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

**Part 3:**

Floor type machines with detached, stationary  
work-holding table

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

*Partie 3: Machines à montant mobile, à taque porte-pièce indépendante*



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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 3070-3 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 3070-2:1978) 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, stationary work-holding table (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 3:

### Floor type machines with detached, stationary work-holding table

#### 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, floor type boring and milling machines with horizontal spindle. These types of machine tool are defined in 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) and
- 6 (spindle head with ram or milling ram)

of ISO 3070-0:1982.

It should be noted that this part of ISO 3070 concerns machines which have a movement of the column or column saddle on the bed (X-axis), a vertical movement of the spindle head (Y-axis), a movement of boring spindle or ram (Z-axis) and possibly a feed movement of radial facing slide in the facing head (U-axis). Some machines also have an intermediate saddle having slideway between column and bed to achieve additional movement of the column parallel to the spindle axis (W-axis).

This part of ISO 3070 also includes the work-holding fixed table, an independent but necessary part of the machine as defined in ISO 7572.

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 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, indication on drawings.*
- ISO 3070-0:—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 millimetres; angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerances are expressed in ratios (e.g. 0,00 x/1 000) 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 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, can not 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 millimetres 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

<p><b>Object</b></p> <p>Checking of straightness of the column movement (W-axis):</p> <ul style="list-style-type: none"> <li>a) in the YZ plane (vertical plane)(EYW);</li> <li>b) in the ZX plane (horizontal plane)(EXW).</li> </ul> <p>(In the case of a column saddle being provided for movement of the column.)</p>	<p><b>G 1</b></p>
<p><b>Diagram</b></p>	
<p><b>Tolerance</b></p> <p>a) and b)          0,02 for measuring lengths up to 1 000          0,03 for measuring lengths above 1 000</p> <p>Local tolerance: 0,006 for any measuring length of 300</p>	<p><b>(Measured deviation)</b></p> <p>a)          b)</p>
<p><b>Measuring instruments</b></p> <p>Straightedge, dial gauge/support and gauge blocks or optical methods</p>	
<p><b>Observations and references to ISO 230-1</b> <span style="float: right;">5.232.11 and 5.232.13</span></p> <p>Set a straightedge on the table, parallel<sup>1)</sup> to the column movement (W-axis) for a) horizontally and b) vertically.</p> <p>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.</p> <p>Traverse the column in the W-direction and note readings.</p> <p>_____</p> <p>1) Parallel means that the readings of the dial gauge touching the straightedge at both ends of the movement are the same value, in which case the maximum difference of the readings gives the straightness deviation.</p>	

<p><b>Object</b></p> <p>Checking of angular deviation of the column movement (W-axis):</p> <ul style="list-style-type: none"> <li>a) in the YZ plane (EAW : pitch);</li> <li>b) in the XY plane (ECW : roll);</li> <li>c) in the ZX plane (EBW : yaw).</li> </ul>	<p><b>G 2</b></p>
<p><b>Diagram</b></p> <p>The diagram illustrates the measurement setup for angular deviation of the column movement (W-axis). It shows a side view of the machine tool's spindle head and work holding table. Three measurement points are indicated: 'a)' on the spindle head, 'b)' on the table, and 'c)' on the table surface. A 'Mirror and autocollimator' is positioned on the table surface to measure point 'c'. The W-axis movement is indicated by a double-headed arrow labeled '+ W'.</p>	
<p><b>Tolerance</b></p> <p>a), b) and c) 0,04/1 000</p> <p>Local tolerance: 0,02/1 000 for any measuring length of 300</p>	<p><b>(Measured deviation)</b></p> <ul style="list-style-type: none"> <li>a)</li> <li>b)</li> <li>c)</li> </ul>
<p><b>Measuring instruments</b></p> <ul style="list-style-type: none"> <li>a) Precision level or optical angular deviation measuring instruments</li> <li>b) Precision level</li> <li>c) Optical angular deviation measuring instruments</li> </ul>	
<p><b>Observations and references to ISO 230-1</b> <span style="float: right;">5.231.3 and 5.232.2</span></p> <p>The level or instrument shall be placed on the spindle head:</p> <ul style="list-style-type: none"> <li>a) (EAW: pitch) in the Z-axis direction (set vertically)</li> <li>b) (ECW: roll) in the X-axis direction (set vertically)</li> <li>c) (EBW: yaw) in the Z-axis direction (set horizontally)</li> </ul> <p>The reference level shall be located on the work holding table, and the spindle head shall be in the middle of the travel range.</p> <p>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.</p> <p>Measurements shall be carried out at a minimum of five positions equally spaced along the travel in both directions of the movement.</p> <p>The difference between the maximum and the minimum readings shall not exceed the tolerance.</p>	

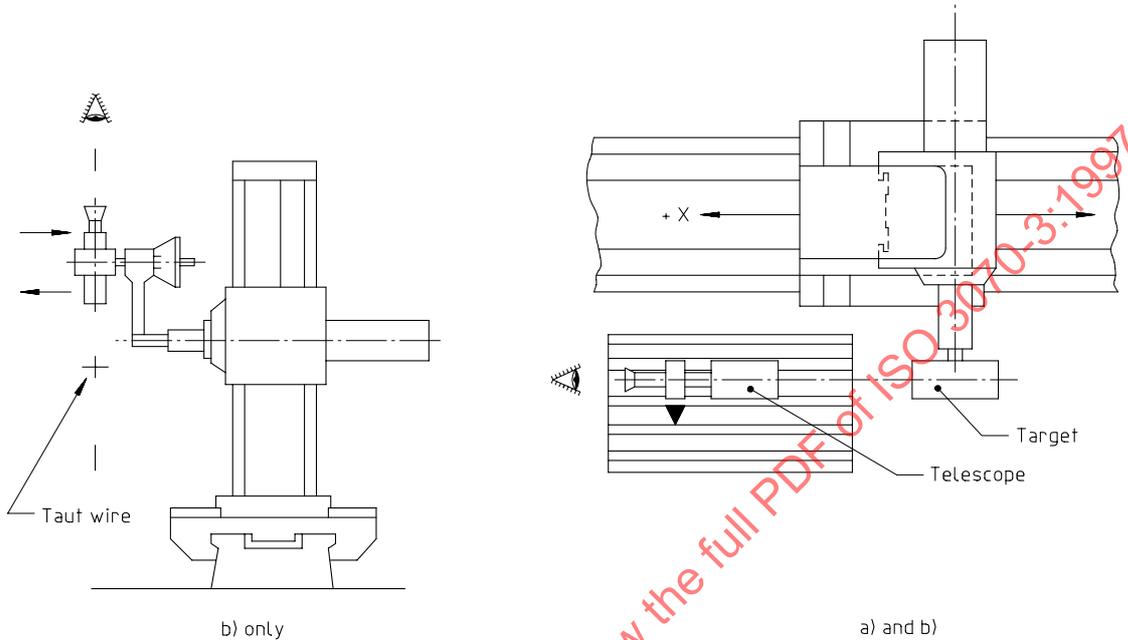
**Object**

**G 3**

Checking of straightness of the column saddle movement (X-axis):

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

**Diagram**



**Tolerance**

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: 0,12

Local tolerance: 0,006 for any measuring length of 300

**(Measured deviation)**

- a)
- b)

**Measuring instruments**

Optical methods or microscope and taut wire

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

5.232.12 and 5.232.13

a) Taut wire is not recommended because of the sag of the wire. The alignment telescope may be fixed vertically on the work-holding table so that the optical beam is parallel<sup>1)</sup> to the X-axis movement of the column saddle movement.

