
**Test conditions for high accuracy turret
and single spindle coordinate drilling
and boring machines with table of fixed
height with vertical spindle — Testing
of the accuracy —**

Part 2:
Portal type machines with moving table

*Conditions d'essai des machines à percer et à aléser verticales
monobroches à coordonnées de haute précision avec table de hauteur
fixe — Contrôle de la précision —*

Partie 2: Machines à portique avec table mobile



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

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Foreword

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

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 3686 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 3686-2 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

This first edition of ISO 3686-2 together with ISO 3686-1 cancel and replace ISO 3686:1976, of which they constitute a technical revision.

ISO 3686 consists of the following parts, under the general title *Test conditions for high accuracy turret and single spindle coordinate drilling and boring machines with table of fixed height with vertical spindle — Testing of the accuracy*:

- *Part 1: Single column type machines*
- *Part 2: Portal type machines with moving table*

Test conditions for high accuracy turret and single spindle coordinate drilling and boring machines with table of fixed height with vertical spindle — Testing of the accuracy —

Part 2: Portal type machines with moving table

1 Scope

This part of ISO 3686 specifies, with reference to ISO 230-1, both geometric tests and machining tests on vertical spindle, portal type coordinate drilling and boring machines. It also specifies the applicable tolerances corresponding to the above-mentioned tests.

It should be noted that, besides drilling and boring operations, it may be possible to carry out light milling operations with these machines. However, this part of ISO 3686 does not deal with jig boring machines or machining centres.

This part of ISO 3686 deals only with the verification of accuracy of the machine. It does not apply to the testing of the machine operation (vibrations, abnormal noises, stick-slip motion of components, etc.), nor the machine characteristics (such as speeds, feeds, etc.), which should generally be carried out before testing the accuracy.

This part of ISO 3686 provides the terminology used for the principle components of the machine and indicates the designation of the axes in accordance with ISO 841.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 3686. For dated references subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 3686 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

