BS ISO 1985:2015

BSI Standards Publication

Machine tools — Test conditions for surface grinding machines with vertical grinding wheel spindle and reciprocating table — Testing of the accuracy

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National foreword

This British Standard is the UK implementation of ISO 1985:2015. It supersedes BS ISO 1985:1998 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MTE/1/2, Machine tools - Accuracy.

A list of organizations represented on this committee can be obtained on request to its secretary.

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INTERNATIONAL STANDARD

ISO 1985

Fourth edition
2015-03-01

Machine tools — Test conditions for surface grinding machines with vertical grinding wheel spindle and reciprocating table — Testing of the accuracy

Machines-outils — Conditions d'essai des machines à rectifier les surfaces planes, à broche porte-meule à axe vertical et à table à mouvement alternatif — Contrôle de l'exactitude

Reference number
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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 39, *Machine Tools*, Subcommittee SC 2, *Test Conditions for Metal Cutting Machine Tools.*

This fourth edition cancels and replaces the third edition (ISO 1985:1998), which has been technically revised.

Introduction

The purpose of this International Standard is to standardize methods of testing the accuracy of general purpose and normal accuracy surface grinding machines with vertical grinding wheel spindle and reciprocating table.

The primary function of such machines is to provide flat surfaces on workpieces. This International Standard specifies the tests to verify the geometric accuracy of the machine to achieve this primary function. For example, the test to check the straightness of the column movement (Y-axis) in the horizontal XY-plane (E_{XY}) is removed from ISO 1985:1998, since it is not directly correlated to this primary function.

Positioning repeatability test for automatic mode (Not NC) is introduced. References to ISO 230-1 are revised and referred to 2012 edition.

INTERNATIONAL STANDARD ISO 1985:2015(E)

Machine tools — Test conditions for surface grinding machines with vertical grinding wheel spindle and reciprocating table — Testing of the accuracy

1 Scope

This International Standard specifies, with reference to ISO 230-1 and ISO 230-7, both geometric and machining tests on general purpose, normal accuracy, manually, and numerically controlled (NC) surface grinding machines with reciprocating table and vertical grinding wheel spindle. It also specifies the applicable tolerances corresponding to the above-mentioned tests.

This International Standard is not applicable to surface grinding machines with fixed or rotating tables or to machines having longitudinal traverse of the wheelhead.

This International Standard deals only with the verification of the geometric accuracy of the machine. It does not apply to the testing of the machine operation (vibrations, abnormal noises, stick-slip motion of components, etc.), nor to the checking of its characteristics (such as speeds, feeds, etc.), which should generally be checked before testing the accuracy. This International Standard provides the terminology used for the principal components of the machine and the designation of the axes with reference to ISO 841:2001.

NOTE In addition to the terms used in the official ISO languages (English and French), this International Standard gives the equivalent terms in the German, Italian, Persian, and Japanese languages in Annex B; these are published under the responsibility of the national member bodies for Germany (DIN), Italy (UNI), Iran (ISIRI), and Japan (JISC). However, only the terms given in the official language can be considered as ISO terms.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 230-1:2012, *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or quasi-static conditions*

ISO 230-2, *Test code for machine tools — Part 2: Determination of accuracy and repeatability of positioning numerically controlled axes*

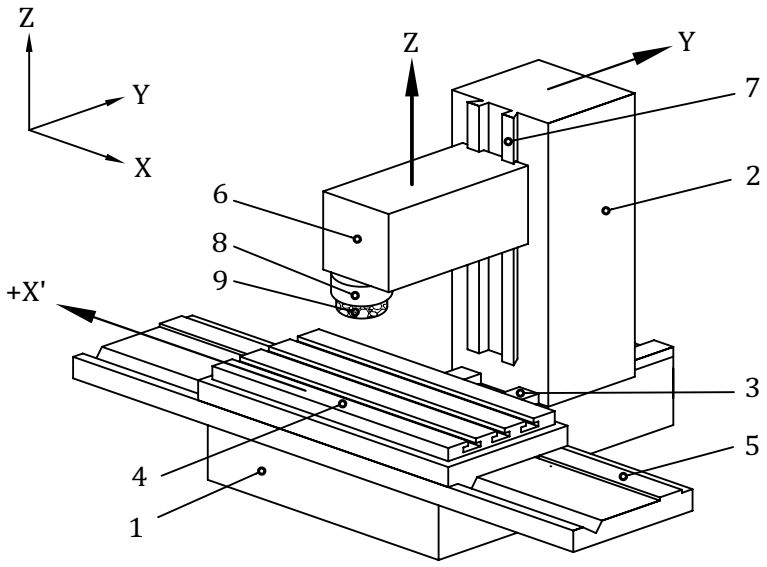
ISO 230-7:—[1)], *Test code for machine tools — Part 7: Geometric accuracy of axes of rotation*

3 Terminology and designation of axes

See Figure 1 and Table 1.

NOTE Some machines do not have the Y-axis.

1) To be published.



NOTE See Table 1 for key reference.

Figure 1 — Typical example of a surface grinding machine with a vertical grinding wheel spindle and a reciprocating table

Table 1 — Terminology

Ref.	English	French
1	bed	banc
2	column (Y-axis)	colonne (axe Y)
3	column slideways	glissières de la colonne
4	table (X-axis)	table (axe X)
5	table slideways	glissières de la table
6	wheelhead (Z-axis)	chariot porte-meule (axe Z)
7	wheelhead slideways	glissières du chariot porte-meule
8	wheel guard	protecteur de meule
9	grinding wheel	meule

4 Preliminary remarks

4.1 Measurement units

In this International Standard, all linear dimensions, deviations, and corresponding tolerances are expressed in millimetres; angular dimensions are expressed in degrees; angular deviations and the corresponding tolerances are expressed primarily in ratios, but in some cases, microradians or arcseconds can be used for clarification purposes. Formula (1) should be used for conversion of angular or tolerances.

$$0{,}010/1\,000 = 10 \times 10^{-6} = 10\ \mu\text{rad} \cong 2'' \quad (1)$$

4.2 Reference to ISO 230-1, ISO 230-2, and ISO 230-7

For application of this International Standard, reference shall be made to ISO 230-1 and to ISO 230-7, especially for the installation of the machine before testing, warming up of the spindles and other moving parts, the description of measuring methods, and recommended accuracy of testing equipment.

In the "Observations" block of tests described in Clause 5, the instructions are preceded by a reference to the corresponding clause/subclause in ISO 230-1 in cases where the test concerned is in compliance with the specifications. Similarly, for tests described in Annex A, the instructions are preceded by a reference to the corresponding clause/subclause in ISO 230-2 and ISO 230-7, respectively. Tolerances are given for each geometric test (see G1 to G12).

4.3 Machine levelling

Prior to conducting tests on a machine, the machine should be levelled according to the recommendations of the manufacturer/supplier (see ISO 230-1:2012, 6.1.2).

4.4 Testing sequence

The sequence in which the geometrics tests are given in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests can be performed in any order.

4.5 Tests to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests given in this International Standard. When the tests are required for acceptance purposes, the choice of tests relating to the components and/or the properties of the machine of interest is at the discretion of the user, in agreement with the manufacturer/supplier. The tests to be used are to be clearly stated when ordering a machine. A mere reference to this International Standard for the acceptance tests, without specifying the tests to be carried out, and without agreement on the relevant expenses, cannot be considered as binding for any contracting parties.

4.6 Measuring instruments

The measuring instruments indicated in the tests described in Clause 5 are examples only. Other instruments measuring the same quantities and having the same or smaller measurement uncertainty can be used. Reference shall be made to ISO 230-1:2012, Clause 5, which indicates the relationship between measurement uncertainties and the tolerances.

4.7 Diagrams

For reasons of simplification, the figures in Clause 5 and Annex A illustrate only one type of machine.

4.8 Software compensation

When built-in software facilities are available for compensating geometric, positioning contouring and/or thermal deviations, their use during these tests shall be based on agreement between the manufacturer/supplier and user, with due consideration to the machine tool intended use.

