
**Test conditions for boring and milling
machines with horizontal spindle —**

**Part 2:
Table-type machines**

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

Partie 2: Machines à montant fixe



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

This second edition of ISO 3070-2 cancels and replaces the first edition of ISO 3070-1 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 (formerly 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.

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

Part 2: Table-type machines

1 Scope

This part of ISO 3070 specifies, with reference to ISO 230-1 and ISO 230-2, geometric tests, tests and tests for checking accuracy and repeatability of positioning by numerical control, on general purpose, normal accuracy, table type boring and milling machines with horizontal spindle. These types of machine tools are defined in sub-clause 3.1 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 both longitudinal (W-axis) and transverse (X-axis) movement of the table, a vertical movement of the spindle head (Y-axis) and may include a rotary or indexing table.

This International Standard deals only with the verification of the accuracy of the machine. It does not apply to the testing of the running of the machine (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:—¹⁾, *Test code for machine tools — Part 2: Determination of accuracy and repeatability of positioning of numerically controlled machine tool axes.*
- ISO 1101:—²⁾, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Generalities, definitions, symbols, indications on drawings.*
- ISO 3070-0:1982³⁾ *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 ISO 3070-1, 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 in principle 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:

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

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 or 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. 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.

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.

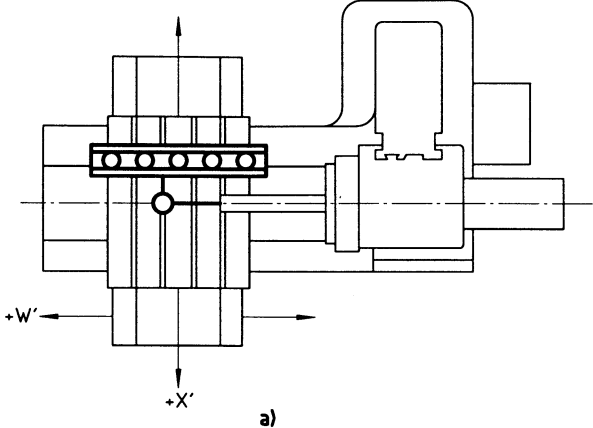
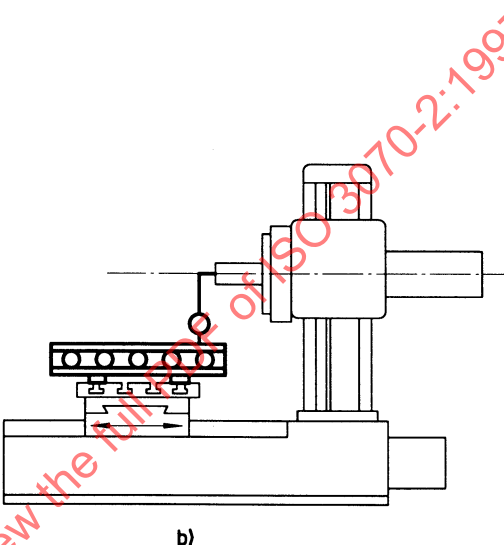
4.7 Minimum tolerance

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.

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5 Geometric tests

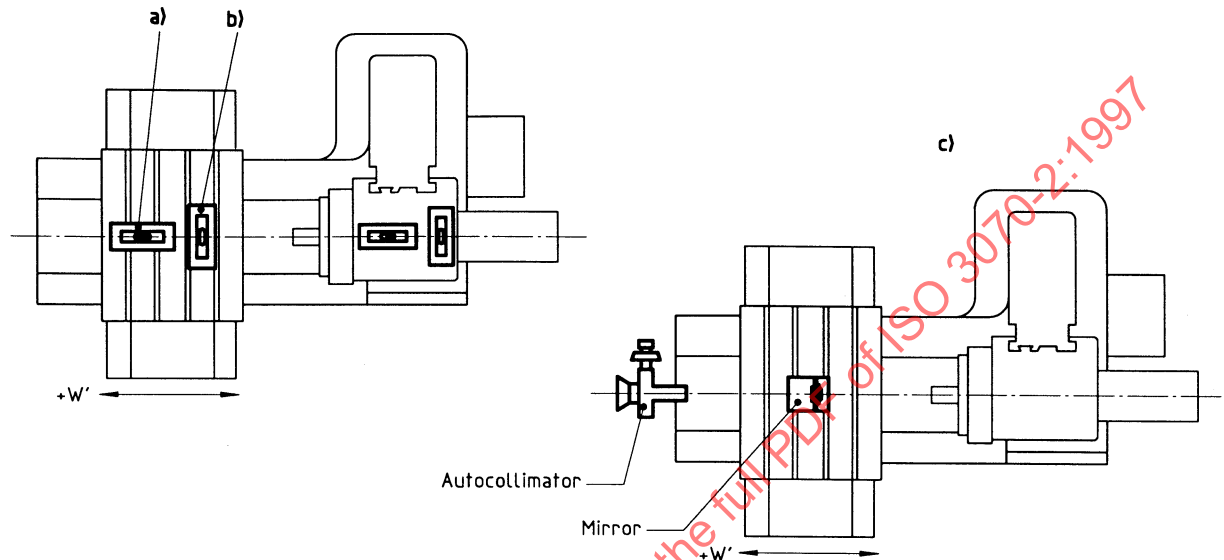
5.1 Straightness and angular deviations of coordinate axes

Object	G 1
Checking of straightness of the table saddle movement (W-axis): a) in the ZX-plane (horizontal plane)(EXW); b) in the YZ-plane (vertical plane)(EYW).	
Diagram	
	
	
Tolerance For 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	(Measured deviation)
Measuring instruments	
Straightedge, dial gauge/support and gauge blocks or optical methods.	
Observations and references to ISO 230-1 5.232.11 and 5.232.13	
Table shall be set at its mid-travel. Set a straightedge on the table, parallel¹⁾ to the table saddle movement (W-axis) for a) horizontally and b) vertically. 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 saddle in the W-direction and note readings. ¹⁾ Parallel means that 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 deviation of the table saddle 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**

For

a), b) and c) 0,04/1 000

Local tolerance: 0,02/1 000 for any measuring length of 300

(Measured deviation)**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 moveable 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 spindle head, 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.

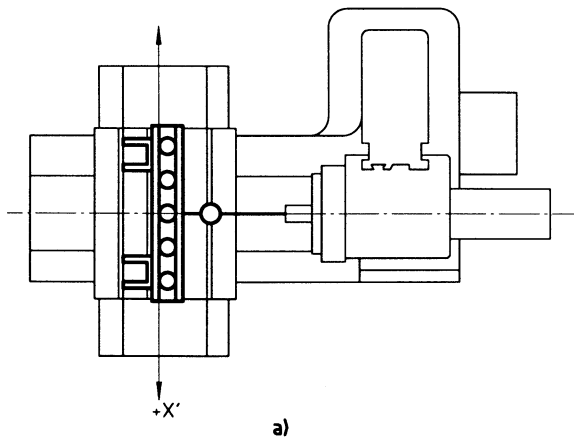
Measurements shall be carried out at a minimum of five positions equally spaced along the travel in both direction of the movement.

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

Diagram**Tolerance**

For 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

(Measured deviation)**Measuring instruments**

Straightedge, dial gauge/support and gauge blocks or optical methods.

Observations and references to ISO 230-1 5.232.11 and 5.232.13

Table shall be set at its mid-travel.

Set a straightedge at the middle position of the table, parallel¹⁾ to the table saddle movement (X-axis) for a) horizontally and b) vertically.

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.