3 Terminology and designation of axes

See Figure 1 and Table 1

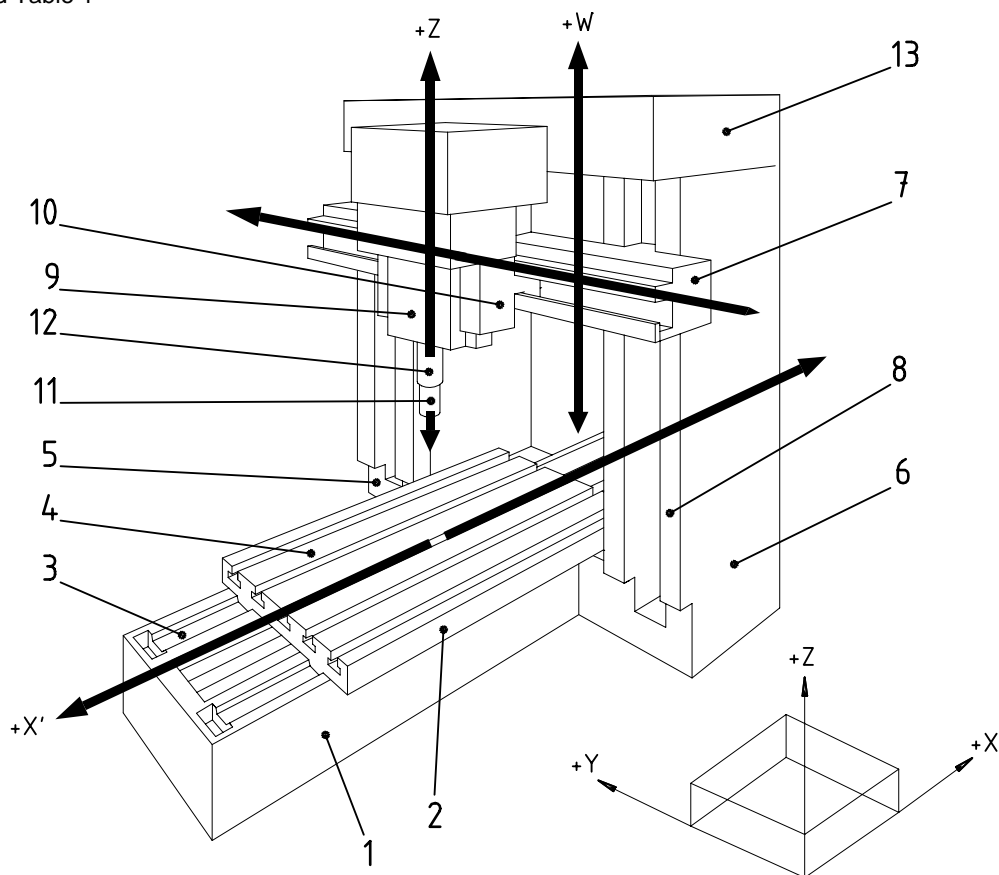


Figure 1

Table 1

Ref.	English	French	German
1	Bed	Banc	Bett
2	Table	Table	Tisch
3	Slideways for table	Glissières de table	Tisch-Führungsbahnen
4	Table surface	Surface de fixation	Aufspannfläche
5	Column, left-hand	Montant, gauche	Ständer, links
6	Column, right-hand	Montant, droit	Ständer, rechts
7	Cross-rail	Traverse	Querbalken
8	Slideways for cross-rail	Glissières de traverse	Querbalken-Führungsbahnen
9	Spindle head	Poupée porte-broche	Spindelstock
10	Spindle head saddle	Chariot poupée porte-broche	Spindelstockschlitten
11	Spindle	Broche	Spindel
12	Quill	Fourreau porte-broche	Spindelpinole
13	Bridge	Pont	Traverse

NOTE In addition to terms used in two of the three ISO languages (English and French), this table gives the equivalent term in German; these are published under the responsibility of member body for Germany (DIN). However, only the terms given in the official languages can be considered as ISO terms.

4 Preliminary remarks

4.1 Measuring units

In this part of ISO 3686, all linear dimensions, deviations and corresponding tolerances are expressed in millimetres; angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerances are expressed primarily in ratios, but in some cases microradians or arcseconds may be used for clarification purposes. The equivalence of the following expressions should be kept in mind:

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

4.2 Reference to ISO 230-1

To apply this part of ISO 3686, 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 clauses 5 and 6 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 ISO 230-1.

4.3 Testing sequence

The sequence in which the tests are presented in this part of ISO 3686 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 3686. 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.

It should be noted that, for turret head-drilling machines, all the geometric tests that concern the rotation of the spindle, i.e., tests G9, G10, G11 and G12, should be carried out on all spindles.

4.5 Measuring instruments

The measuring instruments indicated in the tests described in clauses 5 and 6 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.

4.6 Minimum tolerance

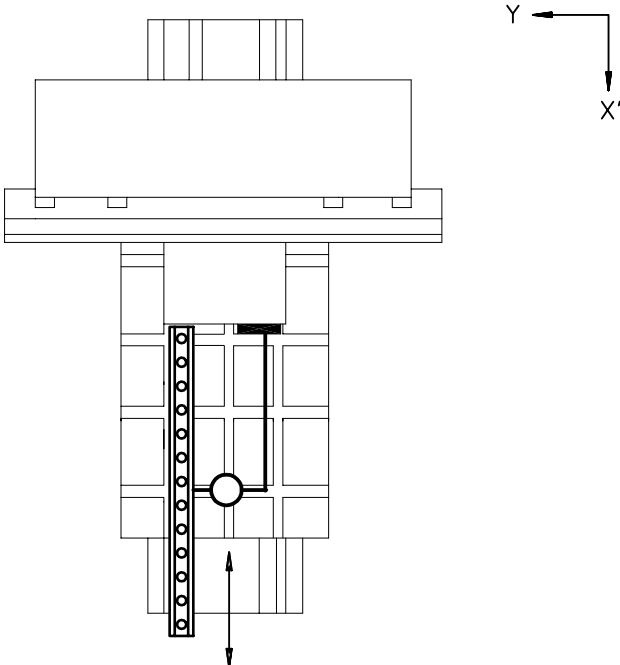
When the tolerance for a geometric test is established for a measuring length different from that given in this part of ISO 3686 (see 2.311 of ISO 230-1:1996), it shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

4.7 Machining tests

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

5 Geometric tests

5.1 Linear axes

<p>Object</p>		<p>G1</p>
<p>Checking of straightness of the X-axis motion in the horizontal XY-plane (EYX).</p>		
<p>Diagram</p> 		
<p>Tolerance</p> <p>0,015 for any measuring length of up to 1 000</p>	<p>Measured deviation</p>	
<p>Measuring instruments</p> <p>Straightedge and dial gauge or microscope and taut wire or optical methods</p>		
<p>Observations and references to ISO 230-1:1996 5.211, 5.23, 5.231.2 and 5.232.1</p> <p>For all machine configurations, either the straightedge, the taut wire or the straightness reflector shall be placed on the table. If the spindle can be locked, either the dial gauge, the microscope or the interferometer may be mounted on it; if the spindle cannot be locked, the instrument shall be placed on the spindle head of the machine.</p> <p>The measuring line should pass as close to the centre of the table as possible.</p>		