When the software compensation is used, this shall be stated in the test reports.

It shall be noted that when software compensation is used, axes shall not be locked for test purposes.

4.9 Minimum tolerance

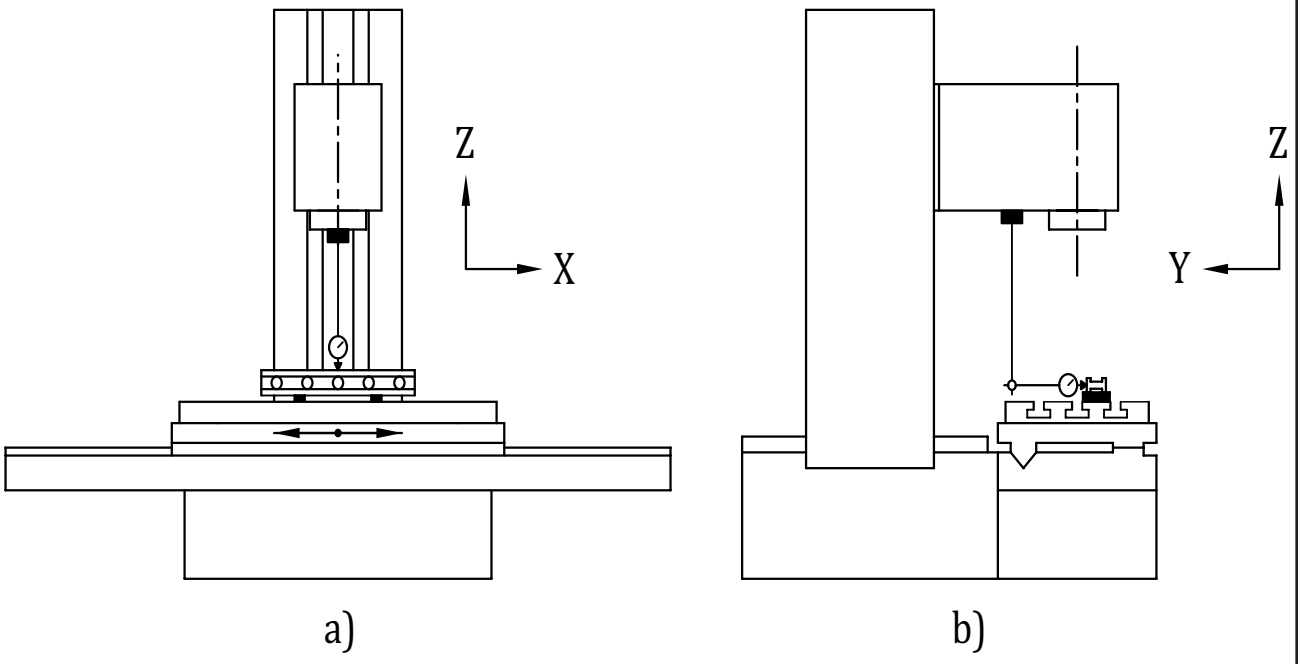
When the tolerance for a geometric test is established for a measuring length different from that given in this International Standard, the tolerance can be determined by means of the law of proportionality (see ISO 230-1:2012, 4.1.2). It shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

4.10 Machining test

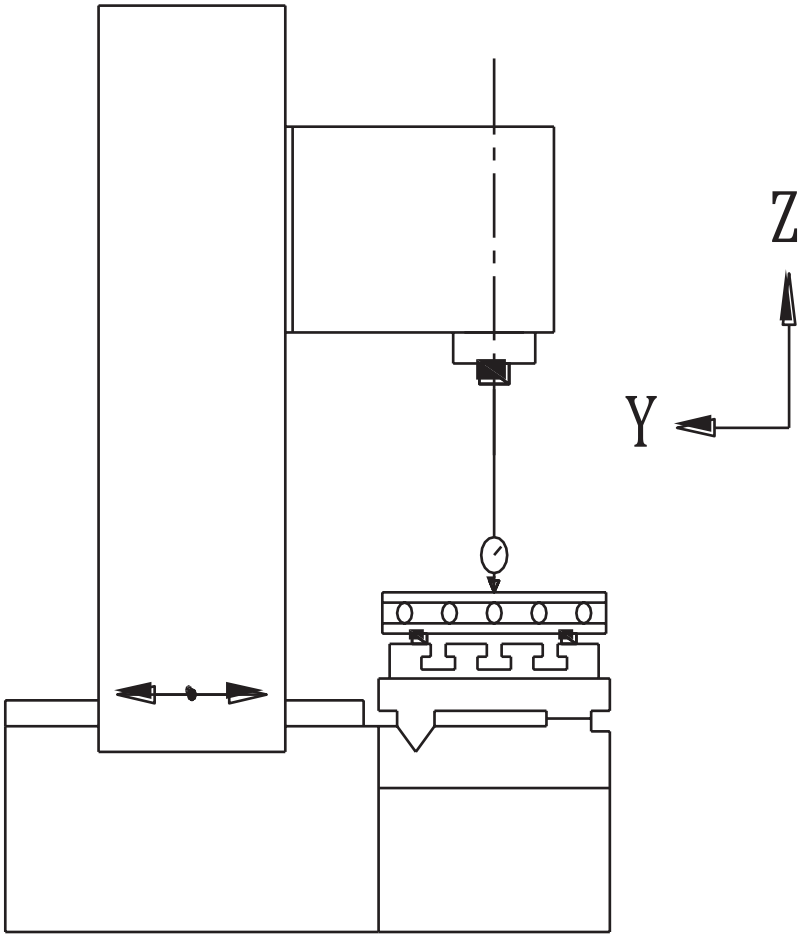
Machining tests shall be made under finishing conditions.

5 Geometric tests

5.1 Linear axes

Object	**G1**
Checking of straightness of the table movement (X-axis) a) in the vertical ZX-plane (E_{ZX}), and b) in the horizontal XY-plane (E_{YX}).	
Diagram  	
Tolerance For a) and b) 0,01 for measuring lengths up to 1 000 For each 1 000 increase in length, add 0,01 to the preceding tolerance Maximum tolerance: 0,025	**Measured deviations** a) b)
Measuring instruments Straightness reference artefact, gauge blocks, and linear displacement sensor	
Observations and references to ISO 230-1:2012, 3.4.8, 8.2.2.1, and 8.2.3 Mount the linear displacement sensor on the head, near the spindle. Adjust the straightness reference artefact to obtain similar readings at each end of the measuring length. Feed the X-axis through the measuring length and record the sensor readings. NOTE The fixture of the straightness reference artefact can affect the test result.	

