INTERNATIONAL STANDARD

ISO 3070-4

Second edition
1998-03-15

Test conditions for boring and milling machines with horizontal spindle — Testing of the accuracy —

Part 4:
Planer type machines with movable column

Conditions d'essai des machines à aléser et à fraiser, à broche horizontale — Contrôle de la précision —

Partie 4: Machines à montant mobile et bancs en croix

Reference number
ISO 3070-4:1998(E)

Contents

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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.

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.

International Standard ISO 3070-4 was prepared by Technical Committee ISO/TC 39, *Machine Tools,* Subcommittee SC 2, *Test conditions for metal cutting machine tools.*

This second edition cancels and replaces the first edition (ISO 3070-3:1982) which has been technically revised.

ISO 3070 consists of the following parts, under the general title *Test conditions for boring and milling machines with horizontal spindle — Testing of the accuracy*:

— *Part 0: General introduction*
(to become part 1 on its next revision)

— *Part 2: Table-type machines*
(formerly part 1)

— *Part 3: Floor type machines with detached work-holding fixed table*
(formely part 2)

— *Part 4: Planer type machines with movable column*
(formerly part 3)

Annex A of this part of ISO 3070 is for information only.

Test conditions for boring and milling machines with horizontal spindle — Testing of the accuracy —

Part 4:
Planer type machines with movable column

1 Scope

This part of ISO 3070 specifies, with reference to ISO 230-1 and ISO 230-2, geometric tests, machining tests and tests for checking accuracy and repeatability of positioning by numerical control, on general purpose, normal accuracy, planer type horizontal spindle boring and milling machines with movable column. These types of machine tool are defined in subclauses 3.2 and 3.3 of ISO 3070-0:1982. This part of ISO 3070 also specifies the applicable tolerances corresponding to the above mentioned tests.

These machines can be provided with spindle heads of different types corresponding in most cases to figures:

4 (spindle head with sliding boring spindle and milling spindle)
5 (spindle head with sliding boring spindle and with facing head)
6 (spindle head with ram or milling ram)

of ISO 3070-0:1982.

In addition, it should be noted that this part of ISO 3070 concerns machines which have movement of the table along the X-axis, a vertical movement of the spindle head along the Y-axis, a movement of the column along the W-axis and may include a rotary or indexing table.

This part of ISO 3070 deals only with the verification of the accuracy of the machine. It does not apply to the testing of the machine operation (vibration, abnormal noise, stick-slip motion of components, etc.) nor to machine characteristics (such as speeds, feeds, etc.), as such checks are generally carried out before testing the accuracy.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 3070. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 3070 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO 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 of numerically controlled axes.*

ISO 1101:— [2], *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Generalities, definitions, symbols, indication on drawings.*

ISO 3070-0:1982[3], *Test conditions for boring and milling machines with horizontal spindle — Testing of accuracy — Part 0: General introduction.*

3 Terminology and designation of axes

See ISO 3070-0.

4 Preliminary remarks

4.1 Measuring units

In this part of ISO 3070, all linear dimensions, deviations and corresponding tolerances are expressed in millimeters; angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerances are expressed in ratios as the primary method, 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:

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

4.2 Reference to ISO 230-1

To apply this part of ISO 3070, 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» block of the tests described in the following sections, the instructions are followed by a reference to the corresponding clause in ISO 230-1 in cases where the test concerned is in compliance with the specifications of that part of ISO 230.

4.3 Testing sequence

The sequence in which the tests are presented in this part of ISO 3070 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 nor possible to carry out all the tests described in this part of ISO 3070. 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. The mere reference to this part of ISO 3070 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.

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1) To be published. (Revision of ISO 230-2:1988)

2) To be published. (Revision of ISO 1101:1983)

3) See “Foreword”.

4.5 Measuring instruments

The measuring instruments indicated in the tests described in the following sections 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 0,001 mm or better.

4.6 Machining tests

Machining tests shall be made with finishing cuts only, not with roughing cuts which are liable to generate appreciable cutting forces.

4.7 Minimum tolerance

When the tolerance for a geometric test is established for a measuring length different from that given in this part of ISO 3070 (See 2.311 of ISO 230-1:1996), it shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

5 Geometric tests

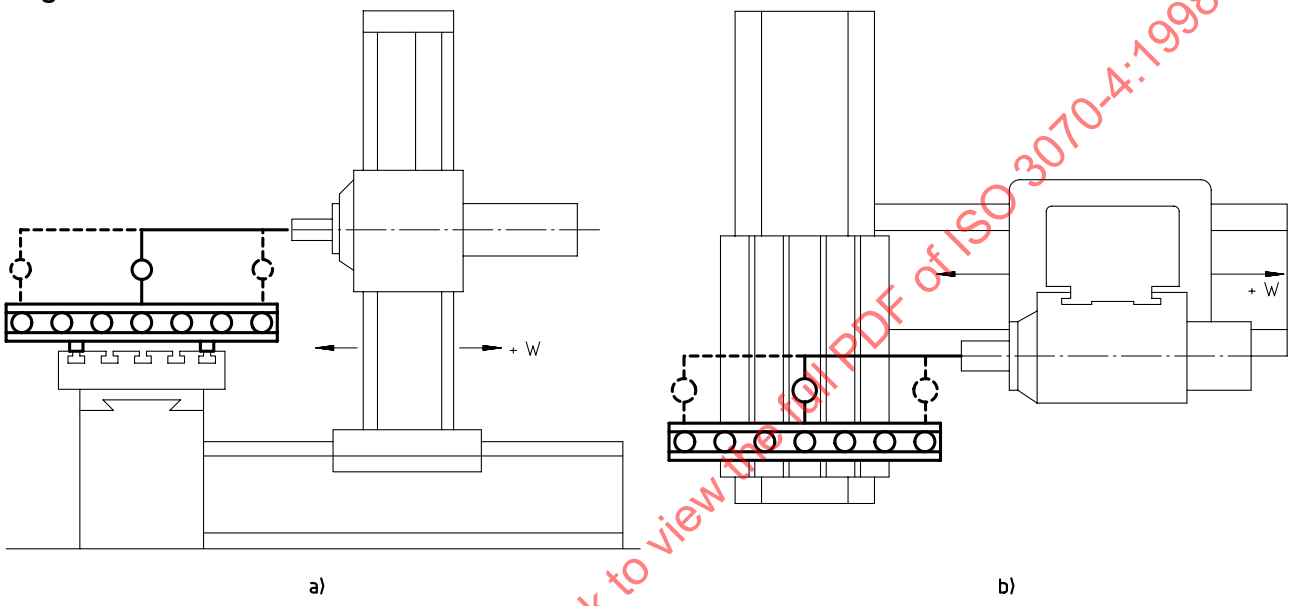
5.1 Straightness and angular deviations of coordinate axes

Object **G 1**

Checking of straightness of the column movement (W-axis):

a) in the YZ-plane (vertical plane)(EYW);
b) in the ZX-plane (horizontal plane)(EXW).

Diagram



Tolerance	**(Measured deviation)**
a) and b) 0,02 for measuring lengths up to 1 000 0,03 for measuring lengths above 1 000 Local tolerance: 0,006 for any measuring length of 300	a) b)

Measuring instruments

Straightedge, dial gauge/support and gauge blocks or optical methods or microscope and taut-wire

Observations and references to ISO 230-1 5.232.11, 5.232.12 and 5.232.13

Table and spindle head locked. Set a straightedge on the table, parallel[1)] to the column movement (W-axis) for a) vertically and b) horizontally.

If the spindle can be locked, mount a dial gauge on it. If the spindle can not be locked, the dial gauge shall be mounted on the head. The stylus shall be normal to the reference face of the straightedge.

Traverse the column in the W-direction and note readings.

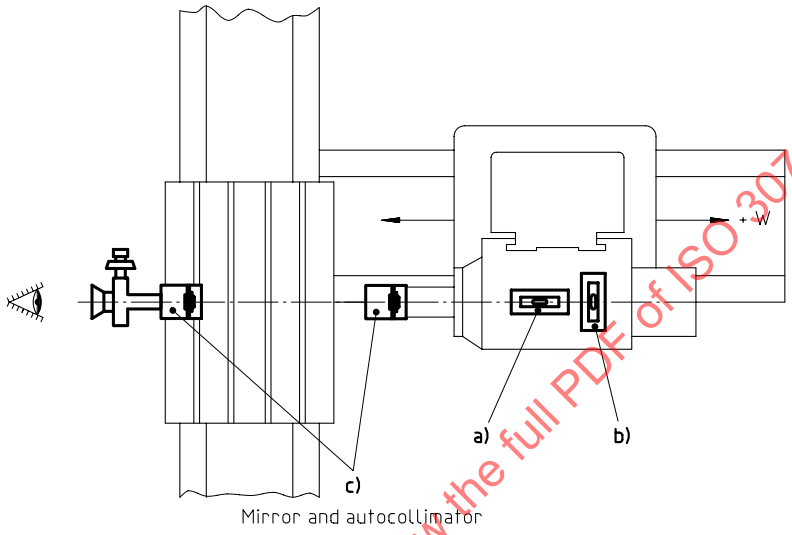
1) Parallel means that the readings of the dial gauge touching the straightedge at both ends of the movement are the same value and in this case, the maximum difference of the readings gives the straightness deviation.