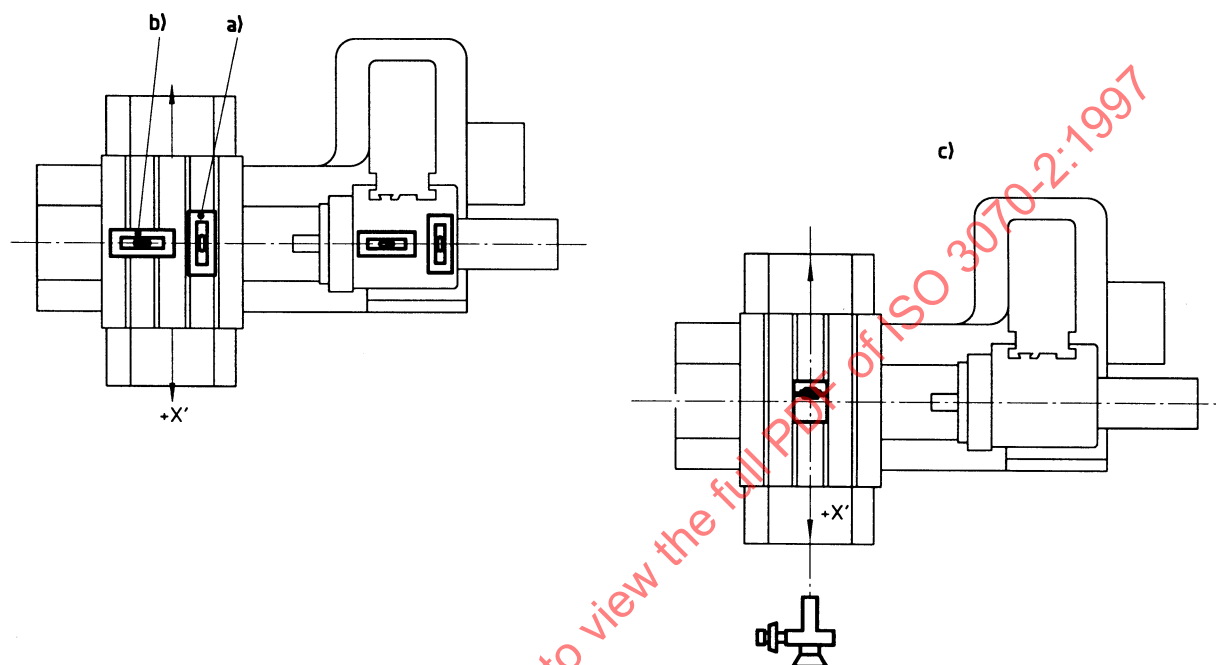
Traverse the table in the X-direction and note the readings.

1) Parallel means that 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.

G 4**Object**

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**

For

a), b) and c) 0,04/1 000

Local tolerance: 0,02/1 000 for any measuring length of 300

(Measured deviation)

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.

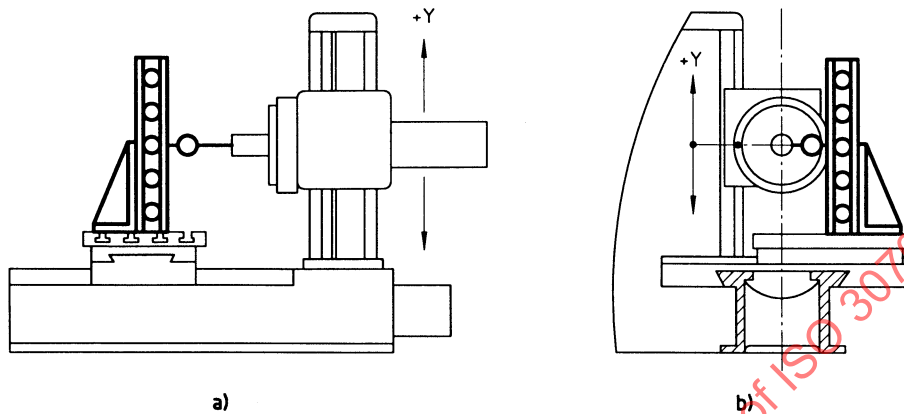
Measurements shall be carried out at a minimum of five positions equally spaced along the travel in both directions of the movement.

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 coaxial with spindle axis)(EZY);
- b) in the XY-plane (vertical plane square to the spindle axis)(EXY).

Diagram**Tolerance**

For a) and b) 0,02 for any measuring length of 1 000

(Measured deviation)**Measuring instruments**

Square and straightedge, or cylindrical square, surface plate, adjustable blocks and dial gauge/support

Observations and references to ISO 230-1 5.232.11

Set a square and a straightedge on the table so that the straightness is parallel¹⁾ to the movement of the spindle head (Y-axis)

Lock the table and the table saddle at mid-travels.

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.

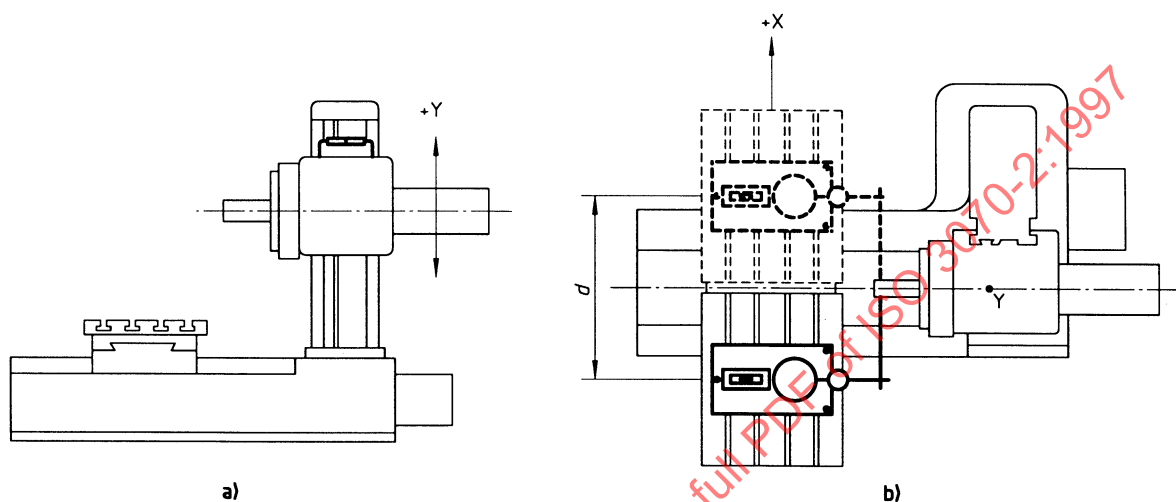
- a) Apply the stylus of the dial gauge to the straightedge in Z-direction and move the head in the Y-direction through measuring length.
- b) Apply the stylus of the dial gauge to the straightedge in X-direction and carry out the same procedure mentioned above.

1) Parallel means that 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 reading gives the straightness deviation.

Object**G 6**

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

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

Diagram**Tolerance**

For a) and b) 0,04/1 000

(Measured deviation)**Measuring instruments**

- a) Precision level or optical angular deviation measuring instruments
- b) Surface plate, 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 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 horizontal.

Place a cylindrical square on the surface plate and touch it by the stylus of the dial gauge mounted on special arm fixed to the spindle head.

