
**Test conditions for internal cylindrical
grinding machines with horizontal
spindle — Testing of accuracy**

*Conditions d'essai des machines à rectifier les surfaces de révolution
intérieures à broche horizontale — Contrôle de la précision*

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International Organization for Standardization
 Case postale 56 • CH-1211 Genève 20 • Switzerland
 Internet central@iso.ch
 X.400 c=ch; a=400net; p=iso; o=isocs; s=central

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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 2407 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

This third edition cancels and replaces the second edition (ISO 2407:1984), which has been technically revised.

Annexes A and B of this International Standard are for information only.

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Test conditions for internal cylindrical grinding machines with horizontal spindle — Testing of accuracy

1 Scope

This International Standard specifies, with reference to ISO 230-1, both geometric and machining tests on general purpose and normal accuracy internal cylindrical grinding machines with horizontal spindle, whether fitted with a facing wheelhead slide or not. It also specifies the applicable tolerances corresponding to the above mentioned tests.

This International Standard deals only with the verification of the accuracy; it applies neither to the testing of the machine operation (vibrations, abnormal noise, stick-slip motion of components, etc.), nor to the checking of its characteristics (such as speeds, feeds, etc.), which should generally be checked before the testing of the accuracy.

This International Standard provides the terminology used for the principal parts of the machine and the designation of the axes with reference to ISO 841.

NOTE — In addition to the terms used in two of the three official ISO languages (English and French), annex A of this International Standard provides the equivalent terms in the German and Italian languages; these are published under the responsibility of the National member bodies for Germany (DIN) and Italy (UNI). However, only the terms given in the official languages can be considered as ISO terms.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard 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.*

3 Machine configurations

3.1 Descriptions

The common characteristic of all internal cylindrical grinding machines with horizontal spindle is that they have at least both horizontal workhead and the wheelhead on the bed and the spindles are facing each other.

The workhead may swivel around a vertical axis (B-axis) for grinding conical surfaces.

Depending upon the machine design, one of the two heads (workhead or wheelhead) can move along the X-axis. The wheelhead usually can move along the Z-axis (see figures 1 and 2).

In some cases these machines are equipped with a facing wheel. This may be accomplished by means of the second wheelhead as shown in figure 3 or by an additional swivelling wheelhead attachment. This attachment is usually mounted on the workhead with a linear movement (W-axis) parallel to Z-axis and a swivelling movement (C-axis) around the W-axis (see figure 4).

3.2 Terminology and designation of axes

See figures 1 to 4 and table 1.

