in) square output shaft drives.

For other output shaft drives, other block and socket combinations may be used. Adaptors between the machine output shaft and the socket of a standard combination may be selected. In these cases, the socket size (inertia) shall be realistic for the machine, and adaptors, if used, shall be as short as possible. The female square-drive sockets shall be within the tolerances specified in ISO 691. If extensions or adaptors are used in the test, they shall be described in the test report.

NOTE The use of extensions and adaptors will normally increase vibration.

8.4.3 Feed force

The applied feed force shall be the minimum force required to ensure stable operation of the machine in accordance with the manufacturer's recommendations.

8.4.4 Test procedure

Each operator (see 8.5) shall carry out a series of five measurements under the operating conditions specified in 8.2.

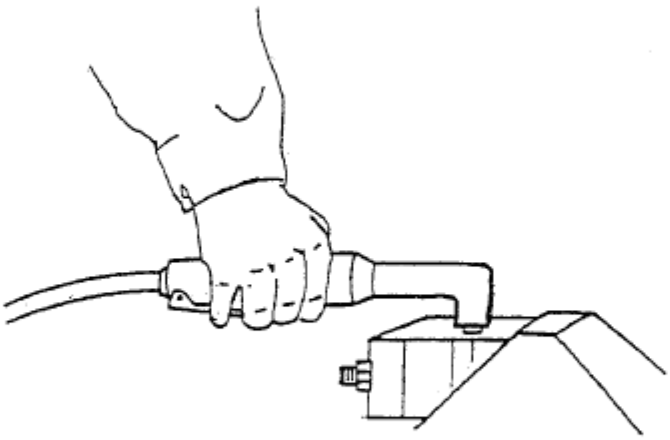
A complete test sequence is set out in the model test report given in Annex A.

Each test run shall be such that the measurements can be carried out with an integration time in accordance with 7.4, when stable operation has been established.

All machine types except for impact and impulse machines shall be measured running free with a standard size socket or toolbit mounted. Impact and impulse machines shall be tested using the devices specified in 8.4.1 and 8.4.2.

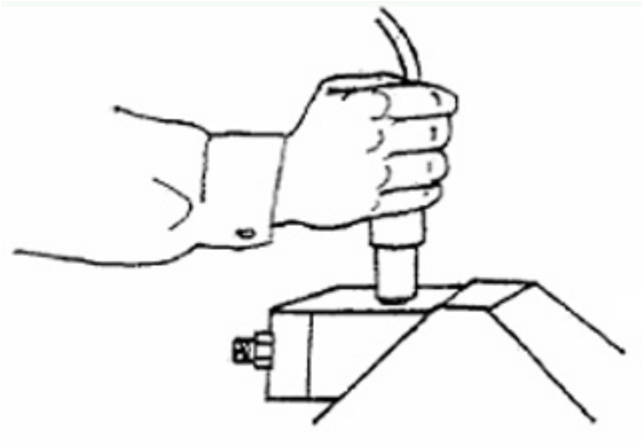
Shut-off impact and impulse machines shall be run (measured) in left-hand/reverse rotation. Any machine run in the left-hand/reverse rotation shall be held with the left hand on the trigger handle.

Figures 21 to 25 show typical working positions for operators during testing of wrenches, nutrunners and screwdrivers with an impact or impulse mechanism in the brake device. Similar hand and arm positions shall be used when machines are run under no-load conditions. Pistol grip machines run in no-load shall have the spindle horizontal.



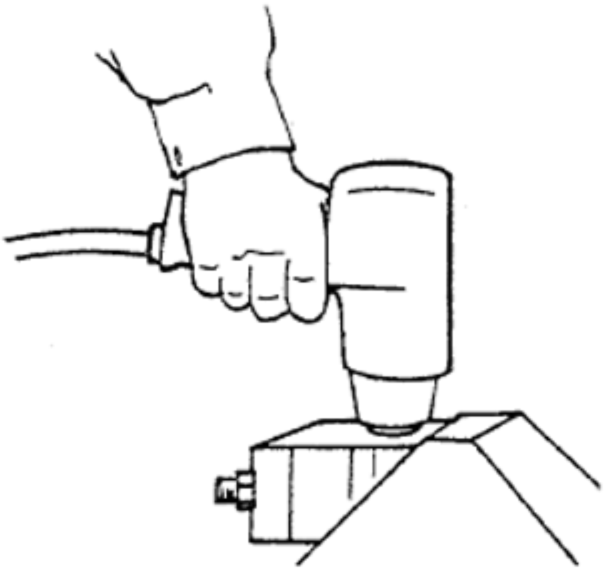
The operator's arm(s) shall be perpendicular to the control handle and in the plane of the motor and output shaft.