<p>Object</p>	<p>G2</p>
<p>Checking of squareness between the table longitudinal movement (X-axis) and the movement of the spindle-head saddle on the cross-rail (Y-axis).</p>	
<p>Diagram</p> <p>The diagram consists of two side-by-side cross-sectional views of a machine tool's spindle head and cross-rail assembly. In both views, a square tool is positioned against the cross-rail, and a straightedge is placed against the square's second arm. The left view shows the initial setup. The right view shows a dial gauge mounted on the straightedge to measure the squareness. Coordinate axes are shown: Y (vertical), X' (horizontal, pointing left), and X (horizontal, pointing right).</p>	
<p>Tolerance</p> <p>0,02 for any measuring length of 500</p>	<p>Measured deviation</p>
<p>Measuring instruments</p> <p>Straightedge, dial gauge and square</p>	
<p>Observations and references to ISO 230-1:1996 5.522.4</p> <p>a) One arm of the square shall be set parallel to the Y-axis movement (parallel means that readings on both ends of the arm are identical), then the straightedge shall be placed against the second arm of the square.</p> <p>b) Then check the X-axis movement.</p>	

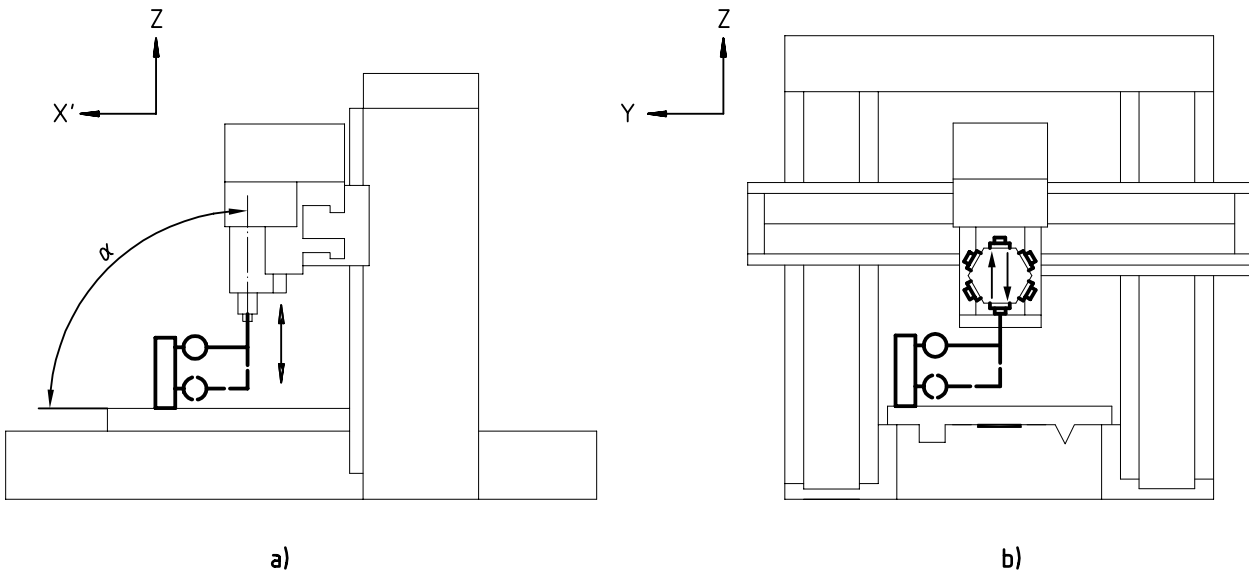
Object

G3

Checking of squareness between the table surface and the vertical movement of the quill or the turret head on its slideway (Z-axis):

- a) in the vertical ZX-plane of symmetry of the machine;
- b) in the YZ-plane perpendicular to the vertical plane of symmetry of the machine.

Diagram



Tolerance

- a) 0,015 for any measuring length of 300 with $\alpha \leq 90^\circ$
- b) 0,015 for any measuring length of 300

Measured deviation

- a)
- b)

Measuring instruments

Dial gauge and square

Observations and references to ISO 230-1:1996

5.522.2

Table locked in central position.

Spindle head and spindle head slide locked.