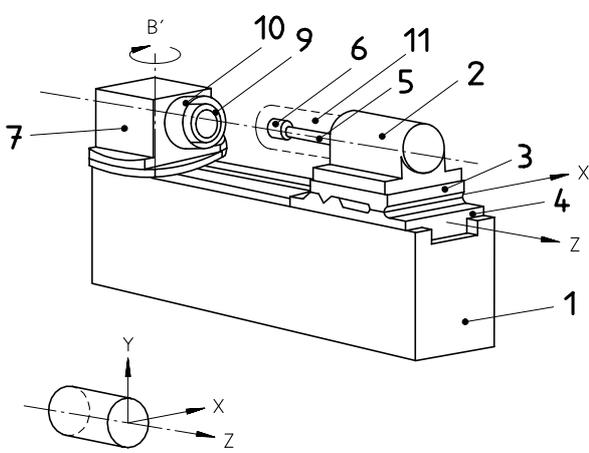


Figure 1

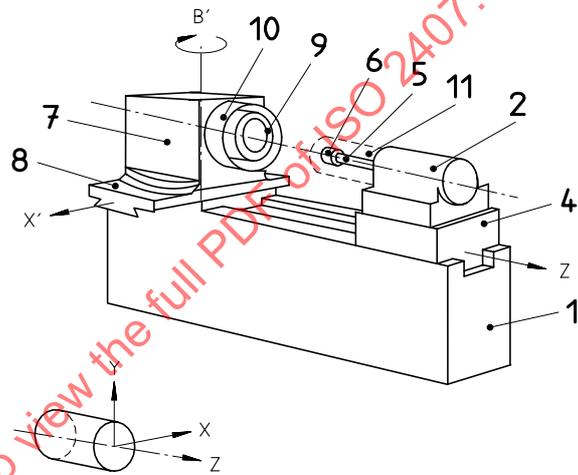


Figure 2

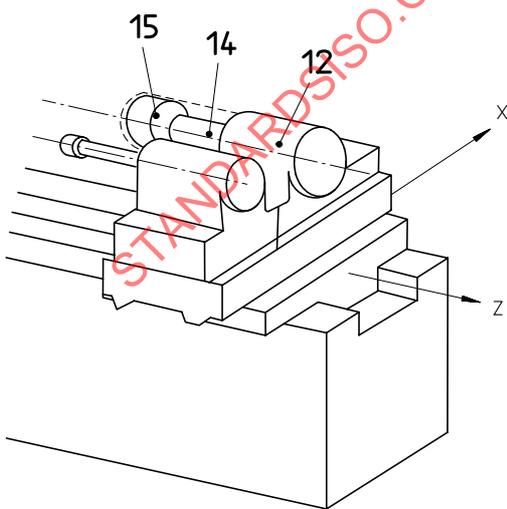


Figure 3

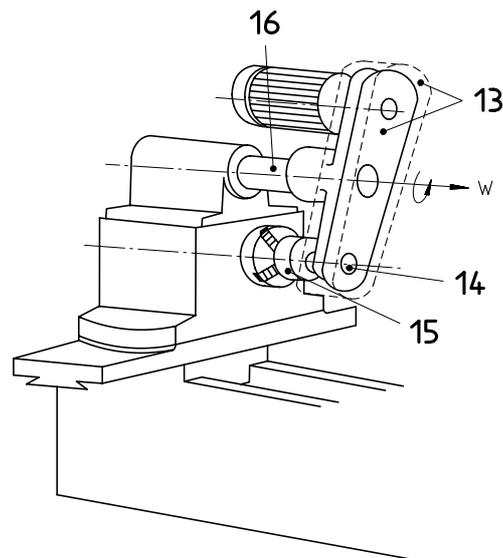


Figure 4

Table 1 — Terminology

Ref.	English	French
1	Bed	Banc
2	Wheelhead	Poupée porte-meule
3	Wheelhead cross slide	Chariot transversal de poupée porte-meule
4	Wheelhead carriage	Chariot de poupée porte-meule
5	Wheel spindle	Broche porte-meule
6	Internal grinding wheel	Meule intérieure
7	Workhead (swivelling)	Poupée porte-pièce (pivotante)
8	Workhead cross slide	Chariot transversal de poupée porte-pièce
9	Workpiece holder	Porte-pièce
10	Workpiece guard	Protecteur de la pièce
11	Wheel guard	Carter de meule
12	Facing wheelhead	Poupée porte-meule à surfacer
13	Swivel arm (with drive and guard)	Bras pivotant (avec dispositif d'entraînement et protecteur)
14	Facing spindle	Broche porte-meule à surfacer
15	Facing wheel	Meule à surfacer
16	Facing wheel quill	Coulant de meule à surfacer

4 Preliminary remarks

4.1 Measuring units

In this International Standard, all linear dimensions, deviations and corresponding tolerances are expressed in millimeters; angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerances are expressed in ratios 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 International Standard, 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 International Standard 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 International Standard. 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 International Standard for the acceptance tests, without specifying the tests to be carried out, and without agreement on the relevant expenses, cannot be considered as binding for any contracting party.

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 millimeters 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 establishing the tolerance for a measuring length different from that given in this International Standard (see 2.311 of ISO 230-1:1996), it shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

4.8 Diagrams

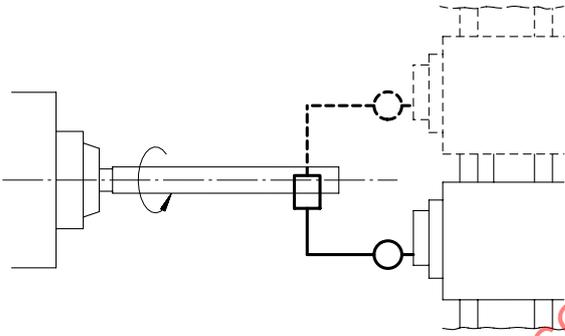
For reasons of simplicity, the diagrams in clauses 5 and 6 of this International Standard illustrate only one type of machine.