Figure 21 — Operator working position — Straight control-handle machines with angle head
(see Figure 5)



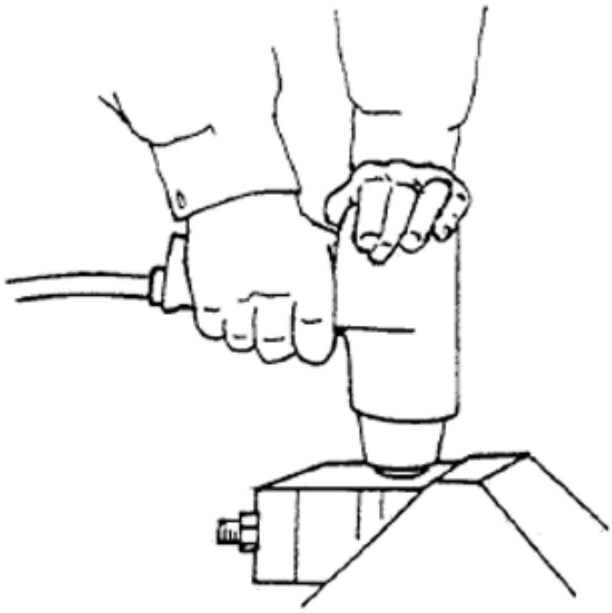
The operator's arm shall be horizontal, and perpendicular to the handle.

Figure 22 — Operator working position — Straight control-handle machines with straight head
(see Figure 6)



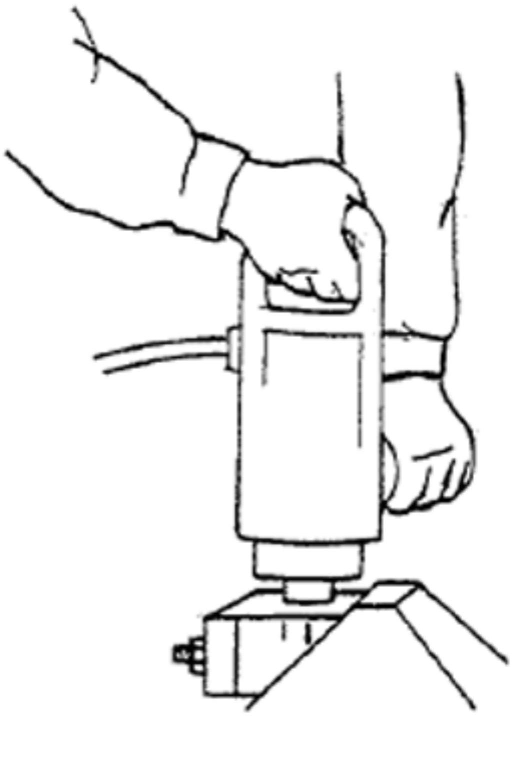
When the mass of the machine is less than 2 kg, one-handed operation shall be used.

Figure 23 — Operator working position — Pistol-grip control-handle machines without support handle
(see Figure 1)



When the mass of the machine is more than 2 kg, two-handed operation shall be used.

Figure 24 — Operator working position — Pistol-grip control handle machines without support handle (see Figure 1)



The operator's arm on the support-handle shall be as parallel as possible to the motor shaft.

Figure 25 — Operator working position — Two-handle machines (see Figures 2, 3 and 9)

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:

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

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

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

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 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 28927-2);

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, integrators, 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).

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 wrenches, nutrunners and screwdrivers

See Tables A.1 and A.2.

Table A.1 — General information and reported results

<table>
<tr><td colspan="2">The test has been carried out in accordance with ISO 28927-2, Hand-held portable power tools — Test method for evaluation of vibration emission — Part 2: Wrenches, nutrunners and screwdrivers</td></tr>
<tr><td colspan="2">Tester:</td></tr>
<tr><td>Measured by (company/laboratory):</td><td>Tested by:
Reported by:
Date:</td></tr>
<tr><td colspan="2">Test object and declared value:</td></tr>
<tr><td>Machine tested (power supply and machine type, manufacturer, machine model and name, mass):</td><td>Declared vibration emission value a_{hd} and uncertainty, K:</td></tr>
<tr><td colspan="2">Measuring equipment:</td></tr>
<tr><td colspan="2">Transducers (manufacturer, type, positioning, fastening method, photos, mechanical filters if used):</td></tr>
<tr><td>Vibration instrumentation:</td><td>Auxiliary equipment:</td></tr>
<tr><td colspan="2">Operating and test conditions and results:</td></tr>
<tr><td colspan="2">Test conditions (test method used, size of socket or toolbit used, type of brake material, operator posture and hand position, photos):</td></tr>
<tr><td>Measured rotational speed (for machines run freely)</td><td>Power supply (air pressure, hydraulic flow, voltage):</td></tr>
<tr><td colspan="2">Any other quantities to report:</td></tr>
</table>

Table A.2 — Measurement results for one machine

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

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

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

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

or

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

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

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

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

where

n is 5, the number of measured values;

$a_{\text{hv}ij}$ is the vibration total value for the i^{th} test with the j^{th} operator;

$\overline{a_{\text{hv}j}}$ 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.

$$s_{\text{op}}{}^2 = \frac{1}{m-1}\sum_{j=1}^{m}(\overline{a_{\text{hv}j}} - a_{\text{h}})^2$$

where

m is three, i.e. the number of operators;

$\overline{a_{\text{hv}j}}$ 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

$$K = 1{,}5\sigma_{\text{t}}$$

where σ_{t} is estimated by the value s_{t}, given by

a) $s_{\text{t}} = \sqrt{\overline{s_{\text{R}}{}^2} + s_{\text{b}}{}^2}$

or

b) $s_{\text{t}} = 0{,}06a_{\text{hd}} + 0{,}3$,

whichever is the greater.

