INTERNATIONAL STANDARD

ISO 4703

Third edition
2001-08-15

Test conditions for surface grinding machines with two columns — Machines for grinding slideways — Testing of the accuracy

Conditions d'essai des machines à rectifier les surfaces planes à deux montants — Machines à rectifier les glissières — Contrôle de la précision

Reference number
ISO 4703:2001(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 4703 was prepared by Technical Committee ISO/TC 39, *Machine Tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

This third edition cancels and replaces the second edition (ISO 4703:1984), which has been technically revised.

Annex A of this International Standard is for information only.

Test conditions for surface grinding machines with two columns — Machines for grinding slideways — Testing of the accuracy

1 Scope

This International Standard specifies, with reference to ISO 230-1 and ISO 230-2, geometric tests, machining tests and tests for checking accuracy and repeatability of positioning on general purpose and normal accuracy surface grinding machines with two columns for grinding slideways. It also specifies the applicable tolerances corresponding to the above-mentioned tests.

This International Standard is applicable to machines with rectilinear grinding movements and with a movable table. It does not include machines with a fixed table or with a rotary table movement.

This International Standard deals only with the verification of the accuracy of the machine. It does not apply to the testing of the machine operation (vibration, abnormal noises, stick-slip motion of components, etc.) nor to machine 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 designations of the axes with reference to ISO 841[1].

NOTE In addition to terms used in the three official ISO languages (English, French and Russian), annex A of this International Standard gives the equivalent terms in the German and Italian languages; these are published under the responsibility of the member bodies for Germany (DIN) and Italy (UNI). However, only the terms given in the official languages can be considered as ISO terms.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 230-1:1996, *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or finishing conditions*

ISO 230-2:1997, *Test code for machine tools — Part 2: Determination of accuracy and repeatability of positioning numerically controlled axes*

3 Terminology and designation of axes

See Figure 1 and Table 1.

NOTE If the horizontal spindle is considered to be the main spindle, axis designations (Y-Z and V-W) may be exchanged. In this case, R will be replaced by Q. In these circumstances, axis designation in the individual tests may be changed accordingly.

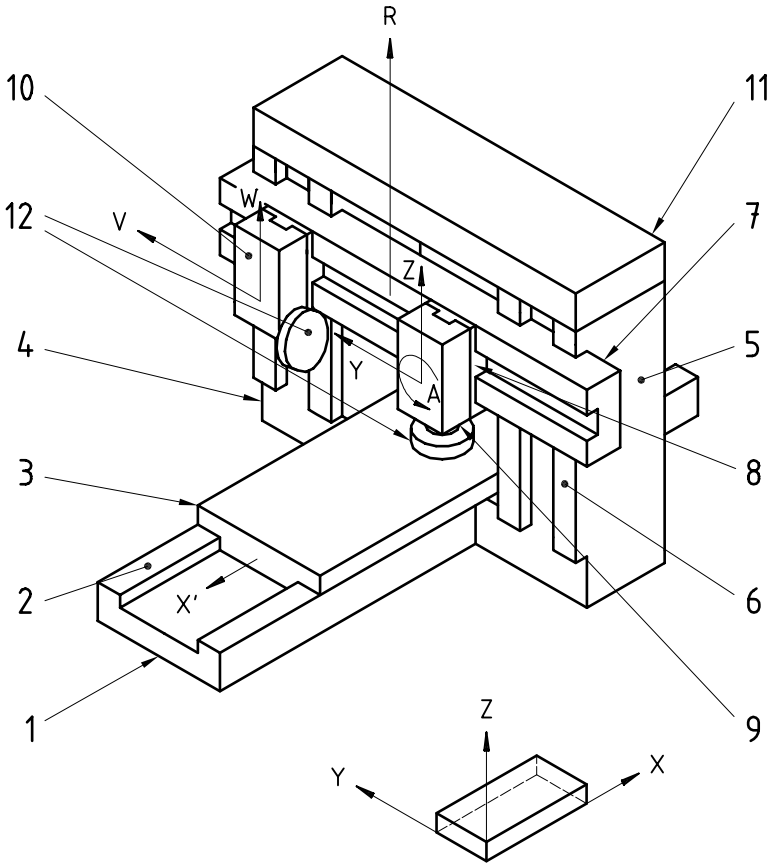


Figure 1

Table 1

No.	English	French	Russian
1	Bed	Banc	Станина
2	Slideway	Glissière	Направляющие
3	Table	Table	Стол
4	Left-hand column	Montant gauche	Левая стойка
5	Right-hand column	Montant droit	Правая стойка
6	Slideway, right-hand column	Glissière, montant droit	Направляющие; правая стойка
7	Cross-rail	Traverse mobile (coulisseau vertical)	Траверса
8	Saddle	Chariot	Салазки
9	Right-hand wheelhead (vertical spindle)	Poupée porte-meule de droite (broche à axe vertical)	Правая шпиндельная бабка (с вертикальным шпинделем)
10	Left-hand wheelhead (horizontal spindle)	Poupée porte-meule de gauche (broche à axe horizontal)	Левая шпиндельная бабка (с горизонтальным шпинделем)
11	Bridge	Entretoise	Поперечная балка
12	Grinding wheel	Meule	Шлифовальный круг

4 Preliminary remarks

4.1 Measuring units

In this International Standard, all linear dimensions, deviations and corresponding tolerances are expressed in millimetres; angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerances are expressed in ratios but, in some cases, microradians or arcseconds may be used for clarification purposes. The equivalence of the following expressions should always be kept in mind:

0,010/1 000 = 10 μrad ≈ 2"

4.2 Reference to ISO 230-1

To apply this International Standard, reference shall be made to ISO 230-1, especially for the installation of the machine before testing, warming up of the spindle and other moving components, description of measuring methods and recommended accuracy of testing equipment.

In the “Observations” box of the tests described in the following clauses, the instructions are accompanied by a reference to the corresponding clause in ISO 230-1 in cases where the test concerned is in compliance with the specifications of ISO 230-1.

Reference should be made to ISO 230-2 for positioning tests.

4.3 Testing sequence

The sequence in which the tests are presented in this International Standard in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests may be performed in any order.

4.4 Tests to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests described in this International Standard. When the tests are required for acceptance purposes, it is up to the user to choose, in agreement with the supplier/manufacturer, those tests relating to the components and/or the properties of the machine which are of interest. These tests are to be clearly stated when ordering a machine. 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 party.

4.5 Measuring instruments

The measuring instruments indicated in the tests described in clauses 6, 7 and 8 are examples only. Other instruments measuring the same quantities and having at least the same accuracy may be used. Dial gauges shall have a resolution of at least 0,001 mm.

4.6 Minimum tolerance

When establishing the tolerance for a measuring length different from that given in this International Standard (see 2.311 of ISO 230-1:1996), it shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

4.7 Machining tests

Machining tests shall be made with finishing cuts only. Roughing cuts shall be avoided since they are liable to generate appreciable cutting forces.

5 Specific installation conditions

5.1 Foundations

Foundations are essential for providing the necessary stiffness to this type of machine which should always be installed in the user's workshop on foundations designed and manufactured correctly.

Foundations suitable to every type of machine are not always available in the manufacturer's assembly workshop; therefore, if the test is being carried out on a machine simply resting on the floor, this shall be taken into account and recorded on the test report.

5.2 Isolation

Foundations should be isolated from the surrounding floor in order not to transmit vibrations and/or heat.

5.3 Thermal conditions

When the table is hydraulically operated, it is subject to thermal distortions due to the temperature difference between the oil beneath and the coolant on its top. The test shall then be carried out after moving the table and delivering coolant for a time sufficient to let it reach the working condition, following the manufacturer's instructions.