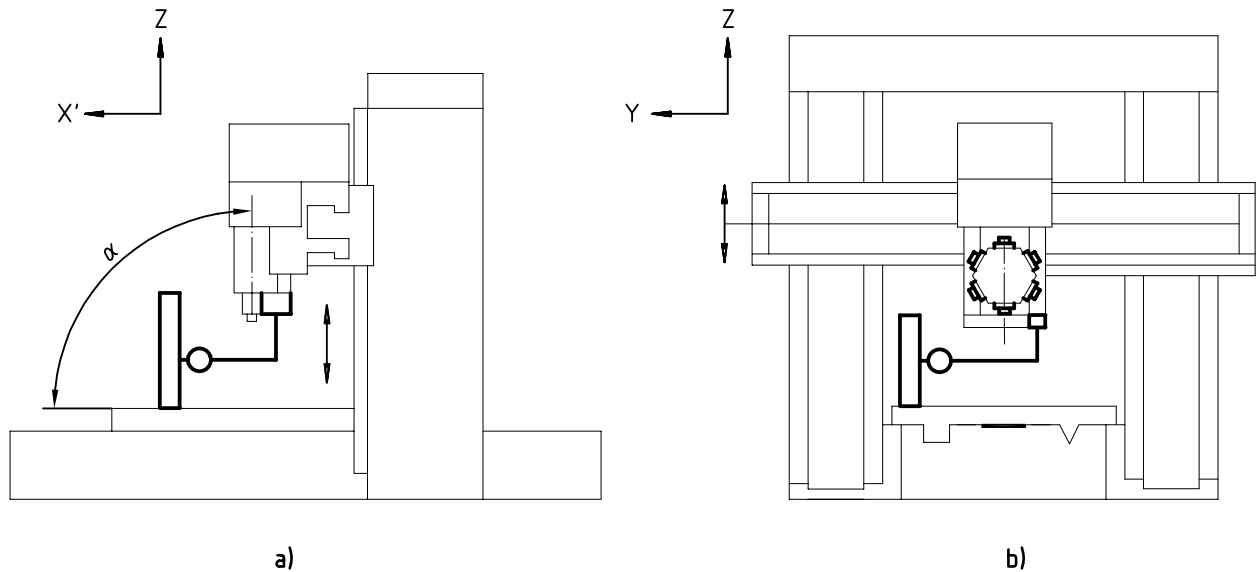
Object

G4

Checking of squareness between the table surface and the vertical movement of the cross-rail on the column:

- a) in the vertical ZX-plane of symmetry of the machine;
- b) in the YZ-plane perpendicular to the vertical plane of symmetry of the machine.

Diagram



Tolerance

- a) 0,015 for any measuring length of 300 with $\alpha \leq 90^\circ$
- b) 0,015 for any measuring length of 300

Measured deviation

- a)
- b)

Measuring instruments

Dial gauge and cylindrical square

Observations and references to ISO 230-1:1996

5.522.2

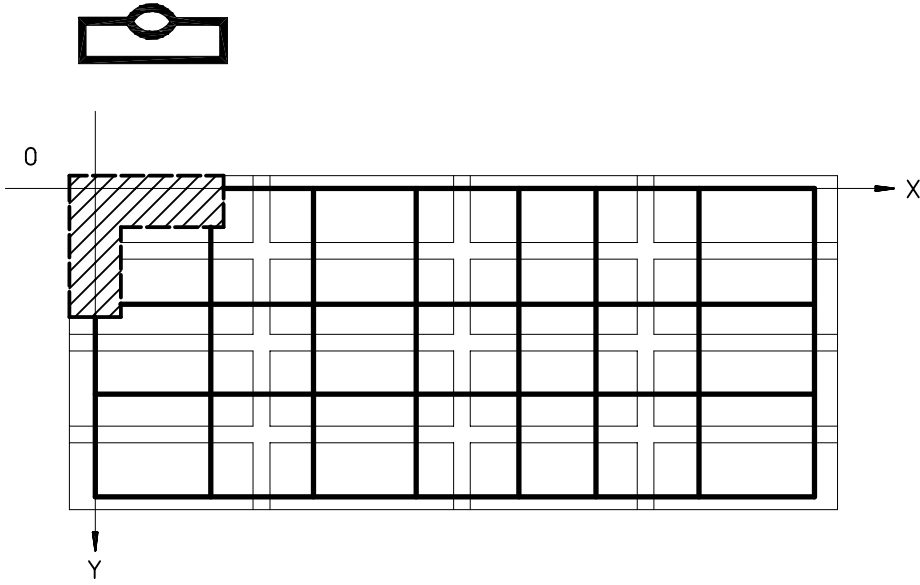
Table locked in central position.