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

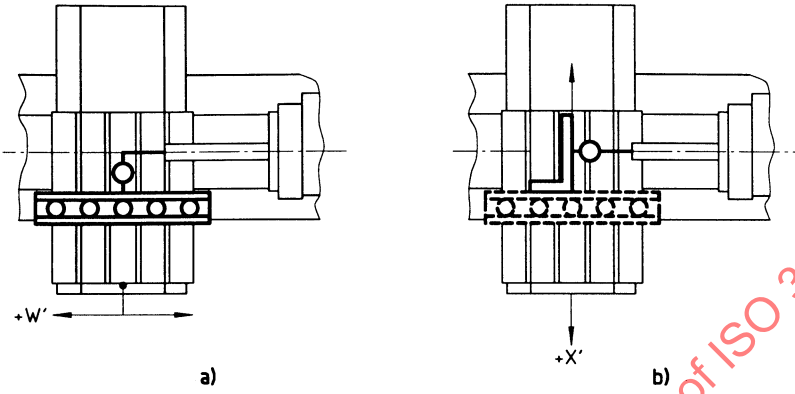
Note the readings at the measuring positions of the spindle head travel (Y-axis).

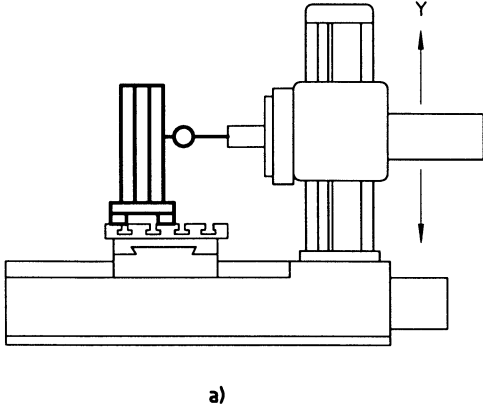
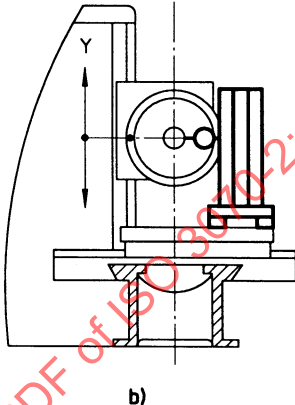
Move the table distance d and reset the dial gauge so that the stylus touches the cylindrical square.

When the level shows a change because of roll in table movement, adjust the level of surface plate to with that of the first position and then note readings at the same measuring positions.

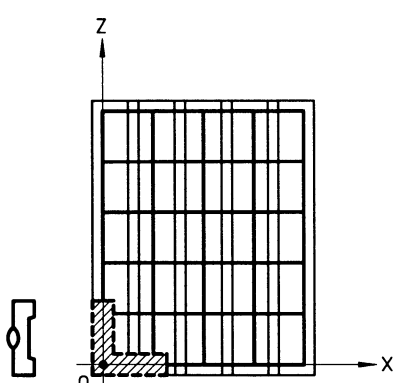
For each measuring position calculate the differences of two readings. The difference of maximum and minimum divided by distance d gives the angular deviation.

5.2 Squareness between the coordinate axes

Object		G 7
Checking of straightness between X-axis movement (table) and the W-axis movement (table saddle).		
Diagram 		
Tolerance 0,02 for any measuring length of 500		(Measured deviation)
Measuring instruments Straightedge, square and dial gauge/support.		
Observations and references to ISO 230-1 5.522.4 Align the straightedge parallel¹⁾ to the table saddle movement (W-axis) and press the square against it. Table saddle shall then be locked at mid-travel. If the spindle can be locked, mount the dial gauge on it. If the spindle can not be locked, dial gauge shall be mounted on the head. Apply stylus of dial gauge normally to square. Move table in X-direction and note readings. ¹⁾ Parallel means that readings of the dial gauge touching the straightedge are identical at both ends of the movement.		

Object Checking of squareness of the spindle head movement (Y-axis) to: - the table saddle movement (W-axis); - the table movement (X-axis).	G 8
Diagram   a) b)	
Tolerance For a) and b) 0,02 for any measuring length of 500	(Measured deviation)
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. Lock the table and table saddle at mid-travel. 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. - Apply the stylus of the dial gauge to the cylindrical square in X-direction and move the head in Y-direction through measuring length and note the maximum difference of readings. - Apply the stylus of the dial gauge to the cylindrical square in W-direction and carry out the same procedure mentioned above.	

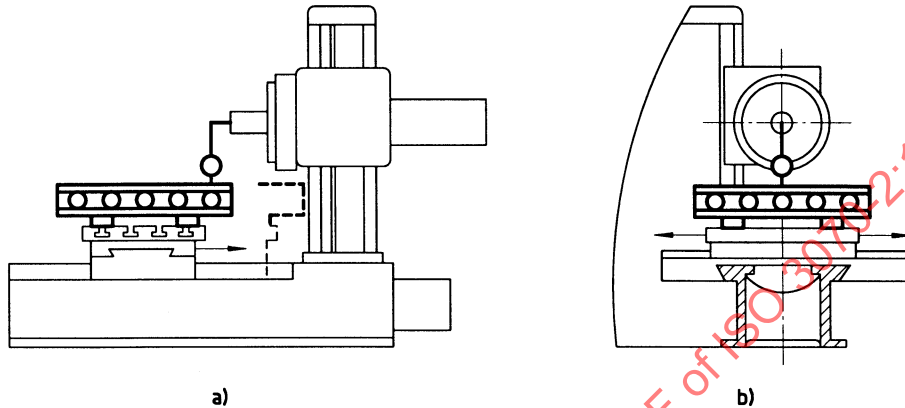
5.3 Table

Object Checking of the flatness of the table surface.	G 9
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: 0,05 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 Table and table saddle are at mid-travel and may be locked.	

Object**G 10**

Checking of parallelism of the table surface to:

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

Diagram**Tolerance**

a) 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

b) 0,04 for any measuring length of 1 000

(Measured deviation)**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 placed on a fixed part of the machine.

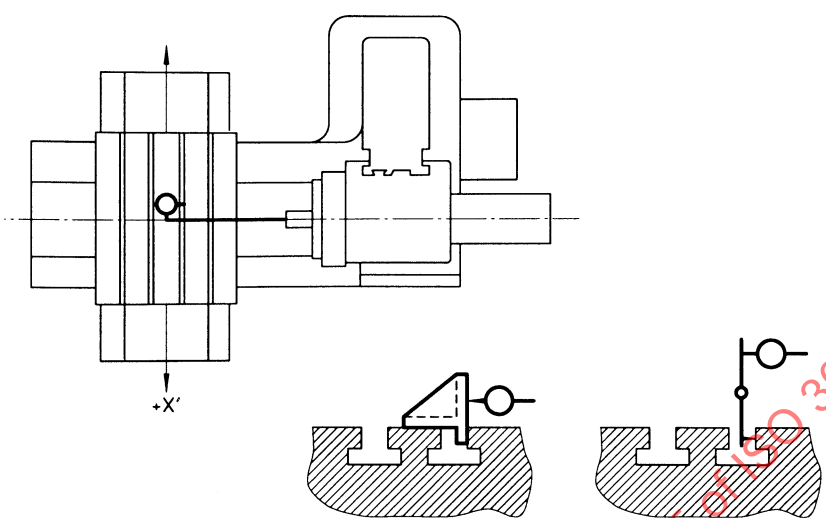
The stylus of the dial gauge shall be placed in an approximately vertical plane coaxial with the spindle axis.

Set the straightedge on the table parallel to the table surface and traverse table or saddle through measuring length and note the variation in reading. If the traverse travel is longer than 1 600, carry out the inspection by successive movement of the straightedge.