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

$\overline{s_{\text{R}}{}^2}$ is the mean value of $s_{\text{R}}{}^2$ 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).

Annex C
(normative)

Brake devices — Assembly drawings and specification of parts

Brake devices consist of the following elements:

— a steel base for mounting the brake and supporting the inner brake block;

— a pair of brake blocks, which can be made as solid blocks of phenolic cotton laminate (fine grade)[12)] or, in newer designs, as aluminum blocks with a lining on the cylindrical surface (see Tables C.1 and C.2 footnotes);

— a steel plate which supports the outer brake block;

— two cover plates made of steel;

— a socket that is rotated by the machine;

— bolts, nuts and spring washers used to apply the contact pressure between the socket and the brake block;

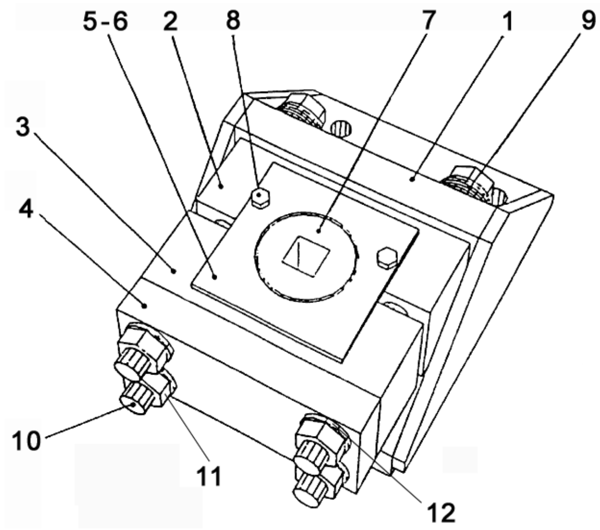
— mounting screws for stopping the axial movements of the socket.

The spring washer shall be mounted in suitable directions to give an appropriate contact pressure, i.e. such that they are half-compressed when the specified rotational frequency is reached.

Intense use of the brake device may necessitate the introduction of air cooling by the addition of a small hole in the lower cover plate.

The mounted test rig shall not have any resonances within the frequency range for hand–arm vibration that could influence the test results. This can be assured by bolting the base frame to a concrete block having a mass of at least 400 kg.

12) The use of pnenolic cotton laminate has been carried over from ISO 8662 (see Foreword).



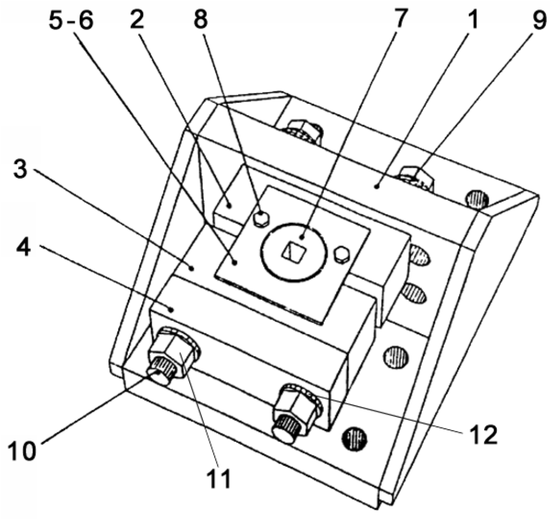
See Table C.1.

Figure C.1 — Brake device, large — For machines with shaft sizes 20 mm**,** 25 mm **and** 40 mm

Table C.1 — Brake device, large

Brake device, large				**Square drive size**		
			in	3/4	1	1 1/2
			mm	20	25	38
Pos.	**Name of part**	**No.**	**Material**	**Quantity**		
1	Base	1001	Structural steel	1	1	1
2	Block, large (R 35)	1002-01	a	1	—	—
2	Block, large (R 51)	1002-02		—	1	1
3	Block, large (R 35)	1002-03		1	—	—
3	Block, large (R 51)	1002-04		—	1	1
4	Plate, large	1004	Tool steel	1	1	1
5	Coverplate, large upper	1006-01	General engineering steel	1	—	—
5	Coverplate, large upper	1006-02	General engineering steel	—	1	1
6	Coverplate, large lower	1007	General engineering steel	1	1	1
7	Socket (3/4; 69,9)	1011-01		1	—	—
7	Socket (1; 101,6)	1011-02		—	1	—
7	Socket (1.1/2; 101,6)	1012		—	—	1
8	Screw M8 x 100		ISO 8.8	2	2	2
9	Conical disc spring 40/20,4/2,25 (approx.)		DIN 2093 – A 40 GR 2	40	40	40
10	Screw M20 × 250		ISO 8.8	4	4	4
11	Nut M20		ISO 8.8	4	4	4
12	Plain washer 37 × 21,3 × 3,3 (approx.)		General engineering steel	8	8	8

[a] Solid block of phenolic cotton laminate (fine grade), or aluminum block with a lining on its cylindrical surface. Linings shall be made of a friction material, whose coefficient of friction shall be tested and the difference between static and dynamic friction shall be less than 20 %.



See Table C.2.