5.4 Testing temperature

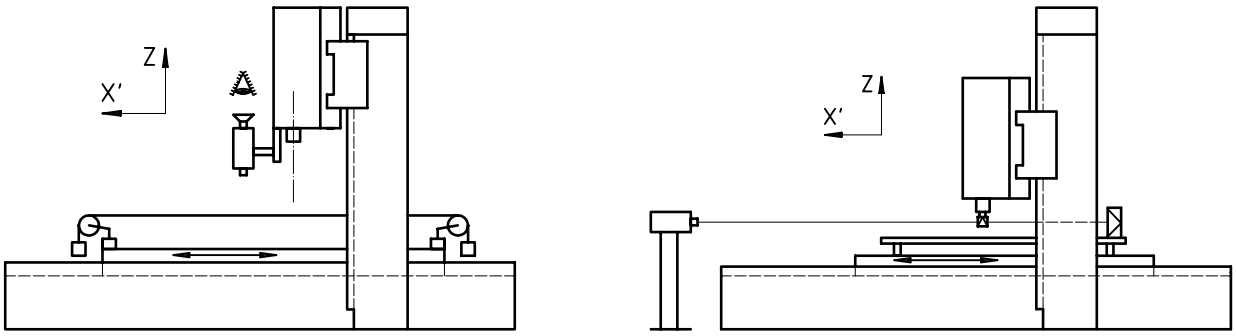
The test room temperature variation should not exceed 2 °C. Otherwise, the ambient temperature conditions throughout the tests shall be specified by agreement between the supplier/manufacturer and user. The machine should be placed in this environment at least 24 h prior to the tests.

6 Geometric tests

6.1 Axes of motion

Object	**G1**
Checking of straightness of the table longitudinal movement (X-axis): a) in the horizontal XY-plane (EYX); b) in the vertical ZX-plane (EZX).	

Diagram



a) **b)**

Tolerance	**Measured deviation**
a) and b) 0,02 for measuring lengths up to 2 000 add 0,01 for each 1 000 increase in length, for length greater than 2 000 mm Maximum tolerance: 0,10 Local tolerance: 0,01 for any measuring length of 1 000	For X = ….. a) b)

Measuring instruments

Optical methods

Observations and references to ISO 230-1:1996 5.232.12, 5.232.13 and 5.232.14

The optical component is mounted on the wheelhead in order to reduce effects of the non-rigid table. The support of the bridge should be at the same distance as the support of the workpiece.

When mounting the telescope, be aware of the possible flexibility of the table.

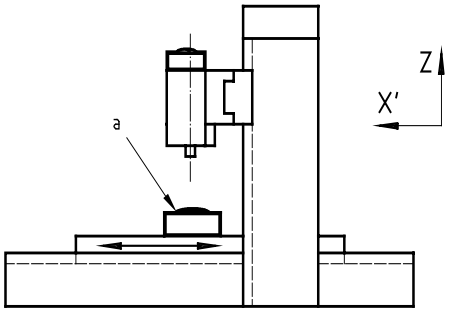
Object **G2**

Checking of angular deviation of the table longitudinal movement (X-axis):

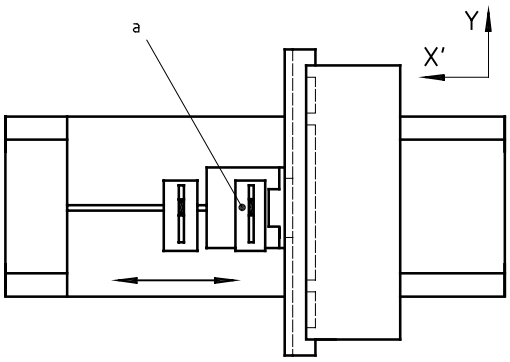
a) in the ZX-plane (EBX: pitch);

b) in the vertical YZ-plane (EAX: roll).

Diagram



a)



b)

a Reference level

Tolerance			**Measured deviation**
	a)	b)	For X = …..
X ⩽ 4 000	0,04/1 000	0,02/1 000	a)
X > 4 000	0,06/1 000	0,03/1 000	b)

Measuring instruments

Precision level or optical methods

Observations and references to ISO 230-1:1996 5.231.3, 5.232.2 and 5.232.21

One level shall be placed on the movable component:

a) (EBX: pitch); in the X-axis direction;

b) (EAX: roll); in the Y-axis direction.

When the X-axis motion causes an angular deviation of both spindle head and work holding table, differential measurements of the two angular deviations shall be made, and this shall be stated.

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

Measurements shall be carried out in at least five equally spaced positions with a maximum distance of 1 000, along the travel in both directions of movement.

The difference between the maximum reading and the minimum reading of the two directions shall not exceed the tolerance.

Measurements shall be repeated with the level placed at two ends (within 500 mm from the edges) and at the middle of the table.

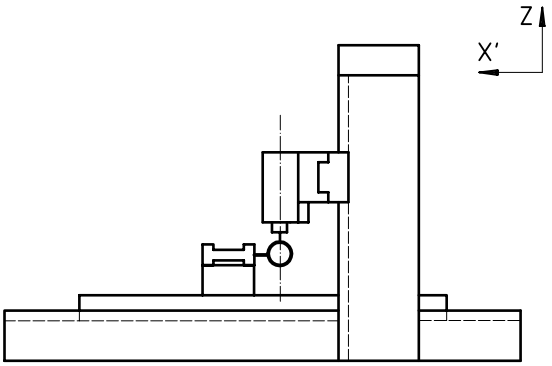
Object	**G3**

Checking of the straightness of the wheelhead saddle movement on the cross-rail (Y-axis):

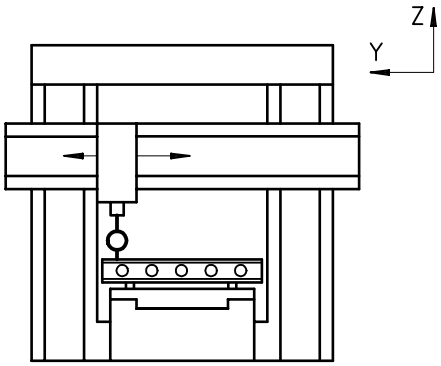
a) in the XY-plane (horizontal plane) (EXY);

b) in the YZ-plane (vertical plane) (EZY).

Diagram



a)



b)

Tolerance	**Measured deviation**
a) and b) 0,02 for measuring lengths $\leqslant$ 1 000; add 0,01 for each 1 000 increase in length, for length greater than 1 000 mm Maximum tolerance: 0,04 Local tolerance: 0,01 for any measuring length of 500	For Y = ... a) b)

Measuring instruments

Straightedge, dial gauge and gauge blocks or optical methods

Observations and references to ISO 230-1:1996 5.232.1, 5.232.11 and 5.232.13 and 5.232.14

Fix the cross-rail at mid-height and place the table at the mid-travel.

Set up the straightedge on the table, parallel[1)] to the Y-axis movement of the grinding head; for a) horizontally and for b) vertically.

Fix a dial gauge support on the grinding head such that the dial gauge stylus is normal to the reference face of the straightedge.

Traverse the grinding head in Y-direction through the measuring length[2)] and note the readings.

---

1) Parallel means: readings of the dial gauge touching the straightedge at both ends of the movement show the same value and, in this case, the maximum difference of the readings gives the straightness deviation.

2) Measuring length means not the full length of cross-rail but the effective travel of the grinding head (usually the length between two columns).