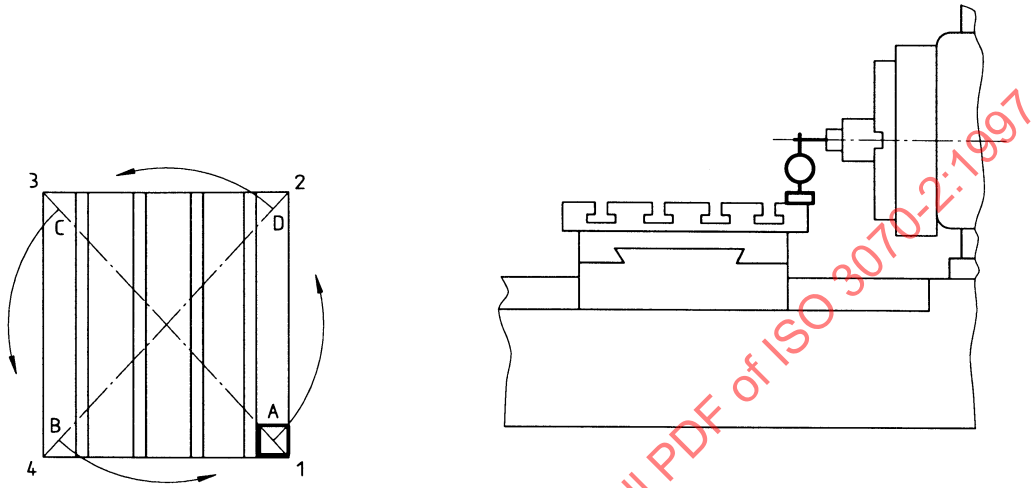
- a) Carry out the test with the table locked at the middle of its travel.
- b) Carry out the test with the saddle locked.

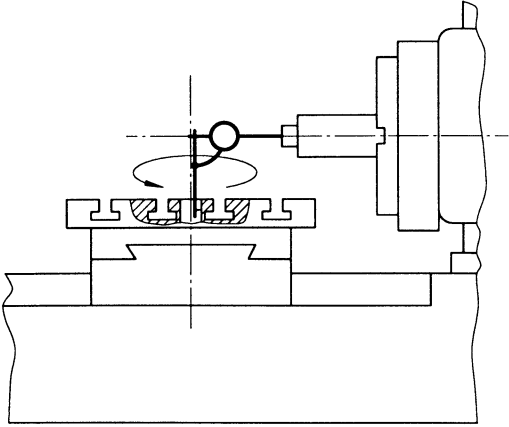
Without using a straightedge, direct measurement of the table surface using dial gauge and gauge block is also possible.

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

Object	G 11
Checking of parallelism of the median or reference T-slot to the table movement (X-axis).	
Diagram 	
Tolerance 0,03 for any measuring length of 1 000 Maximum tolerance: 0,04	(Measured deviation)
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 placed on a fixed part of the machine. The stylus of the dial gauge may touch the reference face of T-slot directly or by using a T-square.	

5.4 Indexing or rotary table

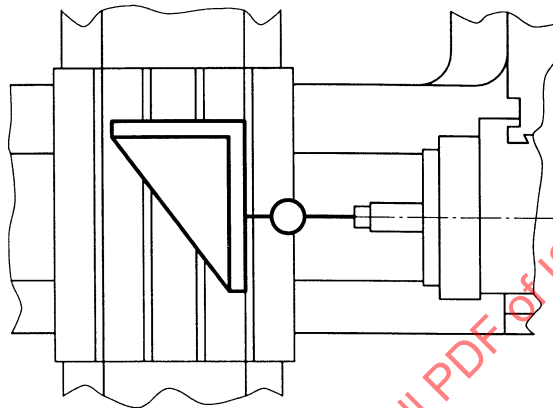
Object Checking of camming of the table surface in its rotating movement.	G 12
Diagram 	
Tolerance 0,02 for a measuring diameter of 1 000	(Measured deviation)
Measuring instruments Dial gauge/support and gauge block	
Observations and references to ISO 230-1 5.632 1) The dial gauge being placed in position 1, place a gauge block near the corner A of the table and take the measurement. Remove the gauge block and rotate 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 camming value. Lock the table before taking each measurements.	

Object	G 13
Checking of run-out of the centring hole of the table in relation to its axis of rotation.	
Diagram 	
Tolerance 0,015	(Measured deviation)
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 placed on a fixed part of the machine. Set the stylus of the dial gauge coaxial in the axis of the centering 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° , 90° , 180° and 270° .

- a) for rotary indexable table with only four fixed positions 90° 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
- b) 0,05 for any measuring length of 500
- c) 0,075 for any measuring length of 500

Measuring instruments

Square and dial gauge/support

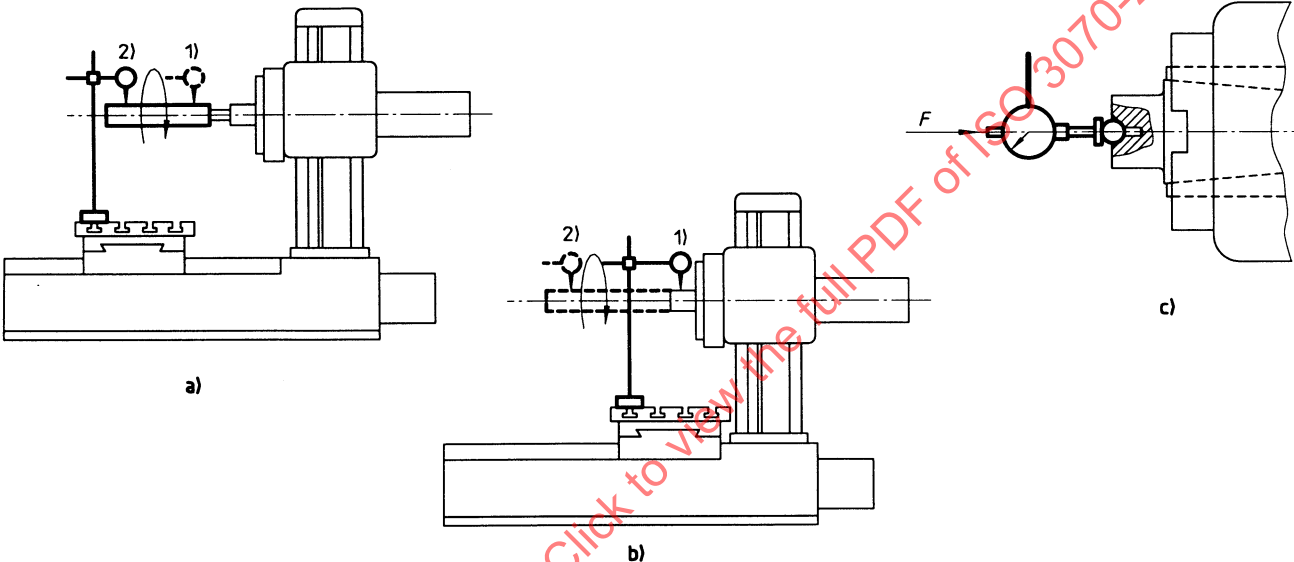
Observations and references to ISO 230-1 6.41, 6.42 and 6.43

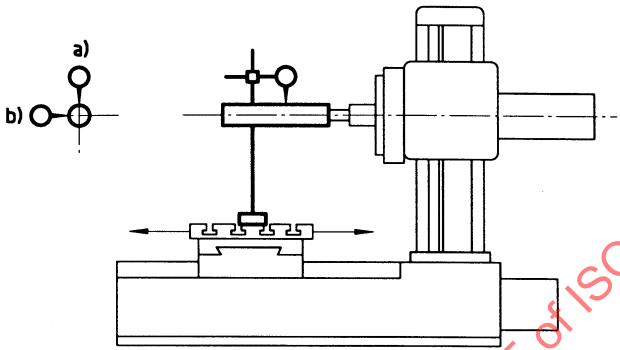
Set a square on the table with one edge parallel to the table movement (X-axis).

