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# INTERNATIONAL STANDARD



# 3686

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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

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## Test conditions for turret and single spindle co-ordinate drilling and boring machines with table of fixed height with vertical spindle — High accuracy machines — Testing of the accuracy

*Conditions d'essai des machines à percer et à aléser verticales à coordonnées à table de hauteur fixe, du type monobroche ou à tourelle revolver — Machines de haute précision — Contrôle de la précision*

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## FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3686 was drawn up by Technical Committee ISO/TC 39, *Machine tools*, and was circulated to the Member Bodies in May 1975.

It has been approved by the Member Bodies of the following countries :

Australia	India	South Africa, Rep. of
Austria	Italy	Spain
Belgium	Japan	Sweden
Czechoslovakia	Korea, Dem. P. Rep. of	Switzerland
France	Mexico	Turkey
Germany	Poland	Yugoslavia
Hungary	Romania	

The Member Bodies of the following countries expressed disapproval of the document on technical grounds :

United Kingdom  
U.S.A.

# Test conditions for turret and single spindle co-ordinate drilling and boring machines with table of fixed height with vertical spindle – High accuracy machines – Testing of the accuracy

## 1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies, with reference to ISO/R 230, both geometrical and practical tests of high accuracy turret and single spindle co-ordinate drilling and boring machines with table of fixed height with vertical spindle, and gives the corresponding permissible deviations which apply.

Moreover, it should be noted that besides drilling and boring operations it may be possible to carry out light milling operations with these machines, but this International Standard does not deal with jig boring machines or machining centres.

This International Standard deals only with the verification of accuracy of the machines. It does not apply to the testing of the running of the machine (vibrations, abnormal noises, stick-slip motion of components, etc.), or to machine characteristics (speeds, feeds, etc.) which should generally be checked before testing accuracy.

There is a wide variety of machine configurations within the scope of these machines, the most common being :

- single column type machines;
- double column type or bridge type machines.

Therefore the geometrical tests given in this International Standard should be selected according to the particular configuration of the machine being considered.

## 2 REFERENCES

ISO/R 230, *Machine tool test code*.

ISO 3190, *Test conditions for turret and single spindle co-ordinate drilling machines with vertical spindle – Testing of the accuracy*.

## 3 PRELIMINARY REMARKS

In this International Standard all the dimensions and permissible deviations are expressed in millimetres and in inches.

To apply this International Standard, reference should be made to ISO/R 230, especially for the installation of the machine before testing, warming up of spindles and other moving parts, description of measuring methods and recommended accuracy of testing equipment.

The sequence in which the geometrical tests are given is related to the sub-assemblies of the machine and this in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests may be applied in any order.

When inspecting a machine, it is not always possible, or necessary, to carry out all the tests described in this International Standard. It is up to the user to choose, in agreement with the manufacturer, those tests relating to the existing elements of the machine or to the properties which are of interest to him, but these tests are to be clearly stated when ordering a machine.

It should be noted that for turret head drilling machines, all the geometrical tests that concern the rotation of the spindle, i.e. tests G7, G8, G9 and G12, should be carried out on all spindles.