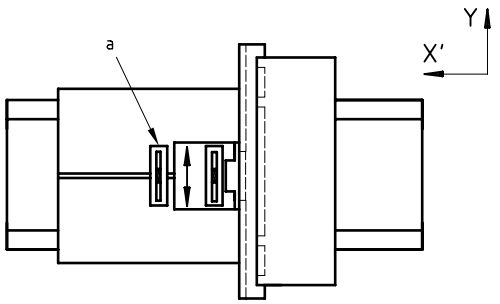
Object	**G4**

Checking of the angular deviations of the Y-axis movement of the wheelhead saddle movement on the cross-rail (Y-axis):

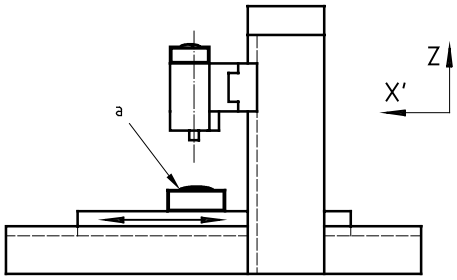
a) in the YZ-plane (EAY: pitch);

b) in the ZX-plane (EBY: roll).

Diagram



a)



b)

a Reference level

Tolerance	**Measured deviation**
a) and b) 0,04/1 000 Local tolerance: 0,02/1 000 (or 20 μrad or 4") for any measuring length of 250	a) b)

Measuring instruments

Precision level or optical methods

Observations and references to ISO 230-1:1996 5.231.3, 5.232.2 and 5.232.21

One level shall be placed on the movable component:

a) (EAY: pitch); in the Y-axis direction,

b) (EBY: roll); in the X-axis direction.

When Y-axis motion causes an angular deviation of both spindle-head and the work-holding table, differential measurements of the two angular deviations shall be made, and this shall be stated.

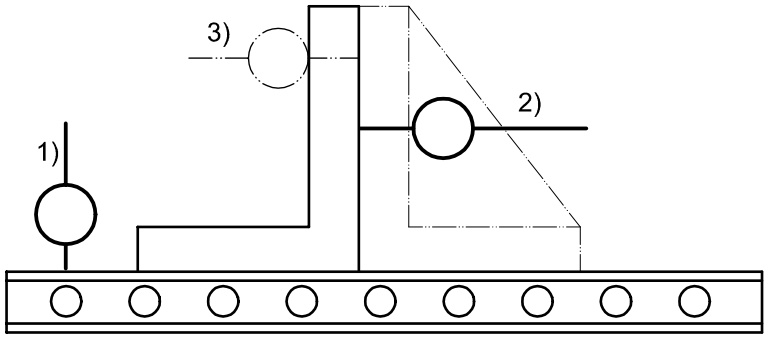
The reference level shall be located on the work-holding table and shall be in the middle of the travel range.

Measurements shall be carried out in at least five equally spaced positions of a maximum distance of 1 000 mm, along the travel in both directions of movement.

The difference between the maximum reading and the minimum reading of the two directions shall not exceed the tolerance.

Object	**G5**
Checking of squareness between the table longitudinal movement (X-axis) and the wheelhead saddle movement on the cross-rail (Y-axis).	

Diagram



Tolerance	**Measured deviation**
0,02 for a measuring length of 500	

Measuring instruments

Straightedge, square and dial gauge

Observations and references to ISO 230-1:1996 5.522.4

Cross-rail in lower range of travel and locked.

1) Fix dial gauge/support to grinding head. Place a straightedge on the table parallel to the X-axis movement of the table.

2) Set the square against the straightedge. Set the dial gauge against the square and move the grinding head by the measuring length. Then read indications.

3) Rotate square 180° and set the dial gauge against it again and repeat measurement by moving the grinding head by the measuring length as done in step 2).

Determine average value of deviations measured in steps 2) and 3), which is the squareness deviation between X-axis and Y-axis.

If the table width exceeds 1 000 mm, the test shall be repeated in different positions along the table width.

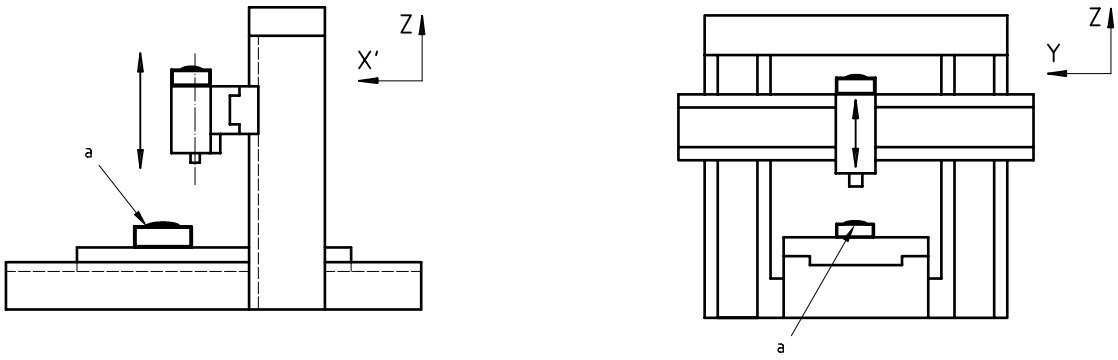
Object **G6**

Checking of angular deviation of the vertical movement of the wheelhead (Z-axis).

a) in the ZX plane (EBZ);

b) in the YZ plane (EAZ).

Diagram



a) **b)**

a Reference level

Tolerance	**Measured deviation**
a) and b) 0,02/1 000 for a vertical travel $\leqslant$ 300	a) b)

Measuring instruments

Laser angular interferometre or precision level

Observations and references to ISO 230-1:1996 5.231.3, 5.232.2 and 5.232.21

One level shall be placed on the movable head, the reference level shall be located in the middle of the table, and the table shall be in the middle of the travel range. The orientation of the levels shall be:

a) in the X-axis direction for the EBZ measurement;

b) in the Y-axis direction for the EAZ measurement.

When the Z-axis motion causes an angular movement of both the wheelhead and the work-holding table, differential measurements of the two angular deviations shall be made, and this shall be stated.

The measurements shall be carried out at the minimum of five equally spaced positions along the travel in both directions of movement.

The difference between the maximum and minimum readings shall not exceed the tolerance.

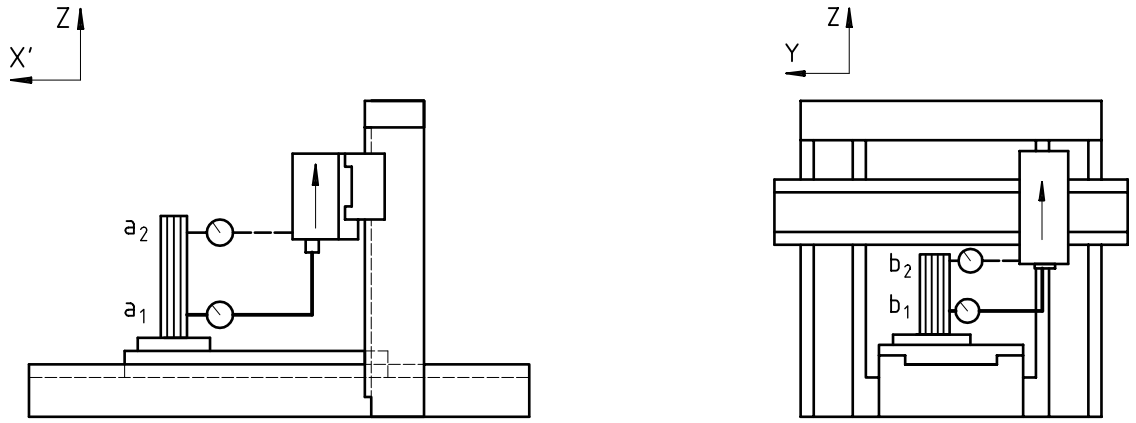
Object	**G7**

Checking of squareness between the vertical movement of the wheelhead (Z-axis) and:

a) the table longitudinal movement (X-axis);

b) the wheelhead saddle movement on the cross-rail (Y-axis).