Figure C.2 — Brake device, small — For machines with shaft sizes 6,3 mm**,** 10 mm**,** 12,5 mm **and** 16 mm

Table C.2 — Brake device, small

Brake device, small				Square drive size					Female hex	
			in	1/4	1/4	3/8	1/2	5/8	1/4	
			mm	6,3	6,3	10	12,5	16		
Pos.	**Name of part**	**No.**	**Material**	**Quantity**						
1	Base	1001	Structural steel	1	1	1	1	1	1	1
2	Block, small (R 11,25)	1003-01		—	1	—	—	—	—	—
2	Block, small (R 16)	1003-02		—	—	1	—	—	—	—
2	Block, small (R 25,5)	1003-03		—	—	—	1	1	—	—
3	Block, small (R 11,25)	1003-04		—	1	—	—	—	—	—
3	Block, small (R 16)	1003-05		—	—	1	—	—	—	—
3	Block, small (R 25,5)	1003-06	a	—	—	—	1	1	—	—
3	Block, small (R 7)	1003-7		1	—	—	—	—	—	—
3	Block, small (R 7)	1003-8		1	—	—	—	—	—	—
3	Block, small (R 5)	1003-9		—	—	—	—	—	1	—
3	Block, small (R 5)	1003-10		—	—	—	—	—	1	—
3	Block, small (R 4)	1003-11		—	—	—	—	—	—	1
3	Block, small (R 4)	1003-12		—	—	—	—	—	—	1
4	Plate, small	1005	Tool steel	1	1	1	1	1	1	1
5	Coverplate, small upper	1008-01	General engineering steel	1	1	1	—	—	1	1
5	Coverplate, small upper	1008-02	General engineering steel	—	—	—	1	1	—	—
5	Coverplate, small upper	1008-03	General engineering steel	—	—	—	—	—	1	1
6	Coverplate, small lower	1009	General engineering steel	1	1	1	1	1	1	1
7	Socket (1/4; 22,2)	1010-01		—	1	—	—	—	—	—
7	Socket (3/8; 22,2)	1010-02		—	—	1	—	—	—	—
7	Socket (1/2; 50,8)	1010-03		—	—	—	1	—	—	—
7	Socket (5/8; 50,8)	1010-04		—	—	—	—	1	—	—
7	Socket (1/4; 14)	1010-05		1	—	—	—	—	—	—
7	Socket (hex 1/4; 10)	1013-01		—	—	—	—	—	1	—
7	Socket (hex 1/4; 8)	1013-02		—	—	—	—	—	—	1
8	Screw M6 x 60		ISO 8.8	2	2	2	2	2	2	2
9	Conical disc spring 31,5/16,3/1,75 (approx.)		DIN 2093 – A 31,5 GR 2	20	20	20	20	20	20	20
10	Screw M16 × 200		ISO 8.8	2	2	2	2	2	2	2
11	Nut M16		ISO 8.8	2	2	2	2	2	2	2
12	Plain washer 30 × 17,3 × 3,3 (approx)		General engineering steel	4	4	4	4	4	4	4

[a] Solid block of phenolic cotton laminate (fine grade), or aluminum block with a lining on its cylindrical surface. Linings shall be made of a friction material, whose coefficient of friction shall be tested and the difference between static and dynamic friction shall be less than 20 %.