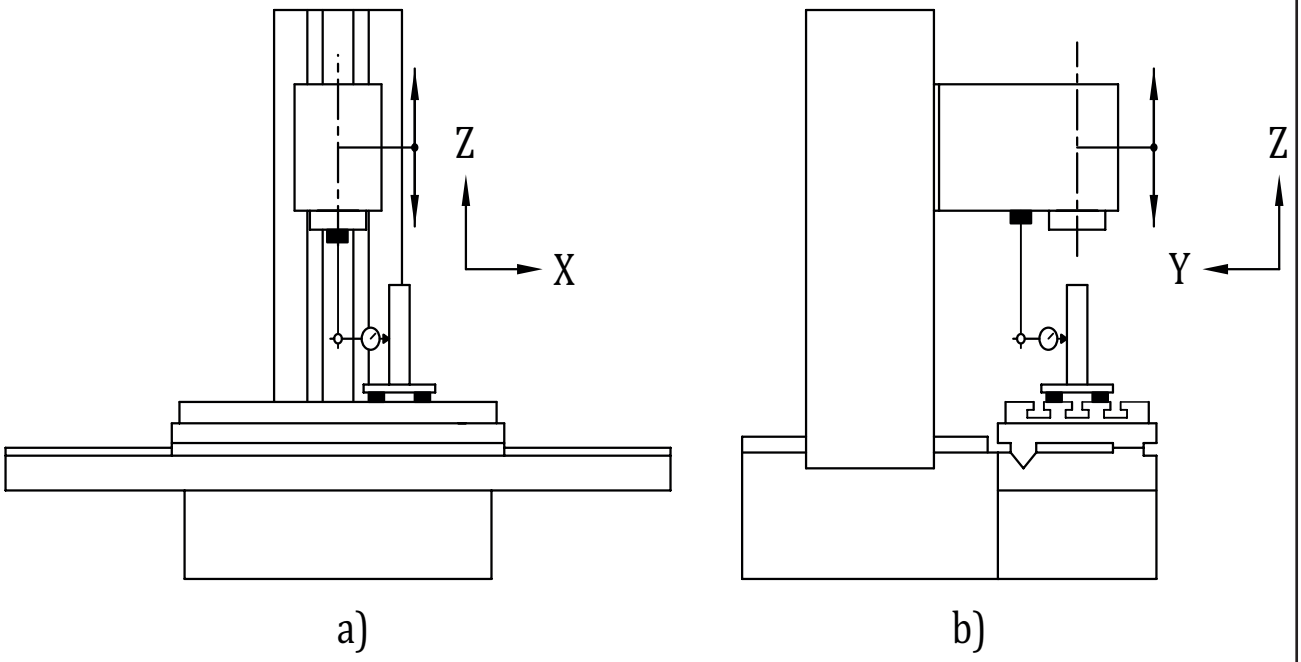
Object	**G2**
Checking of straightness of the column movement (Y-axis) in the horizontal ZY-plane (E_{ZY}) (Only for machines having this movement)	
Diagram	



Tolerance	**Measured deviations**
0,01 for measuring lengths up to 1 000 For each 1 000 increase in length, add 0,01 to the preceding tolerance Maximum tolerance: 0,025	
Measuring instruments Straightness reference artefact, gauge blocks, and linear displacement sensor	
Observations and references to ISO 230-1:2012, 3.4.8, 8.2.2.1, and 8.2.3 Mount the linear displacement sensor on the head, near the spindle. Adjust the straightness reference artefact to obtain similar readings at each end of the measuring length. Feed the Y-axis through the measuring length and record the sensor readings.	

Object	**G3**
Checking of straightness of the vertical movement of the wheelhead (Z-axis) a) in the vertical ZX plane (E_{XZ}), and b) in the vertical YZ plane (E_{YZ}).	

Diagram



Tolerance	**Measured deviations**
For a) and b)	a)
0,02 for a measuring length of 300	b)

Measuring instruments

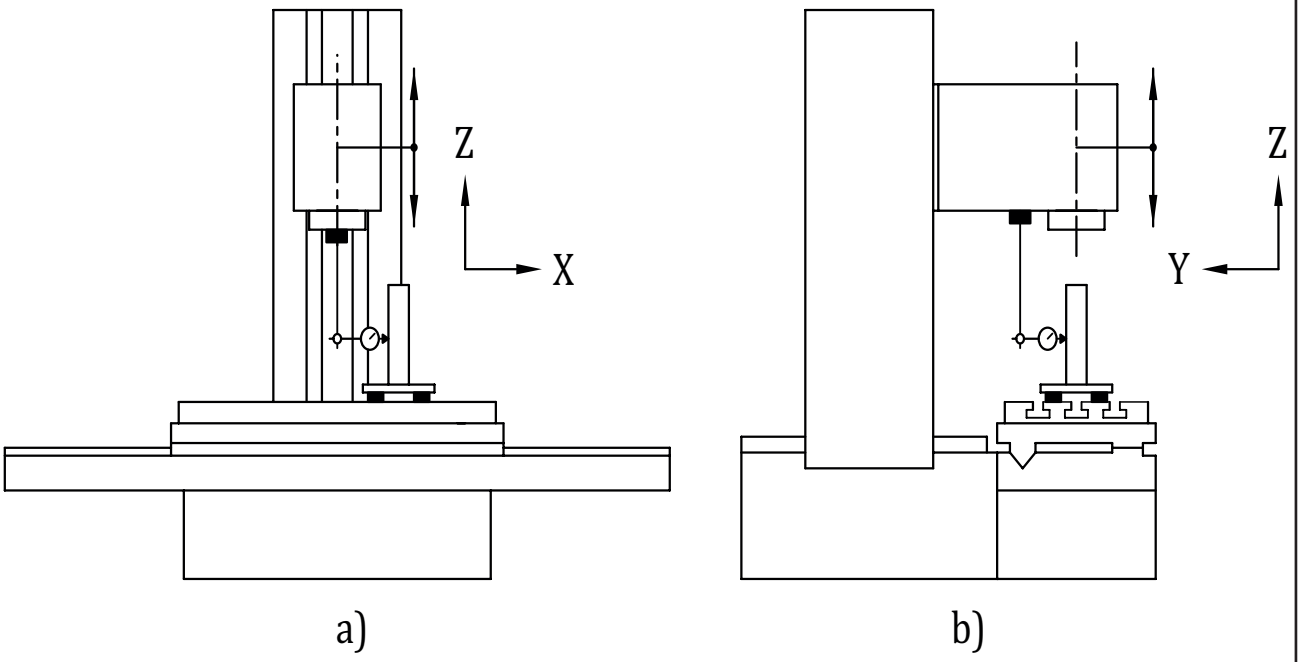
Linear displacement sensor and straightness reference artefact or optical measuring instruments

Observations and references to ISO 230-1:2012, 3.4.8, 8.2.2.1, and 8.2.3

Mount the linear displacement sensor on the head, near the spindle.

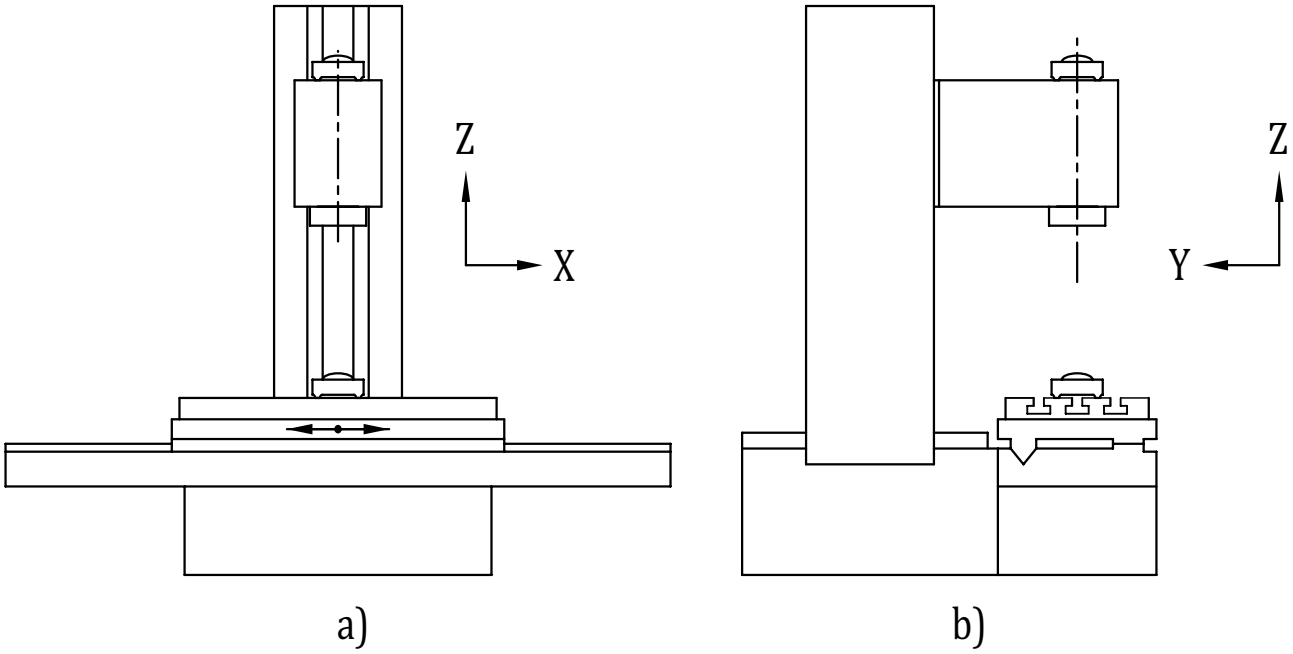
Adjust the straightness reference artefact parallel to the Z-axis to obtain similar sensor readings at each end of the measuring length.