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5 Geometric tests

5.1 Linear axes motions

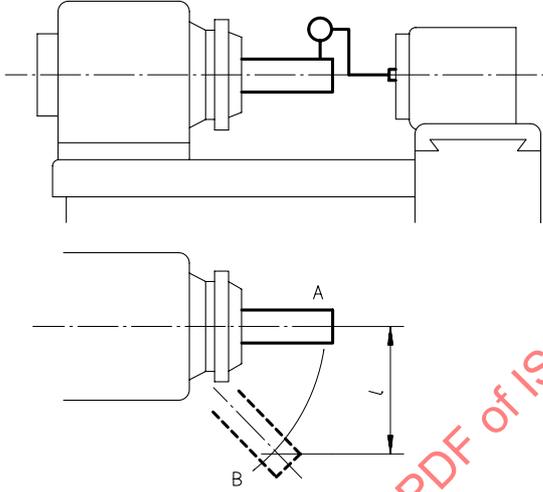
Object		G1
<p>Checking of straightness of the wheelhead (or workhead) slide movement along the Z-axis:</p> <p>a) in the vertical plane; b) in the horizontal plane.</p>		
Diagram		
Tolerance		(Measured deviation)
a) 0,015 for a measuring length of 300		a)
b) 0,008 for a measuring length of 300		b)
Measuring instruments		
Straightedge or test mandrel and dial gauge		
Observations and references to ISO 230-1		5.232.1
<p>When a straightedge is used, the dial gauge support shall be placed on a fixed part of the machine, the stylus touching a straightedge laid parallel to the general direction of the longitudinal motion of the table.</p> <p>When a test mandrel is used, the dial gauge support shall be placed on the wheelhead and the test mandrel in the work holding spindle. The check shall be repeated after rotating the spindle through 180°.</p>		

Object	G2
Checking of squareness between the movement of the wheelhead cross slide or workhead cross slide (X-axis) and the Z-axis motion.	
Diagram 	
Tolerance 0,02/300 where 300 is the distance between the two points touched.	(Measured deviation)
Measuring instruments Test mandrel and dial gauge support	
Observations and references to ISO 230-1 5.512.32 Set a test mandrel on the work-holding spindle and adjust the workhead so that the spindle axis is parallel to the Z-axis motion. Fix the dial gauge support on the test mandrel, with the stylus of the dial gauge touching a point of the wheel spindle. Turn the work-holding spindle through 180° and move the X-axis until the stylus again touches the same point. The difference in readings of the dial gauge corresponding to 300 mm displacement gives the deviation from squareness.	

5.2 Work-holding spindle

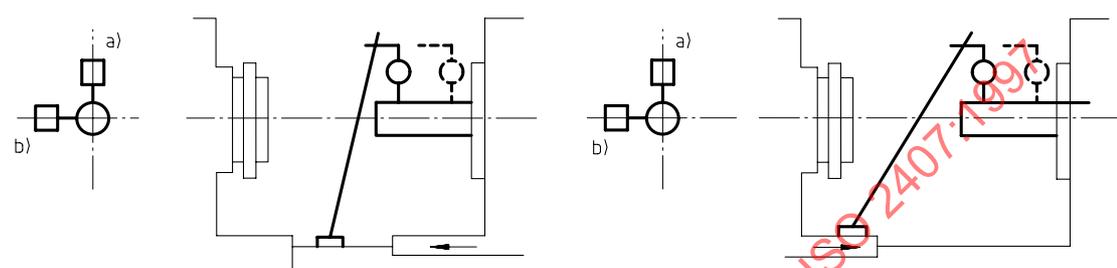
Object		G3
<p>Checking of the work holding spindle rotation:</p> <ul style="list-style-type: none"> a) run-out of the external centering surface; b) periodic axial slip; c) camming of the front resting surface (including periodic axial slip). 		
Diagram		
Tolerance		(Measured deviation)
a) 0,005	b) 0,005	c) 0,01
Measuring instruments		
Dial gauge		
Observations and references to ISO 230-1		
<ul style="list-style-type: none"> a) 5.612.2 In the case of a tapered spindle nose, the stylus of the dial gauge shall be set normal to the surface to be checked. b) 5.622.1 and 5.622.2 c) 5.631 and 5.632 Distance <i>A</i> of the dial gauge from the spindle axis shall be as large as possible. <p>The value and the direction of the axial force <i>F</i> to be applied shall be specified by the supplier/manufacturer.</p> <p>Where preloaded thrust bearings are used, no force need be applied.</p>		