If the spindle can be locked, mount the target mirror on it. If the spindle cannot be locked, the target mirror shall be mounted on the spindle head.

Traverse the column saddle in the X-direction and note the readings.

b) When taut wire is used, the microscope shall be fixed on the spindle or spindle head. When the optical method is used, the telescope shall be set horizontally.

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

<p><b>Object</b></p> <p>Checking of angular deviations of the column saddle movement (X-axis):</p> <ul style="list-style-type: none"> <li>a) in the XY plane (ECX: pitch);</li> <li>b) in the YZ plane (EAX: roll);</li> <li>c) in the ZX plane (EBX: yaw).</li> </ul>	<p><b>G 4</b></p>
<p><b>Diagram</b></p>	
<p><b>Tolerance</b></p> <p style="text-align: center;">a), b) and c)</p> <p style="text-align: center;"><math>X \leq 4\,000</math>: 0,04/1 000</p> <p style="text-align: center;"><math>X &gt; 4\,000</math>: 0,06/1 000</p> <p>Local tolerance: 0,02/1 000 for any measuring length of 300</p>	<p><b>(Measured deviation)</b></p> <ul style="list-style-type: none"> <li>a)</li> <li>b)</li> <li>c)</li> </ul>
<p><b>Measuring instruments</b></p> <ul style="list-style-type: none"> <li>a) Precision level or optical angular deviation measuring instruments</li> <li>b) Precision level</li> <li>c) Optical angular deviation measuring instruments</li> </ul>	
<p><b>Observations and references to ISO 230-1</b> <span style="float: right;">5.231.3 and 5.232.2</span></p> <p>The level or instrument shall be placed on the spindle head:</p> <ul style="list-style-type: none"> <li>a) (ECX: pitch) in the X-axis direction (set vertically)</li> <li>b) (EAX: roll) in the Z-axis direction (set vertically)</li> <li>c) (EBX: yaw) in the X-axis direction (set horizontally)</li> </ul> <p>The reference level shall be located on the work holding table, and the spindle head shall be in the middle of the travel range.</p> <p>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.</p> <p>Measurements shall be carried out at a minimum of five positions equally spaced along the travel in both directions of the movement.</p> <p>The difference between the maximum and the minimum readings shall not exceed the tolerance.</p>	

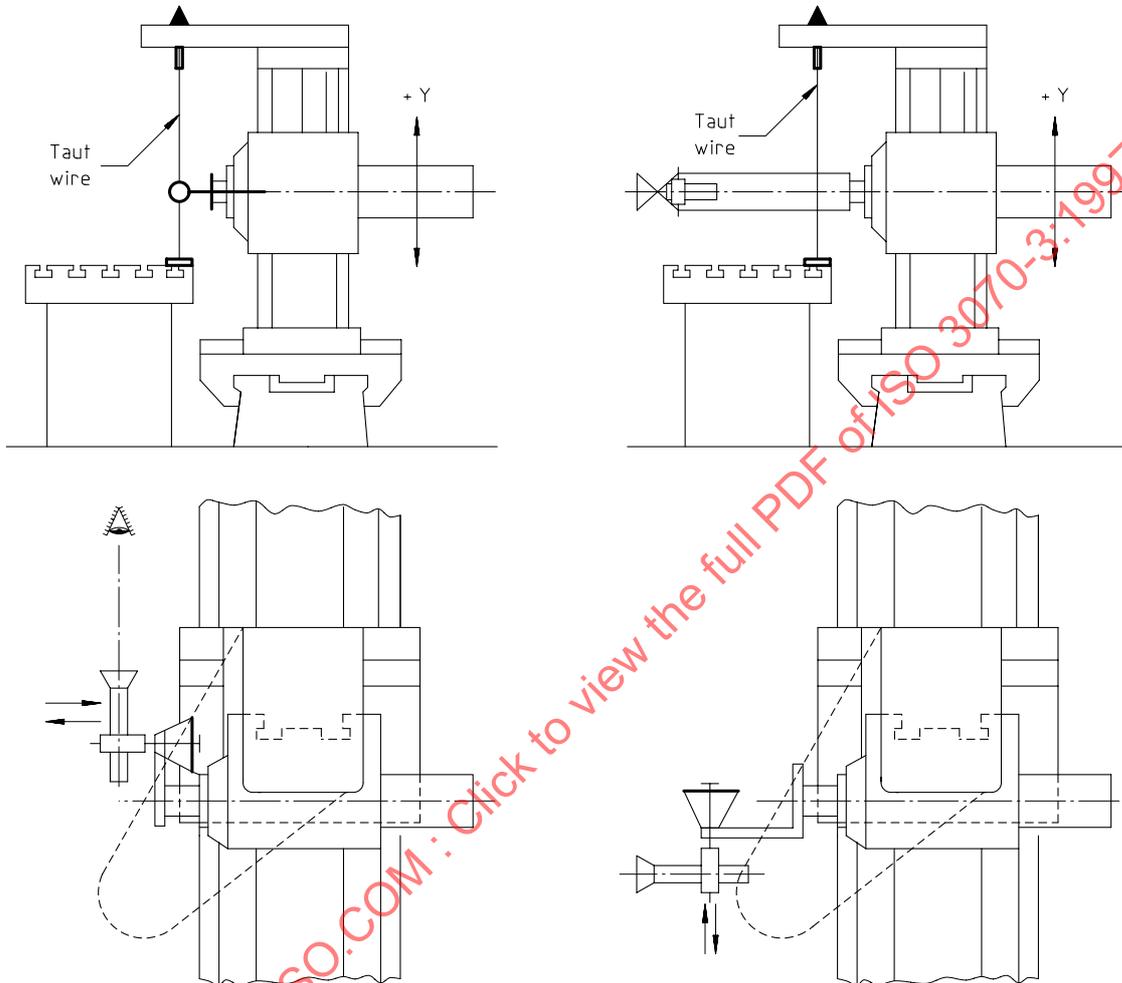
**Object**

**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**

a) and b)  
 0,02 for any measuring length up to 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

**(Measured deviation)**

- a)
- b)

**Measuring instruments**

Microscope and taut wire or optical methods

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

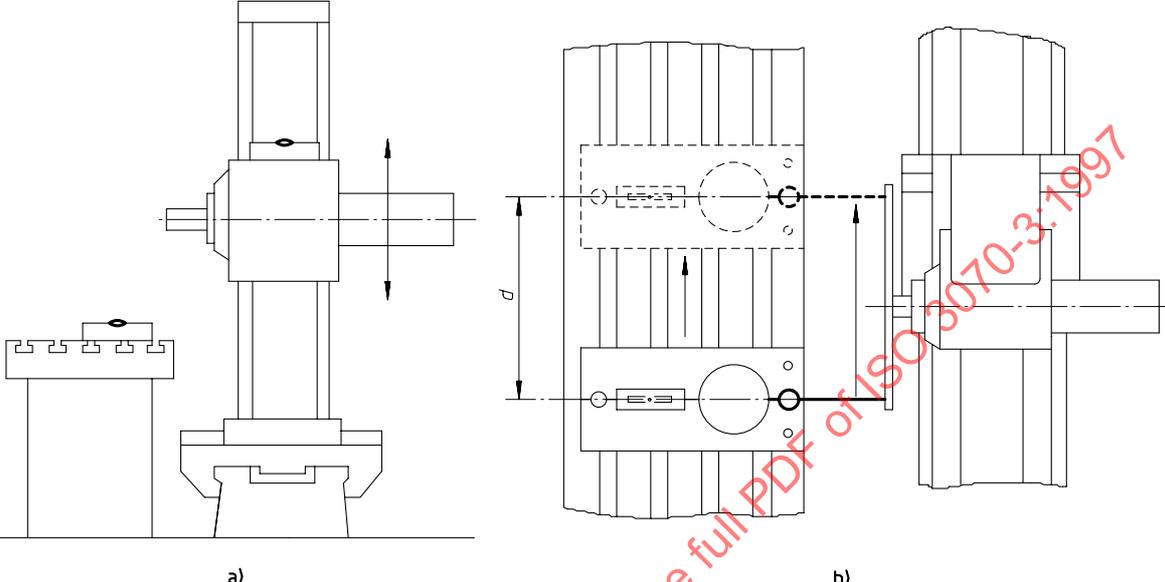
5.232.1, 5.232.12 or 5.232.13

The column saddle shall be locked and the column shall be locked at mid-travel.