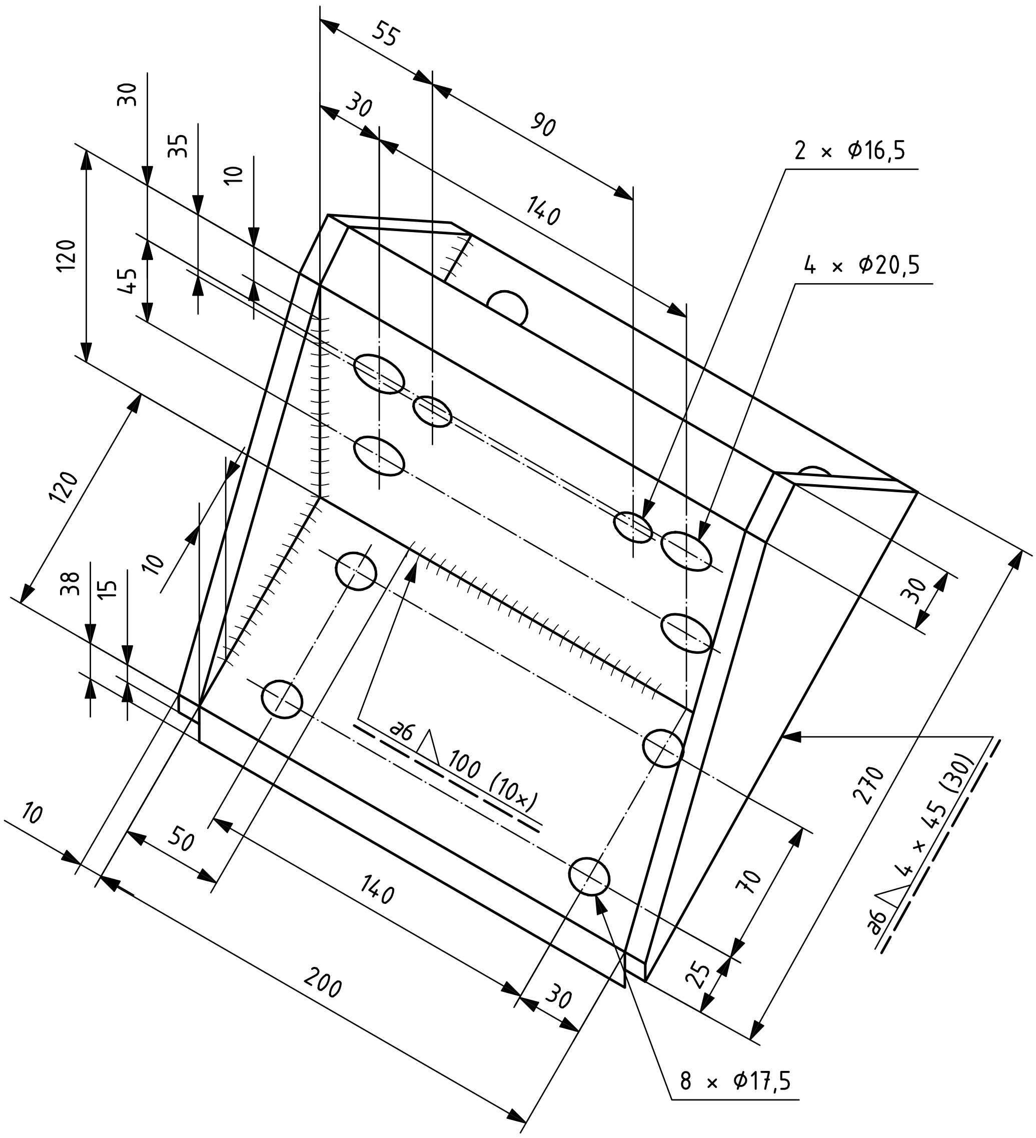
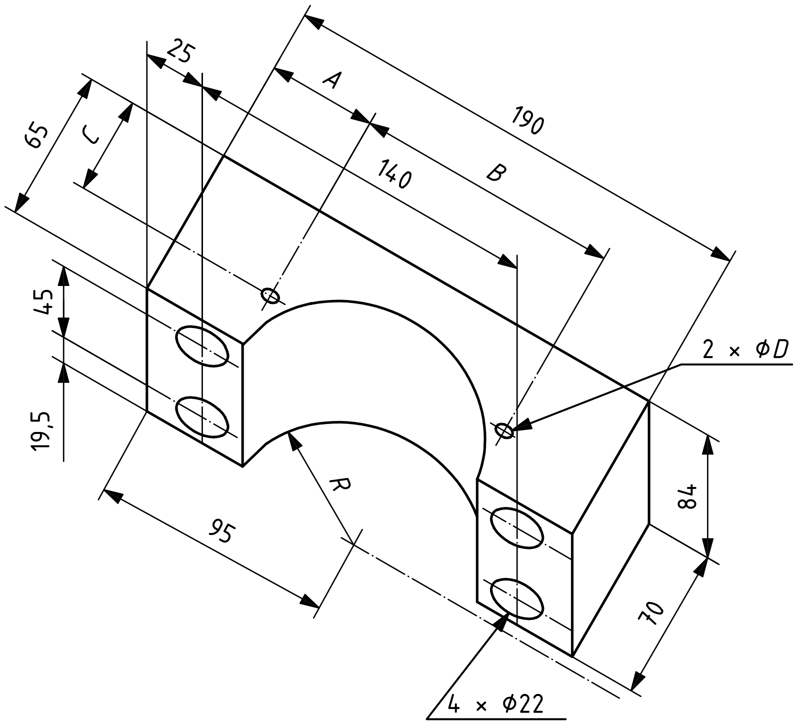
Name of part	Material	Dimensions mm
Base 1001	Structural steel	

Figure C.3 — Base — 1001

<table>
<tr><th>Name of part</th><th>Material</th><th>Dimensions
mm</th></tr>
<tr><td>Block, large 1002</td><td>Solid block of phenolic cotton laminate (fine grade), or aluminum block with a lining on its cylindrical surface. Linings shall be made of a friction material, whose coefficient of friction shall be tested and the difference between static and dynamic friction found to be less than 20 %.</td><td>