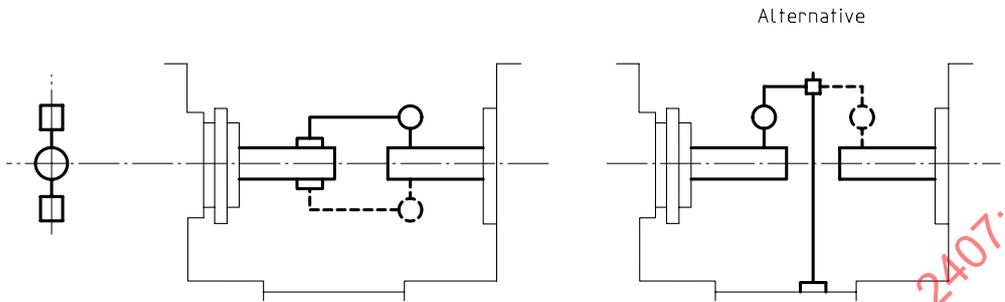
<p>Object</p> <p>Checking of parallelism between the work-holding spindle axis and the Z-axis motion of the wheelhead (or workhead):</p> <p>a) in the vertical plane; b) in the horizontal plane.</p>	<p>G5</p>
<p>Diagram</p>	
<p>Tolerance</p> <p>a) 0,025 for a measuring length of 300 b) 0,01 for a measuring length of 300</p>	<p>(Measured deviation)</p> <p>a) b)</p>
<p>Measuring instruments</p> <p>Test mandrel and dial gauge</p>	
<p>Observations and references to ISO 230-1 5.412.1 and 5.422.3</p> <p>The checking shall be done first at one position of the work-holding spindle and then repeated after rotating the spindle through 180°. Mean values shall be taken at each measuring point in order to evaluate the deviations.</p>	

Object Checking of parallelism between the workhead swivelling plane and the X-axis.	G6
Diagram 	
Tolerance 0,01 for $l = 100$	(Measured deviation)
Measuring instruments Test mandrel and dial gauge	
Observations and references to ISO 230-1 5.432.2 A reading shall be taken when the workhead is locked in position A. Swivel the workhead towards its external position B. Move the cross slide so as to obtain the reading at B.	

5.3 Wheel spindle

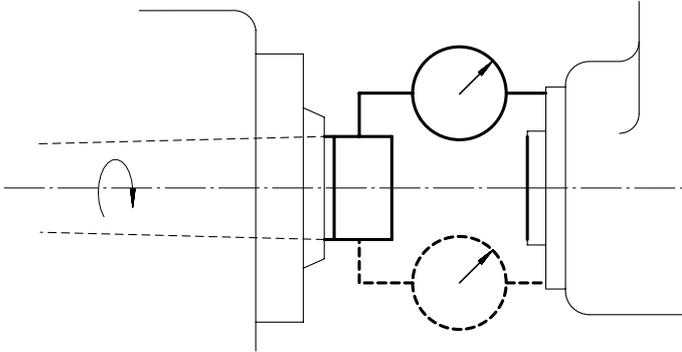
Object		G7
<p>Checking of run-out of internal taper of the wheel spindle (wheel mounting diameter):</p> <p>a) at the outlet of the taper; b) at a distance equal to $D_a/2$ (100 mm minimum and 200 mm maximum).</p> <p>Where D_a is the maximum admissible workpiece diameter.</p>		
Diagram		
Tolerance		(Measured deviation)
a) 0,005	b) 0,01 for a measuring length of 200	a) b)
Measuring instruments		
Test mandrel according to the type of spindle nose and dial gauge		
Observations and references to ISO 230-1		5.612.3
<p>In the case of an internal taper, the test will be made with the aid of a mandrel.</p> <p>In the case of an internal cylindrical centering register, the test will be made with the aid of the dial gauge and without using a test mandrel. In this case, the value of a) will be taken as the tolerance.</p> <p>NOTE — When distance $D_a/2 \neq 200$ mm, the tolerance, T, of b) is determined by the following formula:</p> $T = 0,005 + \frac{0,010 - 0,005}{200} \times \frac{D_a}{2}$		