Diagram



a) **b)**

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

Measuring instruments

Cylindrical square, surface plate, adjustable blocks and dial gauge

Observations and references to ISO 230-1:1996 5.522.4

Cross-rail locked.

Place a surface plate in the centre of the table and adjust its surface parallel to both X- and Y-axes movement, position the cylindrical square on it.

Fix the dial gauge to the grinding head and position the stylus of the dial gauge against the cylindrical square in X-direction and take a reading at a_1, then move the grinding head to a_2 and take another reading.

Rotate the cylindrical square 180° and repeat the measurement in the same sequence.

Determine average value of the measured deviations.

Check subsequently in Y-direction at positions of b_1 and b_2.

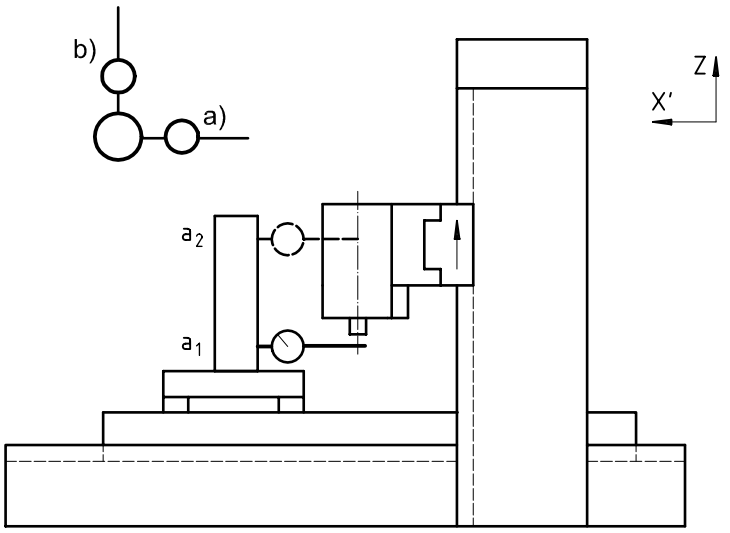
Object	**G8**

Checking of squareness between the vertical movement of the cross-rail (R-axis) and:

a) the table longitudinal movement (X-axis);

b) the wheelhead saddle movement on the cross-rail (Y-axis).

Diagram



Tolerance	**Measured deviation**
a) and b) 0,030 for a measuring length of 500	a) b)

Measuring instruments

Dial gauge, cylindrical square, surface plate and adjustable blocks

Observations and references to ISO 230-1:1996 5.522.4

Place a surface plate in the centre of the table and adjust its surface parallel to both the X- and Y-axes movements; position the cylindrical square on it.

Fix the dial gauge to the grinding head and position the stylus of the dial gauge against the cylindrical square in the X-direction and take a reading at a_1, then move the cross rail to a_2 and take another reading. During the measurement, lock the grinding head to the cross-rail.

Rotate cylindrical square 180° and repeat checking in the same sequence.

Determine the average value of the measured deviations.

Check subsequently in the Y-direction at positions b_1 and b_2.

This test is not necessary when the cross-rail is not used for wheel infeed.

Object	**G9**

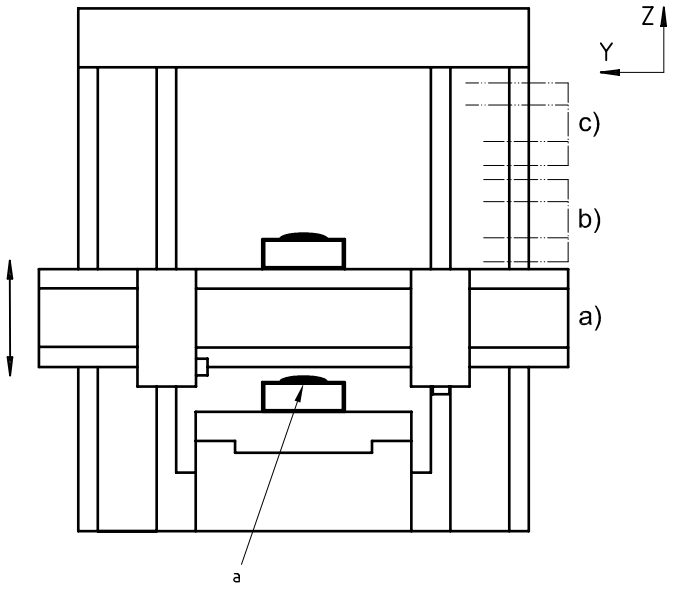
Checking of variation of the level of the cross rail in the YZ plane (angular measurement of R) (EAR):

a) in the lower position;

b) in the central position;

c) in the upper position.

Diagram



[a] Reference level

Tolerance	**Measured deviation**
0,02/1 000 for a vertical travel $\leqslant$ 1 000 0,03/1 000 for 1 000 $<$ vertical travel $\leqslant$ 2 000	

Measuring instruments

Precision level

Observations and references to ISO 230-1:1996 5.231.2, 5.232.2 and 5.232.21

The level shall be placed transversely on the cross-rail. The reference level shall be located in the middle of the table and the table shall be in the middle of its travel range.

When the R-axis motion causes an angular deviation of both the cross-rail and work-holding table, differential measurements of the two angular deviations shall be made and this shall be stated.

Move the cross-rail to the a) lower position, b) central position and c) upper position from the bottom towards the top and read the angular deviation.

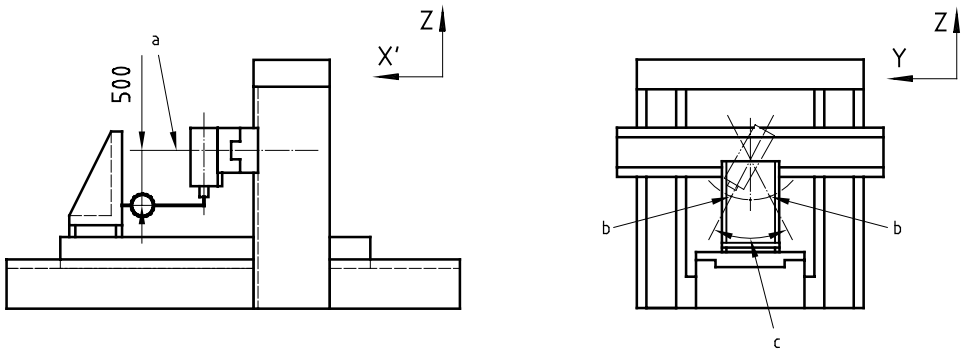
Loads imposed by the wheelheads shall be distributed symmetrically.

Cross-rail locked in each position.

If a cross-rail levelling device is provided, it may be used for reducing the deviation within the tolerance.

Object	**G10**
Checking of parallelism between the wheelhead tilting plane and the YZ-plane (for tilting grinding heads).	

Diagram



a Tilting axes

b Measuring points

c Tilting angle α

Tolerance	**Measured deviation**
For dial gauge placed at 500 mm from grinding head tilting axis — 0,02 for $\alpha \leqslant 30°$ — 0,03 for $\alpha > 30°$	

Measuring instruments

Square, surface plate, adjustable blocks and dial gauge

Observations and references to ISO 230-1:1996 5.422.2

Cross-rail fixed at mid-height, grinding head saddle fixed in mid-travel.