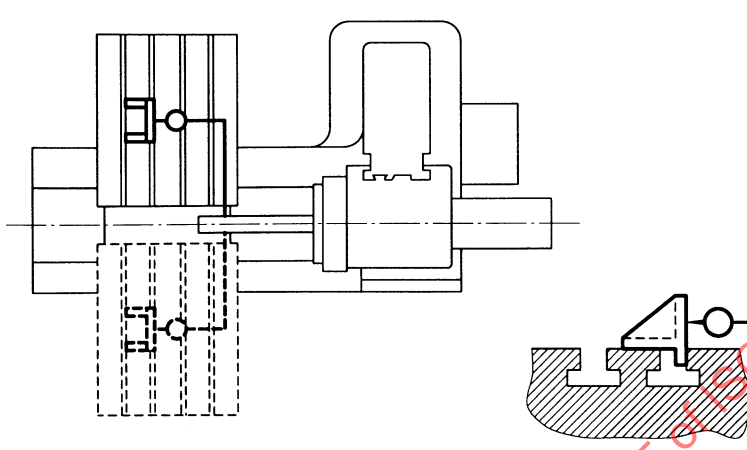
Index the table four times in one direction (90° , 180° , 270° , 360°) and check, in each position, the parallelism between table movement and the corresponding edge of the square.

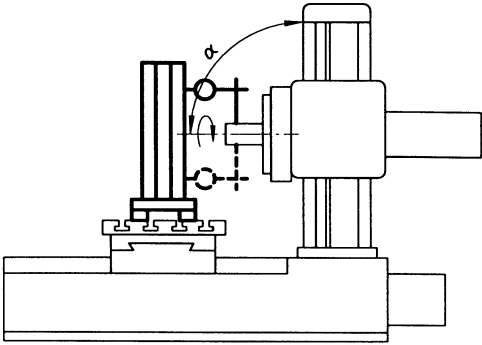
Index the table four times in opposite positions (270° , 180° , 90° , 0°) and check again the parallelism in each position. The maximum difference of the eight readings shall not exceed the tolerance.

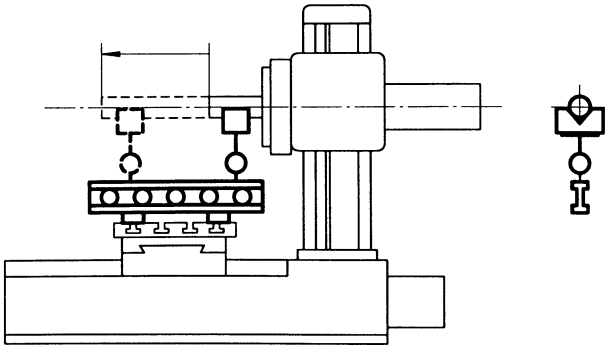
5.5 Boring spindle

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			(Measured deviation)
	$D \leq 125$	$D > 125$	
a) and b)	1) 0,01 2) 0,02	0,015 0,03	
c) is the	0,01	0,015	
where D is the diameter of the boring spindle.			
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 needs to be applied.			

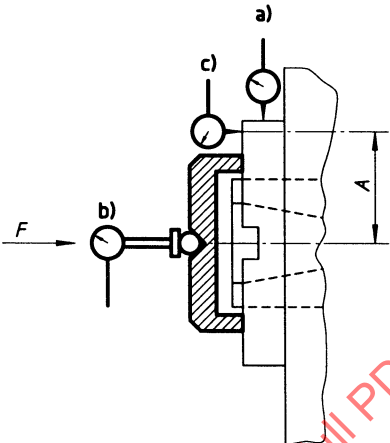
Object	G 16
Checking of parallelism of the boring spindle axis to the table saddle movement (W-axis); a) in the YZ-plane (vertical), b) in the ZX-plane (horizontal).	
Diagram 	
Tolerance For a) and b) 0,02 for any measuring length of 300	(Measured deviation)
Measuring instruments Dial gauge and test mandrel	
Observations and references to ISO 230-1 5.412.1 and 5.422.3 Spindle head locked in mid-travel. Spindle retracted. Table may be locked in central position. 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 180° apart.	

Object	G 17
Checking of squareness of the boring spindle axis to the table movement (X-axis).	
Diagram 	
Tolerance 0,02/500 where 500 is the distance between the two measuring points touched.	(Measured deviation)
Measuring instruments Dial gauge/support and square block	
Observations and references to ISO 230-1 5.512.1 and 5.512.32 Table saddle and spindle head locked. Spindle head in mid travel. 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 defines the deviation from squareness.	

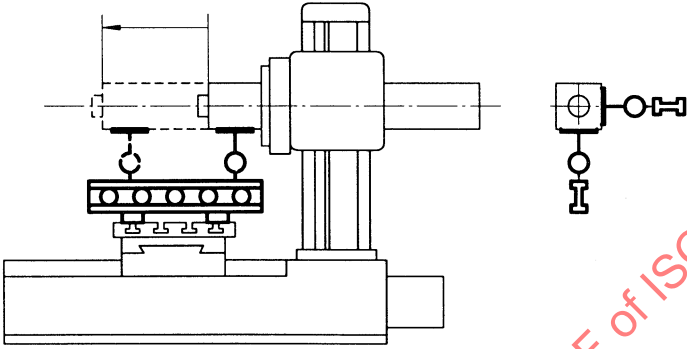
Object	G 18
Checking of squareness of the boring spindle axis to the spindle head movement (Y-axis).	
Diagram 	
Tolerance 0,02/500 with $\alpha \leq 90^\circ$ where 500 is the distance between the two points touched.	(Measured deviation)
Measuring instruments Cylindrical square, adjustable blocks and dial gauge/support	
Observations and references to ISO 230-1 5.512.1 and 5.512.32 Spindle head locked in mid-travel, spindle retracted (sliding spindle). Table and table saddle locked. Cylindrical square shall be set on the table parallel to the Y-axis movement. Turn the spindle with the attached dial gauge and touch the cylindrical square.	

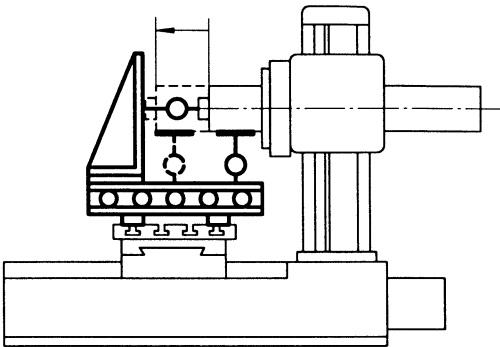
Object		G 19
Checking of the deflection of the boring spindle in its movement (Z-axis).		
Diagram 		
Tolerance For an extension of the spindle equal to: 2 <i>D</i> : + 0,015 (upwards); 4 <i>D</i> : ± 0,02; 6 <i>D</i> : – 0,06 (downwards). where <i>D</i> is spindle diameter. NOTES 1 The extension of the 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 should be agreed upon between user and supplier/manufacturer.		(Measured deviation)
Measuring instruments Straightedge, gauge block and dial gauge		
Observations and references to ISO 230-1 5.422.22 Place the straightedge on the table vertically in a plane containing the spindle axis, adjust it parallel to the table saddle movement (W-axis). Touch the functional surface of the straightedge with the dial gauge fixed on the spindle nose. Extend the spindle to the required length and note the dial gauge readings for each of the successive positions.		