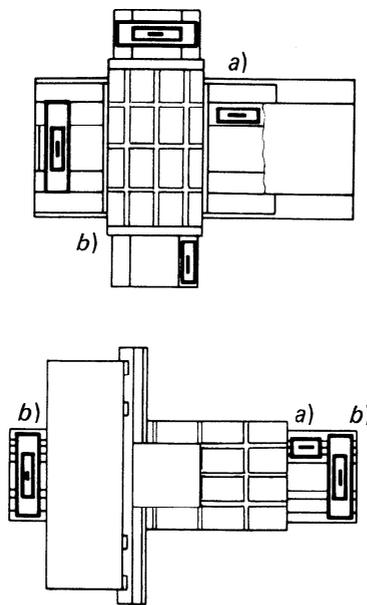
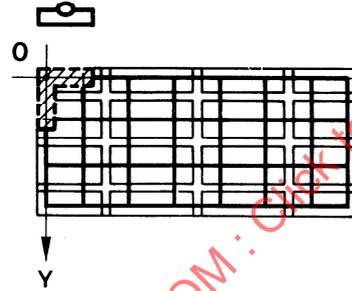
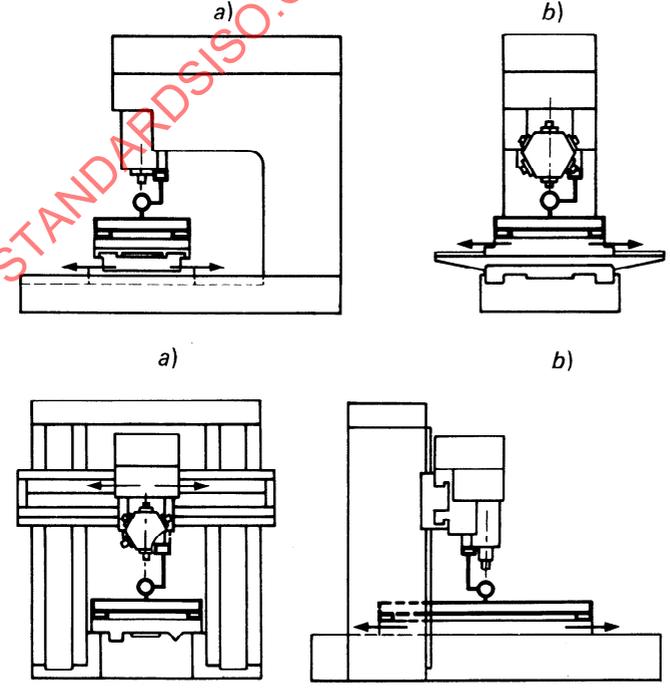
When the tolerance is established for a measuring range different from that given in this International Standard (see 2.311 in ISO/R 230) it should be taken into consideration that the minimum value of tolerance is 0,005 mm (0.000 2 in).

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## 4 TEST CONDITIONS AND PERMISSIBLE DEVIATIONS

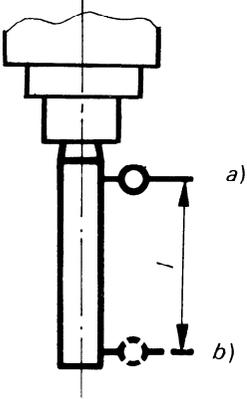
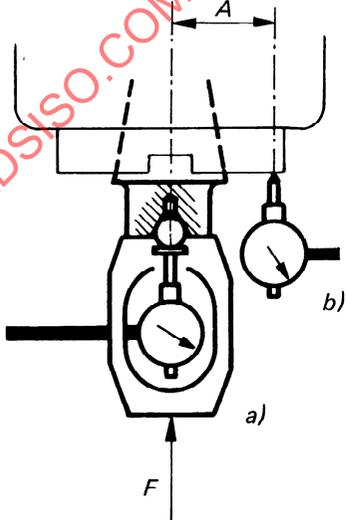
### 4.1 Geometrical tests

No.	Diagram	Object
G 0		<p>Levelling of the machine :</p> <p>a) in the plane of symmetry of the machine;</p> <p>b) in the plane perpendicular to the plane of symmetry of the machine and coaxial with the spindle axis.</p>
G 1		<p>A – TABLE</p> <p>Checking of flatness of the table surface.</p>
G 2		<p>Checking of parallelism of the table surface to :</p> <p>a) transverse movement of the table, or transverse movement of the spindle head;</p> <p>b) longitudinal movement of the table.</p>