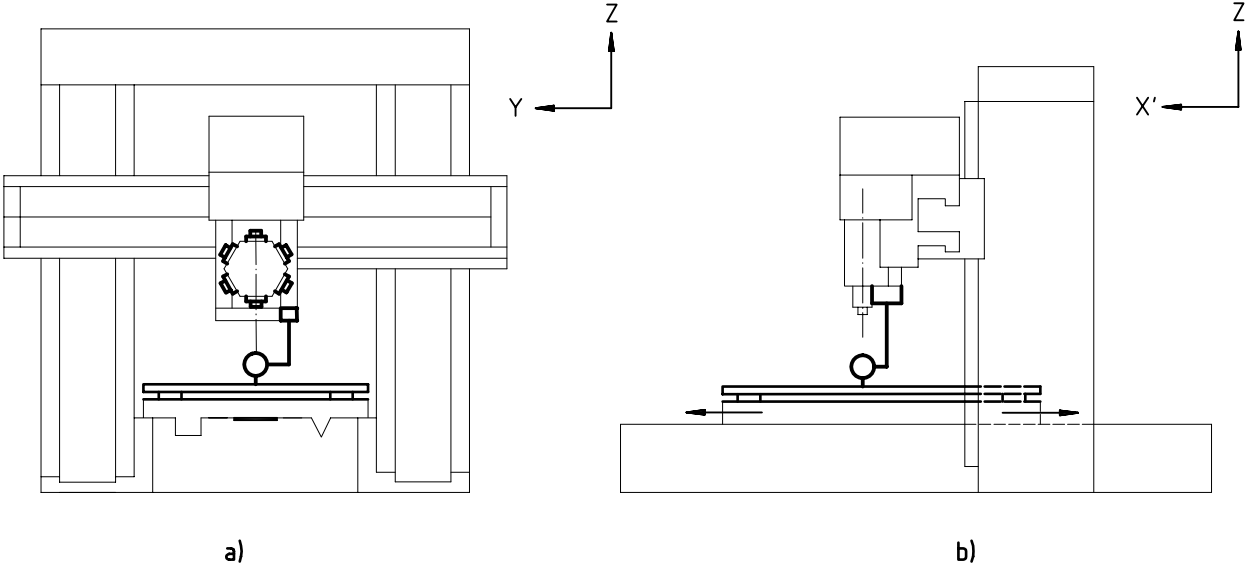
Spindle-head slide locked.

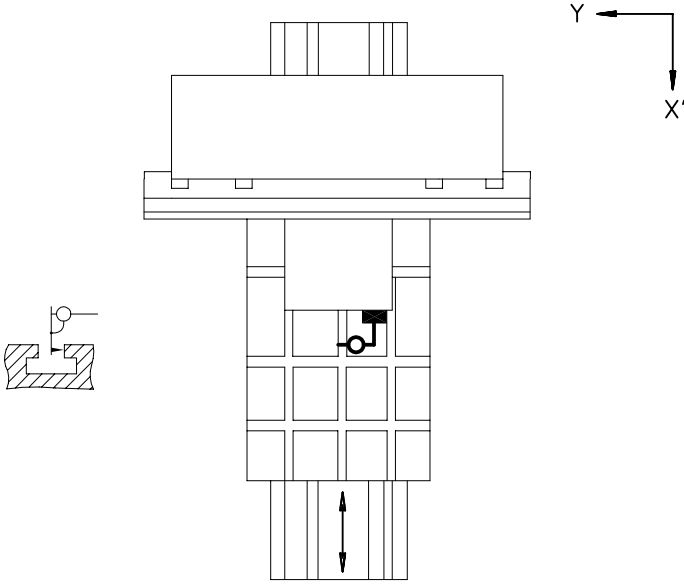
The measurements shall be taken in at least three equispaced positions of the cross-rail.

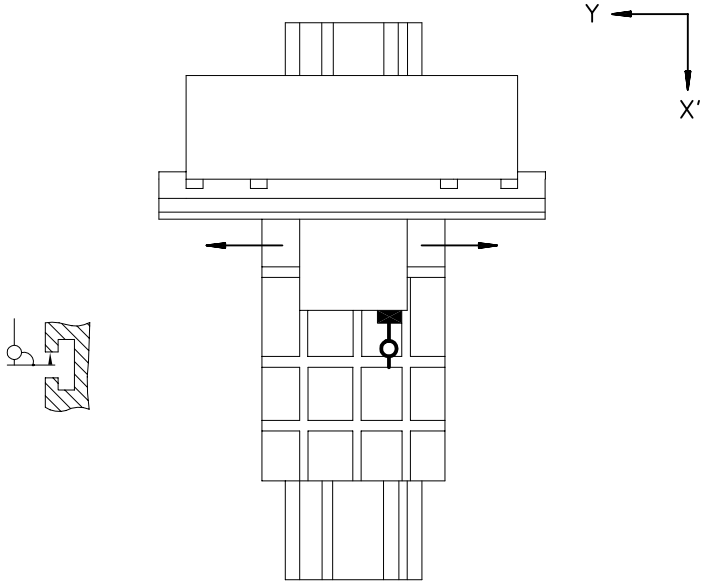
Cross-rail locked when taking measurements.