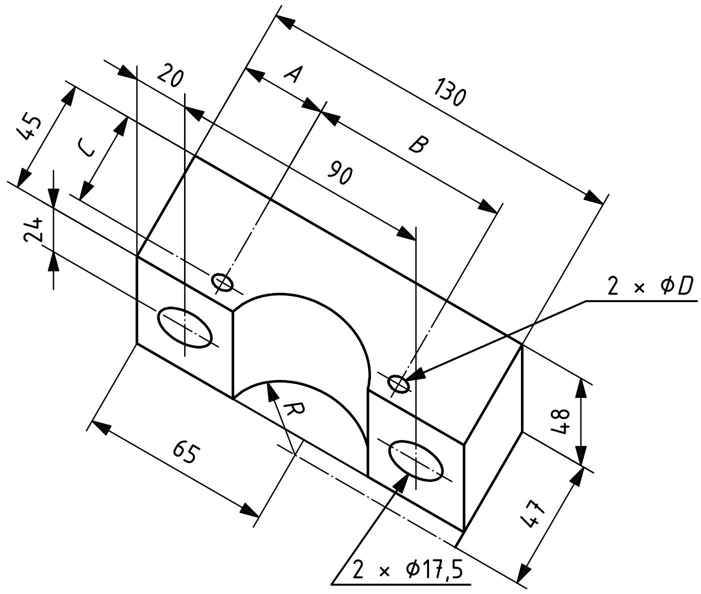


No.	*A*	*B*	*C*	*D*	*R*
1002-01	43	104	45	9	35
1002-02	43	104	35	9	51
1002-03	—	—	—	—	35
1002-04	—	—	—	—	51

</td></tr>
</table>

Figure C.4 — Block, large, 1002

Name of part	Material	Dimensions mm
Block, small 1003	Solid block of phenolic cotton laminate (fine grade), or aluminum block with a lining on its cylindrical surface. Linings shall be made of a friction material, whose coefficient of friction shall be tested and the difference between static and dynamic friction found to be less than 20 %.	See drawing and table below



No.	*A*	*B*	*C*	*D*	*R*
1003-7	34	62	38	7	7
1003-8	—	—	—	—	7
1003-9	34	62	38	7	5
1003-10	—	—	—	—	5
1003-11	34	62	38	7	4
1003-12	—	—	—	—	4
1003-01	34	62	38	7	11,25
1003-02	34	62	38	7	16
1003-03	34	62	30	7	25,5
1003-04	—	—	—	—	11,25
1003-05	—	—	—	—	16
1003-06	—	—	—	—	25,5

Figure C.5 — Block, small, 1003

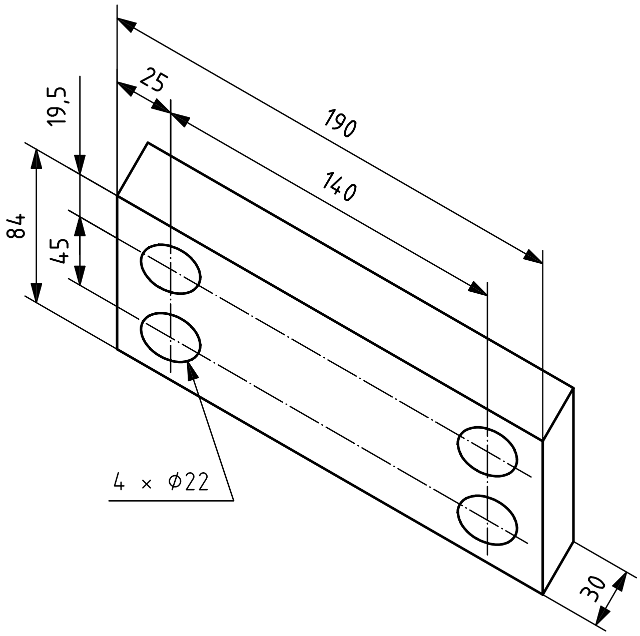
Name of part	Material	Dimensions mm
Plate, large 1004	Tool steel	

Figure C.6 — Plate, large, 1004

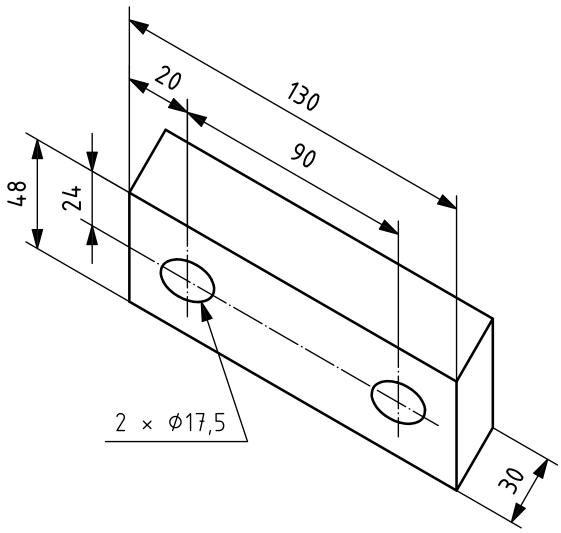
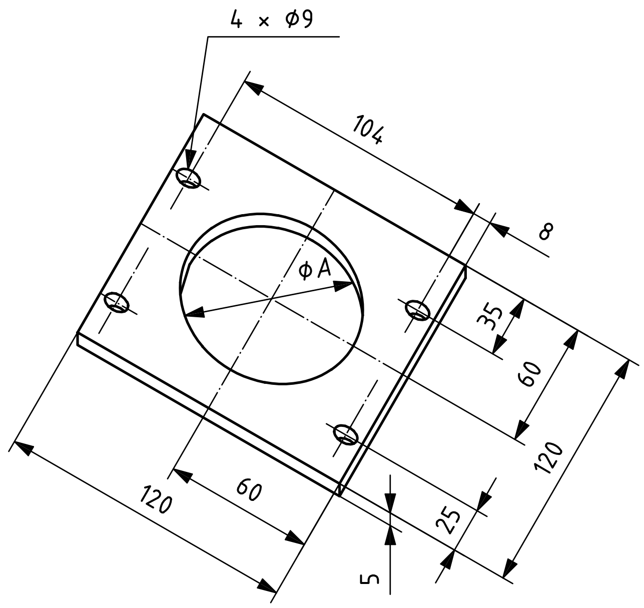
Name of part	Material	Dimensions mm
Plate, small 1005	Tool steel	