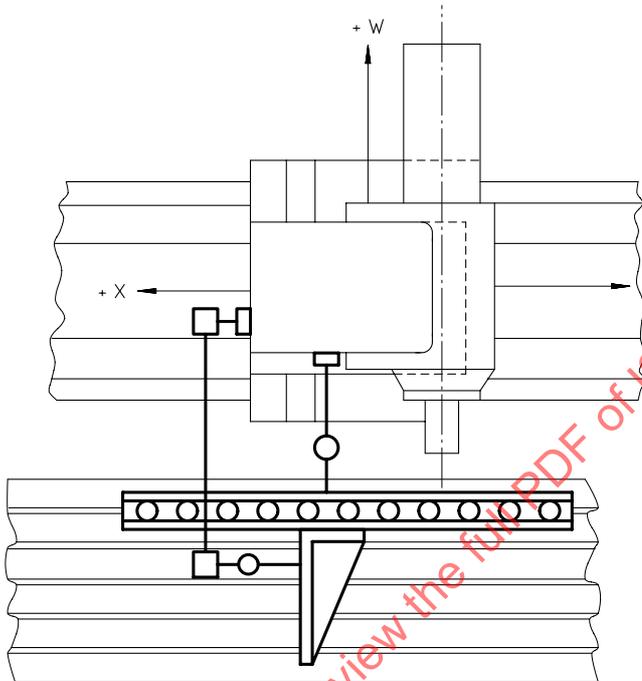
The taut wire shall be tightened between the work-holding table and another fixed part on the machine as near as possible to the vertical slide ways of the column.

If the spindle can be locked, the microscope to 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.

The spindle head shall be locked when taking measurements.

<b>Object</b>	<b>G 6</b>
Checking of angular deviations of the spindle head movement (Y-axis): a) in the YZ plane (EAY); b) in the ZX plane (EBY).	
<b>Diagram</b> 	
<b>Tolerance</b> a) and b) $Y \leq 4\,000$ : 0,04/1 000 $Y > 4\,000$ : 0,06/1 000	<b>(Measured deviation)</b> a) b)
<b>Measuring instruments</b> a) Precision level or optical angular deviation measuring instruments b) Surface plate, cylindrical square, level and dial gauges/support arm	
<b>Observations and references to ISO 230-1</b> <span style="float: right;">5.231.3 and 5.232.2</span> 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 work-holding table in the same direction. When Y 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. The difference between the maximum and the minimum readings shall not exceed the tolerance. b) Mount a surface plate on the work holding table and adjust it so that its face is level. Place a cylindrical square on the surface plate so that it is touched by the stylus of the dial gauge mounted on a special arm fixed to the spindle head. Place a level on the surface plate in the Z-axis direction. Note the readings at the measuring positions of the spindle head travel (Y-axis). Move the surface plate with cylindrical square by a distance $d$ , and adjust the level of the surface plate to its original position. Reset the dial gauge so that the stylus still touches the cylindrical square and take readings at the same measuring positions of the spindle head travel. For each measuring position calculate the differences of two readings; the difference of maximum and minimum divided by distance $d$ then gives the angular deviation.	

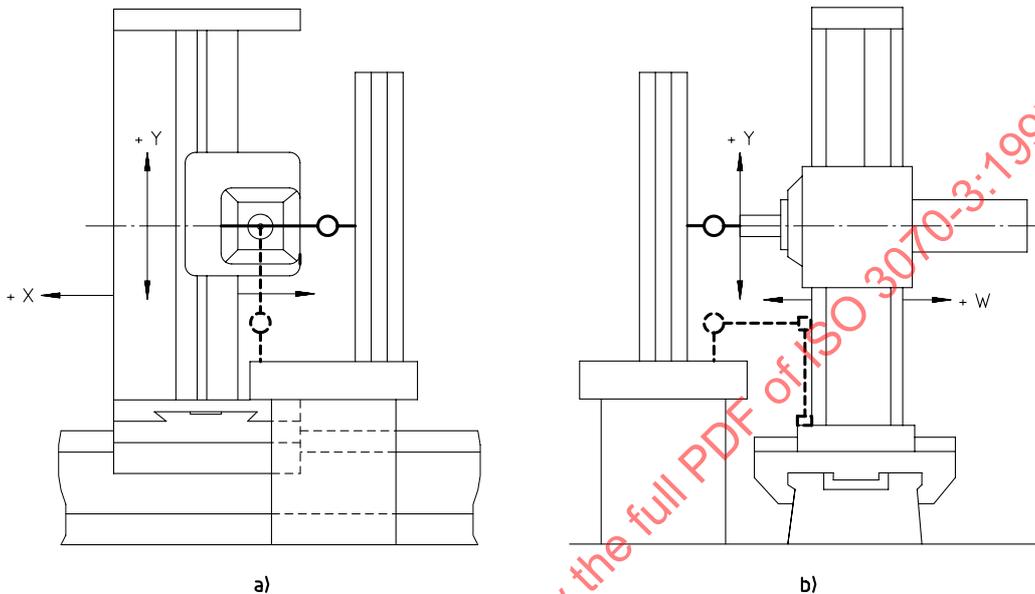
5.2 Squareness between the coordinate axes

<p><b>Object</b></p>	<p><b>G 7</b></p>
<p>Checking of straightness between column saddle movement (X-axis) and the column movement (W-axis).</p>	
<p><b>Diagram</b></p> 	
<p><b>Tolerance</b></p> <p>0,03 for any measuring length of 1 000</p>	<p><b>(Measured deviation)</b></p>
<p><b>Measuring instruments</b></p> <p>Straightedge, square and dial gauge/support</p>	
<p><b>Observations and references to ISO 230-1</b> <span style="float: right;">5.522.4</span></p> <p>Spindle head is locked in mid-travel.</p> <p>Align the straightedge on the work holding table parallel<sup>1)</sup> to the column saddle movement (X-axis) and press the square against it. Column saddle shall then be locked in mid-travel on the bed.</p> <p>If the spindle can be locked, mount the dial gauge on it. If the spindle cannot be locked, dial gauge shall be mounted on the head. Apply stylus of dial gauge normally to square.</p> <p>Move the column in W-direction and note readings.</p> <p>_____</p> <p>1) Parallel means that the readings of the dial gauge touching the straightedge at both ends of the movement are the same value.</p>	

**G 8****Object**

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

- the column saddle movement (X-axis);
- the column movement (W-axis) (only in the case where the column saddle is provided for the W-axis movement of the column).