Object **G 2**

Checking of angular deviations of the column movement (W-axis):

a) in the YZ-plane (EAW : pitch);
b) in the XY-plane (ECW : roll);
c) in the ZX-plane (EBW : yaw).

Diagram



Tolerance	**(Measured deviation)**
a), b) and c) 0,04/1 000 Local tolerance: 0,02/1 000 for any measuring length of 300	a) b) c)

Measuring instruments

a) Precision level or optical angular deviation measuring instruments
b) Precision level
c) Optical angular deviation measuring instruments

Observations and references to ISO 230-1 5.231.3 and 5.232.2

The level or instrument shall be placed on the movable component:

a) (EAW: pitch) in the Z-axis direction (set vertically)
b) (ECW: roll) in the X-axis direction (set vertically)
c) (EBW: yaw) in the Z-axis direction (set horizontally)

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

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

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

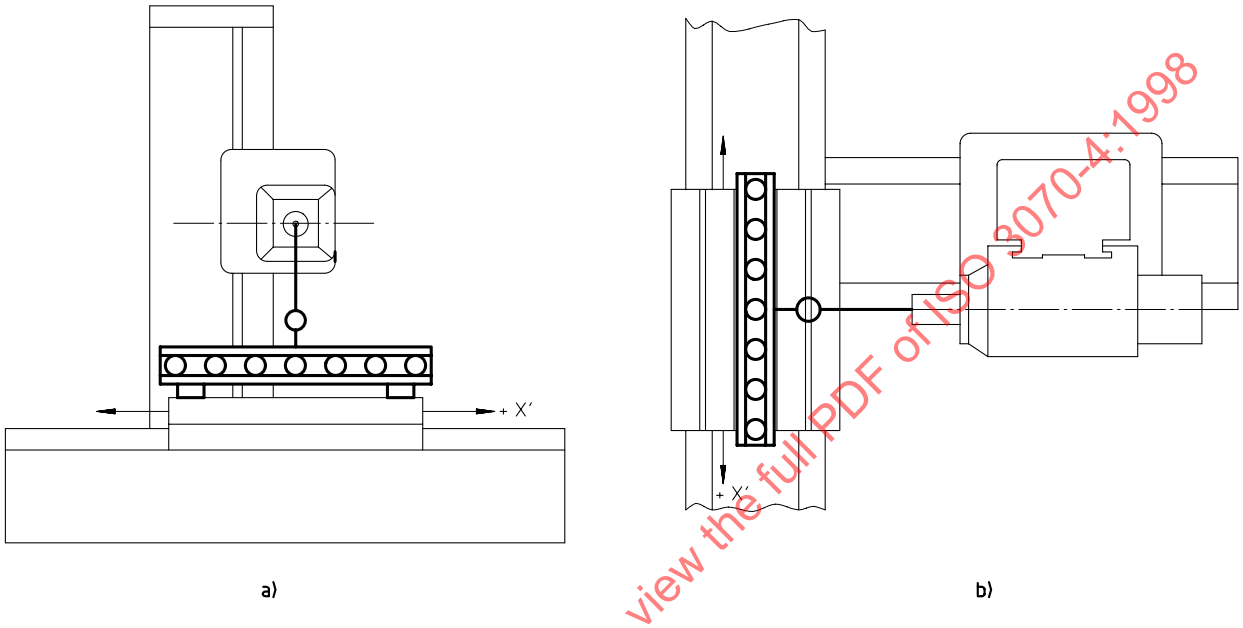
The difference between the maximum and the minimum readings shall not exceed the tolerance.

Object **G 3**

Checking of straightness of the table movement (X-axis):

a) in the XY-plane (vertical plane)(EYX);
b) in the ZX-plane (horizontal plane)(EZX).

Diagram



a) b)

Tolerance	**(Measured deviation)**
a) and b) 0,02 for measuring lengths up to 1 000 Add 0,01 to the preceding tolerance for each 1 000 increase in length beyond 1 000 Maximum tolerance: 0,05 Local tolerance: 0,006 for any measuring length of 300	a) b)

Measuring instruments

Straightedge, dial gauge/support and gauge blocks or optical methods or microscope and taut-wire

Observations and references to ISO 230-1 5.232.11, 5.232.12 and 5.232.13

Set a straightedge at the middle position of the table, parallel[1)] to the X-axis movement of the table for a) vertically and b) horizontally.

If the spindle can be locked, mount a dial gauge on it. If the spindle cannot be locked, the dial gauge shall be mounted on the head. The stylus shall be normal to the reference face of the straightedge.

Traverse the table in the X-axis direction and note the readings.

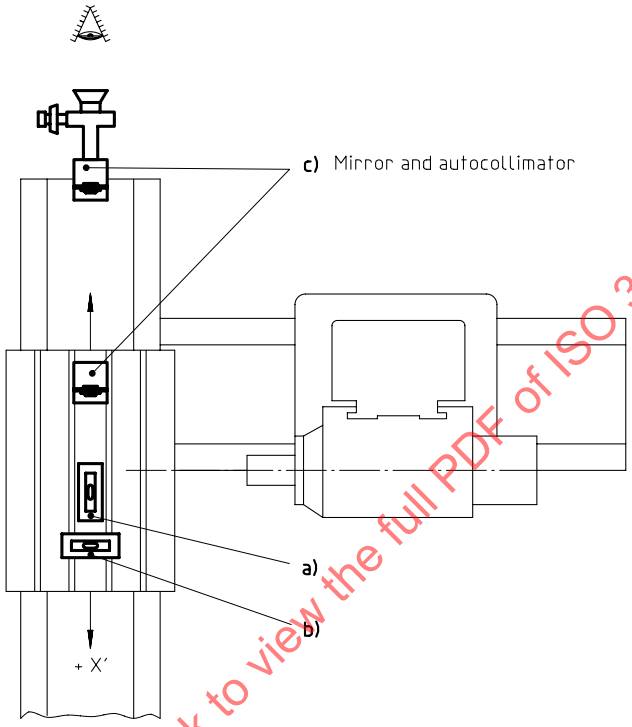
1) Parallel means that the readings of the dial gauge touching the straightedge at both ends of the movement are the same value and in this case, the maximum difference of the readings gives the straightness deviation.

Object **G 4**

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

a) in the XY-plane (ECX: pitch);
b) in the YZ-plane (EAX: roll);
c) in the ZX-plane (EBX: yaw).

Diagram



Tolerance	**(Measured deviation)**
a), b) and c) X ≤ 4 000 0,04/1 000 X > 4 000 0,06/1 000 Local tolerance: 0,02/1 000 for any measuring length of 300	a) b) c)

Measuring instruments

a) Precision level or optical angular deviation measuring instruments
b) Precision level
c) Optical angular deviation measuring instruments

Observations and references to ISO 230-1 5.231.3 and 5.232.2

The level or instrument shall be placed on the movable component:

a) (ECX: pitch) in the X-axis direction (set vertically)
b) (EAX: roll) in the Z-axis direction (set vertically)
c) (EBX: yaw) in the X-axis direction (set horizontally)

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

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

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

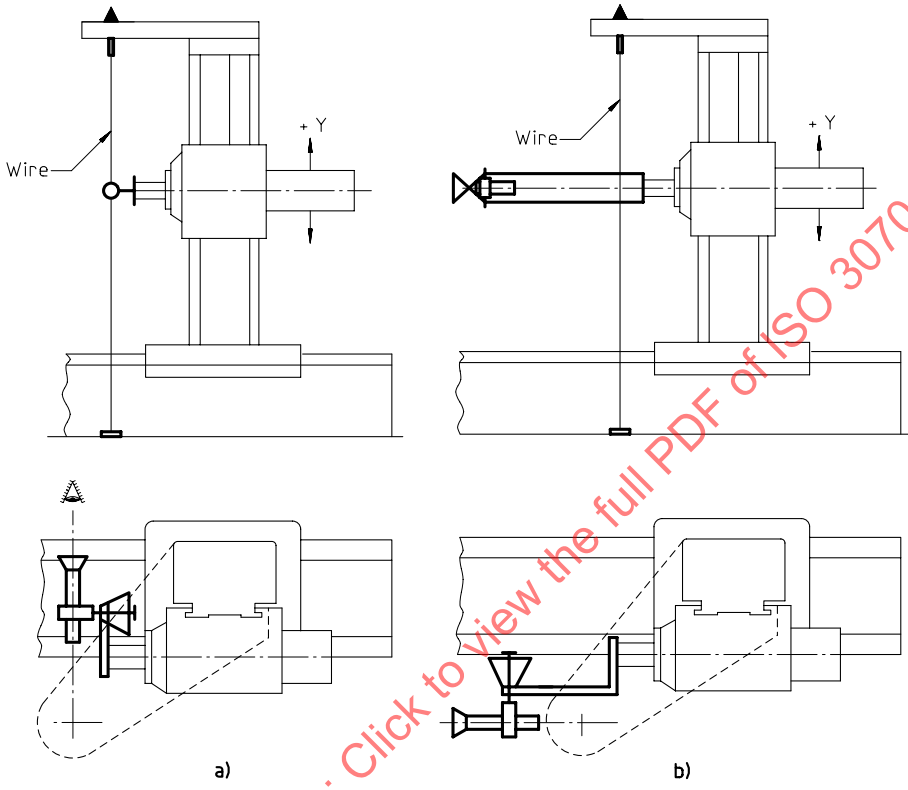
The difference between the maximum and the minimum readings shall not exceed the tolerance.

