INTERNATIONAL STANDARD

ISO 1984-1

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Test conditions for manually controlled milling machines with table of fixed height — Testing of the accuracy —

Part 1: Machines with horizontal spindle

Conditions d'essai des machines à fraiser à table de hauteur fixe à commande manuelle — Contrôle de la précision —

Partie 1: Machines à broche horizontale

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Foreword

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

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

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

Attention is drawn to the possibility that some of the elements of this part of ISO 1984 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 1984-1 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

This first edition of ISO 1984-1, together with ISO 1984-2, cancels and replaces ISO 1984:1982 and ISO 1984-0:1984, of which they constitute a technical revision.

ISO 1984 consists of the following parts, under the general title *Test conditions for manually controlled milling machines with table of fixed height — Testing of the accuracy*:

— *Part 1: Machines with horizontal spindle*

— *Part 2: Machines with vertical spindle*

Test conditions for manually controlled milling machines with table of fixed height — Testing of the accuracy —

Part 1: Machines with horizontal spindle

1 Scope

This part of ISO 1984 specifies, with reference to ISO 230-1, both geometric and machining tests on general purpose and normal-accuracy milling machines with table of fixed height and with a horizontal spindle. It also specifies the applicable tolerances corresponding to the above-mentioned tests.

This part of ISO 1984 deals only with the verification of the geometric accuracy of the machine. It does not apply to the testing of the machine operation (vibrations, abnormal noises, stick-slip motion of components, etc.), nor to the checking of its characteristics (speeds, feeds, etc.), which should generally be checked before testing accuracy.

This part of ISO 1984 defines the terminology used for the principal elements of the machine and indicates the designation of axes in accordance with ISO 841[1].

NOTE Numerically controlled milling machines are covered by ISO 10791-1[2].

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 1984. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 1984 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

3 Terminology, designation of axes and machining operations carried out

3.1 Terminology and designation of axes

See Figure 1 and Table 1.

3.2 Machining operations carried out

See Figure 2.

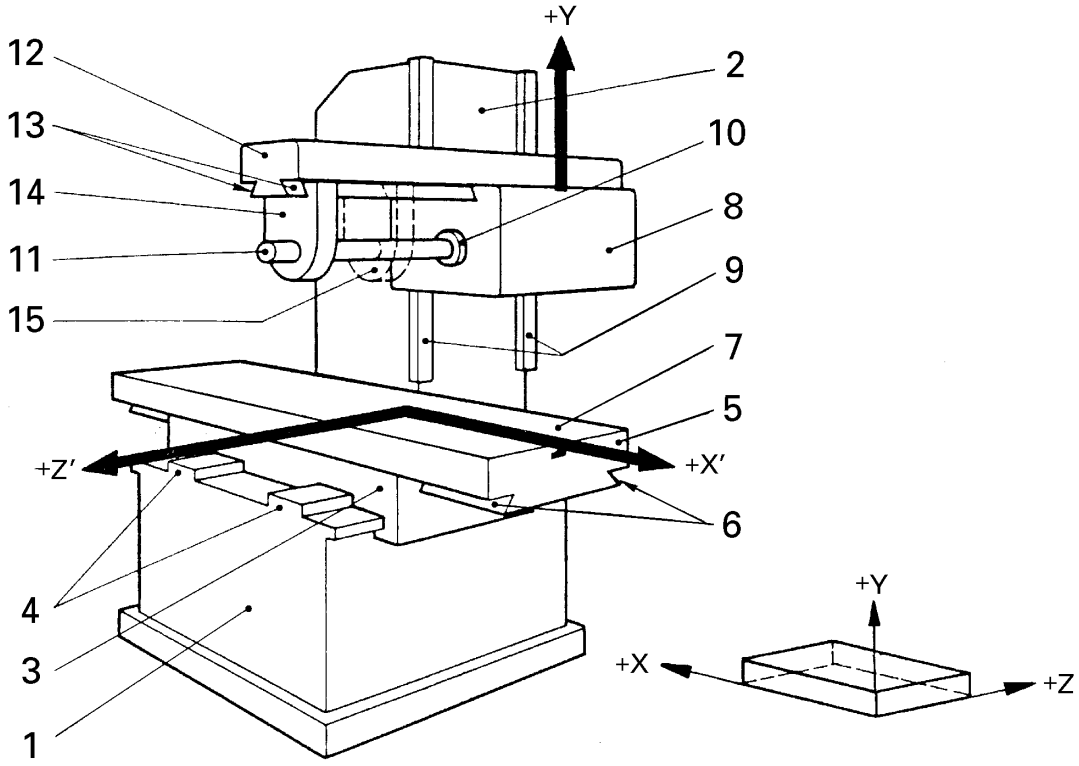
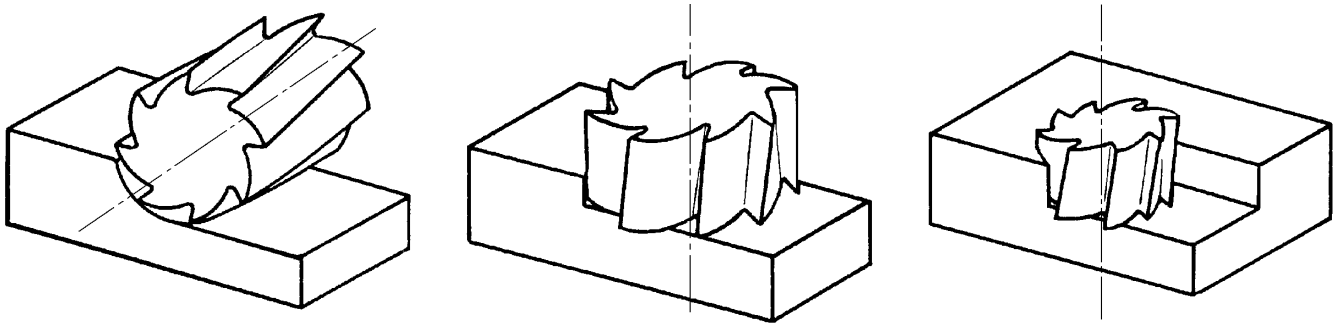