**Diagram****Tolerance**

a) and b)  
0,03 for any measuring length of 1 000

**(Measured deviation)**

a)  
b)

**Measuring instruments**

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

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

5.522.4

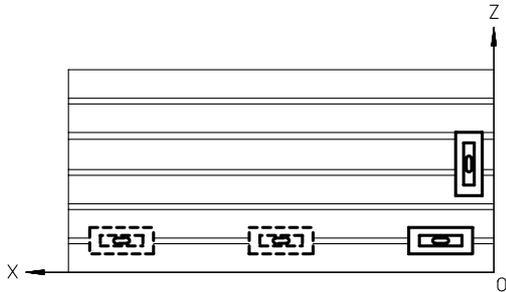
Mount a surface plate on the work holding table as near as possible to the machine. Adjust it so that its surface is parallel to both column saddle (X-axis) and column (W-axis) movements. Place the cylindrical square on the surface plate.

Lock the column and the column saddle in their mid-positions.

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 the X-direction and move the head in the 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 Work-holding fixed table independent of the machine

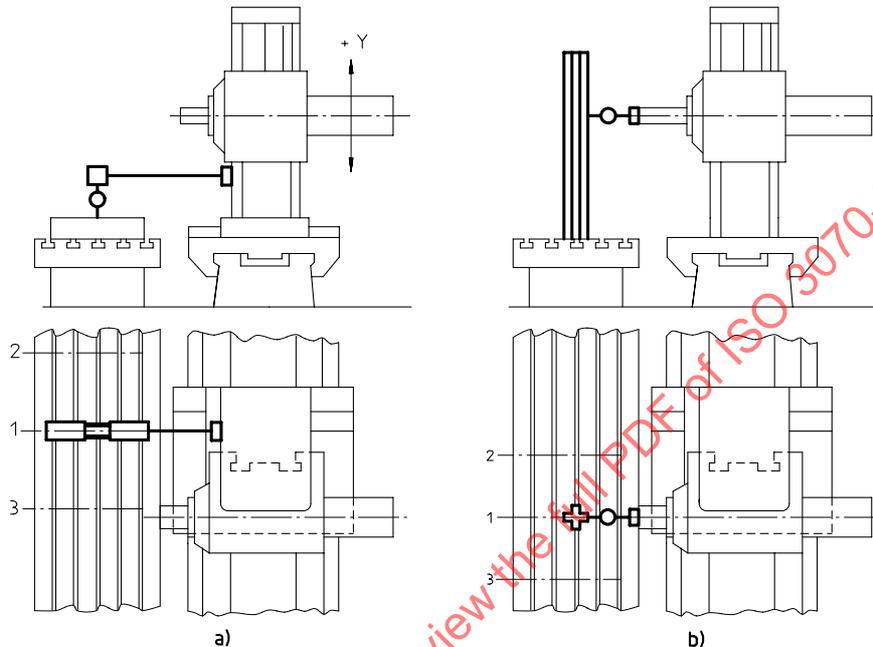
<p><b>Object</b></p> <p>Checking of the flatness of the table surface.</p>	<p><b>G 9</b></p>												
<p><b>Diagram</b></p>  <p>The diagram illustrates the setup for measuring the flatness of a table surface. A coordinate system is defined with the origin '0' at the bottom right corner. The X-axis points to the left, and the Z-axis points upwards. A series of horizontal lines represent the surface profile. A dial indicator is positioned vertically on the right side of the table, with its measuring tip in contact with the surface. Below the table, three gauge blocks are shown: two are enclosed in dashed boxes and one is solid, representing the use of gauge blocks to establish a reference length.</p>													
<p><b>Tolerance</b></p> <p>For the length of longer side length of O-X or O-Z</p> <table border="1" data-bbox="97 891 1099 1167"> <thead> <tr> <th></th> <th>Quality A</th> <th>Quality B</th> </tr> </thead> <tbody> <tr> <td>For measuring lengths up to 1 000:</td> <td>0,05</td> <td>0,08</td> </tr> <tr> <td>For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:</td> <td>0,02</td> <td>0,03</td> </tr> <tr> <td>Maximum tolerance:</td> <td>0,15</td> <td>0,4</td> </tr> </tbody> </table>		Quality A	Quality B	For measuring lengths up to 1 000:	0,05	0,08	For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:	0,02	0,03	Maximum tolerance:	0,15	0,4	<p><b>(Measured deviation)</b></p>
	Quality A	Quality B											
For measuring lengths up to 1 000:	0,05	0,08											
For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:	0,02	0,03											
Maximum tolerance:	0,15	0,4											
<p><b>Measuring instruments</b></p> <p>Precision level or straightedge, gauge-blocks and dial gauge or optical or other equipment</p>													
<p><b>Observations and references to ISO 230-1</b></p> <p style="text-align: right;">5.322, 5.323, 5.324</p>													

<b>Object</b>	<b>G 10</b>												
Checking of parallelism of the median or reference T-slot or any other reference face of the fixed work holding table to the column saddle movement (X-axis).													
<b>Diagram</b>													
<table border="1"> <thead> <tr> <th data-bbox="132 1142 670 1198"><b>Tolerance</b></th> <th data-bbox="670 1142 829 1198">Quality A</th> <th data-bbox="829 1142 1129 1198">Quality B</th> </tr> </thead> <tbody> <tr> <td data-bbox="132 1198 670 1254">For any measuring length up to 1 000:</td> <td data-bbox="670 1198 829 1254">0,090</td> <td data-bbox="829 1198 1129 1254">0,10</td> </tr> <tr> <td data-bbox="132 1254 670 1321">For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:</td> <td data-bbox="670 1254 829 1321">0,025</td> <td data-bbox="829 1254 1129 1321">0,04</td> </tr> <tr> <td data-bbox="132 1321 670 1377">Maximum tolerance:</td> <td data-bbox="670 1321 829 1377">0,250</td> <td data-bbox="829 1321 1129 1377">0,45</td> </tr> </tbody> </table>	<b>Tolerance</b>	Quality A	Quality B	For any measuring length up to 1 000:	0,090	0,10	For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:	0,025	0,04	Maximum tolerance:	0,250	0,45	<b>(Measured deviation)</b>
<b>Tolerance</b>	Quality A	Quality B											
For any measuring length up to 1 000:	0,090	0,10											
For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:	0,025	0,04											
Maximum tolerance:	0,250	0,45											
<b>Measuring instruments</b> Dial gauge and cross-square													
<table border="1"> <thead> <tr> <th data-bbox="132 1590 1129 1657"><b>Observations and references to ISO 230-1</b></th> <th data-bbox="1129 1590 1471 1657">5.422.22</th> </tr> </thead> <tbody> <tr> <td colspan="2" data-bbox="132 1657 1471 1769">                     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 the spindle head.                 </td> </tr> <tr> <td colspan="2" data-bbox="132 1769 1471 2047">                     The stylus of the dial gauge may touch the reference face of T-slot directly or the face of the cross-square pressed to the reference face. Maximum difference of readings gives the parallelism deviation.                 </td> </tr> </tbody> </table>		<b>Observations and references to ISO 230-1</b>	5.422.22	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 the spindle head.		The stylus of the dial gauge may touch the reference face of T-slot directly or the face of the cross-square pressed to the reference face. Maximum difference of readings gives the parallelism deviation.							
<b>Observations and references to ISO 230-1</b>	5.422.22												
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 the spindle head.													
The stylus of the dial gauge may touch the reference face of T-slot directly or the face of the cross-square pressed to the reference face. Maximum difference of readings gives the parallelism deviation.													