Object **G 5**

Checking of straightness of the spindle head movement (Y-axis):

a) in the YZ-plane (vertical plane containing the spindle axis)(EZY);
b) in the XY-plane (vertical plane square to the spindle axis)(EXY).

Diagram



Tolerance	**(Measured deviation)**
a) and b) 0,02 for any measuring length of 1 000 Add 0,01 to the preceding tolerance for each 1 000 increase in length up to 4 000 Add 0,02 for each 1 000 increase in length over 4 000	a) b)

Measuring instruments

Microscope and taut-wire or optical methods

Observations and references to ISO 230-1 5.232.12 or 5.232.13

Carry out the test with the column and table locked, table in mid-travel.

The taut-wire shall be tightened between fixed parts independent of or integral with the machine, and as near as possible to the vertical slideways of the column.

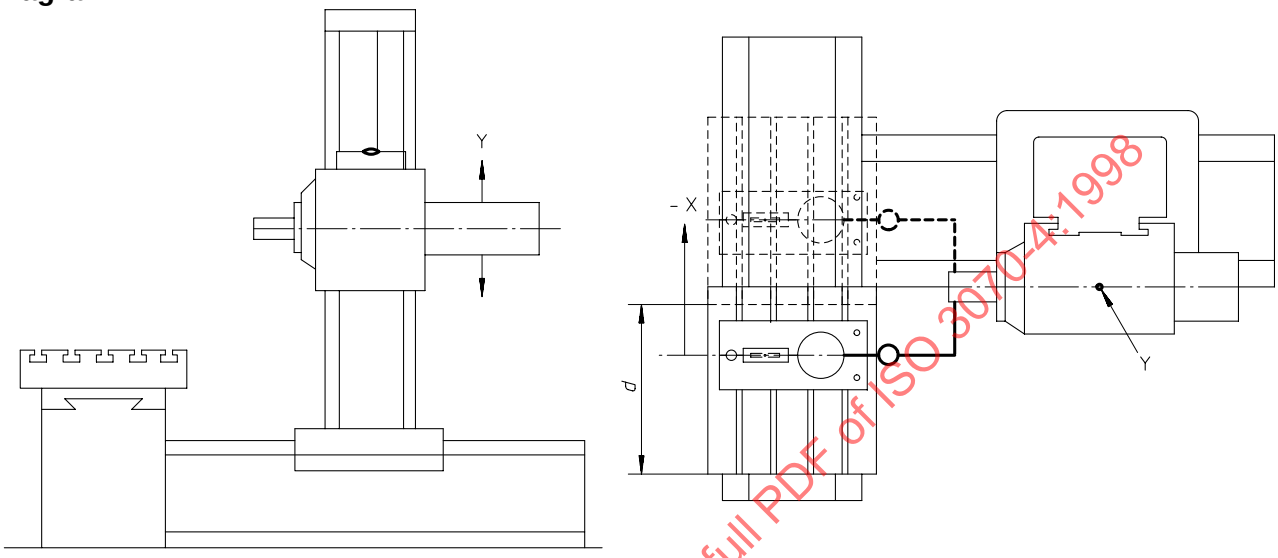
If the spindle can be locked, the microscope or the alignment telescope can be mounted on it. If the spindle cannot be locked, the microscope shall be placed on the spindle head of the machine.

Object **G 6**

Checking of angular deviations of the spindle head movement (Y-axis):

a) in the YZ-plane (EAY);
b) in the ZX-plane (EBY).

Diagram



a) b)

Tolerance	**(Measured deviation)**
a) and b)	a) b)
$X \leq 4\,000$ 0,04/1 000	
$X > 4\,000$ 0,04/1 000	

Measuring instruments

a) Precision level or optical angular deviation measuring instruments
b) Cylindrical square, level and dial gauges/support arm

Observations and references to ISO 230-1 5.231.3 and 5.232.2

Measurements shall be carried out at a minimum of five positions equally spaced along the travel in both directions of up and down movement.

a) Place a level on the spindle head in the Z-axis direction.

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

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

b) Mount a surface plate on the table and adjust it so that its face is levelled.

Place a cylindrical square on the surface plate so that it touches the stylus of the dial gauge mounted on a special arm fixed to the spindle head.

Place level on the surface plate in Z-axis direction.

Note the readings at the measuring positions of the spindle head travel (Y-axis).

Move the table distance *d* and reset the dial gauge so that the stylus touches the cylindrical square.

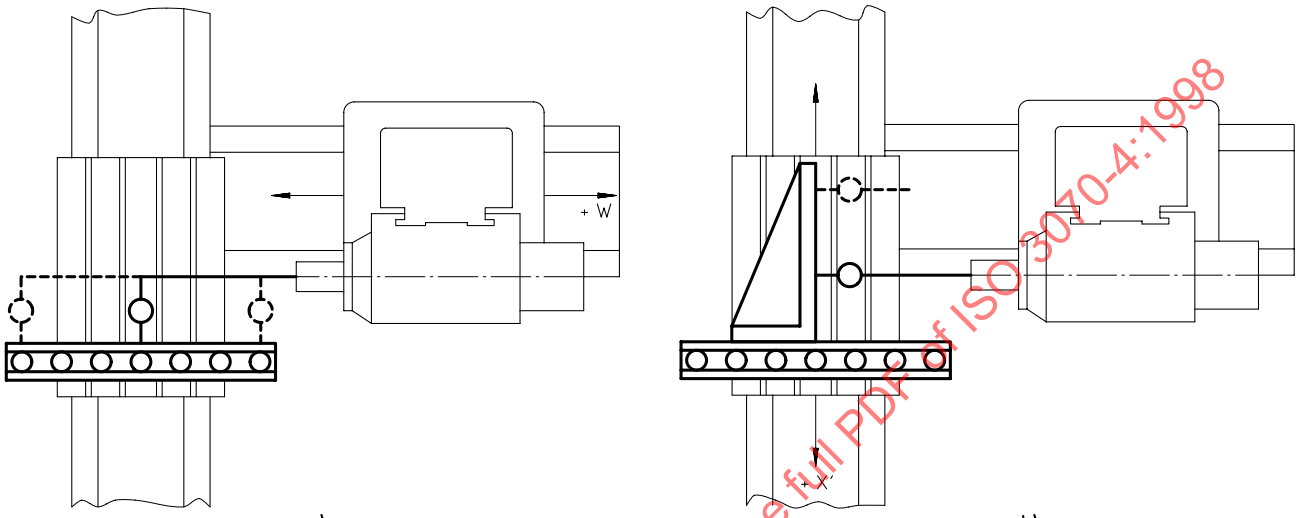
When the level shows a change due to roll in table movement, adjust the level of surface to its starting position and then note readings at the same measuring positions.

For each measuring position calculate the differences of two readings. The difference of maximum and minimum divided by distance *d* then gives angular deviation.

5.2. Squareness between the coordinate axes

Object	**G 7**
Checking of squareness between table movement (X-axis) and the column movement (W-axis).	

Diagram



Tolerance	**(Measured deviation)**
0,03 for any measuring length of 1 000	

Measuring instruments

Straightedge, square and dial gauge/support

Observations and references to ISO 230-1 5.522.4

Spindle head locked in mid-travel.

a) Align the straightedge parallel[1)] to the column movement (W-axis);

b) then press the square against it. Column shall then be locked in mid-travel.

If the spindle can be locked, mount the dial gauge on it. If the spindle cannot be locked, the dial gauge shall be mounted on the head. The stylus shall be normal to the reference face of the square.

Move the table in X-direction and note readings.

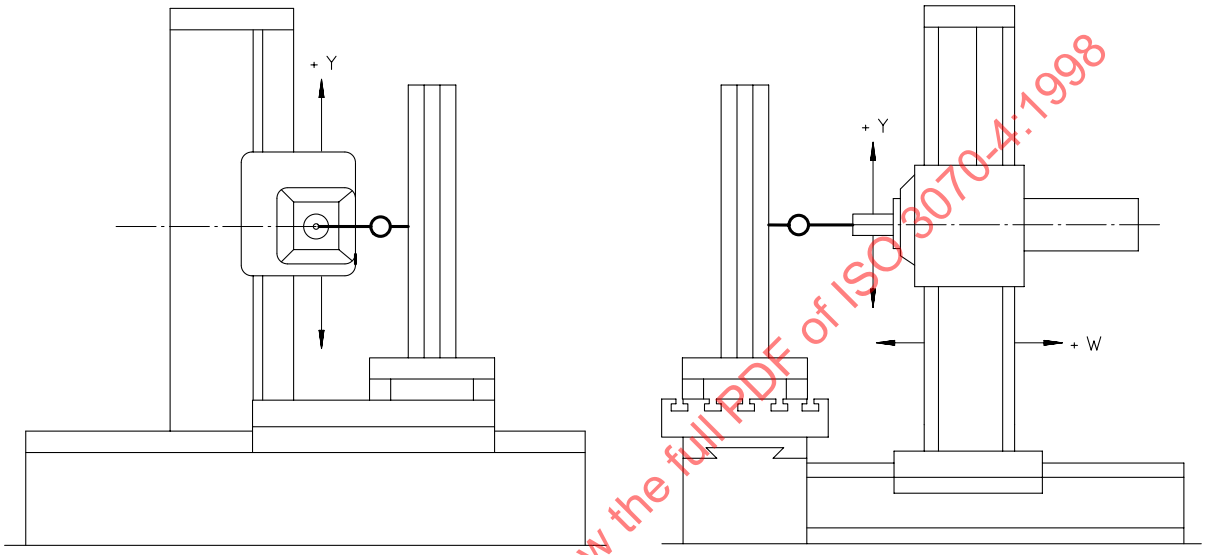
1) Parallel means that the readings of the dial gauge touching the straightedge at both ends of the movement are the same value.