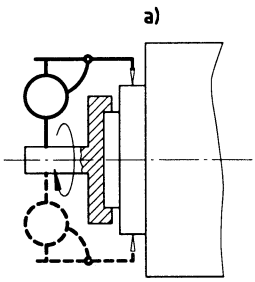
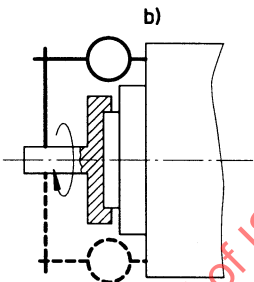
5.6 Milling spindle

Object Checking of the milling spindle nose: a) run-out; b) periodical axial slip; c) camming.	G 20
Diagram 	
Tolerance $D \leq 125$: a) 0,01 b) 0,01 c) 0,02 $D > 125$: a) 0,015 b) 0,015 c) 0,03 where D is the diameter of the milling spindle.	(Measured deviation)
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 axially preloaded bearing is used for spindle, no force F is needed. c) 5.632 The distance A of the dial gauge c) from the spindle axis shall be as great as possible.	

5.7 Ram

Object	G 21
Checking of parallelism of the ram movement (Z-axis) to the table saddle movement (W-axis): a) in the YZ plane (vertical plane); b) in the ZX plane (horizontal plane).	
Diagram 	
Tolerance For a) and b) 0,03 for a measuring length of 500	(Measured deviation)
Measuring instruments Dial gauge and straightedge	
Observations and references to ISO 230-1 5.422.22 Set a straightedge on the table parallel¹⁾ to the table saddle movement (W-axis) for a) vertical and b) horizontal measurement. Table saddle locked in mid-travel. Spindle head locked. Check that the ram movement with respect to the straightedge using a dial gauge fixed on the ram. 1) Parallel means that 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 0,03 for a measuring length of 500	(Measured deviation)
Measuring instruments Straightedge, 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 and place a square on it. 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 centering 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 a) 0,02 b) 0,02/500	(Measured deviation)
Measuring instruments Dial gauge	
Observations and references to ISO 230-1 a) 5.442 Concentricity deviation is defined by half of the maximum difference of the readings. b) 5.512.42	

5.8 Integral facing head

Object

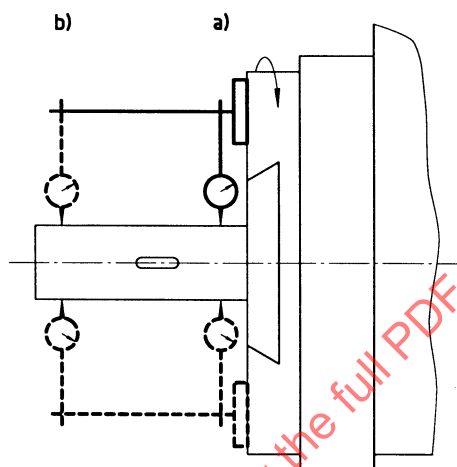
G 24

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

$D \leq 125$:

- a) 0,02 b) 0,03

$D > 125$:

- a) 0,03 b) 0,04

where D is the diameter of the milling spindle.

(Measured deviation)

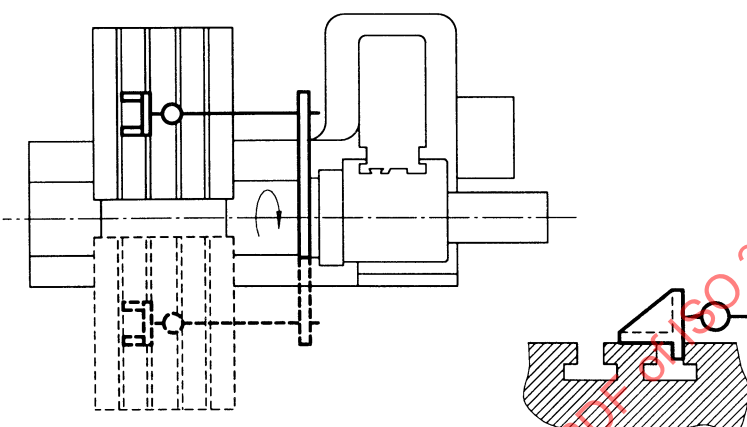
Measuring instruments

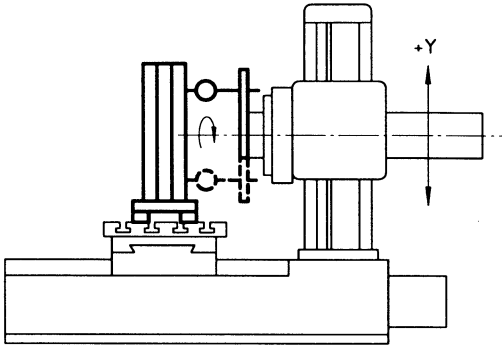
Dial Gauge

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.

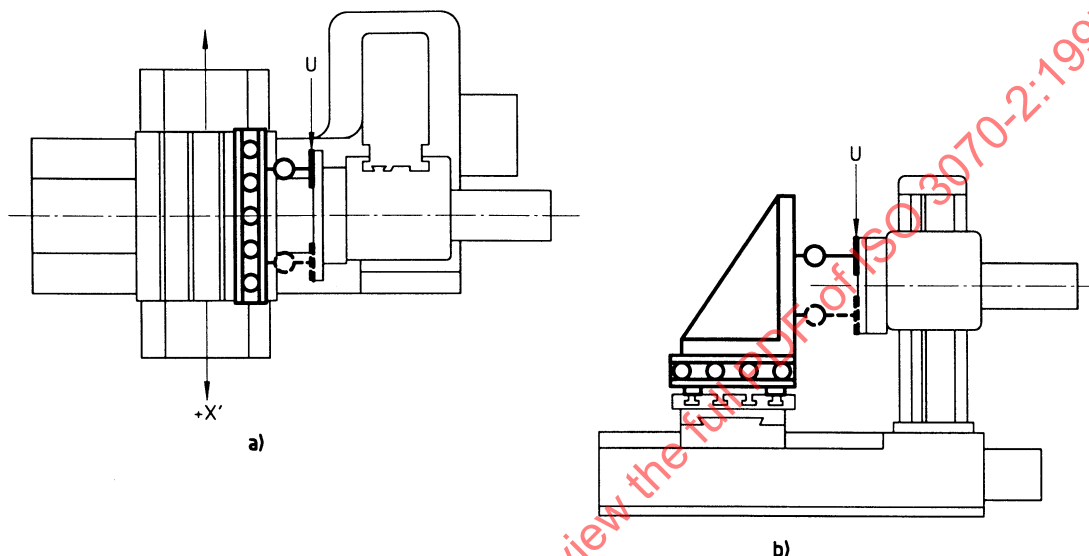
For each operation, determine half the difference of the extreme readings to obtain the coaxiality deviation.

Object	G 25
Checking of squareness of the facing head rotation axis to the X-axis movement of the table. (This check is valid only when the facing head is mounted on bearings independent of those of the boring spindle.)	
Diagram 	
Tolerance 0,02/500 where 500 is the distance between the two measuring points touched.	(Measured deviation)
Measuring instruments Dial gauge/rigid support and square block	
Observations and references to ISO 230-1 5.512.1 and 5.512.32 Place the stylus of the dial gauge against the square block on the table. Turn the facing head with dial gauge 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 defines the deviation from squareness.	