<b>Object</b>		<b>G 11</b>												
<p>Checking of parallelism of the surface of the fixed work holding table to the column saddle movement (X-axis).</p>														
<p><b>Diagram</b></p>														
<b>Tolerance</b>	<table border="1"> <thead> <tr> <th></th> <th>Quality A</th> <th>Quality B</th> </tr> </thead> <tbody> <tr> <td>For any measuring length up to 1 000:</td> <td>0,100</td> <td>0,15</td> </tr> <tr> <td>For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:</td> <td>0,025</td> <td>0,04</td> </tr> <tr> <td>Maximum tolerance:</td> <td>0,300</td> <td>0,60</td> </tr> </tbody> </table>		Quality A	Quality B	For any measuring length up to 1 000:	0,100	0,15	For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:	0,025	0,04	Maximum tolerance:	0,300	0,60	<b>(Measured deviation)</b>
	Quality A	Quality B												
For any measuring length up to 1 000:	0,100	0,15												
For each 1 000 increase in length beyond 1 000, add to the preceding tolerance:	0,025	0,04												
Maximum tolerance:	0,300	0,60												
<p><b>Measuring instruments</b></p> <p>Dial gauge, straightedge and gauge-blocks or optical method</p>														
<p><b>Observations and references to ISO 230-1</b></p> <p>The column is locked in mid-travel. The spindle head is in low position.</p> <p>Set the straightedge on the work-holding fixed table in the X-axis direction parallel to the table surface, traverse the column saddle and note the variation in readings.</p> <p>Without using the straightedge, direct measurement of the table surface using the dial gauge and gauge block is also possible.</p>		5.422.22												

**G 12****Object**

- a) Checking of parallelism of the surface of work holding fixed table to the column movement (W-axis).
- b) Checking of squareness of the surface of work-holding fixed table to the spindle head movement (Y-axis) when the column does not have W-axis motion.

**Diagram****Tolerance**

	Quality A	Quality B
a) for any measuring length of 1 000:	0,065	0,13
b) for any measuring length of 1 000:	0,100	0,20

**(Measured deviation)**

- a)  
b)

**Measuring instruments**

- a) Dial gauge and straightedge or optical method  
b) Cylindrical square or precision square and dial gauge or optical method

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

This test shall be carried out for three positions (middle and near the end positions) of the column saddle along the bed.

a) 5.422.22

Set the straightedge on the fixed work-holding table in W-axis direction parallel to the table surface and traverse column through measuring length and note the variation in readings.

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

b) 5.522.2

Place a cylindrical square on the fixed work-holding table and attach a dial gauge to the spindle such that its stylus touches the cylindrical square in the direction of spindle axis.

Lock the column when taking measurement. Move the spindle head through the measuring length and note the variation in readings.

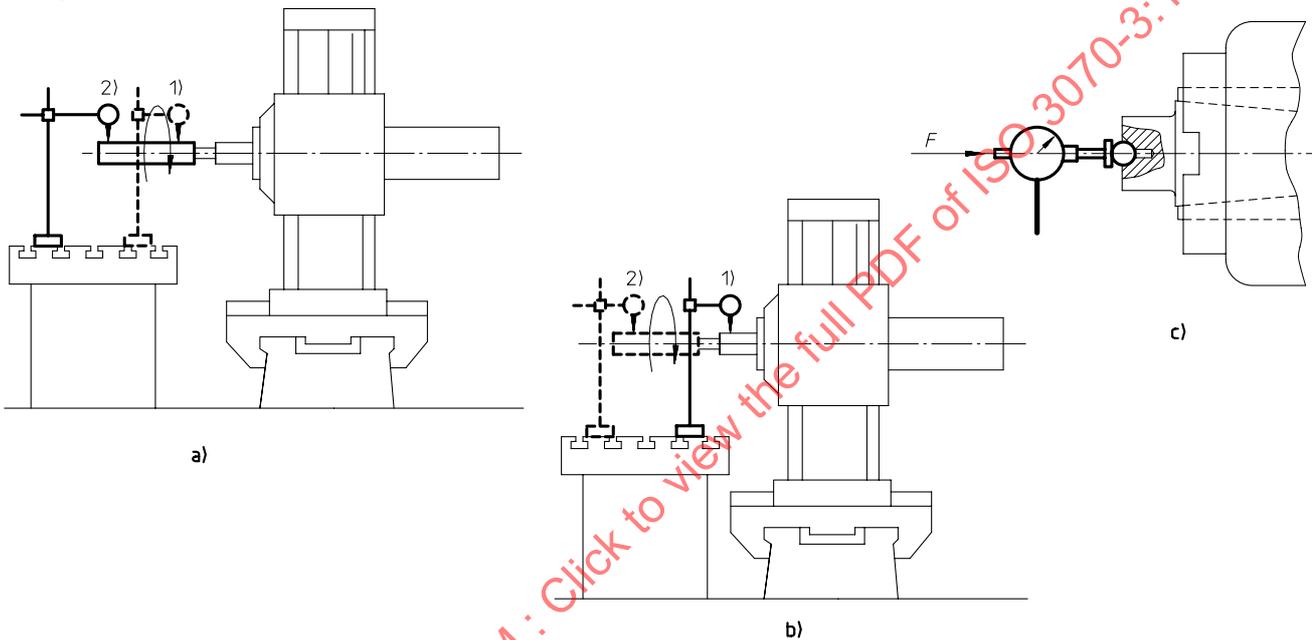
5.4 Boring spindle

**G 13**

**Object**

- 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**

		$D \leq 125$	$D > 125$
a) and b)	1)	0,01	0,015
	2)	0,02	0,030
c)		0,01	0,015

**(Measured deviation)**

- a)
- b)
- c)

where  $D$  is the diameter of the boring spindle

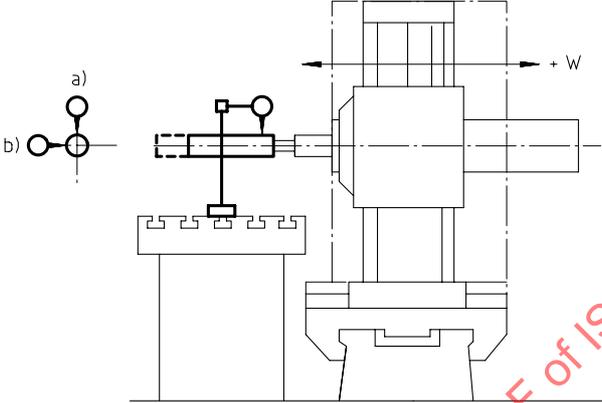
**Measuring instruments**

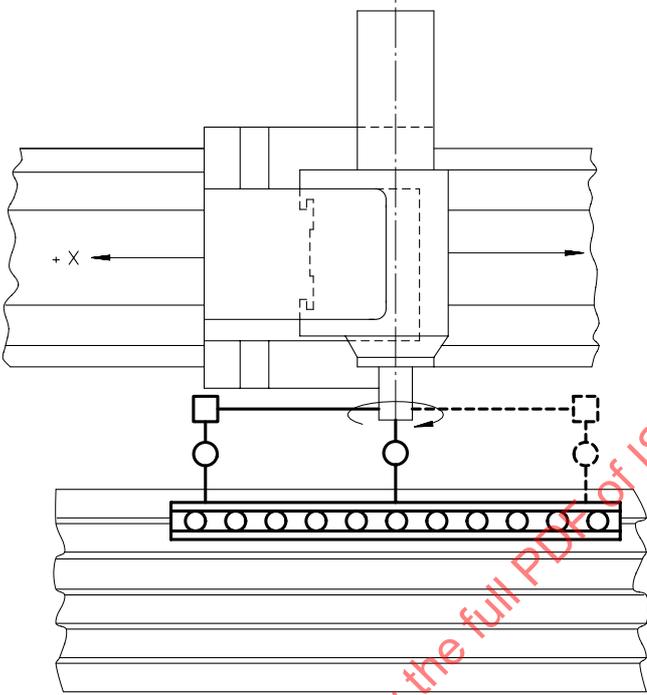
Test mandrel and dial gauge

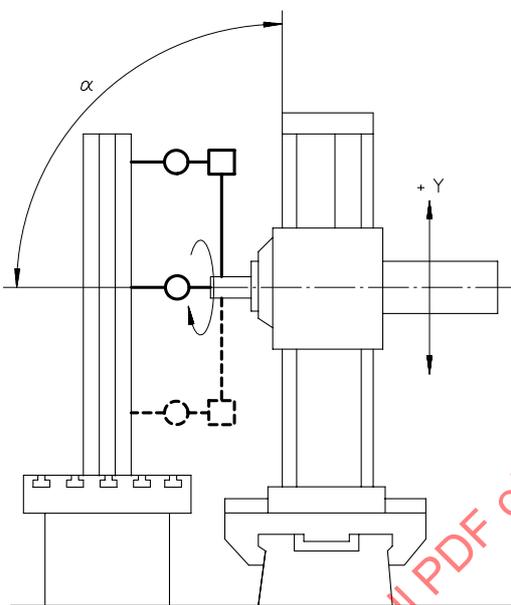
**Observations and references to ISO 230-1**

- 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 need be applied.