Figure 1 — Machine with horizontal spindle

Table 1 — Terminology

Reference	English	French
1	Bed	Banc
2	Column	Montant
3	Saddle/cross-slide	Selle/chariot transversal
4	Saddle slideways	Glissières de table
5	Table	Table
6	Table slideways	Glissières de la table
7	Table surface	Surface de fixation
8	Spindle head	Poupée porte-broche
9	Spindle head slideways	Glissières de poupée porte-broche
10	Spindle nose	Nez de broche
11	Arbor	Arbre porte-fraise
12	Overarm	Bras-support
13	Overarm slideways	Glissières du bras support
14	Front arbor support	Lunette avant
15	Rear arbor support	Lunette arrière



a) Slab milling b) Face milling c) End milling

Figure 2 — Milling operations

4 Preliminary remarks

4.1 Measuring units

In this part of ISO 1984, 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 as the primary method, but in some cases microradians or arc seconds may be used for clarification purposes. The equivalence of the following expressions should always be kept in mind:

$0{,}010/1000 = 10\ \mu\text{rad} \approx 2''$

4.2 Reference to ISO 230-1

To apply this part of ISO 1984, reference shall be made to ISO 230-1, especially for the installation of the machine before testing, warming up of the spindle and other moving components, description of measuring methods and recommended accuracy of testing equipment.

In the "Observations" block of the tests described in clauses 5 and 6, the instructions are preceded by a reference to the corresponding clause in ISO 230-1 in cases where the test concerned is in compliance with the specifications of ISO 230-1.

4.3 Testing sequence

The sequence in which the tests are presented in this part of ISO 1984 in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests may be performed in any order.

4.4 Tests to be performed

When testing a machine, it is not always necessary nor possible to carry out all the tests described in this part of ISO 1984. 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.

4.5 Measuring instruments

The measuring instruments indicated in the tests described in clauses 5 and 6 are examples only. Other instruments measuring the same quantities and having at least the same accuracy may be used. Dial gauges shall have a resolution of 0,001 mm.