5.2 Table

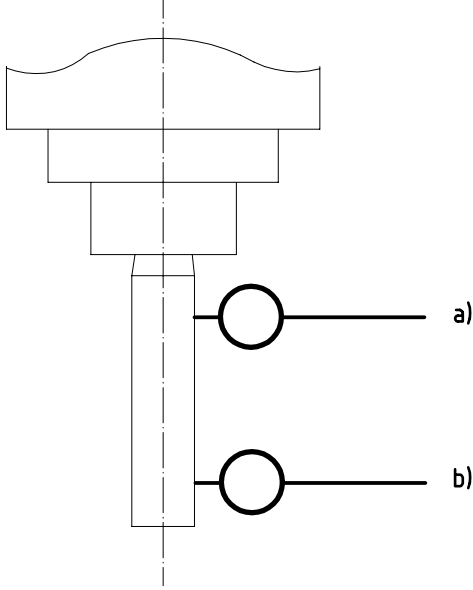
<p>Object</p> <p>Checking of flatness of the table surface:</p>	<p>G5</p>
<p>Diagram</p> 	
<p>Tolerance</p> <p>0,03 up to 1 000</p> <p>For each 1 000 increase in length beyond 1 000, add 0,01 to the preceding corresponding tolerance</p> <p>Maximum permissible deviation: 0,05</p>	<p>Measured deviation</p>
<p>Measuring instruments</p> <p>Precision level or straightedge and gauge blocks</p>	
<p>Observations and references to ISO 230-1:1996 5.322 and 5.323</p> <p>Table locked in central position.</p>	

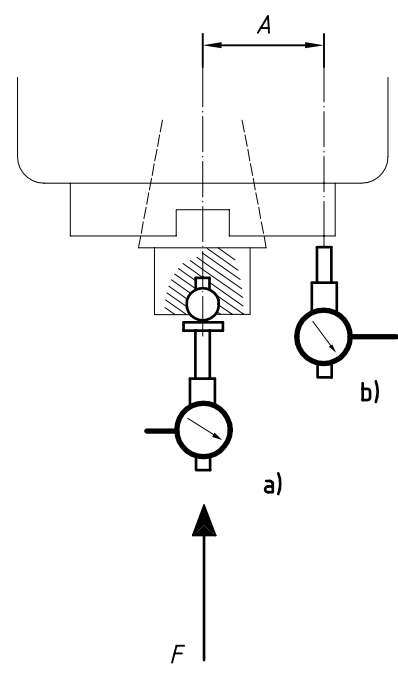
<p>Object</p> <p>Checking of parallelism of the table surface to:</p> <p>a) transverse movement of the spindle-head saddle (Y-axis);</p> <p>b) longitudinal movement of the table (X-axis).</p>	<p>G6</p>
<p>Diagram</p>  <p style="text-align: center;">a) b)</p>	
<p>Tolerance</p> <p>For a) and b)</p> <p>0,015 for any measuring length of 300</p> <p>Maximum permissible deviation: 0,03</p>	<p>Measured deviation</p> <p>a)</p> <p>b)</p>
<p>Measuring instruments</p> <p>Straightedge and dial gauge</p>	
<p>Observations and references to ISO 230-1:1996 5.422.21</p> <p>The stylus of the dial gauge shall be placed approximately on the spindle axis.</p> <p>The measurement may be made on a straightedge laid parallel to the table surface.</p> <p>If the table length is greater than 1 000 mm, the inspection shall be carried out by successive movements of the straightedge.</p> <p>If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, then the dial gauge shall be placed on a fixed part of the machine.</p> <p>Cross-rail locked.</p> <p>a) Table locked;</p> <p>b) Spindle-head saddle locked.</p>	

<p>Object</p>	<p>G7</p>
<p>Checking of parallelism of the longitudinal median or reference T-slot of the table to its longitudinal movement (X-axis).</p>	
<p>Diagram</p>  <p>The diagram illustrates the measurement setup for checking the parallelism of a T-slot on a machine table. It shows a cross-section of the table with a T-slot. A dial gauge is positioned to measure the parallelism of the longitudinal median or reference T-slot. A coordinate system is defined with the X' axis pointing downwards and the Y axis pointing to the left. A vertical double-headed arrow indicates the longitudinal movement of the table.</p>	
<p>Tolerance</p> <p>0,015 for any measuring length of 500</p> <p>Maximum permissible deviation: 0,035</p>	<p>Measured deviation</p>
<p>Measuring instruments</p> <p>Dial gauge</p>	
<p>Observations and references to ISO 230-1:1996 5.422.21</p> <p>Spindle-head saddle locked.</p>	