<b>Object</b> 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). (In the case where the column has W-axis motion.)	<b>G 14</b>
<b>Diagram</b> 	
<b>Tolerance</b> For a) and b) 0,02 for any measuring length of 300	<b>(Measured deviation)</b> a) b)
<b>Measuring instruments</b> Dial gauge and, possibly test mandrel and surface plate	
<b>Observations and references to ISO 230-1</b> 5.412.1 and 5.422.3 Spindle head locked at mid-travel. Spindle retracted. Column saddle may be locked at mid-travel. 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.	

<p><b>Object</b></p>	<p><b>G 15</b></p>
<p>Checking of squareness of the boring spindle axis to the column saddle movement (X-axis).</p>	
<p><b>Diagram</b></p> 	
<p><b>Tolerance</b></p> <p style="text-align: center;">0,03/1 000</p> <p>where 1 000 is the distance between the two measuring points touched</p>	<p><b>(Measured deviation)</b></p>
<p><b>Measuring instruments</b></p> <p>Dial gauge/support and possibly straightedge</p>	
<p><b>Observations and references to ISO 230-1</b>      5.512.1 and 5.512.32</p> <p>Set straightedge horizontally on the fixed work holding table, parallel<sup>1)</sup> to the column saddle movement.</p> <p>Column and column saddle should be locked at mid-travel. Spindle head should be locked in low position on the column. Spindle and possibly ram should be retracted.</p> <p>Set a dial gauge on the spindle and the stylus of the dial gauge normally against the reference face of the straightedge. Note the reading.</p> <p>Turn the boring spindle until the stylus once more touches the reference face of the straightedge. Note the reading.</p> <p>The squareness deviation is the difference between the two readings divided by the distance between the two measuring points.</p> <p>_____</p> <p>1) Parallel means that readings of the dial gauge touching the square at both ends of the movement are the same value.</p>	

<b>Object</b>	<b>G 16</b>
Checking of squareness of the boring spindle axis to the spindle head movement (Y-axis).	
<b>Diagram</b> 	
<b>Tolerance</b> $0,03/1\ 000$ with $\alpha \leq 90^\circ$ where 1 000 is the distance between the two points touched	<b>(Measured deviation)</b>
<b>Measuring instruments</b> Cylindrical square, adjustable blocks and dial gauge/support	
<b>Observations and references to ISO 230-1</b> 5.512.1 and 5.512.32 <p>Cylindrical square shall be set on the fixed work holding table, parallel<sup>1)</sup> to the Y-axis movement of the spindle head.</p> <p>Spindle head locked at mid-travel, spindle and possibly ram retracted.</p> <p>Set a dial gauge on the spindle and touch the stylus of the dial gauge normally against the cylindrical square. Note the reading.</p> <p>Turn the boring spindle with the attached dial gauge and touch the cylindrical square again. Note the reading.</p> <p>The squareness deviation is the difference between the two readings divided by the distance between the two measuring points.</p> <p>_____</p> <p>1) Parallel means that readings of the dial gauge touching the square at both ends of the movement are the same value.</p>	

<p><b>Object</b></p> <p>Checking of the boring spindle sliding movement (Z-axis):</p> <p>a) (when column saddle is provided) parallelism to the column movement (W-axis);</p> <p>b) (when column is placed directly on the bed) squareness to the spindle head movement (Y-axis).</p>	<p><b>G 17</b></p>
<p><b>Diagram</b></p>	
<p><b>Tolerance</b></p> <p>For an extension of the spindle equal to:</p> <p>2D: + 0,015 (upwards);</p> <p>4D: ± 0,02;</p> <p>6D: - 0,06 (downwards).</p> <p>where <i>D</i> is the diameter of the boring spindle</p> <p>NOTES</p> <p>1 The extension of the spindle is limited to six times the spindle diameter and shall not exceed 900 mm.</p> <p>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.</p>	<p><b>(Measured deviation)</b></p>
<p><b>Measuring instruments</b></p> <p>Straightedge, gauge block and dial gauge</p>	
<p><b>Observations and references to ISO 230-1</b>      5.232.1, 5.422.22 and 5.522.4</p> <p>a) Place a straightedge on the fixed work holding table vertically in a plane containing the spindle axis; adjust it parallel to the column movement (W-axis).</p> <p>Spindle rotation is locked.</p> <p>Touch the functional surface of the straightedge with the dial gauge fixed on the spindle nose.</p> <p>Extend the spindle to the required length and note the dial gauge readings for each of the successive positions.</p> <p>b) Align the straightedge so that the vertical plane of a square laid on this straightedge is parallel to the spindle head movement (Y-axis), then check same with a).</p>	

5.5 Milling spindle

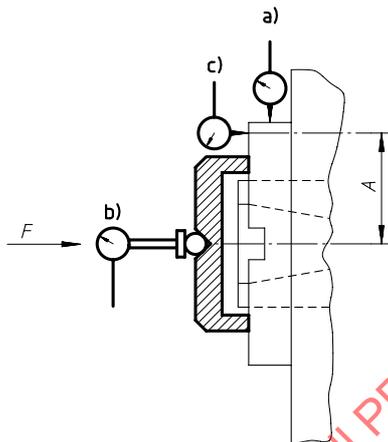
G 18

**Object**

Checking of the milling spindle nose:

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

**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)**

- a)
- b)
- c)

**Measuring instruments**

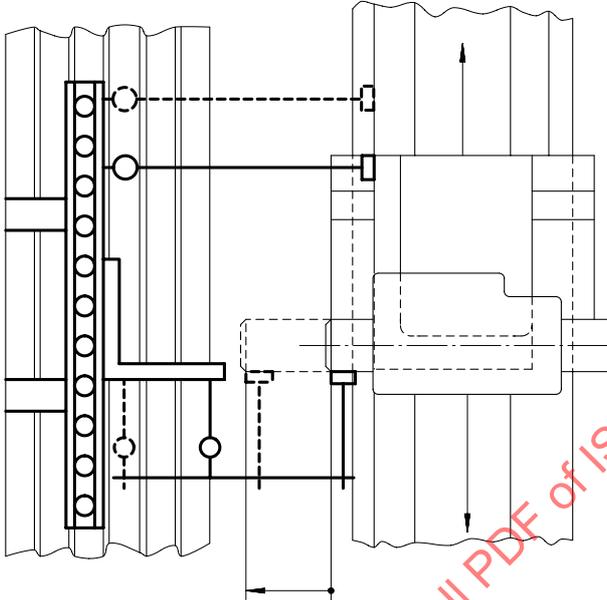
Dial gauge

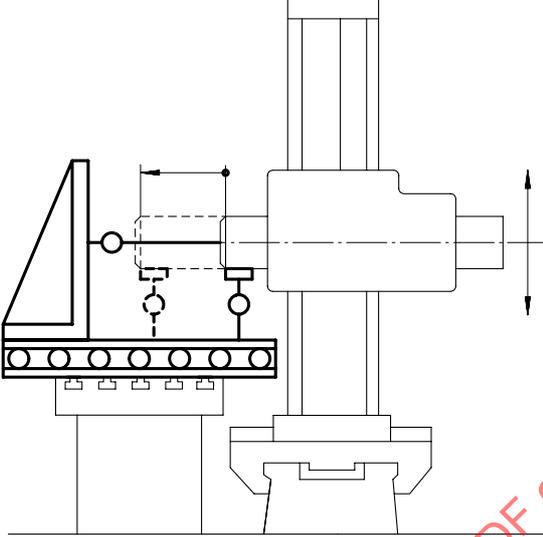
**Observations and references to ISO 230-1**

- 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 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.