Feed the Z-axis through the measuring length and record the sensor readings.

Object	**G4**
Checking of squareness error of the vertical movement of the wheelhead (Z-axis) to a) the X-axis motion ($E_{B(0X)Z}$), and b) the Y-axis motion ($E_{A(0Y)Z}$).	
Diagram  	
Tolerance for a) and b) 0,05/1 000 (0,015/300)	**Measured deviations** a) b)
Measuring instruments Squareness reference artefact, surface plate, adjustable blocks and linear displacement sensor, or optical measuring instruments	
Observations and references to ISO 230-1:2012, 3.6.7, 10.3.2.2, and 10.3.2.5 Mount the surface plate on the table and adjust it so that the surface is parallel to both the X- and Y- axis. Place the squareness reference artefact on the surface plate. Mount the linear displacement sensor on the wheelhead. a) Set the linear displacement sensor against the squareness reference artefact in the X-direction and move the wheelhead in the Z-direction through the measuring length, and record the sensor readings at several positions. The inclination of the reference straight line of the trajectory of the sensor readings is the squareness error and shall be reported (see ISO 230-1:2012, 3.6.7). b) Repeat the check in the same way in the Y-direction.	

Object	**G5**
Checking of angular deviations of the table movement (X-axis) a) in the vertical ZX-plane (pitch, E_{BX}), and b) in the vertical YZ-plane (roll, E_{AX}).	

Diagram



Tolerance	**Measured deviations**
a) 0,04/1 000	a)
b) 0,02/1 000	b)

Measuring instruments

Precision level or optical angular deviation measuring instruments

Observations and references to ISO 230-1:2012, 3.4.16, 8.4.2.1, 8.4.2.2, and 8.4.3

The level or the instrument shall be placed longitudinally for a) and transversely for b)

1) on the first 300 mm of the table surface,

2) on the centre of the table, and

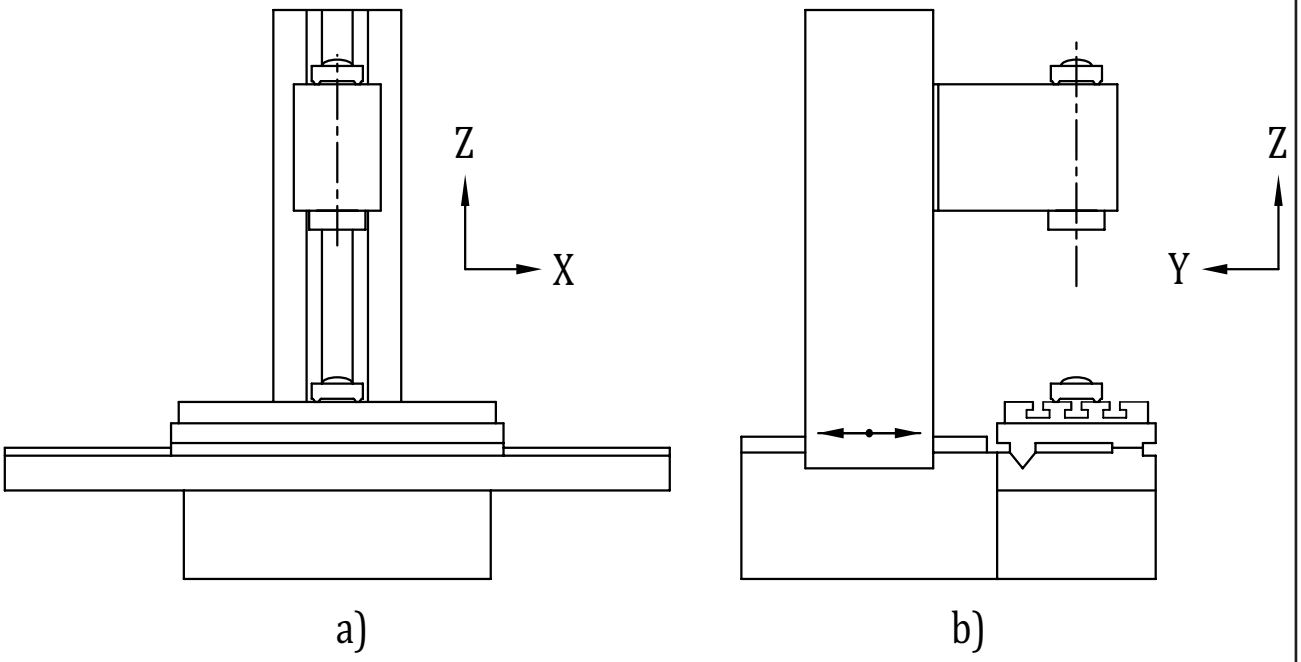
3) on the last 300 mm of the table surface.

When X-axis motion causes an angular movement of both spindle head and workholding table, differential measurements of the two angular movements shall be made and this shall be stated.

The reference level (when used) shall be located on the spindle head, and the spindle head shall be in the middle of the travel range.

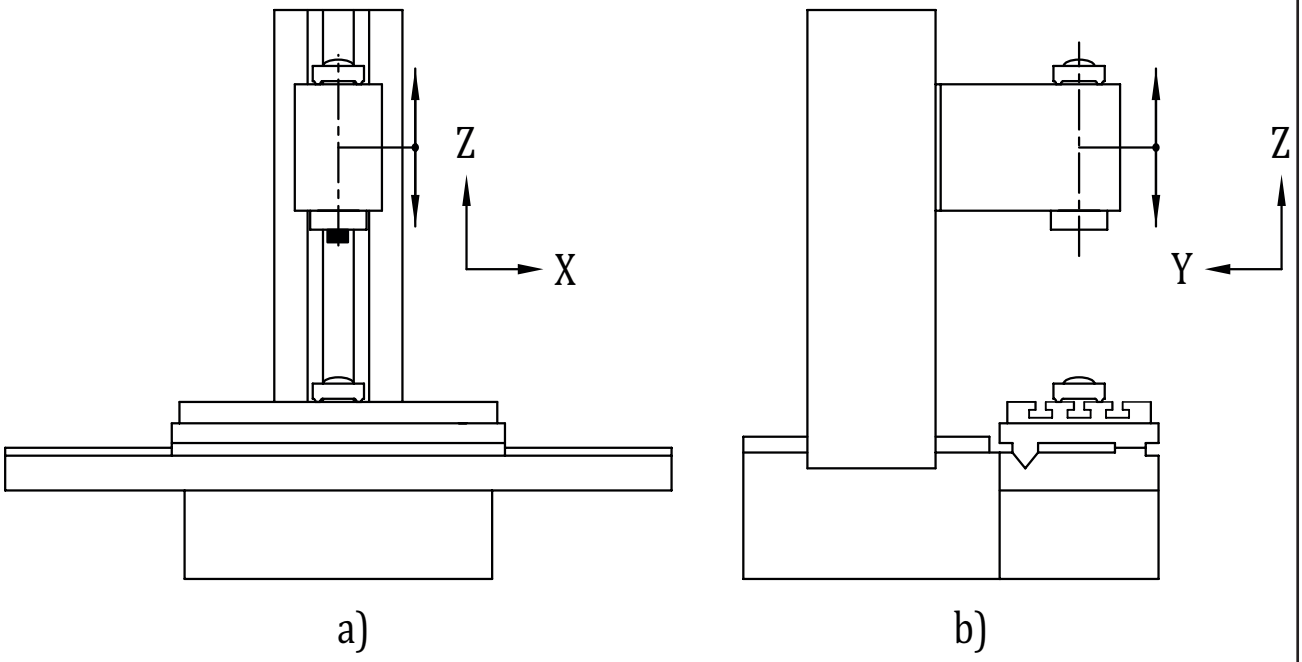
Measurements shall be taken at a number of positions equally spaced along the travel.