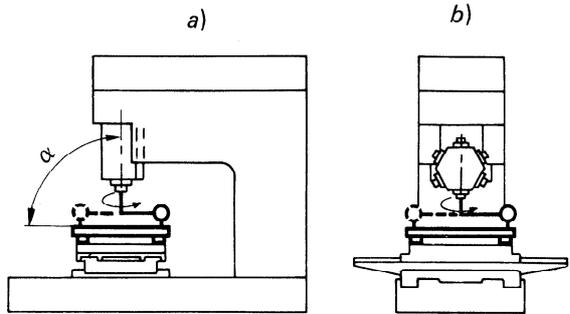
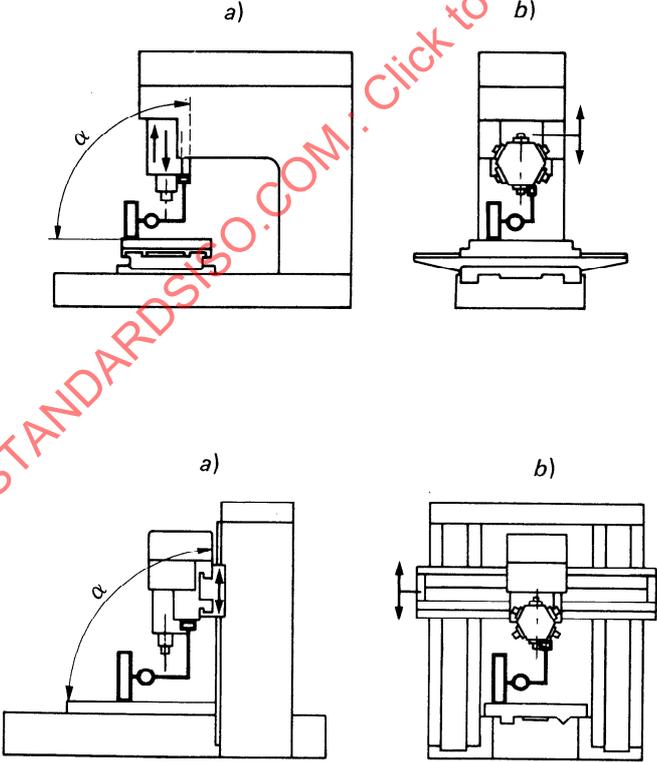
Permissible deviation		Measuring instruments	Observations and references to the test code ISO/R 230
mm	in		
0,03/1000	0.0012/40	Level and straightedge	<p>Clauses 3.11 and 5.212.21</p> <p>This preliminary levelling operation is to be carried out subject to agreement between manufacturer and user.</p>
0,03 up to 1000  For each 1000 increase in length beyond : 1000 add to the preceding corresponding tolerance : 0,01 Maximum permissible deviation : 0,05	0.0012 up to 40  40  40  0.0004  0.002	Precision level or straightedge and gauge blocks	Clauses 5.322 and 5.323
0,015 for any measuring length of : 300 Maximum permissible deviation : 0,03	0.0006  12  0.0012	Straightedge and dial gauge	<p>Clause 5.422.21</p> <p>The stylus of the dial gauge shall be placed approximately at 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 1000 mm (40 in) 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>Spindle head and knee or beam locked.</p> <p>a) Table locked;</p> <p>b) Cross slide locked.</p>

No.	Diagram	Object
G 3		<p>Checking of straightness of the longitudinal median, or reference tee slot of the table.</p>
G 4		<p>Checking of parallelism of the longitudinal median or reference tee slot of the table to its longitudinal movement.</p>
G 5		<p>Checking of parallelism of the transverse median or reference tee slot of the table to the transverse table movement.</p>
G 6		<p>Checking of squareness of the table longitudinal movement to its transverse movement or to the movement of the spindle head on the beam.</p>

Permissible deviation		Measuring instruments	Observations and references to the test code ISO/R 230
mm	in		
0,01 for any measuring length of : 500 Maximum permissible deviation : 0,02	0.0004 20 0.0008	Straightedge, dial gauge or gauge blocks and block	Clauses 5.212, 5.212.1, 5.212.3 or 5.232  The straightedge may be placed directly on the table.
0,015 for any measuring length of : 500 Maximum permissible deviation : 0,035	0.0006 20 0.0014	Dial gauge	Clause 5.422.21  Cross slide locked.
0,015 for any measuring length of : 500 Maximum permissible deviation : 0,035	0.0006 20 0.0014	Dial gauge	Clause 5.422.21  Table locked in central position.
0,02/500	0.0008/20	Straightedge, dial gauge and square	Clause 5.522.4  a) The straightedge shall be set parallel to the longitudinal movement of the table; then the square shall be placed against the straightedge. Table locked in central position.  b) Then check the table transverse movement or the spindle head movement on the beam.