Place a surface plate vertically on the table so as the face is parallel to both Y-and Z-axes movements.

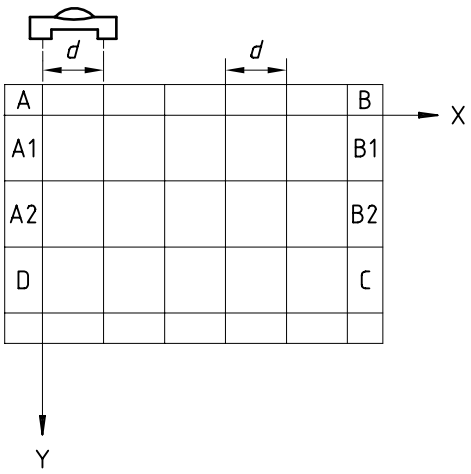
Fix a dial gauge to the grinding head so that the stylus of the dial gauge is 500 mm from the grinding head tilting axis.

Position the stylus of the dial gauge against the surface plate in X-direction, tilt the grinding head and take readings.

6.2 Table

Object	**G11**
Checking of flatness of the table surface within the grinding area.	

Diagram



Tolerance	**Measured deviation**
For table width ⩽ 1 600 mm: 0,02 for a measuring length ⩽ 2 000 mm add 0,005 for each 1 000 mm increase in length for length > 2 000 mm Maximum tolerance: 0,060 For table width > 1 600 mm: 0,02 for a measuring length ⩽ 2 000 mm add 0,008 for each 1 000 mm increase in length for length > 2 000 mm Maximum tolerance: 0,080	

Measuring instruments

Straightedge and gauge blocks, precision level or other methods

Observations and references to ISO 230-1:1996 5.322, 5.323 and 5.324

Table non-locked in mid-travel. The last 150 mm at both ends of the table in longitudinal direction and the last 50 mm on both sides in cross direction may be neglected.

For large tables, the following procedure is recommended for making measurement and calculating the resulting deviation easier:

a) A bridge shall be set on points A and B by means of two supports. The level shall then be placed on the bridge and zeroed.

b) The bridge and relevant supports shall then be displaced in joints C and D. Readings shall be taken.

c) Straightness measurements of the cross line A1-B1, A2-B2, A*n*-B*n* shall be carried out.

d) Straightness measurements of the longitudinal external lines AC and BD shall be carried out.

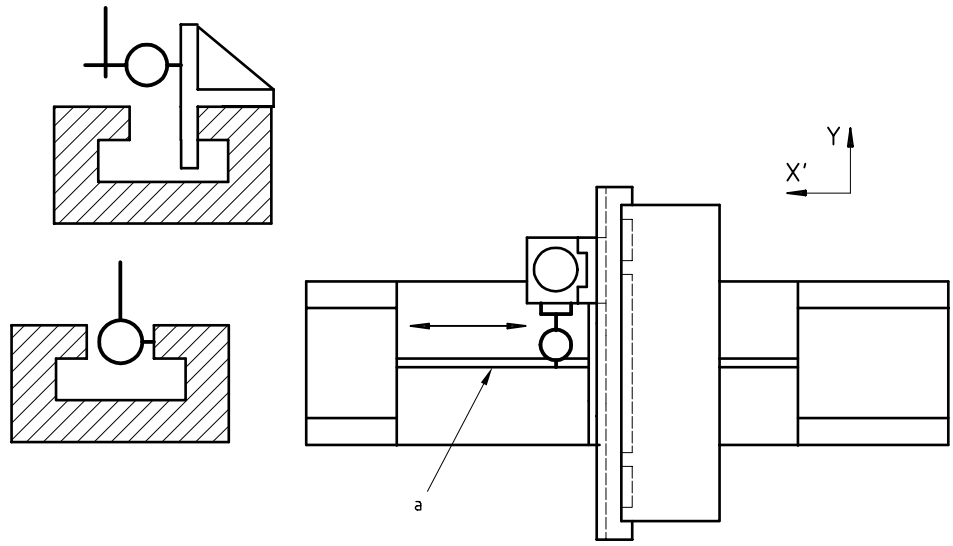
e) The elevations of the pairs of points A and D, and B and C respectively, shall be equalized by calculation. The elevations of the end points of the cross lines shall then be brought to coincide with the corresponding points on the longitudinal lines.

f) If possible, the minimum distance between two parallel planes, in which the actual surface is contained, shall be determined.

Object	**G12**

Checking of parallelism between the median or reference T-slot and the longitudinal movement of the table (X-axis).

Diagram



[a] Reference T-slot

Tolerance	**Measured deviation**
0,02 for a measuring length $\leqslant$ 5 000 0,03 for a measuring length $>$ 5 000 Local tolerance: 0,01 for any measuring length of 1 000	

Measuring instruments

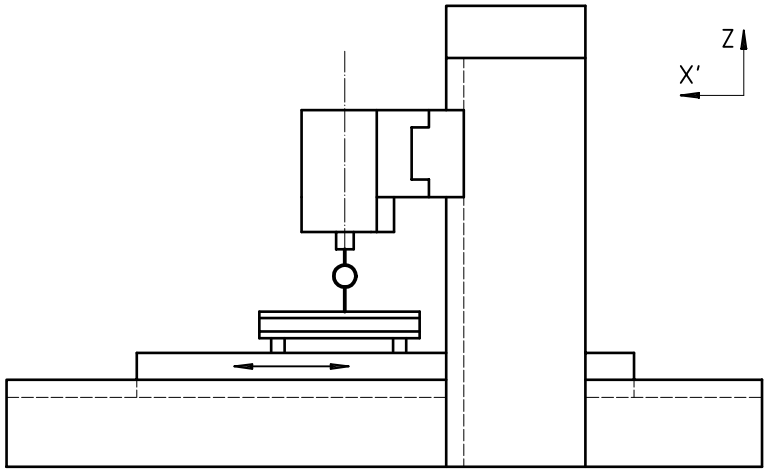
Dial gauge and special block

Observations and references to ISO 230-1:1996 5.422.1 and 5.422.21

If the spindle can be locked, then the dial gauge may be mounted on it. If the spindle cannot be locked, then the dial gauge shall be placed near the spindle.

Object	**G13**
Checking of parallelism between the table surface and its longitudinal movement along the X-axis.	

Diagram



Tolerance	**Measured deviation**
0,025 for measuring length $\leqslant$ 2 000 mm add 0,013 for each 1 000 mm increase in length, for length $>$ 2 000 mm Maximum tolerance: 0,130	

Measuring instruments

Dial gauge, straightedge and gauge blocks

Observations and references to ISO 230-1:1996 5.422.21

The dial gauge shall be fixed on the wheelhead.

The stylus shall be set on the straightedge or the gauge blocks placed on the table and the maximum deviation shall be noted.