Object	G 26
Checking of squareness of the facing head rotation 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 0,02/500 where 500 is the distance between the two measuring points touched.	(Measured deviation)
Measuring instruments Dial gauge/rigid support, surface plate, gauge blocks and cylindrical square	
Observations and references to ISO 230-1 5.512.1 and 5.512.32 Set a cylindrical square on the table parallel to Y axis movement. Spindle head locked in mid-travel on the column. Set a dial gauge to a rigid arm fixed to the facing head so that it touches the cylindrical square. Turn the facing head with dial gauge so that it touches the cylindrical square. The difference between the two readings divided by the distance between the two measuring points defines the deviation from squareness.	

Object**G 27**

- a) Checking of parallelism of the radial facing slide movement (U-axis) in horizontal plane to the table movement (X-axis).
- b) Checking of squareness of the radial facing slide movement (U-axis) in vertical plane to the table saddle movement (W-axis).

Diagram**Tolerance**

For a) and b)

0,025 for a measuring length of 300

(Measured deviation)**Measuring instruments**

- a) Straightedge, gauge blocks and dial gauge/support
- b) Straightedge, gauge blocks, 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 of 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 table saddle 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 of the readings.

Repeat the same operation after turning the plate through 180°.

5.9 Steady block

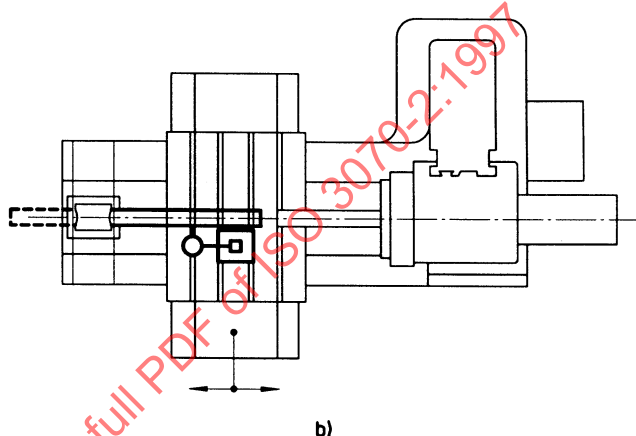
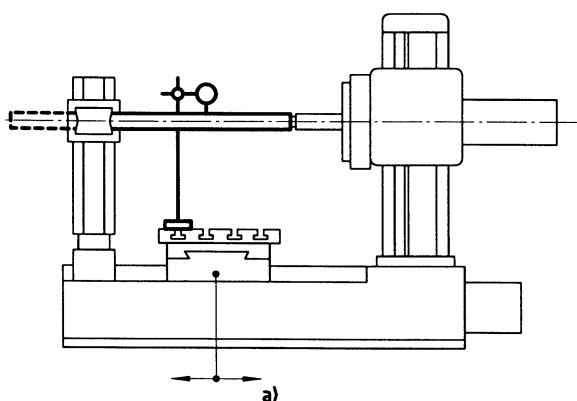
Object

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

- a) 0,04 for a measuring length of 1 000
- b) 0,03 for a measuring length of 1 000

(Measured deviation)

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 of sufficient length to pass completely through the steady block while mounted in the boring spindle when in its retracted position, shall be used.

A dial gauge shall be set on the table with the stylus touching the test mandrel and the table moved over its entire traverse. The measurement is made at the two extremities: spindle end and steady block end.

Repeat the same operations with the spindle extended.

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 possibly the table base locked in central position.

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

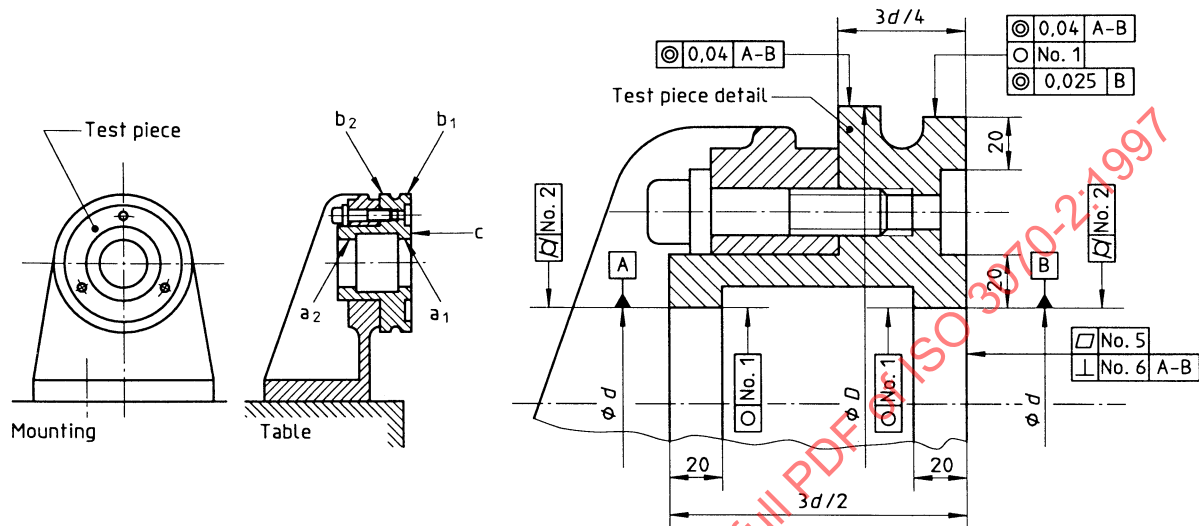
M 1

Machining of a single test piece including

- boring of the internal cylindrical holes a_1 and a_2 ;
- turning of the external cylindrical surfaces b_1 and b_2 ;
- 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)



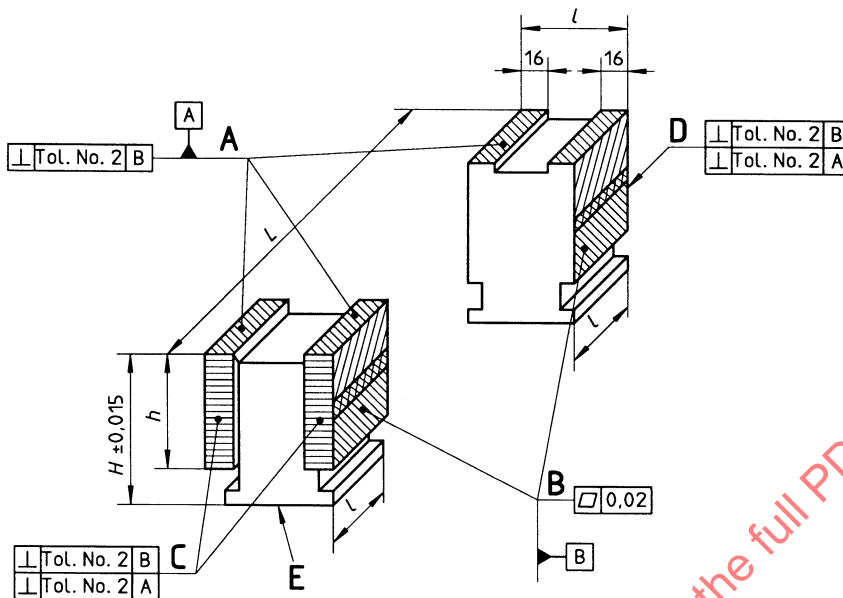
NOTES

- The boring diameter d shall be equal to or slightly greater than the boring spindle diameter.
- 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.
- 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 : $d \leq 125$: $0,0075^*)$ $d > 125$: $0,01^*)$ b_1 : $D \leq 300$: $0,01$ $300 < D \leq 600$: $0,015^*)$ 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.
2	Cylindricity (Subclause 17.4 of ISO 1101:—) of the internal cylindrical holes a_1 and a_2 .	$d \leq 125$: $0,01$, $d > 125$: $0,015$		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.
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	2) Turning of the external cylindrical surface b_1 . With a short tool mounted on the facing head with movement of the table saddle (W-axis)
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 table saddle of 300	Mandrel and dial gauge	3) Movement of the table saddle (W-axis) 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.
5	Flatness (Subclause 17.2 of ISO 1101:—) of the machined surface	0,015 for a diameter D of 300	Straightedge and gauge blocks	4) Machining of the surface c by automatic movement of the radial facing slide or by milling.
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	Definitions of circularity and cylindricity tolerances are given in ISO 1101.