Object **G 8**

Checking of squareness of the spindle head movement (Y-axis) to:

a) the table movement (X-axis);
b) the column movement (W-axis).

Diagram



a) b)

Tolerance	**(Measured deviation)**
a) and b) 0,03 for any measuring length of 1 000	a) b)

Measuring instruments

Cylindrical square, surface plate, adjustable blocks and dial gauge/support

Observations and references to ISO 230-1 5.522.4

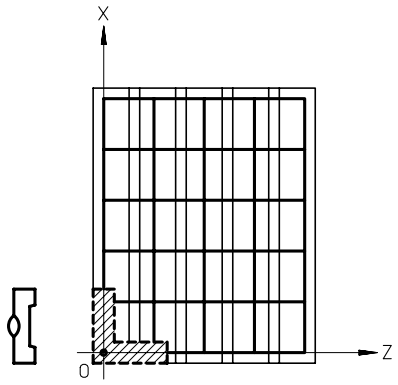
Mount a surface plate on the table and adjust it so that its surface is parallel to both X and W-axes movements. Place the cylindrical square on the surface plate.

If the spindle can be locked, the dial gauge can be mounted on it. If the spindle cannot be locked, the dial gauge shall be placed on the spindle head of the machine.

a) Apply the stylus of the dial gauge to the cylindrical square in the X-direction and move the head in the Y-direction through the measuring length and note the maximum difference of readings.

b) Apply the stylus of the dial gauge to the cylindrical square in the W-direction and carry out the same procedure mentioned above.

5.3 Table

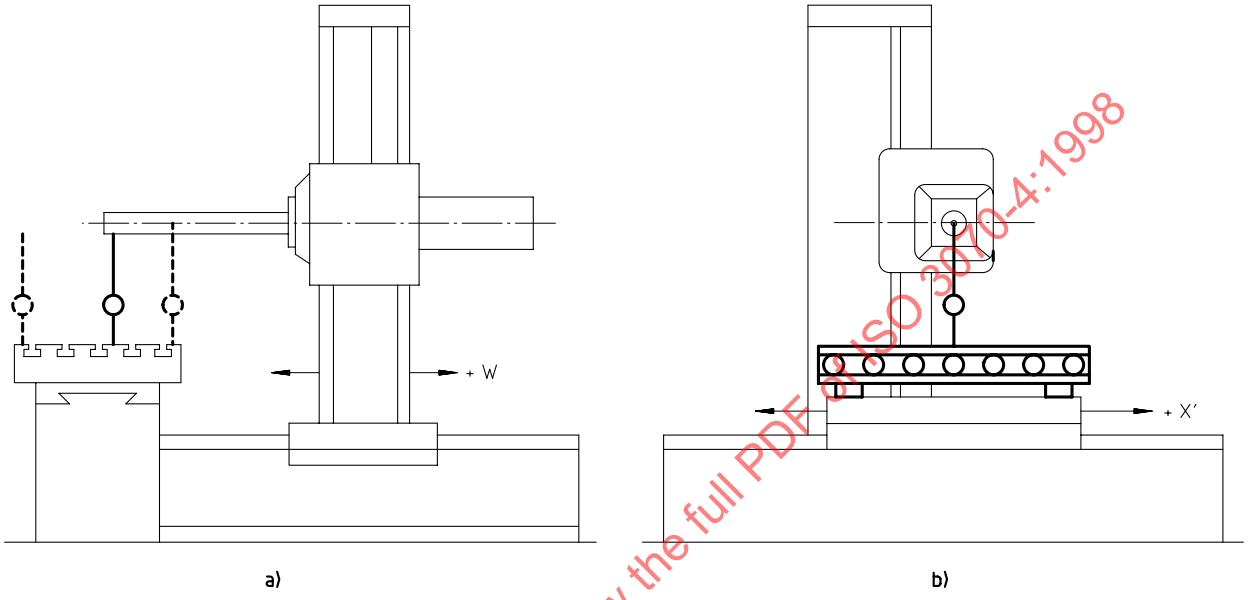
Object	**G 9**
Checking of the flatness of the table surface.	
Diagram  	
Tolerance For longer side length of O-X or O-Z 0,03 for measuring lengths up to 1 000; (flat to concave) Add 0,01 to the preceding tolerance for each 1 000 increase in length beyond 1 000 Maximum tolerance: 0,06 Local tolerance: 0,015 for any measuring length of 300	**(Measured deviation)**
Measuring instruments Precision level or straightedge, gauge-blocks and dial gauge or optical or other equipment	
Observations and references to ISO 230-1 5.322, 5.323, 5.324 The table and column may be locked in the mid-positions of their travel.	

Object **G 10**

Checking of parallelism of the table surface to:

a) the column movement (W-axis);
b) the table movement (X-axis).

Diagram



Tolerance

a) and b)

0,04 for measuring lengths up to 1 000

Add 0,01 to the preceding tolerance for each 1 000 increase in length beyond 1 000

Maximum tolerance: 0,06

Local tolerance : 0,015 for any measuring length of 300

(Measured deviation)

a) b)

Measuring instruments

Dial gauge, straightedge and gauge-blocks

Observations and references to ISO 230-1 5.422.21

If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge shall be mounted on the head. The stylus of the dial gauge shall be placed approximately in a vertical plane coaxial with the spindle axis.

a) The table shall be locked at mid-travel. Set the straightedge on the table in the W-direction parallel to the table surface and traverse the column through the measuring length and note the variation in readings.

b) The column be locked. Set the straightedge in the X-direction and traverse the table through the measuring length and note the variation in readings.

If the traverse travel is longer than 1 600, carry out the inspection by successive movement of the straightedge.

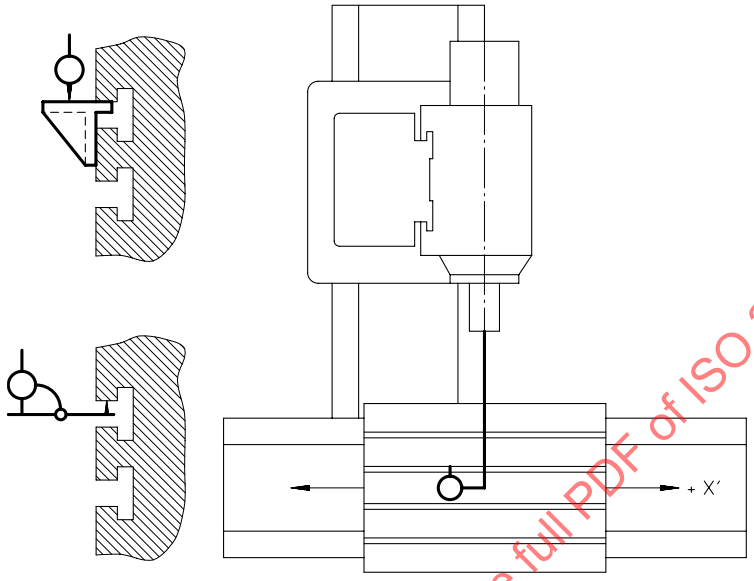
Without using a straightedge, direct measurement of the table surface using a dial gauge and a gauge block is also possible.

For rotary type tables, tests shall be carried out at each of the following indexed positions of the rotary table: 0^{o}, 90^{o}, 180^{o} and 270^{o}.

Object **G 11**

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

Diagram



Tolerance	**(Measured deviation)**
0,03 for any measuring length of 1 000 Maximum tolerance: 0,04	

Measuring instruments

Dial gauge and cross-square

Observations and references to ISO 230-1 5.422.21

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

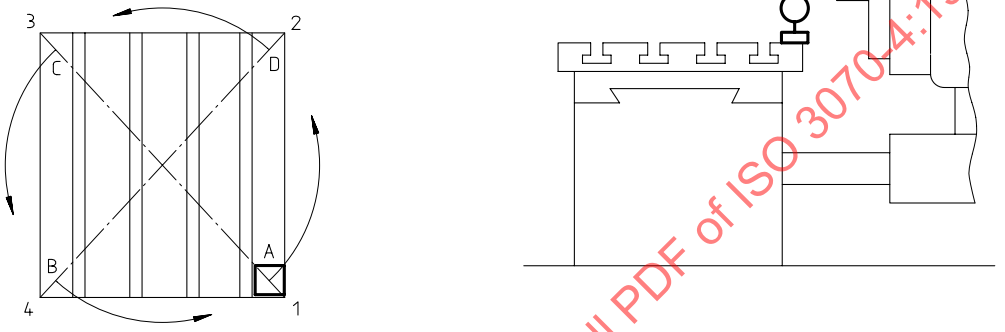
The stylus of the dial gauge may touch the reference face of T-slot directly or by using a cross-square.