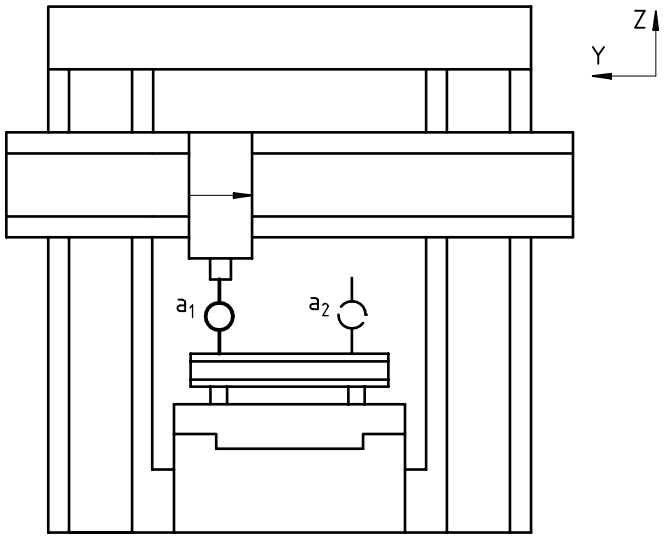
The measurements shall be carried out in the middle of the table and very close to the two outside edges.

The dial gauge shall be reset before every measurement.

Object	**G14**

Checking of parallelism between the table surface and the transverse movement of the wheelheads along the Y-axis.

Diagram



Tolerance	**Measured deviation**
0,025 for measuring length $\leqslant$ 1 000 mm add 0,013 for each 1 000 mm increase in length, for length $>$ 1 000 mm Maximum tolerance: 0,050	

Measuring instruments

Dial gauge, straightedge and gauge blocks

Observations and references to ISO 230-1:1996 5.422.22

Table in mid-travel.

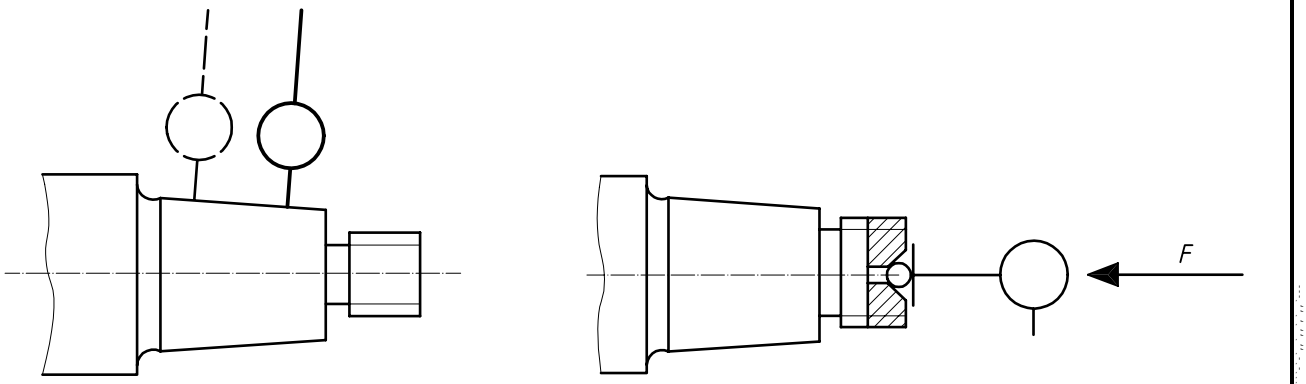
The dial gauge shall be attached to the wheelhead.

The stylus of the dial gauge shall be set at point a_1 on the straightedge (gauge blocks) and reset before travel.

The wheelhead shall be moved by the measuring length to point a_2 and the maximum deviation shall be noted.

The measurement shall be carried out in the lowest possible position of the cross rail.

6.3 Spindle

Object	**G15**
Checking of the grinding spindle: a) run-out of the external taper; b) periodic axial slip.	
Diagram  **a)** **b)**	
Tolerance a) and b) 0,005	**Measured deviation** a) b)
Measuring instruments Dial gauge	
Observations and references to ISO 230-1:1996 5.612.1, 5.612.2, 5.622.1 and 5.622.2 a) The stylus shall be placed perpendicular to the surface of the taper. In addition to specifications of ISO 230-1, measurement shall be carried out at each end of the taper. Rotate the spindle manually or by means of a short impulse of the motor. b) The stylus of the dial gauge shall be set coaxial with the spindle axis. The magnitude, value and direction of the force F shall be specified by the supplier/manufacturer. When axially pre-loaded thrust bearing is used, no force F is needed. Rotate the spindle manually or by means of a short impulse of the motor. Carry out all the checks for vertical and horizontal grinding spindles.	

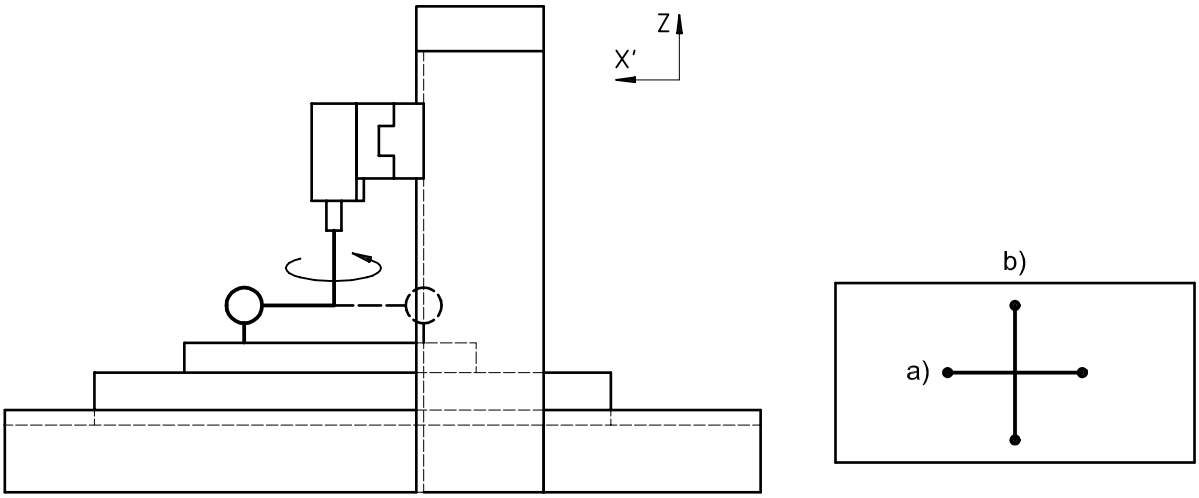
Object	**G16**

Checking of squareness between the vertical grinding spindle axis and:

a) the table longitudinal movement (X-axis);

b) the wheelhead saddle movement on the cross-rail (Y-axis).

Diagram



Tolerance	**Measured deviation**
a) and b) 0,02/500[1)]	a) b)

1) Distance between the two points touched.

Measuring instruments

Dial gauge arm and straightedge or surface plate

Observations and references to ISO 230-1:1996 5.512.42

a) Set a straightedge vertically at the centre of the table parallel to the X-axis movement of the table. Table locked at mid-travel.

Cross-rail at mid-height and locked, vertical spindle grinding head at mid-travel and locked.

Support the arm with dial gauge fixed to the grinding spindle. Touch the stylus of the dial gauge to the straightedge and read indication. Then rotate the spindle 180° and read the new indication.

b) Carry out the check in the same way with the straightedge set parallel to the Y-axis movement.