Nature of test**M 2**

- Milling of strips of surfaces A, C and D by automatic X-axis movement of the table, automatic vertical movement of the spindle head and manual W-axis movement of the table saddle.
- Milling of surface B by automatic X-axis movement of the table and manual vertical movement of the spindle head at least in two cuts overlapping by about 5 mm to 10 mm.

Diagram and dimensions of test pieces

L (length of the test piece or distance between the opposite faces of two test pieces) = $\frac{1}{2}$ X-axis travel of the table

$l = h = 150$ for $L \leq 1\,000$

$= 200$ for $L > 1\,000$

Material: cast iron

No.	Check to be applied	Tolerance	Measuring instruments	Observations and references to ISO 230-1
1	Surface B on each blocks shall be flat.	0,02	Surface plate, dial gauge, coordinate measuring machine	Subclauses 3.1, 3.22, 4.1, 4.2, 5.321 and 5.325.
2	The planes containing the strips of surfaces A, C and D shall be perpendicular to each other and to surface B.	0,02/100	Square and gauge blocks	
3	The height H of the block (or blocks) shall be constant.	0,03	Micrometer	

Cutting conditions and cutters

For a), with a shell end mill, mounted at the end of the spindle on a mandrel of a suitable length

For b), slab milling with the same cutter

Cutter: The cutter shall be sharpened on its arbor and when mounted shall conform to the following tolerances:

- Out of round (See ISO 1101)
 $\leq 0,01$
- Run-out
 $\leq 0,02$
- Camming
 $\leq 0,03$

(The drill-bit shall be set in its mandrel.)

Procedure

Before beginning the test make sure that surface E is flat.

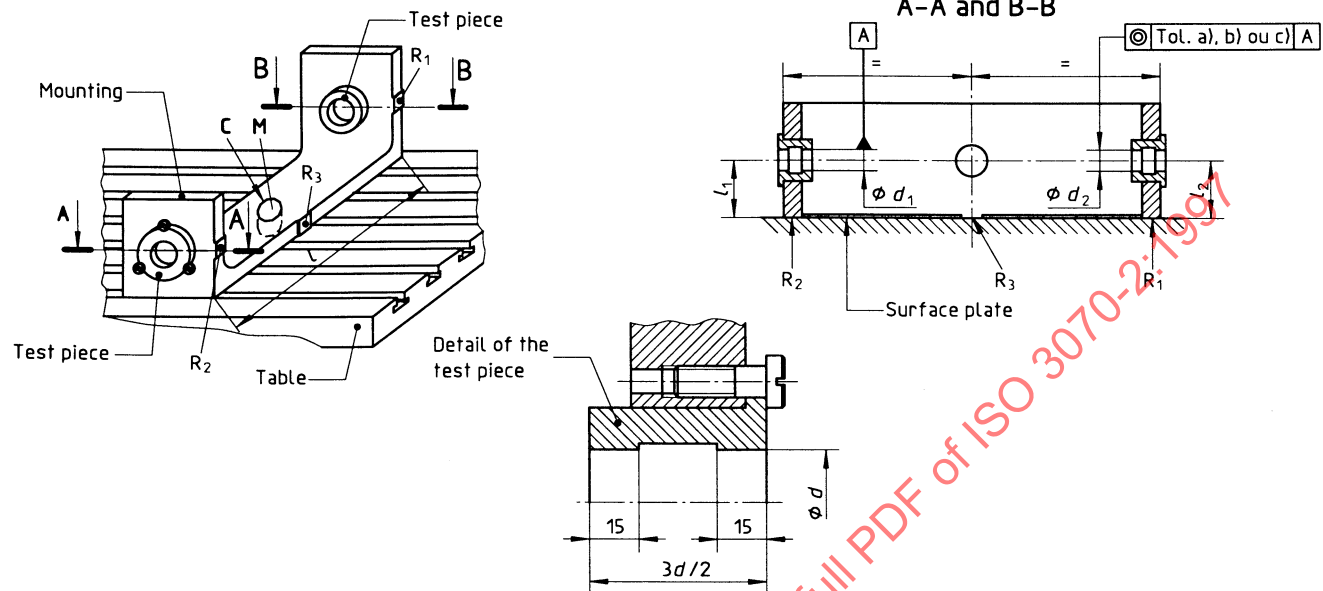
Test pieces shall be aligned parallel to the direction of the X-axis movement of table so that the length L is equally distributed on either side of the table centre.

All non-operating slides shall be locked during cutting.

NOTE — Subject to agreement between the user and supplier/manufacturer, the test piece shown in the diagram may be replaced by a simpler testpiece having sides of full width, but the test carried out should be at least as severe as those carried out using the form shown in the diagram.

Nature of test**M 3**

Boring and finishing of two pieces mounted opposite each other on a single axis parallel with the surface and in a vertical plane coaxial with the centre of rotation of the table.

Diagram and dimensions of test pieces**NOTES**

- 1 The fixture length L shall be equal to or slightly less than the table width.
- 2 The bore diameters d_1 and d_2 shall be equal to or slightly greater than half of the boring spindle diameter.
- 3 Test piece material: Cast iron (CG8)

No.	Check to be applied	Tolerance	Measuring instruments	Observations and references to the ISO 230-1
1	Checking of the equidistance of the axes of the bores d_1 and d_2 in relation to a vertical plane through R_1 , R_2 and R_3 . (The distances l_1 and l_2 are equivalent.) (Coaxiality of bore d_2 with bore d_1 .)	a) For rotary tables with only four fixed indexing positions 90° apart: 0,06 for a length L equal to 1 000 b) For rotary tables with any number of fixed indexing positions: 0,1 for a length L equal to 1 000 c) For rotary table with automatic positioning for indexing and rotation: 0,15 for a length L equal to 1 000	Test mandrels and dial gauge/support or gauge blocks or height gauge or coordinate measuring machine	3.1,3.22, 4.1, 4.2, and 5.432.1 To perform this test, the test pieces shall not be dismantled from the fixture (or support). The fixture with the test pieces mounted on it can be laid on a surface plate. Before commencing the test make sure that the fixture surface which bears on the table is flat and that the bore axes intended for supporting the test pieces and the axis of centering C are equidistant from a vertical reference plane defined by the three blocks R_1 , R_2 and R_3 .

Procedure ¹⁾

Before laying the mounting on the table, make sure that the axis of rotation of the table is situated exactly in the vertical plane through the boring spindle axis, then lock the table base on its slideways.

Arrange the mounting on the table so that its centering C coincides exactly with the axis of rotation of the table, possibly using a centering mandrel M.

Swivel the mounting on the table, setting the reference blocks R_1 and R_2 in a vertical plane through the boring spindle axis.

Lock the mounting on the table and assemble the test pieces as shown in the diagram.

Bore the first test piece to diameter d with axial movement of the boring spindle.

Rotate the table through 180° and bore the second test piece similarly.

1) Except for the rotation of the table and the rotation of the boring spindle, all other parts of the machine shall be locked during the test.