No.	Diagram	Object
G 7	 <p>The diagram shows a vertical spindle with a tapered section. Two measurement points are indicated: 'a)' is a small circle on the upper part of the taper, and 'b)' is a small circle on the lower part of the taper. A vertical dimension line with arrows at both ends is positioned between the two measurement points, indicating the distance between them.</p>	<p><b>B – SPINDLE</b></p> <p>Measurement of run-out of the internal taper of the spindle :</p> <p>a) near the spindle nose;</p> <p>b) at a distance <math>l</math> of 300 mm (12 in) from the spindle nose.</p>
G 8	 <p>The diagram shows a cross-sectional view of a spindle nose. A force <math>F</math> is applied upwards from the bottom. A distance <math>A</math> is marked between two vertical dashed lines. Two measurement points are shown: 'a)' is a dial indicator measuring the face of the spindle nose, and 'b)' is a dial indicator measuring the periodic axial slip. The spindle nose is shown with a chamfered edge.</p>	<p>a) Measurement of periodic axial slip;</p> <p>b) Measurement of camming of the face of the spindle nose (including periodic axial slip).</p>

Permissible deviation		Measuring instruments	Observations and references to the test code ISO/R 230
mm	in		
0,01	a) 0.0004	Dial gauge and test mandrel	<p>Clause 5.612.3</p> <p>Checking shall be repeated for all spindles, in the case of turret head drilling machines.</p>
0,02	b) 0.0008		
0,01	a) 0.0004	Dial gauge	<p>a) Clauses 5.622.1 and 5.622.2</p> <p>A force <math>F</math>, specified by the manufacturer of the machine, shall be exerted by pressing towards the housing for tests <i>a)</i> and <i>b)</i>.</p> <p>b) Clause 5.632</p> <p>The distance <math>A</math> of dial gauge <i>b)</i> from the spindle axis shall be as large as possible.</p> <p>Checking shall be repeated for all spindles, in the case of turret head drilling machines.</p>
0,02	b) 0.0008		

No.	Diagram	Object
G 9		<p>Checking of squareness of the spindle axis to the table surface and of straightness of the vertical slideways of the column :</p> <p>a) in the vertical plane of symmetry of the machine;</p> <p>b) in the plane perpendicular to the vertical plane of symmetry of the machine.</p>
G 10		<p><b>C – SPINDLE HEAD</b></p> <p>Checking of squareness of the table surface to the vertical movement of the spindle head or the beam on the columns :</p> <p>a) in the vertical plane of symmetry of the machine;</p> <p>b) in the plane perpendicular to the vertical plane of symmetry of the machine.</p>

Permissible deviation		Measuring instruments	Observations and references to the test code ISO/R 230
mm	in		
<p>1 Single spindle machines :</p> <p>0,015/300* with <math>\alpha \leq 90^\circ</math></p> <p>0,015/300*</p> <p>2 Turret machines</p> <p>0,025/300* with <math>\alpha \leq 90^\circ</math></p> <p>0,025/300*</p>	<p>a) 0.0006/12* with <math>\alpha \leq 90^\circ</math></p> <p>b) 0.0006/12*</p> <p>a) 0.001/12* with <math>\alpha \leq 90^\circ</math></p> <p>b) 0.001/12*</p>	<p>Dial gauge and test mandrel</p>	<p>Clauses 5.512.1 and 5.512.42</p> <p>Spindle head, table, cross slide, and beam locked.</p> <p>Checking shall be repeated for all spindles, in the case of turret head drilling machines.</p> <p>The checking of the squareness shall be carried out by positioning the spindle head in the lower, middle and upper positions successively.</p> <p>* Distance between the two points touched.</p>
<p>0,015/300 with <math>\alpha \leq 90^\circ</math></p> <p>0,015/300</p>	<p>a) 0.0006/12 with <math>\alpha \leq 90^\circ</math></p> <p>b) 0.0006/12</p>	<p>Dial gauge and cylindrical square.</p>	<p>Clause 5.522.2</p> <p>Table locked in central position.</p> <p>Cross slide locked.</p> <p>The measurements shall be taken in at least three equi-spaced positions of the spindle head or beam.</p> <p>Spindle head or beam locked when taking measurements.</p>