5.4 Indexing or rotary table

Object **G 12**

Checking of camming of the table surface in its rotating movement.

Diagram



Tolerance	**(Measured deviation)**
0,02 for a measuring diameter of 1 000	

Measuring instruments

Dial gauge/support and gauge block

Observations and references to ISO 230-1 5.632

1) The dial gauge being placed in position **1**, place a gauge block near the corner A of the table and take the measurement. Remove the gauge block and rotate the table till the corner of B comes to the measuring position and take the measurement by inserting the same gauge block. Carry out the same operation at the corners of C and D by rotating the table.

2) Repeat the same process, placing the dial gauge in the successive positions of **2**, **3** and **4** or at least in position **2**.

For each of those positions, note the difference between the maximum and minimum readings.

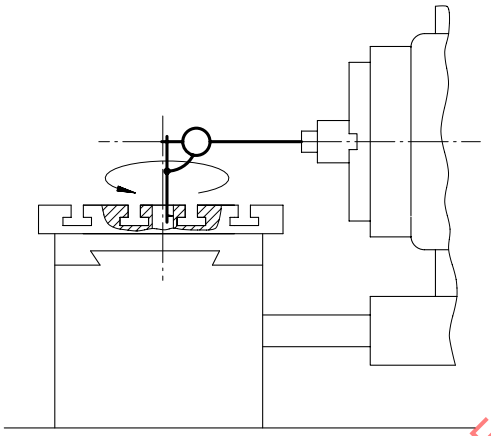
Use the greatest of these differences as the value of camming.

Lock the table each time before taking measurements.

Object **G 13**

Checking of run-out of the centring hole of the table in relation to its axis of rotation.

Diagram



Tolerance	**(Measured deviation)**
0,015	

Measuring instruments

Dial gauge/support and possibly test mandrel

Observations and references to ISO 230-1 5.612.3

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

Set the stylus of the dial gauge coaxial with the axis of the centring hole and as near as possible to the table surface.

Rotate the table and use the difference between the maximum and the minimum readings as the measured deviations.

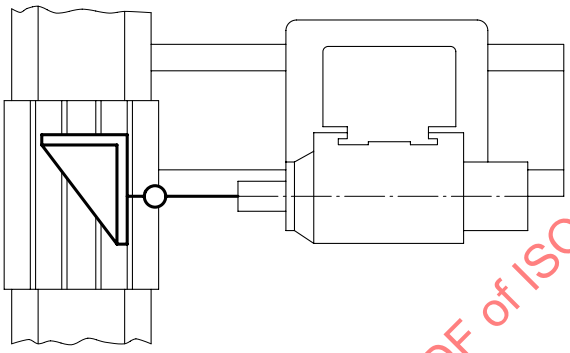
Checking may also be carried out using a cylindrical mandrel inserted into the centre hole.

Object **G 14**

Checking of accuracy of the table angular positions at 0^o, 90^o, 180^o and 270^o.

a) for rotary indexable table with only four fixed positions 90^o apart.
b) for rotary indexable table with any number of fixed positions.
c) for rotary table capable of any angle positioning.

Diagram



Tolerance	**(Measured deviation)**
a) 0,03 for any measuring length of 500	a)
b) 0,05 for any measuring length of 500	b)
c) 0,075 for any measuring length of 500	c)

Measuring instruments

Square and dial gauge/support

Observations and references to ISO 230-1 6.41, 6.42 and 6.43

Set a square on the table with one edge parallel to the table movement (X-axis).

Index the table four times in one direction (90^o, 180^o, 270^o, 360^o) and check in every position the parallelism between table movement and the corresponding edge of the square.

Index the table four times in opposite positions (270^o, 180^o, 90^o, 0^o) and check again the parallelism in every position. The maximum difference of the eight readings shall not exceed the tolerance.

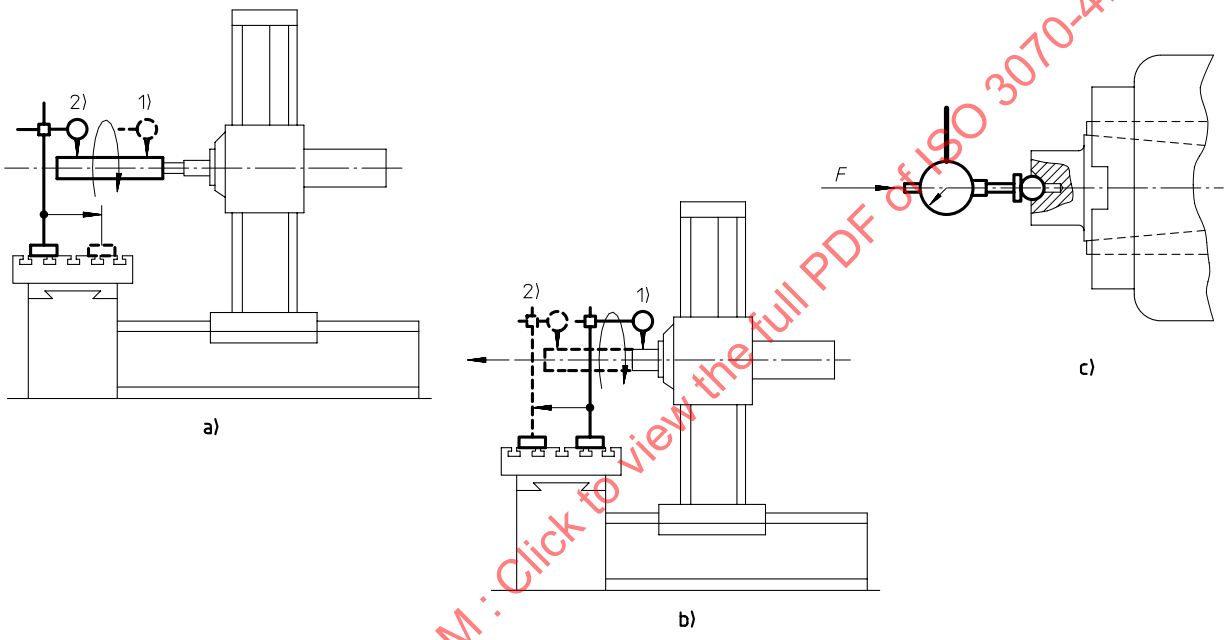
5.5 Boring spindle

Object **G 15**

Checking of the boring spindle

a) Run-out of the internal taper, spindle retracted:
   1) at the mouth of taper;
   2) at a distance of 300 mm from spindle nose.
b) Run-out of the external diameter:
   1) spindle retracted;
   2) spindle extended 300 mm.
c) Periodic axial slip, spindle retracted.

Diagram



Tolerance

		$D \leqslant 125$	$D > 125$
a) and b)	1)	0,01	0,015
	2)	0,02	0,03
c)		0,01	0,015

where D is the diameter of the boring spindle

(Measured deviation)

a) b) c)

Measuring instruments

Test mandrel and dial gauge

Observations and references to ISO 230-1

a) 5.612.3

b) 5.612.2

c) 5.622.1 and 5.622.2

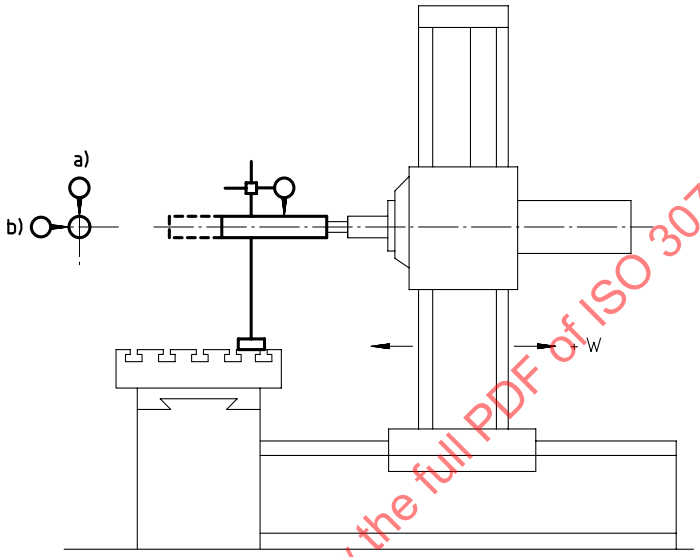
The value and the direction of application of force F shall be specified by the supplier/manufacturer. When preloaded bearings are used, no force need to be applied.

Object **G 16**

Checking of parallelism of the boring spindle axis to the column movement (W-axis);

a) in the YZ-plane (vertical),
b) in the ZX-plane (horizontal).

Diagram



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

Measuring instruments

Dial gauge and test mandrel

Observations and references to ISO 230-1 5.412.1 and 5.422.3

Spindle head locked in mid-travel. Table locked. Spindle retracted.