The difference between the maximum reading and the minimum reading of the two directions shall be reported, both for the centre of the table and for the ends of the table.

Object	**G6**
Checking of angular deviations of the column movement (Y-axis) (only for machines having this movement) a) in the vertical ZX-plane (roll, E_{BY}), and b) in the vertical YZ-plane (pitch, E_{AY}).	
Diagram	
	
Tolerance a) 0,02/1 000 b) 0,04/1 000	**Measured deviations** a) b)
Measuring instruments Precision level or optical angular deviation measuring instruments	
Observations and references to ISO 230-1:2012, 3.4.16, 8.4.2.1, 8.4.2.2, and 8.4.3 The level or the instrument shall be placed transversely for a) and longitudinally for b). When Y-axis motion causes an angular movement of both spindle head and workholding table, differential measurements of the two angular movements shall be made and this shall be stated. The reference level (when used) shall be located on the work-holding table, and the spindle head shall be in the middle of the travel range. Measurements shall be taken at a number of positions equally spaced along the travel. The difference between the maximum reading and the minimum reading of the two directions shall be reported.	

Object	**G7**
Checking of angular deviations of the vertical movement of the wheelhead (Z-axis) a) in the vertical ZX plane (E_{BZ}), and b) in the vertical YZ plane (E_{AZ}).	

Diagram



Tolerance	**Measured deviations**
a) 0,04/1 000	a)
b) 0,02/1 000	b)

Measuring instruments

Precision level or optical angular deviation measuring instruments

Observations and references to ISO 230-1:2012, 3.4.16, 8.4.2.1, 8.4.2.2, and 8.4.3

The level or the instrument shall be placed X-direction for a) and Y-direction for b).

When Z-axis motion causes an angular movement of both spindle head and workholding table, differential measurements of the two angular movements shall be made and this shall be stated.

The reference level (when used) shall be located on the workholding table.

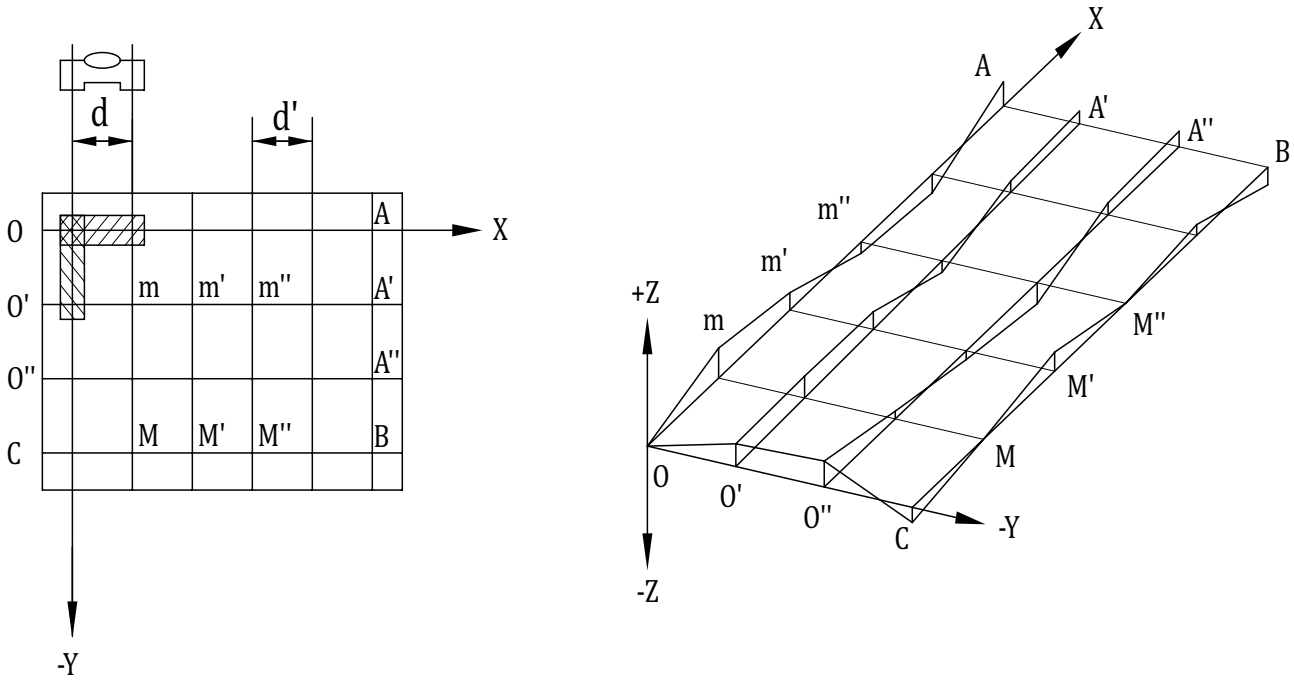
Measurements shall be taken at a number of positions equally spaced along the travel.

The difference between the maximum reading and the minimum reading shall be reported.

5.2 Table

Object	**G8**
Checking of flatness of the table surface	

Diagram



Tolerance	**Measured deviations**
0,01 for measuring lengths up to 1 000 For each 1 000 increase in length, add 0,01 to the preceding tolerance Maximum tolerance: 0,04 Local tolerance: 0,005 over any measuring area of 300 × 300	

Measuring instruments

Straightness reference artefact and gauge blocks or precision level or optical measuring instruments

Observations and references to ISO 230-1:2012, 12.2.4.2, 12.4.2.1, and 12.2.5

Set the table at the centre of X-axis and Y-axis motion. Place the precision level on the table surface and move it in X- and Y-directions in the steps corresponding to its length and record the readings. For each direction measurement, angular deviation method (ISO 230-1:2012, 12.1.3) is the basis of this measurement.

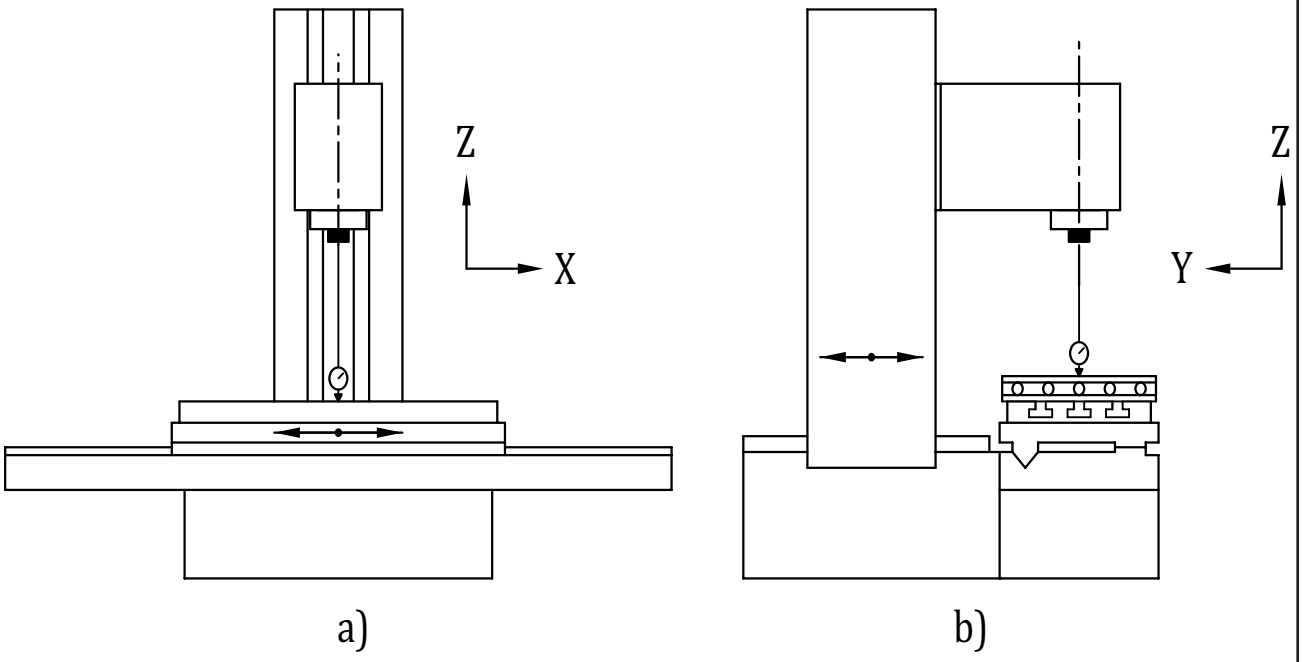
Measuring shall start from the point O, O',.... and C and be implemented on the line OA, line O'A',... and line CB in the direction of X-axis, and then start from the point O and be implemented on the line OC in the Y-direction.