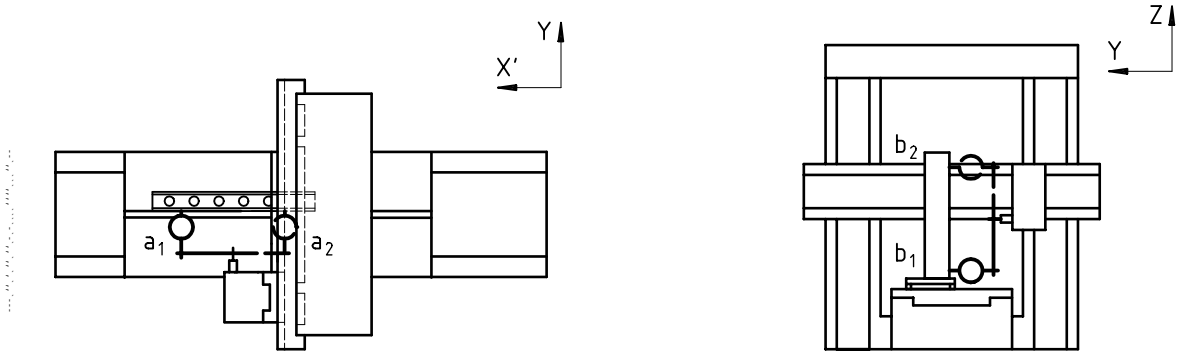
Object **G17**

Checking of squareness between the horizontal grinding spindle axis and:

a) the table longitudinal movement (X-axis);

b) the vertical movement of the cross-rail (Z-axis).

Diagram



a) **b)**

Tolerance	**Measured deviation**
a) and b) 0,012/300	a) b)

Measuring instruments

Straightedge, cylindrical square and dial gauge

Observations and references to ISO 230-1:1996 5.512.42

Lock the cross-rail in mid-position.

a) Horizontal grinding head in mid-travel.

Set a straightedge horizontally on the table parallel to the X-axis movement of the table.

Attach the dial gauge arm to the grinding spindle.

Touch the stylus of dial gauge normal to the reference face of the straightedge at position a_1 and note reading. Then rotate the grinding spindle until stylus touches at position a_2.

b) Set the square on the table parallel to Z-axis movement and check the dial gauge indications b_1 and b_2.

7 Machining tests

7.1 General

Machining tests M1 and M2 are only to be carried out if there is no particular machining test specified (that is, machining of a special workpiece requested by the user).

7.2 Surface grinding

Object **M1**

Surface grinding of 5, 7 or 8 test pieces.

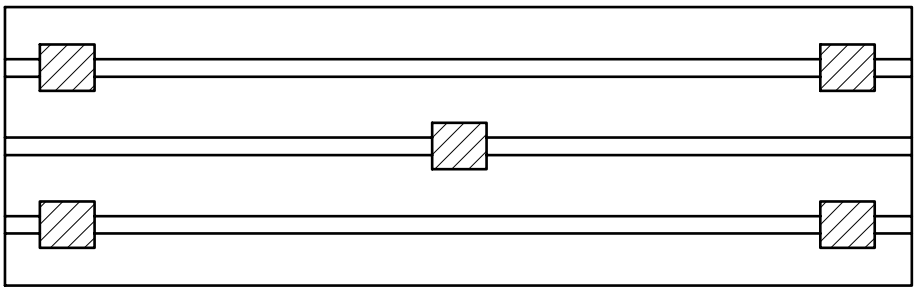
The surfaces of the test pieces that are in contact with the table shall be ground before carrying out the test.

The test pieces shall be positioned as follows:

— in the case of 5 pieces: one at the central position of the table; one at each of the four corners of the table;

— in the case of 7 or 8 pieces: by agreement.

Diagram



Machining of:

— 5 test pieces for table length $\leqslant$ 5 000 mm;

— 7 or 8 test pieces for table length $>$ 5 000 mm.

Material of test pieces: cast iron or steel

All the test pieces shall have the same hardness and shall be suitably fixed on the table.

The dimensions of the surface to be ground may be as small as possible; for example, square with sides 50 mm $\times$ 50 mm, cylinder with $\varnothing$ 50 mm.

Check to be applied	Tolerance	Measuring instrument	Observation and reference to ISO 230-1:1996
The thickness of the test pieces after grinding shall be identical.	For a distance between any two test pieces of: distance $\leqslant$ 1 000: 0,01 1 000 $<$ distance $\leqslant$ 2 000: 0,02 2 000 $<$ distance $\leqslant$ 3 000: 0,03 distance $>$ 3 000: 0,04	Surface plate and precision dial gauge/support.	4.1, 4.2 Test pieces ground, taken off the machine and placed on a surface plate shall be successively measured with an appropriate measuring instrument.

7.3 Grinding of slideways

Object **M2**

Grinding of narrow surfaces F_1, F_2 and F_3 representing slideways.

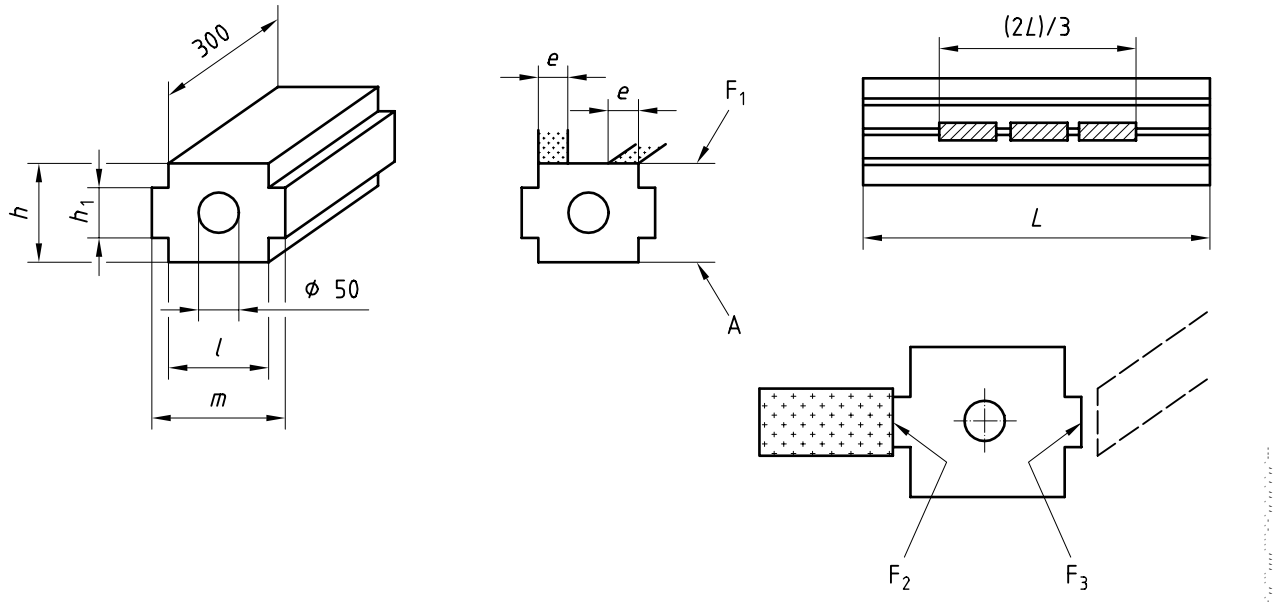
Mounting of the test pieces on the table shall be made so that the pieces are not subject to deformation.

Mount three test pieces at the centre of the table longitudinally with the same distance between them so that the total length of test pieces is two-thirds of table length.

The surface A, which is used as a reference surface for the measurements, shall be carefully machined flat before mounting.

Diagram

Dimensions in millimetres



l = h

h_1 = $h/3$

m = l + 0,5 mm

L = length to be ground

$\frac{2L}{3}$ = length of the test pieces, mounted in succession

e = width of the grinding wheel

$l \geqslant 3e$

l_{max} = 150

Check to be applied	Tolerance	Measuring instrument	Observation and reference to ISO 230-1:1996
a) Variation in height in the longitudinal direction. b) Variation in width.	For a) and b) For the mounting length on the table ($2L/3$): ($2L/3$) $\leqslant$ 2 000: 0,010 2 000 $<$ ($2L/3$) $\leqslant$ 4 000: 0,015 4 000 $<$ ($2L/3$) $\leqslant$ 6 000: 0,020 6 000 $<$ ($2L/3$) $\leqslant$ 8 000: 0,025	a) Precision dial gauge/support and surface plate b) Precision dial gauge/support and surface plate or micrometer	4.1 and 4.2 Test pieces ground, taken off the machine and placed on a surface plate shall be successively measured with an appropriate measuring instrument. The point of measurement is at the centre of width and 75 mm from both ends of each of the test pieces of the ground surfaces.