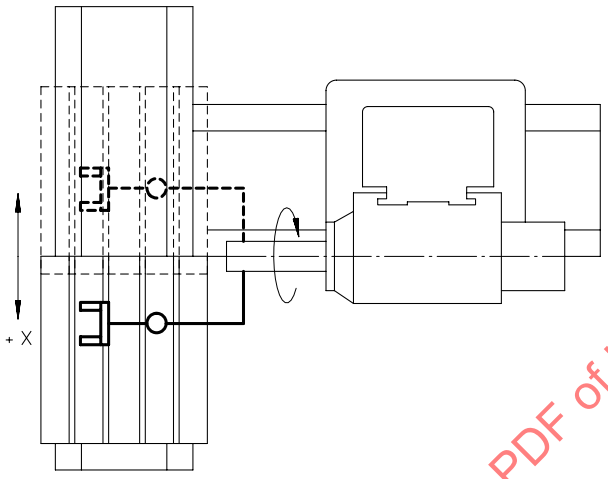
Measurement shall be carried out with the aid of the test mandrel mounted in the spindle nose.

Carry out the measurement at the mean position of run-out of the spindle rotation or evaluate the mean value of measurements taken at two positions of the spindle rotation at 180° apart.

Object **G 17**

Checking of squareness of the boring spindle axis to the table movement (X-axis).

Diagram



Tolerance	**(Measured deviation)**
0,02/500 where 500 is the distance between the two measuring points touched	

Measuring instruments

Dial gauge/support and square block

Observations and references to ISO 230-1 5.512.1 and 5.512.32

Spindle head locked in mid-travel, spindle and possibly ram retracted. Column locked in near position to the table.

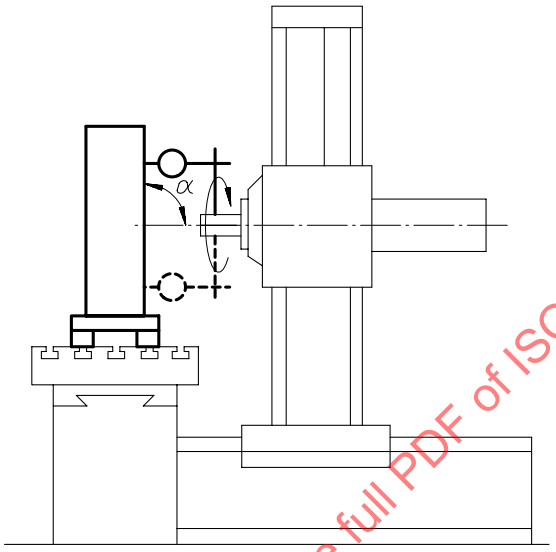
Place the stylus of the dial gauge against the square block on the table. Turn the boring spindle and move the table to touch the square block at the same point.

The difference between the two readings divided by the distance between the two measuring points define the squareness deviation.

Object **G 18**

Checking of squareness of the boring spindle axis to the spindle head movement (Y-axis).

Diagram



Tolerance

0,02/500 with $\alpha \leqslant 90^{o}$

where 500 is the distance between the two measuring points touched

(Measured deviation)

Measuring instruments

Cylindrical square, adjustable blocks and dial gauge/support

Observations and references to ISO 230-1 5.512.1 and 5.512.32

Spindle head locked in mid-travel, spindle and possibly ram retracted.

Column locked in near position to the table.

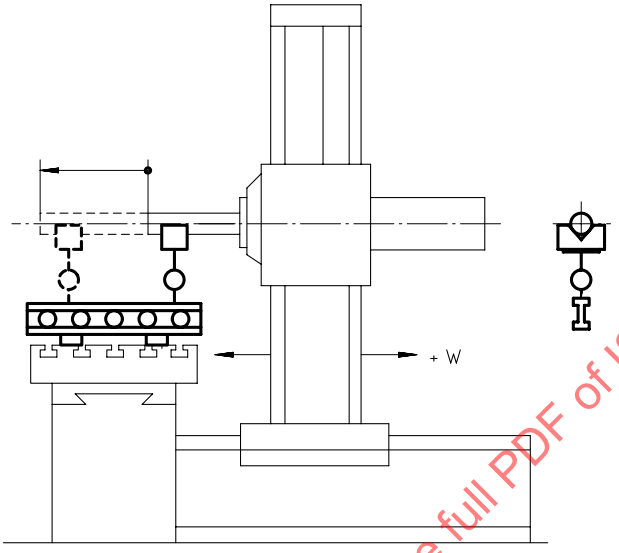
Cylindrical square shall be set on the table parallel to the spindle head movement (Y-axis).

Turn the spindle with the attached dial gauge and touch the cylindrical square.

Object **G 19**

Checking of parallelism of the boring spindle sliding movement (Z-axis) to the column movement (W-axis).

Diagram



Tolerance **(Measured deviation)**

For an extension of the spindle equal to:

$2D$: + 0,015 (upwards);
$4D$: ± 0,02;
$6D$: − 0,06 (downwards);

where D is spindle diameter

NOTES

1 The extension of the spindle is limited to six times the spindle diameter and shall not exceed 900.

2 Tolerance is limited to spindle diameter of 150 mm, when the spindle diameter is over 150 mm, the tolerance shall be agreed upon between user and supplier/manufacturer.

Measuring instruments

Straightedge, gauge block and dial gauge

Observations and references to ISO 230-1 5.232.1 and 5.422.22

Place a straightedge vertically on the table in a plane containing the spindle axis, adjust it parallel to the column movement (W-axis).

Touch the functional surface of the straightedge with the dial gauge fixed on the spindle nose.

Spindle rotation locked.

Extend the spindle to the required length and note the dial gauge readings for each of the successive positions.

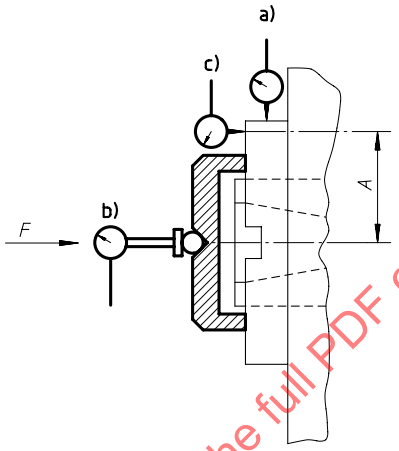
5.6 Milling spindle

Object **G 20**

Checking of the milling spindle:

a) run-out;
b) periodic axial slip;
c) camming of the face of the spindle nose (including periodic axial slip).

Diagram



Tolerance	**(Measured deviation)**
$D \leqslant 125$: a) 0,01 b) 0,01 c) 0,02	a) b) c)
$D > 125$: a) 0,015 b) 0,015 c) 0,03	a) b) c)
where D is the diameter of the milling spindle	

Measuring instruments

Dial gauge

Observations and references to ISO 230-1

a) 5.612.2

b) 5.622.1 and 5.622.2

The value and direction of application of force F shall be specified by the supplier/manufacturer.

When an axially preloaded bearing is used for the spindle, no force F is needed.

c) 5.632

The distance A of the dial gauge c) from the spindle axis shall be as large as possible.

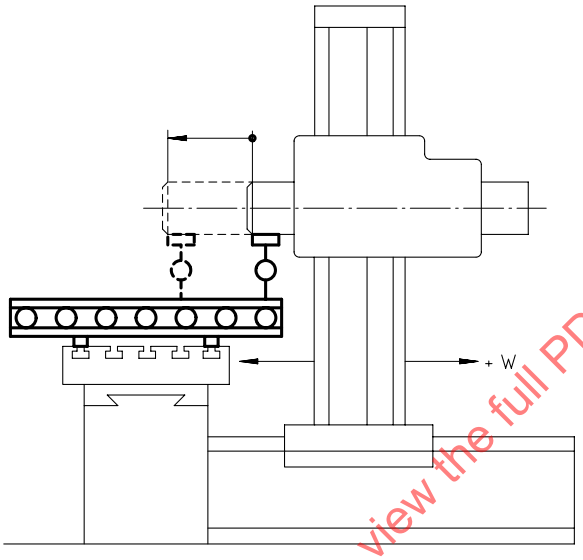
5.7 Ram

Object **G 21**

Checking of parallelism of the ram movement (Z-axis) to the column movement (W-axis):

a) in the YZ plane (vertical plane);
b) in the ZX plane (horizontal plane).

Diagram



Tolerance	**(Measured deviation)**
a) and b) 0,03 for a measuring length of 500	a) b)

Measuring instruments

Straightedge, gauge block and dial gauge/support

Observations and references to ISO 230-1 5.422.22

Set a straightedge on the table parallel[1)] to the column movement (W-axis) for a) vertical and b) horizontal measurement.

Column locked in mid-travel. Spindle head locked.

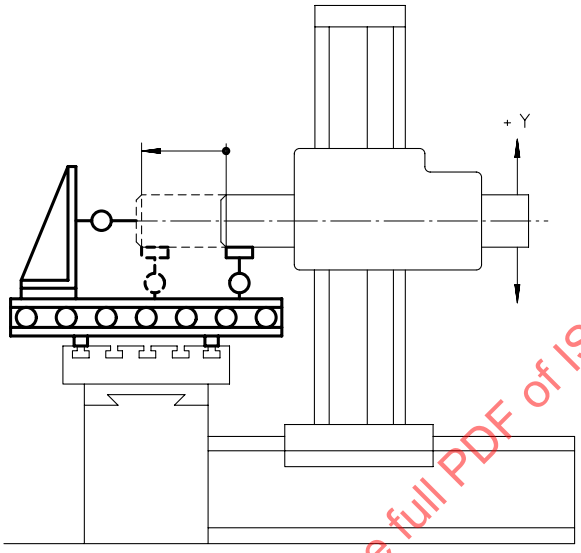
The ram movement shall then be checked with respect to the straightedge using a dial gauge fixed on the ram.