5.6 Ram

<p><b>Object</b></p> <p>Checking of parallelism of the ram movement (Z-axis) to the column movement (W-axis):</p> <p>a) in the YZ plane (vertical plane);</p> <p>b) in the ZX plane (horizontal plane).</p> <p>(In the case where the column has W-axis motion.)</p>		<p><b>G 19</b></p>
<p><b>Diagram</b></p>		
<p><b>Tolerance</b></p> <p>a) and b)</p> <p>0,03 for a measuring length of 500</p>	<p><b>(Measured deviation)</b></p> <p>a)</p> <p>b)</p>	
<p><b>Measuring instruments</b></p> <p>Straightedge, gauge block and dial gauge/support</p>		
<p><b>Observations and references to ISO 230-1</b>      5.422.22</p> <p>Set a straightedge on the fixed work holding table parallel<sup>1)</sup> to the column movement (W-axis) for a) vertical and for b) horizontal measurement.</p> <p>Column locked at mid-travel. Spindle head locked.</p> <p>The ram movement shall then be checked with respect to the straightedge using a dial gauge fixed on the ram.</p>		
<p>1) Parallel means that readings of the dial gauge touching the straightedge at both ends of the movement are the same value in which case, the maximum difference between the readings gives the straightness deviation.</p>		

<b>Object</b>	<b>G 20</b>
Checking of squareness of the ram movement (Z-axis) to the column saddle movement (X-axis).	
<b>Diagram</b> 	
<b>Tolerance</b> 0,03 for a measuring length of 500	<b>(Measured deviation)</b>
<b>Measuring instruments</b> Straightedge, square and dial gauge/support	
<b>Observations and references to ISO 230-1</b> 5.522.4 Column is locked at mid-travel. Set a straightedge on the fixed work-holding table parallel to the column saddle movement and then press a square to the straightedge. The ram movement shall then be checked with respect to the square using a dial gauge fixed on the ram.	

<p><b>Object</b></p>	<p><b>G 21</b></p>
<p>Checking of squareness of the ram movement (Z-axis) to the spindle head movement (Y-axis).</p>	
<p><b>Diagram</b></p> 	
<p><b>Tolerance</b></p> <p>0,03 for a measuring length of 500</p>	<p><b>(Measured deviation)</b></p>
<p><b>Measuring instruments</b></p> <p>Straightedge, square, gauge blocks and dial gauge/support</p>	
<p><b>Observations and references to ISO 230-1</b>      5.522.4</p> <p>Column is locked at mid-travel.</p> <p>Set a straightedge on the fixed work holding table parallel to the ram movement in a vertical plane containing the ram axis, and then place a square on it.</p> <p>The spindle head movement shall then be checked with respect to the square using a dial gauge fixed on the ram.</p>	

<b>Object</b>		<b>G 22</b>
<p>a) Checking of concentricity of the milling spindle and of the front centering of tool or accessories on the ram.</p> <p>b) Checking of squareness of the support face of tools or accessories on the ram to the rotation axis of the milling spindle.</p> <p>(These checks are valid only if there is a circular locating surface on the ram.)</p>		
<b>Diagram</b>		
<b>Tolerance</b>	<p>a) 0,02</p> <p>b) 0,02/500</p>	<b>(Measured deviation)</b>
		<p>a)</p> <p>b)</p>
<b>Measuring instruments</b>		
Dial gauge		
<b>Observations and references to ISO 230-1</b>		
<p>a) 5.442</p> <p>Concentricity deviation is the half of the maximum difference of the readings.</p> <p>b) 5.512.42</p>		

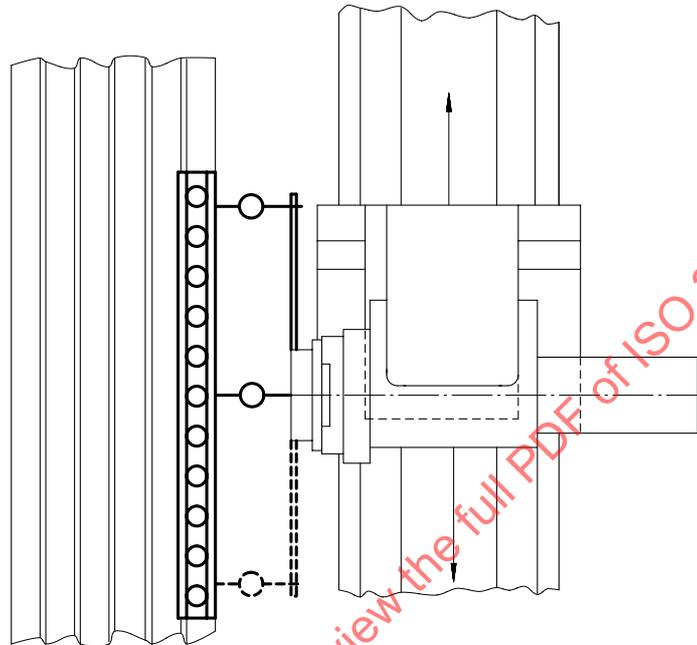
5.7 Integral facing head

<b>Object</b>			<b>G 23</b>
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.)			
<b>Diagram</b>			
<b>Tolerance</b>	$D \leq 125$	$D > 125$	<b>(Measured deviation)</b>
a)	0,02	0,03	a)
b)	0,03	0,04	b)
where $D$ is the diameter of the milling spindle			
<b>Measuring instruments</b>			
Dial gauge			
<b>Observations and references to ISO 230-1</b> 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.			

**G 24****Object**

Checking of squareness of the facing head rotation axis to the column saddle 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**
 $0,03/1\ 000$ 

where 1 000 is the distance between the two measuring points touched

**(Measured deviation)****Measuring instruments**

Dial gauge/rigid support and straightedge

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

5.512.1 and 5.512.32

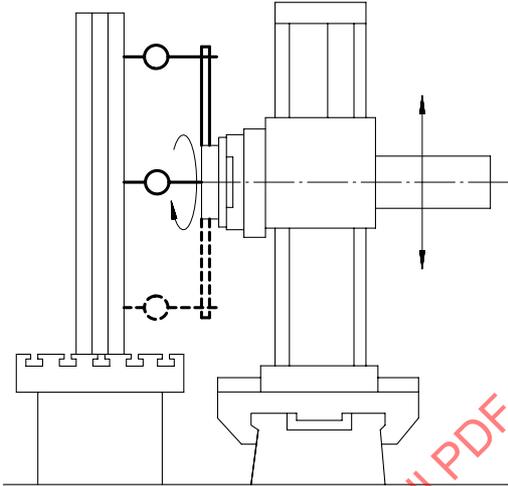
Column is locked at mid-travel. Spindle head is locked in low position.