The flatness error shall be calculated according to ISO 230-1:2012, 12.2.4.2 and reported.

If the machine is equipped with a magnetic chuck, the test can be carried out on its top surface.

Object	**G9**
Checking of parallelism between the table surface (Table) and a) its movement (X-axis, $E_{B(0X)Table}$), and b) the movement of the wheel head column or the table (Y-axis, $E_{A(0Y)Table}$). (Only for machines having this movement)	

Diagram



Tolerance	**Measured deviations**
a) 0,010 × L/1 000 Maximum tolerance: 0,030 Local tolerance: 0,003 for any measuring length of 300 b) 0,007 × L/1 000 where L = measuring length	a) b)

Measuring instruments

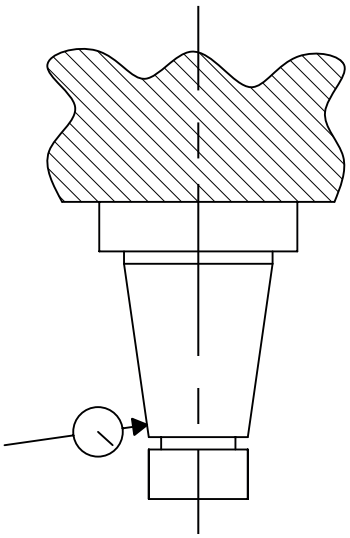
Linear displacement sensor and straightedge reference artefact

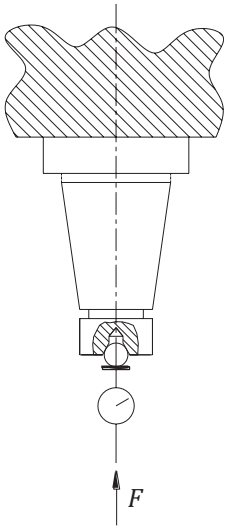
Observations and references to ISO 230-1:2012, 3.6.5 and 12.3.2.5

Mount the linear displacement sensor on the head, with its stylus approximately aligned to the grinding wheel spindle axis.

When the direct measurement of table surface is difficult due to e.g. T-slots, a straightness reference artefact set on the table can be used (see ISO 230-1:2012, 12.3.2.5.2).

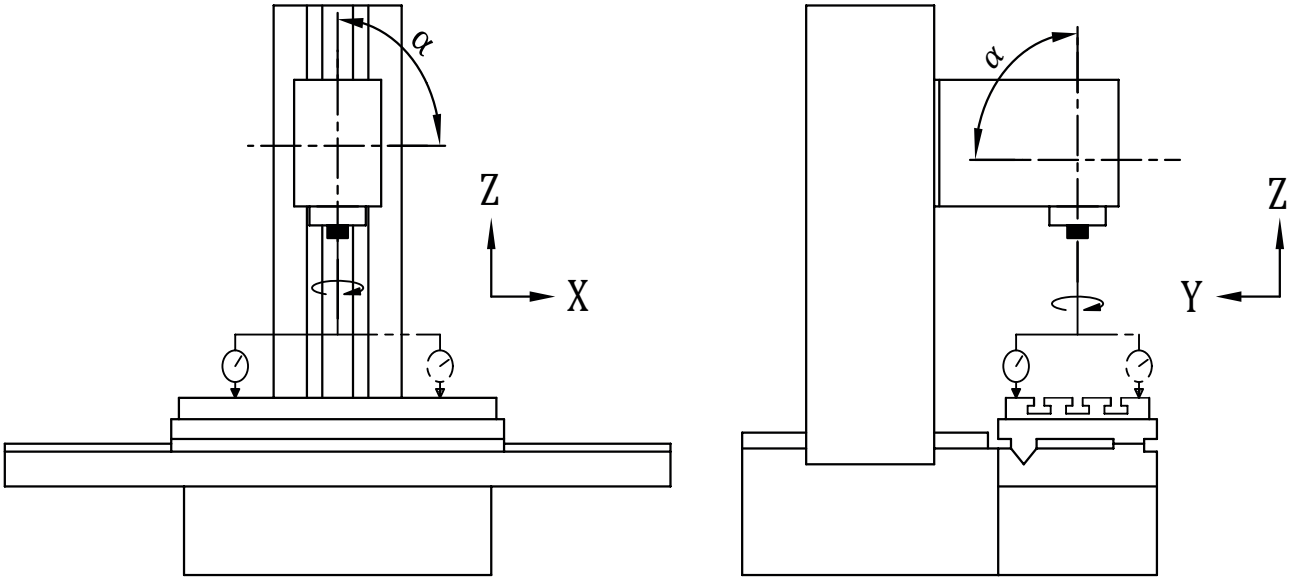
5.3 Spindle

Object	**G10**
Checking of the run-out of the wheel spindle nose	
Diagram 	
Tolerance 0,005	**Measured deviations**
Measuring instruments Linear displacement sensor	
Observations and references to ISO 230-1:2012, 3.9.7 and 12.5.3 The stylus of the linear displacement sensor should be set normal to the surface which is to be checked. Checking should be carried out at each extremity of the taper. The wheel-spindle shall be rotated at slow speed. NOTE Refer to Annex A, AR1 for comparable results.	

Object	**G11**
Checking of axial error motion of the wheel spindle	
Diagram  	
Tolerance 0,005	**Measured deviations**
Measuring instruments Linear displacement sensor	
Observations and references to ISO 230-1:2012, 3.9.7 and 12.5 Axial force *F* can be applied if bearings are not preloaded. The force *F*, specified by the manufacturer/supplier of the machine, should be exerted coaxially with the spindle. The line of action of the stylus of the linear displacement sensor should be co-axial with the spindle. NOTE Refer to Annex A, AR1 for comparable results.	

Object	**G12**
Checking of squareness error of the wheel spindle axis to a) the X-axis motion ($E_{B(OX)(C)}$), and b) the Y-axis motion ($E_{A(OY)(C)}$). (For machines which have no wheel spindle adjustment in that plane)	

Diagram



a) b)

Tolerance	**Measured deviations**
For a) and b) 0,033/1000 (0,01/300[1)]) 1) Where 300 is the distance between the two measuring points touched.	a) b)

Measuring instruments

Linear displacement sensor

Observations and references to ISO 230-1:2012, 10.3.3

The test a) can be performed by using the setup in G1 a). The test b) can be performed by using the setup in G2 a).

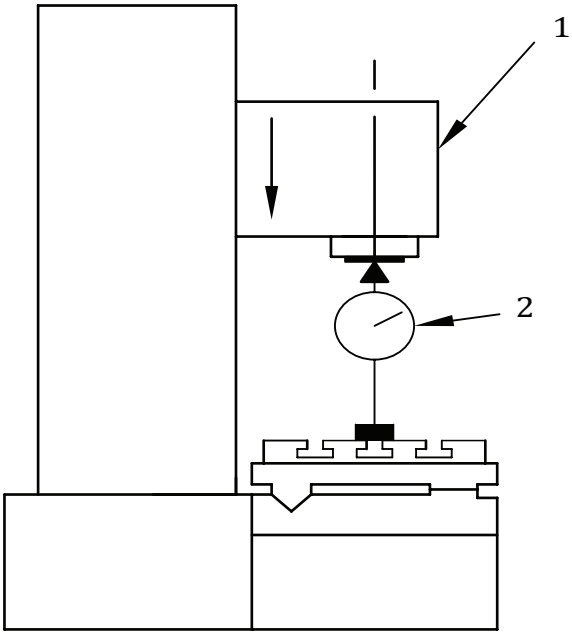
The table is in central position. The Z-axis is clamped, if possible (see 4.8).