1) Parallel means that the readings of dial gauge touching the straightedge at both ends of the movement are the same value.

Object **G 22**

Checking of squareness of the ram movement (Z-axis) to the spindle head movement (Y-axis).

Diagram



Tolerance	**(Measured deviation)**
0,03 for a measuring length of 500	

Measuring instruments

Straightedge, square, adjustable blocks and dial gauge/support

Observations and references to ISO 230-1 5.522.4

Place a straightedge on the table parallel to the ram movement (Z-axis) using adjustable blocks.

Place a square on the straightedge and check parallelism between free arm of the square and the spindle head movement.

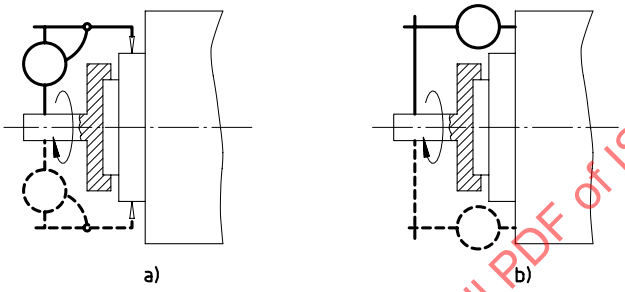
Object **G 23**

a) Checking of concentricity of the milling spindle and of the front centring of tool or accessories on the ram.

b) Checking of squareness of the support face of tools or accessories on the ram to the rotation axis of the milling spindle.

(These checks are valid only if there is a circular locating surface on the ram.)

Diagram



Tolerance	**(Measured deviation)**
a) 0,02 b) 0,02/500	a) b)

Measuring instruments

Dial gauge

Observations and references to ISO 230-1

a) 5.442

Concentricity deviation is the half of the maximum difference of the readings.

b) 5.512.42

5.8 Integral facing head

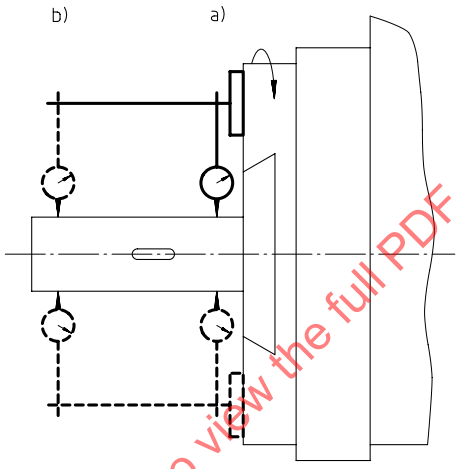
Object **G 24**

Checking of coaxiality of the boring spindle rotating axis and of the facing head axis:

a) at the mouth of spindle housing;
b) at a distance of 300 mm from the spindle housing face.

(These checks are valid only when the facing head is mounted on bearings independent of those of the boring spindle.)

Diagram



Tolerance

	$D \leqslant 125$	$D > 125$
a)	0,02	0,03
b)	0,03	0,04

where D is the diameter of the milling spindle

(Measured deviation)

a) b)

Measuring instruments

Dial Gauge

Observations and references to ISO 230-1 5.442

A dial gauge fixed on the facing head shall touch the boring spindle at the mouth and at 300 mm.

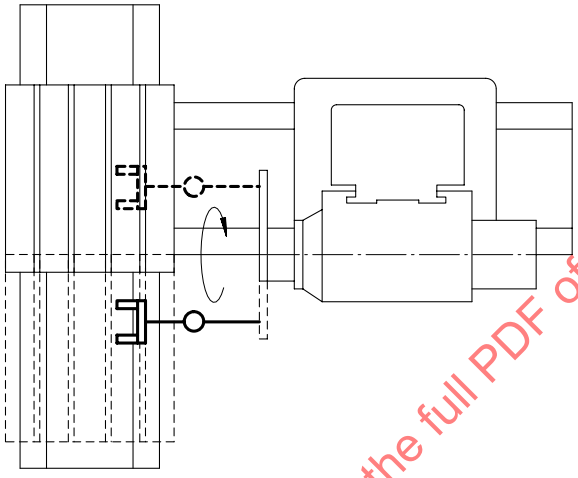
For each operation, determine half the difference of the extreme readings to obtain the coaxiality deviation.

Object **G 25**

Checking of squareness of the facing head rotation axis to the table movement (X-axis) .

(This check is valid only when the facing head is mounted on bearings independent of those of the boring spindle)

Diagram



Tolerance	**(Measured deviation)**
0,02/500 where 500 is the distance between the two measuring points touched	

Measuring instruments

Dial gauge/rigid support and square block

Observations and references to ISO 230-1 5.512.1 and 5.512.32

Column and spindle head locked.

Place the stylus of the dial gauge set on the facing head against the square block on the table.

Turn the facing head with dial gauge and move the table to touch the square block with the stylus at the same point.

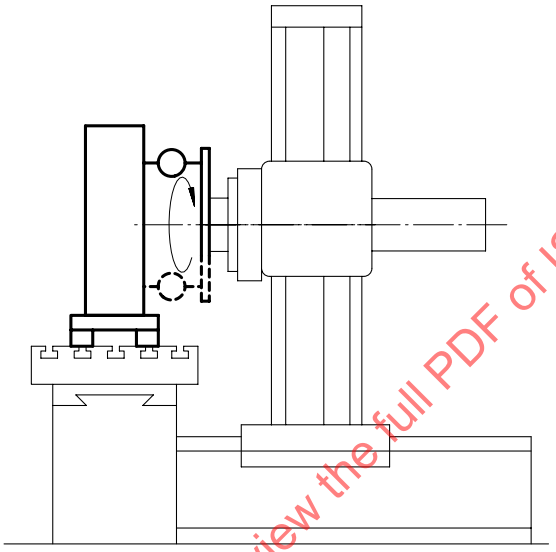
The difference between the two readings divided by the distance between the two measuring points defines the squareness deviation.

Object **G 26**

Checking of squareness of the facing head axis to the spindle head movement (Y-axis).

(This check is valid only when the facing head is mounted on the bearings independent of those of the boring spindle.)

Diagram



Tolerance (**Measured deviation)**

0,02/500

where 500 is the distance between the two measuring points touched

Measuring instruments

Dial gauge/rigid support, gauge blocks and cylindrical square

Observations and references to ISO 230-1 5.512.1 and 5.512.32

Column locked near the table. Spindle head locked in mid travel.

Set a cylindrical square on the table parallel to Y axis movement.

Set a dial gauge to a rigid arm fixed to the facing head and set the stylus of it against the cylindrical square. Note the reading.

The difference between the two readings divided by the distance between the two measuring points defines the squareness deviation.

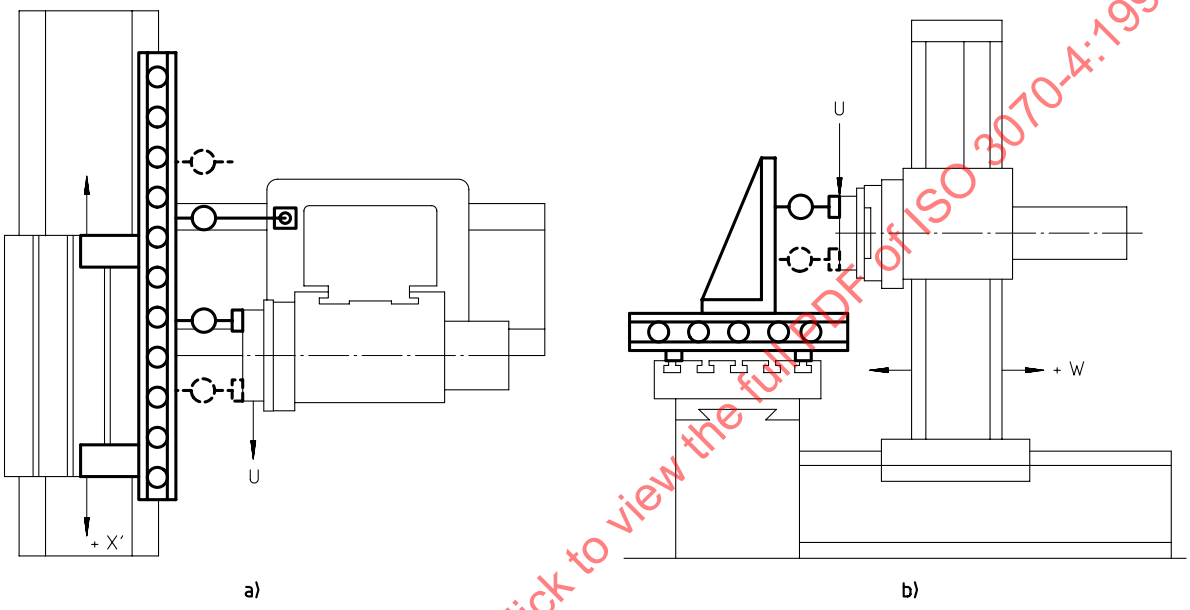
Object **G 27**

a) Checking of parallelism between the facing slide movement (U-axis), in a horizontal plane, and the table movement (X-axis);

and/or:

b) checking of squareness of the facing slide movement (U-axis), in a vertical plane, with the column movement (W-axis).