<p>Object</p>	<p>G8</p>
<p>Checking of parallelism of the transverse median or reference T-slot of the table to the movement of the spindle-head saddle on the cross-rail (Y-axis).</p>	
<p>Diagram</p> 	
<p>Tolerance</p> <p>0,015 for any measuring length of 500</p> <p>Maximum permissible deviation: 0,035</p>	<p>Measured deviation</p>
<p>Measuring instruments</p> <p>Dial gauge</p>	
<p>Observations and references to ISO 230-1:1996 5.422.22</p> <p>Table locked in central position.</p>	

5.3 Spindle

<p>Object</p>		<p>G9</p>
<p>Checking of the run-out of the internal taper of the spindle:</p> <p>a) near the spindle nose;</p> <p>b) at a distance of 300 mm from the spindle nose.</p>		
<p>Diagram</p> 		
<p>Tolerance</p> <p>a) 0,01</p> <p>b) 0,02</p>	<p>Measured deviation</p> <p>a)</p> <p>b)</p>	
<p>Measuring instruments</p> <p>Dial gauge and test mandrel</p>		
<p>Observations and references to ISO 230-1:1996 5.612.3</p> <p>Checking shall be repeated for all spindles, in the case of turret head-drilling machines.</p>		

<p>Object</p> <p>Checking of:</p> <p>a) periodic axial slip;</p> <p>b) camming of the face of the spindle nose (including periodic axial slip).</p>		<p>G10</p>
<p>Diagram</p> 		
<p>Tolerance</p> <p>a) 0,01</p> <p>b) 0,02</p>	<p>Measured deviation</p> <p>a)</p> <p>b)</p>	
<p>Measuring instruments</p> <p>Dial gauge</p>		
<p>Observations and references to ISO 230-1:1996</p> <p>a) 5.622.1 and 5.622.2</p> <p>A force F, specified by the supplier/manufacturer of the machine, shall be exerted by pressing towards the housing for tests a) and b).</p> <p>b) 5.632</p> <p>The distance A from the dial gauge for test b) to the spindle axis shall be as long as possible.</p> <p>Checking shall be repeated for all spindles, in the case of turret head-drilling machines.</p>		

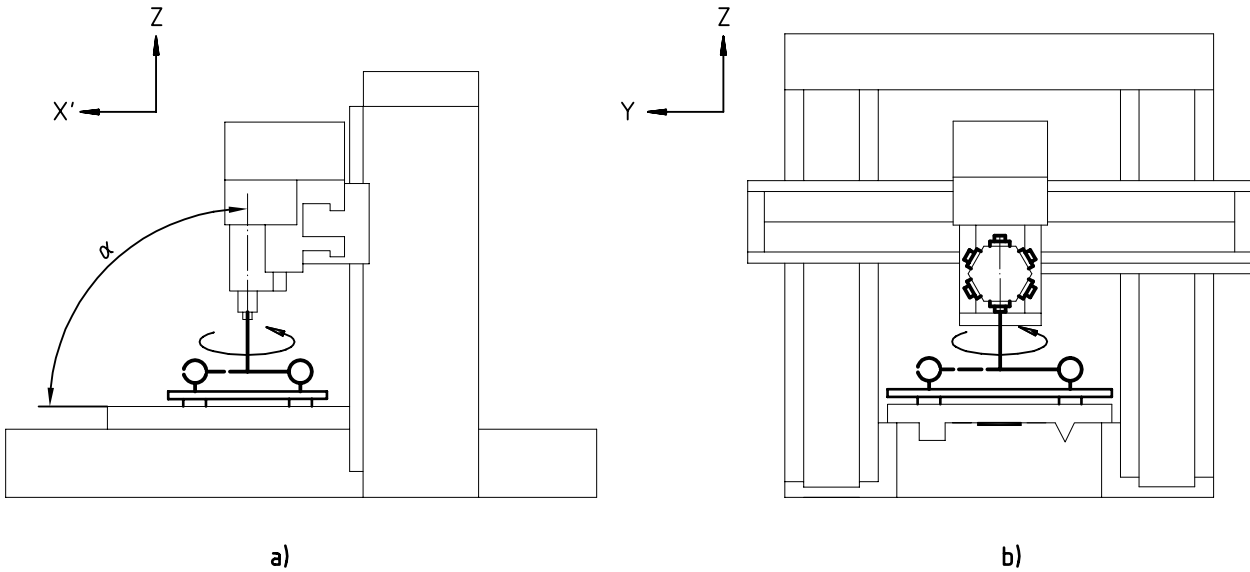
Object

G11

Checking of squareness between the spindle axis and the table surface:

- a) in the vertical ZX-plane of symmetry of the machine;
- b) in the YZ-plane perpendicular to the vertical plane of symmetry of the machine.