The straightness reference artefact shall be set parallel to a) the X-axis or b) the Y-axis, or the lack of parallelism shall be considered in the measurement.

The value of angle α, being less than, equal to or greater than 90°, shall be reported.

6 Positioning tests

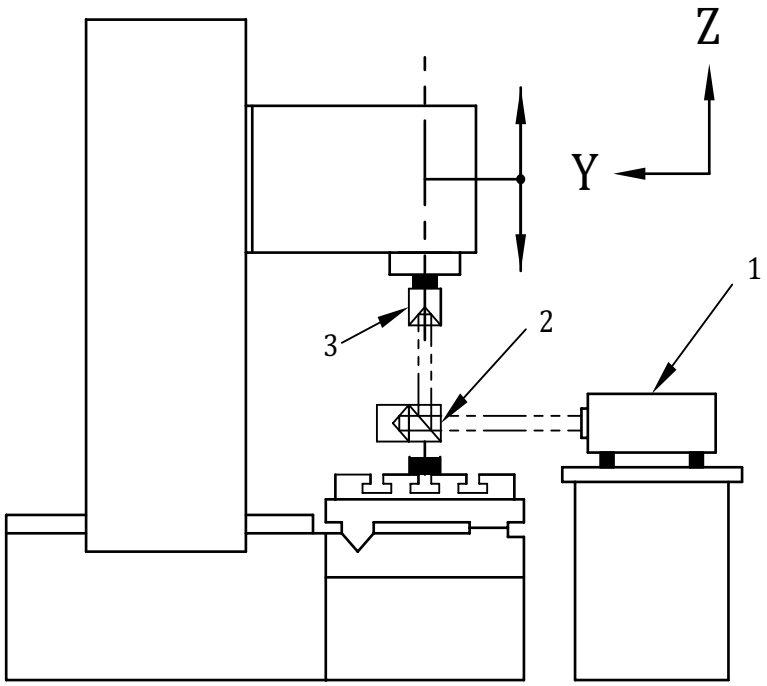
6.1 Positioning of manual or automatic (but not numerically controlled) linear axes

Object	**P1**
Checking of repeatability of the final approach and positioning of Z-axis motion. a) final approach repeatability; b) incremental minimum step feed and positioning. NOTE The test applies only to machines equipped for infeed grinding operations.	
Diagram  **Key** 1 wheelhead 2 linear displacement sensor	
Tolerance a) 0,003 b) 0,005	**Measured deviations**
Measuring instruments Linear displacement sensor	
Observations and references to ISO 230-1:2012, 3.4.7 and 8.3 Linear displacement sensor shall be placed on the table against to the wheel head (spindle end) so as to measure relative displacement between the spindle side and the table side. a) Carry out five consecutive tests for the wheelhead positioning, the movement being obtained by a fast approach followed by a slow approach. A range of five readings shall be reported. b) Incremental positioning at five positions to the Z- direction with minimum step feed values, e.g. in the case of 10 µm minimum step, total travel length is 50 µm, the movement by a slow feed rate. A maximum difference of five incremental readings shall be reported.	

6.2 Positioning of numerically controlled linear axis

Object	**P2**
Checking of accuracy, repeatability, and reversal value of positioning of the Z-axis motion	

Diagram



Key

1 laser head

2 interferometer

3 reflector

Tolerance		**Measuring length**			**Measured deviation**
		≤250	≤500	≤1 000	
Bi-directional accuracy of positioning	$E_{ZZ,A}$	0,022	0,025	0,032	
Unidirectional repeatability of positioning	$E_{ZZ,R\uparrow}$ and $E_{ZZ,R\downarrow}$	0,006	0,008	0,010	
Bi-directional repeatability	$E_{ZZ,R}$	0,012	0,015	0,018	
Reversal value of axis	$E_{ZZ,B}$	0,010	0,010	0,012	
Mean reversal value	$E_{ZZ,\overline{B}}$	0,006	0,006	0,008	
Bi-directional systematic deviation of positioning	$E_{ZZ,E}$	0,015	0,018	0,023	
Mean bi-directional positional deviation of the axis	$E_{ZZ,M}$	0,010	0,012	0,015	

Measuring instruments

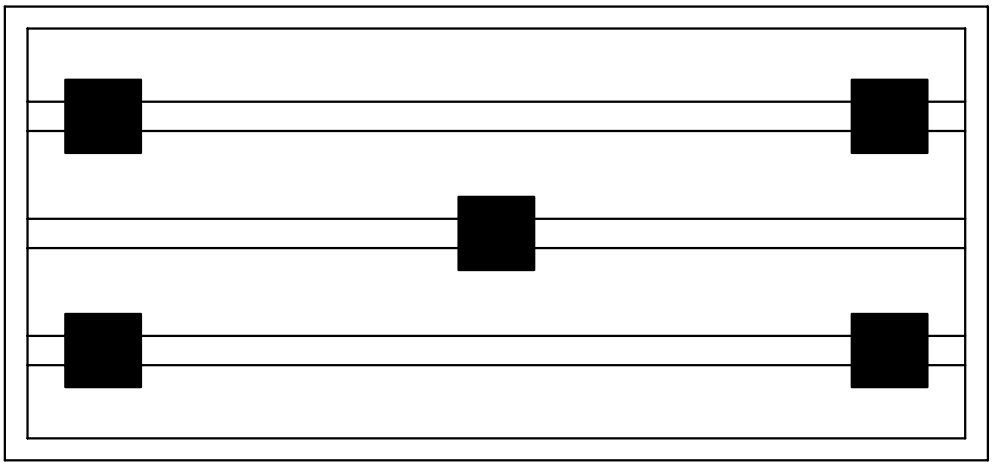
Laser measurement equipment or standard scale of length and microscope

Observations and reference to ISO 230-1:2012, 8.3 and ISO 230-2

Standard scale of length or beam axis of laser measurement equipment shall be set parallel to the axis under test.

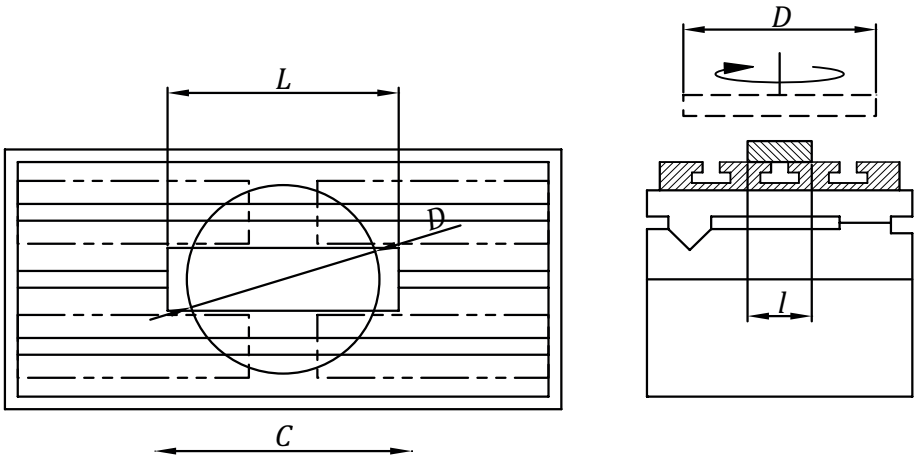
Rapid feed is used for positioning in principle, but arbitrary feed rate can be used in agreement between user and manufacturer/ supplier.