8 Accuracy and repeatability of numerically controlled positioning axes

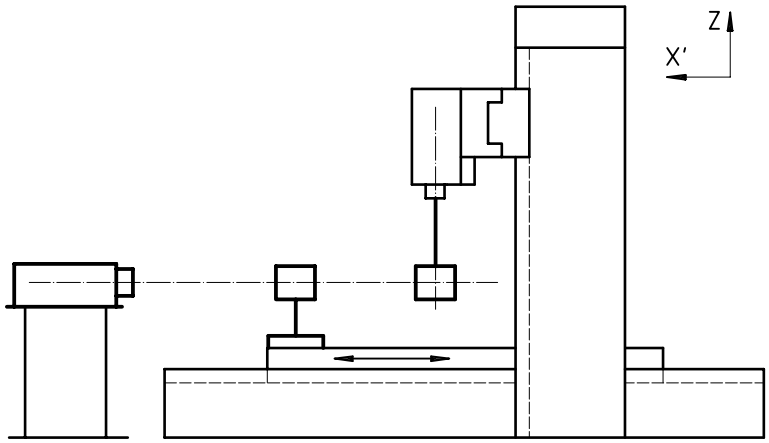
These tests only apply to numerically controlled grinding machines with two columns for grinding slideways.

To apply these tests, reference should be made to ISO 230-2, especially for the environmental conditions, warming up of the machine, measuring methods, evaluation and interpretation of the results.

Object **P1**

Checking of the accuracy and repeatability of positioning of the X-axis movement of the table by numerical control.

Diagram



Tolerance		Measuring length			**Measured deviation**
		$L \leqslant 2\,000$	$2\,000 < L \leqslant 5\,000$	$5\,000 < L \leqslant 10\,000$	
* Bi-directional accuracy of positioning	A	0,042	—	—	
* Unidirectional repeatability of positioning	R↑ and R↓	0,013	—	—	
Bi-directional repeatability	R	0,025	—	—	
Reversal value	B	0,016	0,025	0,040	
Mean reversal value	$\overline{B}$	0,010	0,016	0,025	
* Bi-directional systematic deviation of positioning	E	0,032	0,050	0,080	
Range of the mean bi-directional positional deviation	M	0,020	0,032	0,050	

NOTE * May provide a basis for machine acceptance.

Measuring instruments

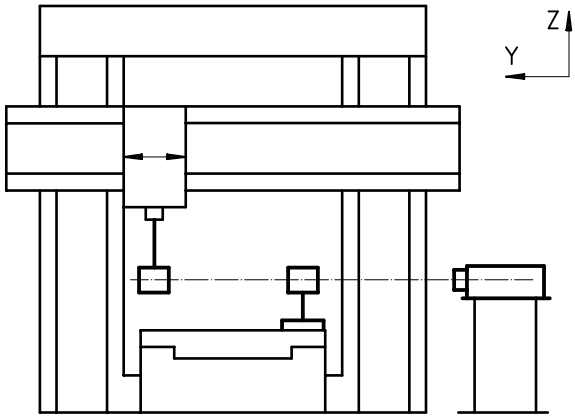
Standard length scale and microscope or laser measuring equipment

Observations and references to ISO 230-1 and ISO 230-2

Object **P2**

Checking of the accuracy and repeatability of positioning of the Y-axis movement of the wheelhead by numerical control.

Diagram



Tolerance		Measuring length				**Measured deviation**
		$L \leqslant 500$	$500 < L \leqslant 800$	$800 < L \leqslant 1\,250$	$1\,250 < L \leqslant 2\,000$	
* Bi-directional accuracy of positioning	A	0,022	0,025	0,032	0,042	
* Unidirectional repeatability of positioning	R↑ and R↓	0,006	0,008	0,010	0,013	
Bi-directional repeatability	R	0,012	0,015	0,018	0,020	
* Reversal value	B	0,010	0,010	0,012	0,012	
Mean reversal value	$\overline{B}$	0,006	0,006	0,008	0,008	
* Bi-directional systematic deviation of positioning	E	0,015	0,018	0,023	0,030	
Range of the mean bi-directional positional deviation	M	0,010	0,012	0,015	0,020	

NOTE * May provide a basis for machine acceptance.

Measuring instruments

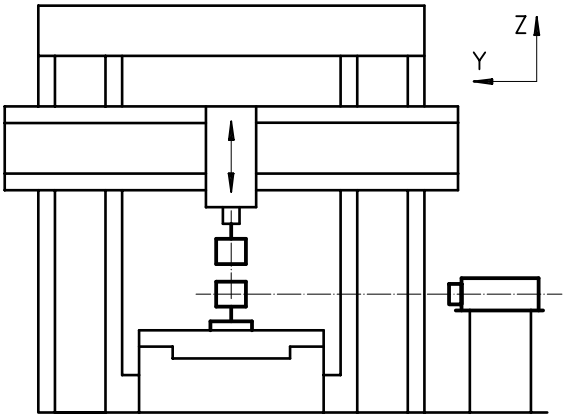
Standard length scale and microscope or laser measuring equipment

Observations and references to ISO 230-1 and ISO 230-2

Object **P3**

Checking of the accuracy and repeatability of positioning of the Z-axis movement of the table by numerical control.

Diagram



Tolerance		Measuring length				**Measured deviation**
		$L \leqslant 500$	$500 < L \leqslant 800$	$800 < L \leqslant 1\,250$	$1\,250 < L \leqslant 2\,000$	
* Bi-directional accuracy of positioning	A	0,022	0,025	0,032	0,042	
* Unidirectional repeatability of positioning	R↑ and R↓	0,006	0,008	0,010	0,013	
Bi-directional repeatability	R	0,012	0,015	0,018	0,020	
* Reversal value	B	0,010	0,010	0,012	0,012	
Mean reversal value	$\overline{B}$	0,006	0,006	0,008	0,008	
* Bi-directional systematic deviation of positioning	E	0,015	0,018	0,023	0,030	
Range of the mean bi-directional positional deviation	M	0,010	0,012	0,015	0,020	

NOTE * May provide a basis for machine acceptance.

Measuring instruments

Standard length scale and microscope or laser measuring equipment

Observations and references to ISO 230-1 and ISO 230-2

Annex A
(informative)

Equivalent terms in German and Italian
(see clause 3, Figure 1 and Table 1)

Ref.	German	Italian
1	Bett	Banco
2	Führungsbahn	Guida
3	Tisch	Tavola
4	Ständer links	Montante sinistro
5	Ständer rechts	Montante destro
6	Führungsbahn, Ständer rechts	Guida, montante destro
7	Querbalken	Traversa mobile
8	Schlitten	Slitta orizzontale
9	Schleifspindelstock rechts	Testa porta-mola di destra (mandrino verticale)
10	Schleifspindelstock links	Testa porta-mola di sinistra (mandrino orizzontale)
11	Traverse	Traversa fissa
12	Schleifschelbe	Mola

Bibliography

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

1) To be published. (Revision of ISO 841:1974)

ICS 25.080.50

Price based on 28 pages