Set a straightedge on the fixed work holding table parallel to the column saddle movement in horizontal plane.

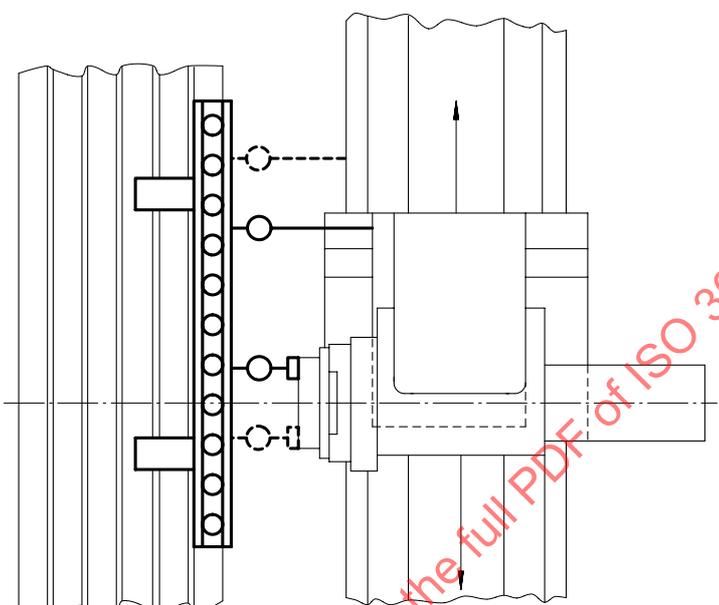
Set a dial gauge to a rigid arm fixed on the facing head and the stylus of dial gauge against the straightedge. Note the reading.

Turn the facing head until the stylus again touches against the straightedge. Note the reading.

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

<p><b>Object</b></p> <p>Checking of squareness of the facing head rotation axis to the spindle head movement (Y-axis).</p> <p>(This check is valid only when the facing head is mounted on the bearings independent of those of the boring spindle.)</p>	<p><b>G 25</b></p>
<p><b>Diagram</b></p> 	
<p><b>Tolerance</b></p> <p style="text-align: center;">0,03/1 000</p> <p>where 1 000 is the distance between the two measuring points touched</p>	<p><b>(Measured deviation)</b></p>
<p><b>Measuring instruments</b></p> <p>Dial gauge/rigid support and cylindrical square</p>	
<p><b>Observations and references to ISO 230-1</b>      5.512.1 and 5.512.32</p> <p>Column is locked at mid-travel.</p> <p>Set a cylindrical square on the fixed work holding table parallel to Y axis movement. Spindle head locked at mid-travel on the column.</p> <p>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.</p> <p>Turn the facing head with dial gauge, and touch the cylindrical square again. Note the reading.</p> <p>The deviation from squareness is the difference between the two readings divided by the distance between the two measuring points.</p>	

### 5.8 Radial facing slide movement (U-axis)

<b>Object</b>	<b>G 26</b>
Checking of parallelism of the radial facing slide movement (U-axis) in a plane horizontal to the column saddle movement (X-axis).	
<b>Diagram</b> 	
<b>Tolerance</b> 0,025 for a measuring length of 300	<b>(Measured deviation)</b>
<b>Measuring instruments</b> Straightedge and dial gauge/support	
<b>Observations and references to ISO 230-1 5.422.5 and 5.422.2</b> <p>Set a straightedge horizontally on the fixed work-holding table parallel to the column saddle movement (X-axis), using a dial gauge fixed on the radial facing slide of the facing head.</p> <p>Move the radial facing slide, and note the difference in the readings.</p> <p>Repeat the test after turning the facing head through 180°.</p>	

<p><b>Object</b></p> <p>a) Checking of parallelism of the radial facing slide movement in a plane vertical to the spindle head movement (Y-axis).              b) Checking of squareness of the radial facing slide movement in a plane vertical to the column saddle movement (W-axis)              (When there is the column movement.)</p>	<p><b>G 27</b></p>
<p><b>Diagram</b></p> <p>The diagram consists of two parts, a) and b). Part a) shows a vertical straightedge mounted on a fixed work-holding table. A dial gauge is attached to the radial facing slide of the machine tool. The dial gauge's measuring head is in contact with the straightedge. A vertical double-headed arrow indicates the spindle head movement (Y-axis). Part b) shows a horizontal straightedge mounted on a table. A square is placed on top of the straightedge. A dial gauge is attached to the radial facing slide, with its measuring head in contact with the square. A horizontal double-headed arrow indicates the column saddle movement (W-axis).</p>	
<p><b>Tolerance</b></p> <p>a) and b)              0,025 for a measuring length of 300</p>	<p><b>(Measured deviation)</b></p>
<p><b>Measuring instruments</b></p> <p>a) and b): Straightedge, square and dial gauge/support</p>	
<p><b>Observations and references to ISO 230-1</b></p> <p>a) 5.422.2              Set a straightedge vertically on the fixed work-holding table parallel to the spindle head movement (Y-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°.</p> <p>b) 5.522.4              Set a straightedge horizontally on the table parallel to the column movement (W-axis) and set a square on that straightedge.              Using a dial gauge fixed on the radial facing slide, move the radial facing slide vertically and note the difference in the readings.              Repeat the same operation after turning the plate through 180°.</p>	

6 Machining tests

M 1

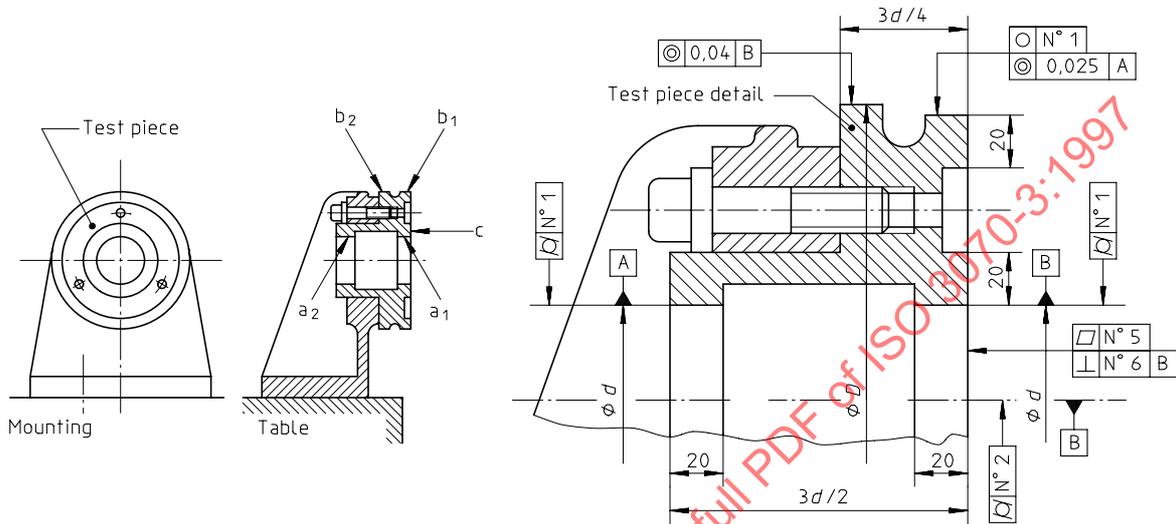
Nature of test

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 $a_2$ : $d \leq 125$ : 0,007 5*) $d > 125$ : 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 $a_2$ 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 column.
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	3) Movement of the column or 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.
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.