Figure C.7 — Plate, small, 1005

Name of part	Material	Dimensions mm
Coverplate, large, upper 1006	Tool steel	

No.	*A*
1006-01	46
1006-02	75

Figure C.8 — Coverplate, large, upper, 1006

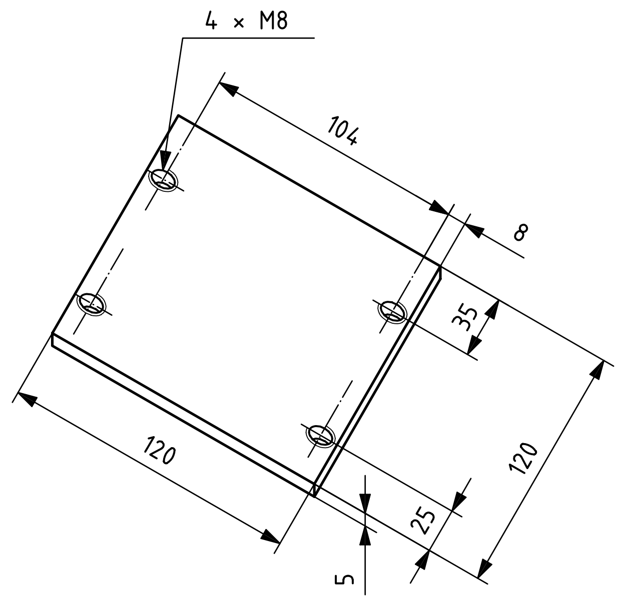
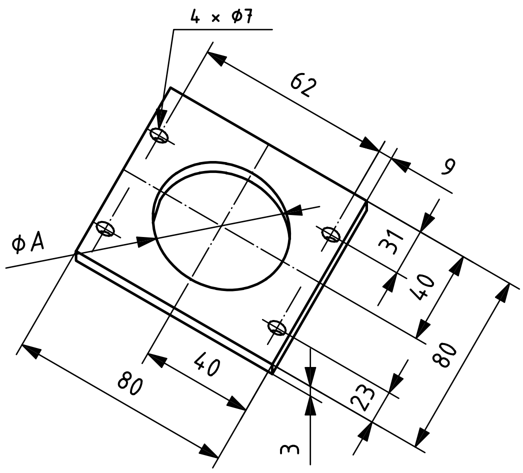
Name of part	Material	Dimensions mm
Coverplate, large, lower 1007	General engineering steel	

Figure C.9 — Coverplate, large, lower, 1007

Name of part	Material	Dimensions mm
Coverplate, small, upper 1008	General engineering steel	

No.	*A*
1008-01	19
1008-02	46
1008-03	12
1008-04	7,5

Figure C.10 — Coverplate, small, upper, 1008

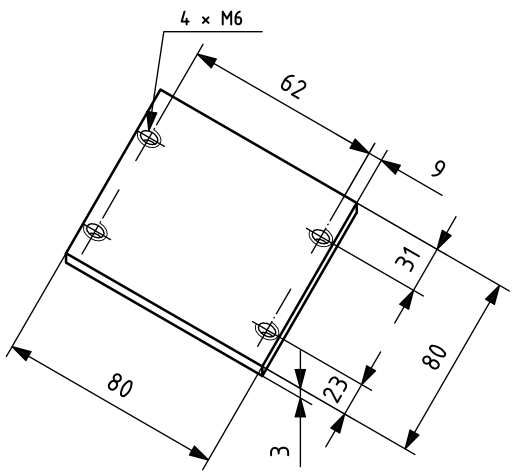
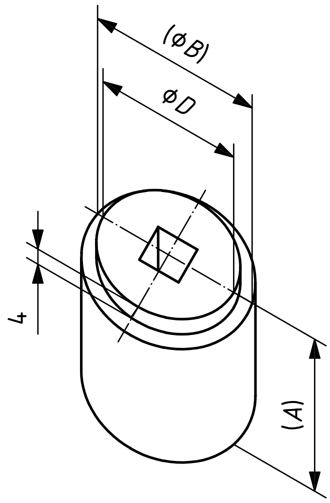
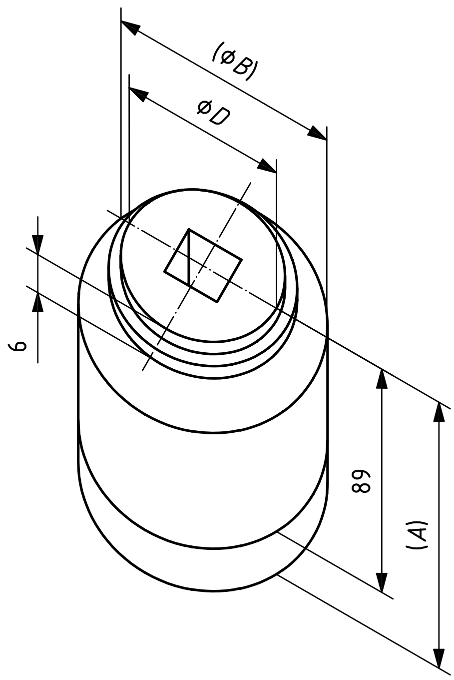
Name of part	Material	Dimensions mm
Coverplate, small, lower 1009	General engineering steel	