Diagram



Tolerance	(**Measured deviation**)
a) and b) 0,025 for a measuring length of 300	a) b)

Measuring instruments

a) Straightedge and dial gauge/support
b) Straightedge, square and dial gauge/support

Observations and references to ISO 230-1

a) 5.422.2 and 5.422.5

Set a straightedge horizontally on the table parallel to the table movement (X-axis), using a dial gauge fixed on the radial facing slide of the facing head.

Move the radial facing slide, and note the difference in the readings.

Repeat the test after turning the facing head through 180°.

b) 5.522.4

Set a straightedge horizontally on the table parallel to the column movement (W-axis) and place a square on it.

The stylus of dial gauge fixed on the radial facing slide touches the free arm of the square.

Move the radial facing slide vertically and note the difference in the readings.

Repeat the test after turning the facing head through 180°.

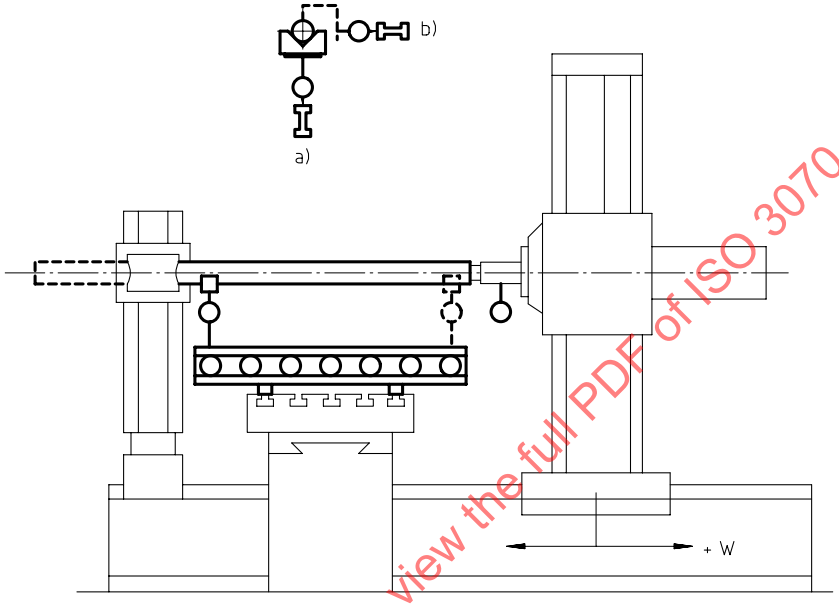
5.9 Steady block

Object **G 28**

Checking of coincidence of the steady block bore with the boring spindle axis:

a) in the vertical plane (YZ-plane)
(for machines having synchronized movements of the steady block and spindle head);
b) in the horizontal plane (ZX-plane).

Diagram



Tolerance	(**Measured deviation**)
a) 0,04 for a measuring length of 1 000	a)
b) 0,03 for a measuring length of 1 000	b)

Measuring instruments

Dial gauge and boring bar or test mandrel

Observations and references to ISO 230-1

Due to the great distance between supports, a cylindrical bar or a test mandrel used in these tests shall have sufficient length to pass completely through the steady block while mounted in the boring spindle when in its retracted position.

Test a) shall be carried out setting the spindle head and steady block first in the high position, then in the low position, or vice versa.

Test b) shall be carried out setting the spindle head and steady block locked in mid-travel, and the table and the table base locked in central position.

A straightedge shall be set parallel to the column movement (W-axis) by using dial gauge set to the extended boring bar, then the column locked in mid-travel and boring bar retracted.

A dial gauge set on the cylindrical bar or on the test mandrel shall touch the functional surface of the straightedge.

The measurement is made at the extremities: spindle end and steady block end.

In the case of large machines, it may be desirable to use two short test mandrels, placed in the spindle nose and in the steady block bore, in place of a single mandrel.

6 Machining tests

Nature of test

M 1

Machining of a single test piece including

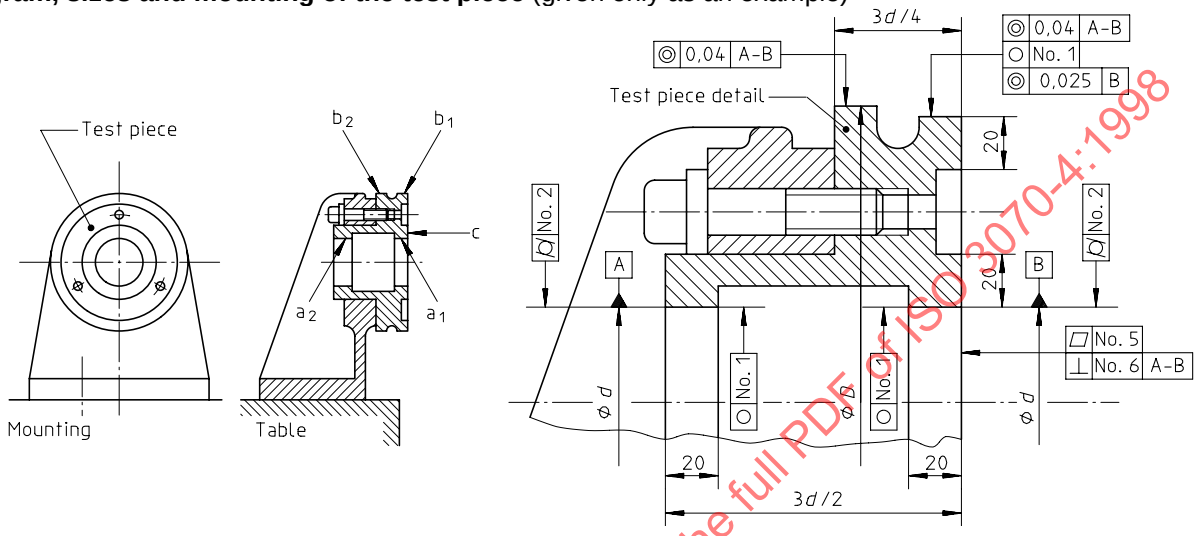
a) boring of the internal cylindrical holes a_1 and a_2;

b) turning of the external cylindrical surfaces b_1 and b_2;

c) facing of the surface c.

NOTE — Facing test only applies to machines having both a sliding boring spindle and either an integral or a detachable facing head, or an independent milling spindle.

Diagram, sizes and mounting of the test piece (given only as an example)



NOTES

1 The boring diameter d shall be equal to or slightly greater than the boring spindle diameter.

2 The turning diameter D shall be determined so that the value $\frac{D-d}{2}$ is equal to or slightly less than the maximum travel of the radial facing slide.

3 Test piece material: cast iron.

No.	Check to be applied	Tolerance	Measuring instruments	Observations and references to ISO 230-1
1	Circularity (Subclause 17.3 of ISO 1101:—) of the internal cylindrical holes a_1 and a_2 and of the external cylindrical surface b_1: — machined from the sliding spindle; — machined from column movement.	a_1 and a_2: $d \leqslant 125$: 0,007 5*) $d > 125$: 0,01*) b_1: $D \leqslant 300$: 0,01 $300 < D \leqslant 600$: 0,015*) For each 300 mm increase in diameter, add 0,005 mm	Bore gauge and micrometer or measuring instruments having the appropriate accuracy	Subclauses 3.1 and 3.22, 4.1 and 4.2, 5.442, 5.512.42 and 5.611.3 Before commencing the test make sure that the mounting surface which bears on the table is flat and that the testpiece surface which bears on the mounting is perpendicular to the axis of its housing. *) Tolerance indicated for machining tests 1 and 2 are related to the radius; to relate to the diameter, they shall be multiplied by 2. Directions for machining 1) Boring and finishing of the two internal cylindrical holes a_1 and a_2. Table locked and axial movement of the sliding boring spindle. 2) Turning of the external cylindrical surface b_1. With a short tool mounted on the facing head with movement of the column. 3) Movement of the column or of the ram of 300 mm and turning of external cylindrical surface b_2. Tool mounted on the facing head, with the aid of a support or a tool holder having a suitable length. 4) Machining of the surface c by automatic movement of the radial facing slide or by milling. Definitions of circularity and cylindricity tolerances are given in ISO 1101.
2	Cyindricity (Subclause 17.4 of ISO 1101:—) of the internal cylindrical holes a_1 and a_2.	$d \leqslant 125$: 0,01, $d > 125$: 0,015		
3	Concentricity (Subclause 17.11.1 of ISO 1101:—) of the internal cylindrical holes a_1 and of the external cylindrical surface b_1.	0,025	Mandrel and dial gauge	
4	Coaxiality (Subclause 17.11.2 of ISO 1101:—) of the external cylindrical surface b_1 and b_2 with the reference axes of the internal cylindrical holes a_1 and a_2.	0,04 for a longitudinal movement of the column of 300	Mandrel and dial gauge	
5	Flatness (Subclause 17.2 of ISO 1101:—) of the machined surface	0,015 for a diameter D of 300	Straightedge and gauge blocks	
6	Perpendicularity (Subclause 17.8 of ISO 1101:—) of the machined surface c with the reference axes of the internal cylindrical holes a_1 and a_2.	0,025/300	Mandrel and dial gauge or level and special support	