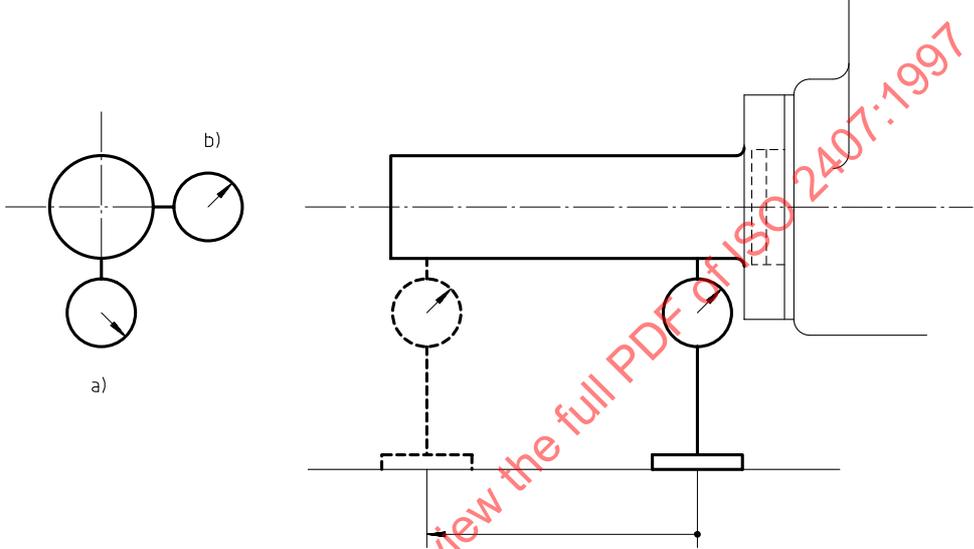
Object	G8
<p>Checking of parallelism between the wheel spindle axis and the Z-axis motion of the wheelhead (or workhead):</p> <p>a) in the vertical plane; b) in the horizontal plane.</p>	
Diagram 	
Tolerance <p>a) 0,02 for a measuring length of 300 b) 0,01 for a measuring length of 300</p>	(Measured deviation) <p>a) b)</p>
Measuring instruments <p>Test mandrel and dial gauge</p>	
Observations and references to ISO 230-1 <p style="text-align: right;">5.412.1 and 5.422.3</p> <p>The checking shall be done first at one position of the wheel spindle and then repeated after rotating the spindle through 180°. Mean values shall be taken at each measuring point in order to evaluate the deviations.</p>	

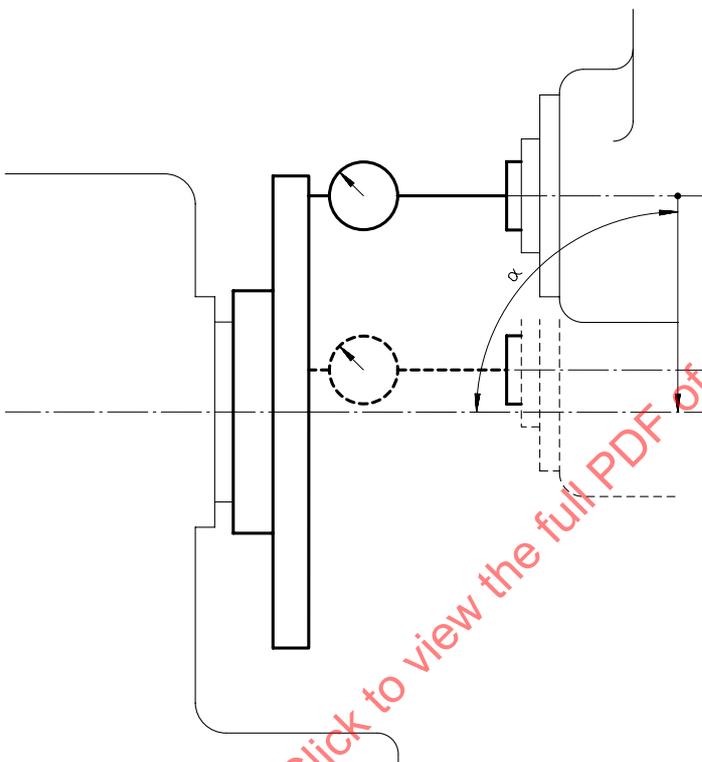
<p>Object</p>	<p>G9</p>
<p>Checking of the equidistance (difference in height) of the work spindle axis and the grinding spindle axis in the vertical plane.</p>	
<p>Diagram</p>  <p style="text-align: center;">Alternative</p>	
<p>Tolerance</p> <p style="text-align: center;">0,025</p>	<p style="text-align: center;">(Measured deviation)</p>
<p>Measuring instruments</p> <p>Dial gauge and dial gauge support or special rest</p>	
<p>Observations and references to ISO 230-1 5.432.1</p> <p>The test shall be carried out in the vertical plane after having obtained alignment in the horizontal plane.</p> <p>In the alternative case, the test can be carried out with the dial gauge support set directly on the reference ZX plane (composed of X and Z axes motions), which may be the surface of the slideways provided they are flat.</p>	