Figure C.11 — Coverplate, small, lower, 1009

<table>
<tr><th>Name of part</th><th>Material</th><th>Dimensions
mm</th></tr>
<tr><td>Socket
1010</td><td>General engineering steel</td><td>


<table>
<tr><th>No.</th><th>Square drive</th><th>A</th><th>B</th><th>D</th></tr>
<tr><td>1010-01</td><td>6,3; 1/4</td><td>50,8</td><td>22,2</td><td>17</td></tr>
<tr><td>1010-02</td><td>10; 3/8</td><td>50,8</td><td>31,8</td><td>17</td></tr>
<tr><td>1010-03</td><td>12,5; 1/2</td><td>50,8</td><td>50,8</td><td>43</td></tr>
<tr><td>1010-04</td><td>16; 5/8</td><td>50,8</td><td>50,8</td><td>43</td></tr>
<tr><td>1010-05</td><td>6,3; 1/4</td><td>50,8</td><td>14</td><td>10</td></tr>
</table>
A may be made shorter if a suitable stud is added between the socket and the lower cover plate. Other combinations of square drive size and socket outer diameter may be used as long as the rotational speed can be kept within given limits.
</td></tr>
</table>

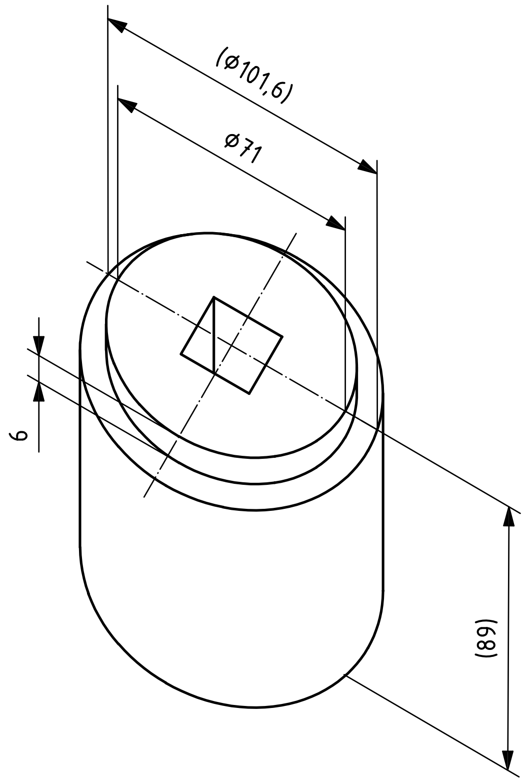
Figure C.12 — Socket, 1010

Name of part	Material	Dimensions mm
Socket 1011	General engineering steel	

No.	Square drive	*A*	*B*	*D*
1011-01	20; 3/4	101,6	69,9	42
1011-02	25; 1	114,3	101,6	71

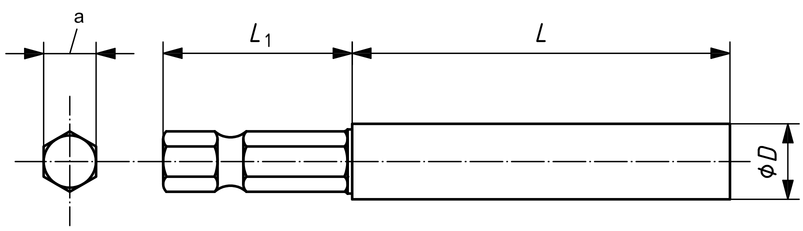
A may be made shorter if a suitable stud is added between the socket and the lower cover plate. Other combinations of square drive size and socket outer diameter may be used as long as the rotational speed can be kept within given limits.

Figure C.13 — Socket, 1011

<table>
<tr><th>Name of part</th><th>Material</th><th>Dimensions
mm</th></tr>
<tr><td>Socket 1012</td><td>General engineering steel</td><td>

Square drive 11/2 38 mm</td></tr>
</table>

Figure C.14 — Socket, 1012

<table>
<tr><th>Name of part</th><th>Material</th><th>Dimensions
mm</th></tr>
<tr><td>Socket 1013</td><td>General engineering steel</td><td>

<table>
<tr><th>No.</th><th>a</th><th>L_1</th><th>L</th><th>D</th></tr>
<tr><td>1013-01</td><td rowspan="2">1/4</td><td>25</td><td>50</td><td>10</td></tr>
<tr><td>1013-02</td><td>25</td><td>50</td><td>8</td></tr>
<tr><td colspan="5">[a] Standard hex drive 1/4 inch or other drive suitable for the machine to be tested.</td></tr>
</table>
L may be made shorter if a suitable stud is added between the socket and the lower cover plate.</td></tr>
</table>

Figure C.15 — Socket, 1013

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*

[3] DIN 2093, *Disc springs — Quality specifications — Dimensions*

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