Diagram



Tolerance

- 1) Single spindle machines:
 - a) 0,015/300^a with $\alpha \leq 90^\circ$
 - b) 0,015/300^a
- 2) Turret machines:
 - a) 0,025/300^a with $\alpha \leq 90^\circ$
 - b) 0,025/300^a

^a Distance between the two measuring points touched

Measured deviation

- a)
- b)
- a)
- b)

Measuring instruments

Dial gauge, straightedge or gauge blocks

Observations and references to ISO 230-1:1996

5.512.1 and 5.512.42

Spindle-head, table and saddle locked.

Checking shall be repeated for all spindles, in the case of turret head-drilling machines.

The checking of the squareness of one representative spindle shall be carried out by positioning the cross-rail in the lower, middle and upper positions successively.

5.4 Multi-spindle turret head

<p>Object</p> <p>Checking of the accuracy of the positioning of the axes of the internal mounting surface of the spindles and checking of the repeatability of these positionings:</p> <p>a) in the vertical YZ-plane perpendicular to the axis of rotation of the turret;</p> <p>b) in the vertical ZX-plane containing both the axes of rotation of the turret and the spindle.</p>		<p>G12</p>
<p>Diagram</p>		
<p>Tolerance</p> <p style="text-align: center;">For a) and b) 0,02</p>	<p>Measured deviation</p> <p>a)</p> <p>b)</p>	
<p>Measuring instruments</p> <p>Dial gauge and test mandrel</p>		
<p>Observations and references to ISO 230-1:1996 5.412.1 and 6.4</p> <p>For a) and b), the dial-gauge support shall be set so as to place the stylus on the centreline of the test mandrel and as near as possible to the spindle nose.</p> <p>The dial gauge shall be adjusted to give the zero reading on the test mandrel in the reference spindle at mean run-out position.</p> <p>For a) then move the table (X-axis) in order to take away the dial gauge.</p> <p>The turret shall be rotated one complete revolution. If it is not possible to rotate one complete revolution, the turret shall be revolved through the largest possible fraction of a revolution, first in one direction, then in the opposite direction, so as to bring it back to its original position.</p> <p>The turret shall then be indexed and locked and the deviation observed.</p> <p>The turret shall then be indexed to the next position and the test mandrel transferred from the reference spindle.</p> <p>Similarly but without the dial gauge being re-zeroed, the spindle shall be rotated to the mean run-out and the deviation observed before and after one complete (or partial) revolution of the turret.</p> <p>Repeat for all spindles:</p> <p>a) Spindle-head saddle (Y-axis) locked.</p> <p>b) Table (X-axis) locked.</p>		

6 Machining test

<p>Object</p>		<p>M1</p>
<p>Checking of distance accuracy and diameter difference of machined holes in finish machining conditions:</p>		
<p>a) distance accuracy; b) diameter difference measured in X, Y, direction.</p>		
<p>Diagram</p>		<p>Workpiece: Steel 180 × 150 × <i>t</i> recommended <i>t</i>:25</p>
	<p>Machining pattern: Four two-step holes as shown</p>	<p>$D_1 = 19$ to 21 $D_2 = 20$ to 22 $D_3 > D_2 > D_1$</p>
<p>Machining sequence: Small-diameter boring shall be performed after positive direction positioning in X-and Y-axes. Large-diameter (upper hole) boring shall be performed after negative direction positioning. Radial stock removal shall not exceed 1 mm.</p>		
<p>Tolerance</p>	<p>a) Distance accuracy (for upper and lower holes) for 90 and 120: 0,02 for diagonal (150): 0,03 b) Concentricity in X, Y directions: 0,02</p>	<p>Measured deviation</p>
<p>Measuring instruments</p>		
<p>Coordinate-measuring machine or optical-measuring machine Inner-diameter-measuring equipment, pins and micrometer</p>		
<p>Observations and references to ISO 230-1:1996</p>		
<p>Premachined holes may be machined before setting the work piece on the table or after setting, but uniform radial removal is desired.</p>		
<p>Parts with predrilled holes may be used making sure that a uniform amount of stock is to be removed during finish boring.</p>		

Bibliography

- [1] ISO 841:—¹⁾, *Industrial automation systems — Physical device control — Coordinate system and motion nomenclature.*
- [2] ISO 3190:1975, *Test conditions for turret and single spindle co-ordinate drilling machines with vertical spindle — Testing of the accuracy.*

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

ICS 25.080.20; 25.080.40

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