5.4 Facing wheelhead

Object			G10
Checking of the facing spindle: <ol style="list-style-type: none"> a) run-out of the external centering surface; b) periodic axial slip; c) camming of the front resting surface (including periodic axial slip). 			
Diagram			
Tolerance			(Measured deviation)
a) 0,005	b) 0,005	c) 0,01	a) b) c)
Measuring instruments			
Dial gauge			
Observations and references to ISO 230-1			
a) 5.612.1 and 5.612.2 In the case of a tapered spindle nose, the stylus of the dial gauge shall be set normal to the surface to be checked.			
b) 5.622.1 and 5.622.2			
c) 5.631 and 5.632 The distance A of the dial gauge from the spindle axis shall be as large as possible.			
The value and the direction of the axial force F to be applied shall be specified by the supplier/manufacturer.			
When preloaded thrust bearings are used, no force need be applied.			

<p>Object</p>	<p>G11</p>
<p>Checking of squareness between the flange face of the facing spindle and the work-holding spindle axis.</p>	
<p>Diagram</p> 	
<p>Tolerance</p> <p style="text-align: center;">0,02/300</p> <p>where 300 is the distance between the two points touched.</p>	<p>(Measured deviation)</p>
<p>Measuring instruments</p> <p>Dial gauge and special support</p>	
<p>Observations and references to ISO 230-1</p> <p style="text-align: right;">5.512.1 and 5.512.42</p>	

<p>Object</p> <p>Checking of parallelism between the facing spindle axis and the Z-axis motion (of the wheelhead or workhead):</p> <p>a) in the vertical plane; b) in the horizontal plane.</p>	<p>G12</p>
<p>Diagram</p> 	
<p>Tolerance</p> <p>a) 0,02 for a measuring length of 300 (test mandrel end directed upwards)</p> <p>b) 0,01 for a measuring length of 300</p>	<p>(Measured deviation)</p> <p>a)</p> <p>b)</p>
<p>Measuring instruments</p> <p>Dial gauge and special support</p>	
<p>Observations and references to ISO 230-1 5.412.1 and 5.422.3</p> <p>The checking shall be done first at one position of the facing spindle and then repeated after rotating the spindle through 180°. Mean values shall be taken at each measuring point in order to evaluate the deviations.</p>	

<p>Object</p>	<p>G13</p>
<p>Checking of squareness between the swivelling movement of the facing wheelhead and the work holding spindle axis.</p>	
<p>Diagram</p>  <p>The diagram illustrates the measurement setup. A dial gauge is used to measure the squareness of the facing wheelhead's swivelling movement relative to the work holding spindle axis. A flat disc or straightedge is used as a reference surface. The angle α is shown between the spindle axis and the reference surface.</p>	
<p>Tolerance</p> <p>0,01 for a measuring length of 300 with $\alpha \geq 90^\circ$</p>	<p>(Measured deviation)</p>
<p>Measuring instruments</p> <p>Dial gauge and flat disc or straightedge</p>	
<p>Observations and references to ISO 230-1</p>	<p>5.522.3</p>