No.	Diagram	Object
G 11		<p>Checking of squareness of the table surface to the vertical movement of the spindle housing or quill or the turret head on its slideways :</p> <p>a) in the vertical plane of symmetry of the machine;</p> <p>b) in the plane perpendicular to the vertical plane of symmetry of the machine.</p>
G 12		<p><b>D – MULTI SPINDLE TURRET HEAD</b></p> <p>Measurement 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 a vertical plane perpendicular with a vertical plane passing through the axis of rotation of the turret;</p> <p>b) in the vertical plane passing through the axis of rotation of the turret.</p>

Permissible deviation		Measuring instruments	Observations and reference to the test code ISO/R 230
mm	in		
0,01/300 with $\alpha \leq 90^\circ$  0,01/300	a) 0.0004/12 with $\alpha \leq 90^\circ$  b) 0.0004/12	Dial gauge and square	Clause 5.522.2  Table locked in central position.  Spindle head and cross slide locked.
0,02	0.0008	Straightedge, dial gauges, and test mandrel	Clauses 5.412.1 and 6.4  For <i>a</i> ) and <i>b</i> ) the dial gauge support shall be set against the straightedge to place the stylus on the centre line of the test mandrel and as near as possible to the spindle nose.  The dial gauge shall be adjusted to give zero reading on the test mandrel in reference spindle at mean runout position.  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.  The turret shall then be indexed and locked and the deviation observed.  The turret shall then be indexed to the next position and the test mandrel transferred from the reference spindle.  Similarly but without the dial gauge being re-zeroed, the spindle shall be rotated to the mean runout and the deviation observed before and after one complete (or partial) revolution of the turret.  Repeat for all spindles.  All slides locked except drilling feed slide.

4.2 Practical test

No.	Diagram	Nature of test
P 1	<p>The diagram consists of four parts:</p> <ul style="list-style-type: none"> <li><b>a)</b> A side-view schematic of a machine tool's spindle and table assembly. A force <math>F</math> is applied to the spindle, and a measurement <math>M</math> is taken at the table.</li> <li><b>b)</b> A top-view schematic of the same assembly, showing measurement points <math>A</math> and <math>B</math> on the spindle.</li> <li>A larger central diagram shows a spindle with a downward-pointing arrow, indicating the direction of the applied force.</li> <li><b>Special equipment (alternative)</b>: A schematic of an alternative test setup. It shows a spindle mounted on a table. A force <math>F</math> is applied to the spindle, and a measurement <math>M</math> is taken at the table. The table is supported by a frame with points <math>A</math> and <math>B</math>.</li> </ul>	<p>Measurement of deflection of the spindle axis from its position square with the table under an axial force applied to the spindle :</p> <ul style="list-style-type: none"> <li>a) in the plane of symmetry of the machine;</li> <li>b) in the plane perpendicular to the plane of symmetry of the machine.</li> </ul>

Permissible deviation		Measuring instruments	Observations and reference to the test code ISO/R 230
mm	in		
1/1000	0.04/40	Special equipment Dial gauge and load cell	<p>It is unnecessary to follow the test code ISO/R 230. A drilling test shall not be carried out but an axial force <math>F</math> shall be exerted on the spindle nose, using the table surface as a support.</p> <p>The application of force <math>F</math> and the measurement of the deflection under load of the axis of the spindle in relation to the table surface shall be made directly on the spindle nose with the aid of special equipment <b>A</b> mounted directly on the spindle nose.</p> <p>The base <b>B</b> of the load cell shall be of sufficient area and rigidity to eliminate any deformation of the table.</p> <p>The value of force <math>F</math> to be exerted shall be specified by the manufacturer. In the absence of a specified load, reference shall be made to the graph given in the annex to determine the load as a function of the drilling capacity of the machine.</p> <p>Spindle retracted. Spindle head or drilling feed slide, table, cross slide, beam shall be placed and locked in mid-position on their respective slideways.</p> <p>A calibration sheet of the test instrument <b>M</b> shall be supplied.</p>