7 Machining tests

Object	**M1**
Grinding of five cylindrical or rectangular test pieces Checking of the variation in the thickness of test pieces machined at different positions on the machine table	
Diagram 	
Checks to be applied After grinding, test pieces should have the same thickness.	
Tolerance 0,005 for a distance between test pieces of 300 Add 0,01 or each increase of 1 000 in distance between test pieces. Maximum tolerance: 0,05	**Measured deviations**
Measuring instruments Linear displacement sensor or thickness tester	
Observations and references to ISO 230-1:2012, Annex B.1 The surface of the test pieces in contact with the table should be ground before carrying out the test. The test pieces should be positioned as follows: — one at the central point of the table; — one at each of the four corners of the table. Material from which the test pieces should be manufactured can be either cast iron or steel. The test pieces should be of equal hardness and should be suitably fixed to the table. The dimensions of the functional surfaces of the test pieces should be as small as practicable, for instance: 50 mm × 50 mm square or 50 mm diameter.	

Object	**M2**
Grinding of a rectangular test piece in a single cut For the first test, the test piece should be fixed at the central position on the table. For any additional test, the test pieces can be fixed at each of the four corners of the table. Checking of the flatness of the test piece(s)	

Diagram and sizes of test pieces



$l \geq D/3 \quad L \geq C/2$

where

D is the diameter of grinding wheel;
l is the width of test piece;
L is the length of test piece;
C is the length of table travel.

Checks to be applied

Checking of the flatness of the test piece(s)

Tolerance	**Measured deviations**
0,005 for a measuring distance of 300 Maximum tolerance: 0,03	

Measuring instruments

Linear displacement sensor

Observations and references to ISO 230-1:2012, Annex B.1

The test piece should be clamped to the table by mechanical means. The rigidity of the test piece shall be such as to prevent the clamping causing any deformation of the test piece.

Material from which the test pieces should be manufactured can be either cast iron or steel.

Grind the test piece's upper surface. Then, fix the test piece upside down (i.e. the ground surface is the reference surface in contact with the table) at the same position. Grind the test piece and measure the thickness of the test piece over the test piece length L.

Let the maximum difference of the thickness be the flatness.

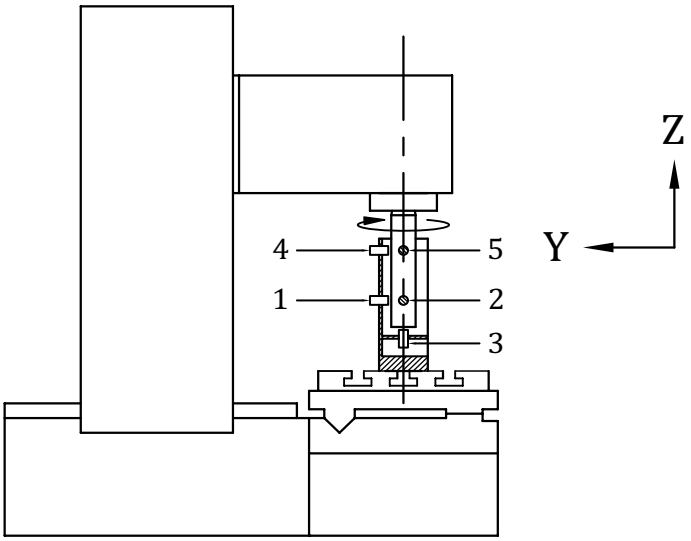
For additional tests, fix the same test piece at each of the four corners of the table, with the same reference surface in contact with the table. For each position, grind the test piece and measure the thickness of the test piece over the test piece length L. Additional test pieces can be ground at different Y-axis position, if the machine has the Y-axis. In such a case, the Y-axis position shall be reported.

Annex A
(informative)

Tests for checking accuracy of axes of rotation

Object	**AR1**
Axis of rotation error motion for wheel spindle a) axial error motion ($E_{axial(C)}$), and b) tilt error motion ($E_{tilt(C)}$).	

Diagram



Key

1 to 5 linear displacement sensors (probes). (See Observations)

Tolerance				**Measured deviation**
at percentage of maximum speed				
	10 %	50 %	100 %	
a) total axial error motion value $E_{axial(C)}$	0,010	0,014	0,020	
b) total tilt error motion value $E_{tilt(C)}$	0,040/1 000	0,060/1 000	0,080/1 000	
If the minimum speed is larger than 10 % of the maximum speed, then the spindle should be operated at minimum speed.				

Measuring instruments

Test mandrel, non-contacting probes, and angular measuring device or

two precision spheres located slightly eccentric to spindle average line and non-contacting probes.

Observations and references to ISO 230-7:—

This test is a spindle test with rotating sensitive direction (5.3).

After set-up of the measuring instrument, the spindle shall be warmed up at 50 % of the maximum spindle speed for a period of 10 min, if not otherwise agreed between manufacturer/supplier and user.

Total error motion is defined in ISO 230-7:—, 3.5.1; total error motion value is defined in ISO 230-7:—, 3.8.3. Measurements shall be carried out as follows:

a) total axial error motion value $E_{\mathrm{axial(C)}}$ (using probe 3)

Axial error motion measurement is described in ISO 230-7:—, 5.3.4.

For the axial error motion $E_{\mathrm{axial(C)}}$, a total error motion polar plot (ISO 230-7:—, 3.6.2) with a polar chart (PC) centre (ISO 230-7:—, 3.7.3) shall be provided.

b) total tilt error motion values $E_{\mathrm{tilt(C)}}$ (using probes 1,2,4,5)

Tilt error motion measurement is described in ISO 230-7:—, 5.3.3. The tilt error motion can also be checked with just two non-contacting probes (see ISO 230-7:—, 5.3.3.2 and ISO 230-7:—, 5.3.3.3).

For the tilt error motion $E_{\mathrm{tilt(C)}}$, a total error motion polar plot (ISO 230-7:—, 3.6.2) with a PC centre (ISO 230-7:—, 3.7.3) shall be provided.

For these tests, the following parameters shall be stated:

— radial, axial or face locations at which the measurements are made;

— identification of all artefacts, targets, and fixtures used;

— location of the measurement set-up;

— position of any linear or rotary positioning stages that are connected to the device under test;

— direction angle of the sensitive direction, e.g. axial, radial or intermediate angles as appropriate;

— presentation of the measurement result, for example error motion value, polar plot, time-based plot, frequency content plot;

— rotational speed of the spindle (zero for static error motion);

— time duration, expressed in seconds or number of spindle rotations;

— appropriate warm-up or break-in procedure;

— frequency response of the instrumentation, expressed in hertz or cycles per revolution, including roll-off characteristics of any electronic filters. In the case of digital instrumentation, state the displacement resolution and sampling rate;

— structural loop, including the position and orientation of sensors relative to the spindle housing from which the error motion is reported, specified objects with respect to which the spindle axes and the reference coordinate axes are located, and the elements connecting these objects;

— time and date of measurement;

— type and calibration status of all measurement instrumentation;

— other operating conditions which can influence the measurement, such as ambient temperature.

Annex B
(informative)

Equivalent terms in German, Italian, Persian, and Japanese

Table B.1 — Non-ISO languages terms for Table 1 in the main part

Ref.	German	Italian	Persian	Japanese
1	Maschinenbett	Banco	بستر	ベッド
2	Ständer (Y-Achse)	Montante	ستون(محور Y)	コラム
3	Führungsbahn, Ständer	Guide del montante	ریل ستون	コラム案内面
4	Maschinentisch (X-Achse)	Tavola (asse X)	میز(محور X)	テーブル(X 軸)
5	Führungsbahn, Maschinentisch	Guide della tavola	ریل میز	テーブル案内面
6	Schleifspindelstock	Testa porta-mola (asse Z)	کلگی سنگ(محور Z)	といし軸頭(Z 軸)
7	Führungsbahn, Schleifspindelstock	Guide della testa porta-mola	ریل کلگی سنگ	といし軸頭案内面
8	Schutzabdeckung	Riparo della mola	محافظ سنگ	といし覆い
9	Schleifscheibe	Mola	چرخ سنگ	といし

Bibliography

[1] ISO 841:2001, *Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature*

[2] ISO 3002-5:1989, *Basic quantities in cutting and grinding — Part 5: Basic terminology for grinding processes using grinding wheels*.

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