4.6 Machining test

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

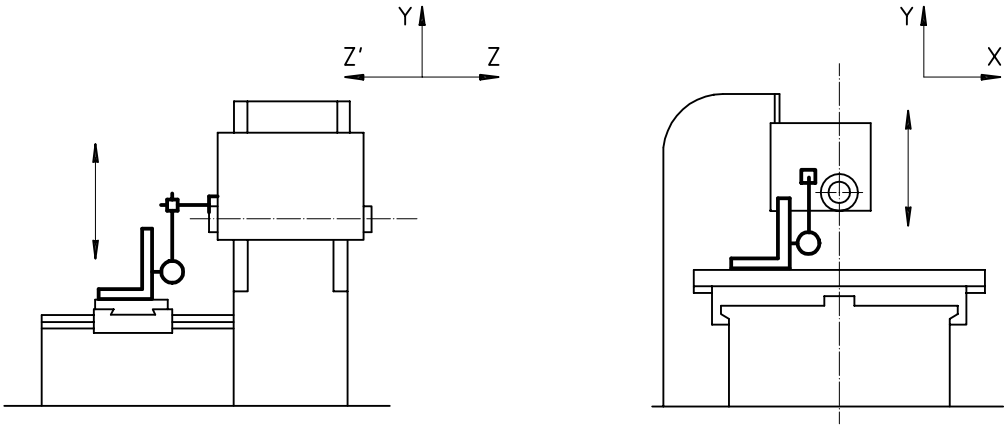
When establishing the tolerance for a measuring length different from that given in this part of ISO 1984 (see 2.311 of ISO 230-1:1996), it shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

5 Geometric tests

5.1 Axes of motion

Object	**G1**
Checking of straightness of the vertical movement of the spindle-head slide (Y-axis): a) in the YZ-plane (EZY); b) in the XY-plane (EXY).	

Diagram



a) **b)**

Tolerance	**Measured deviation**
For a) and b) 0,025 for a measuring length of 300	a) b)

Measuring instruments

Dial gauge and square.

Observations and references to ISO 230-1:1996 5.232.11

Adjust the square to obtain similar readings at both ends of its measuring length.

Table in central position:

a) cross-slide (Z'-axis) or spindle head (Z-axis) locked;

b) table (X-axis) locked.

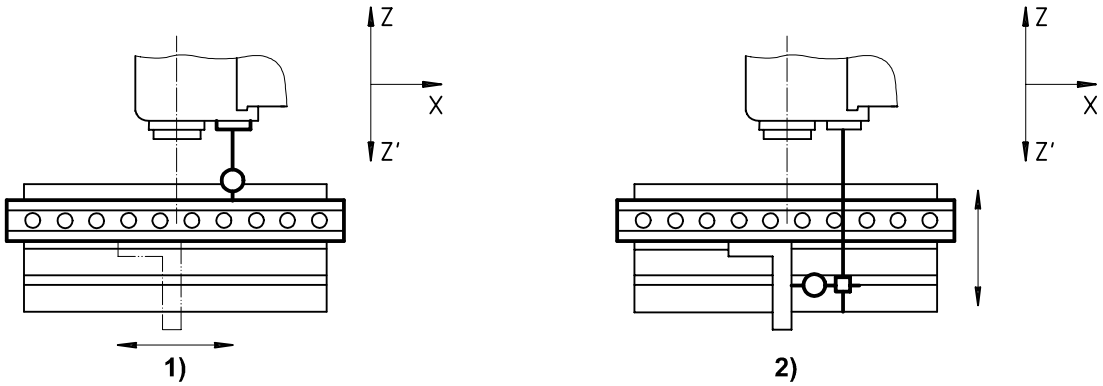
If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge shall be placed on a fixed part of the spindle head.

Object

Checking of squareness between the transverse cross-slide movement (Z'-axis), or the spindle head movement (Z-axis), and the longitudinal table movement (X-axis).

G2

Diagram



Tolerance	**Measured deviation**
0,02 for a measuring length of 300	

Measuring instruments

Straightedge, dial gauge and square

Observations and references to ISO 230-1:1996 5.522.4

Spindle-head slide (Y-axis) locked.

1) The straightedge shall be set parallel to the longitudinal table movement (X-axis); then the square shall be placed against the straightedge. The table shall then be locked in the central position. This test can also be performed without the straightedge, aligning the long arm of the square parallel to the X-axis.

2) The transverse cross-slide movement (Z'-axis), or the spindle-head movement (Z-axis) shall then be checked.

If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge shall be placed on a fixed part of the spindle head.

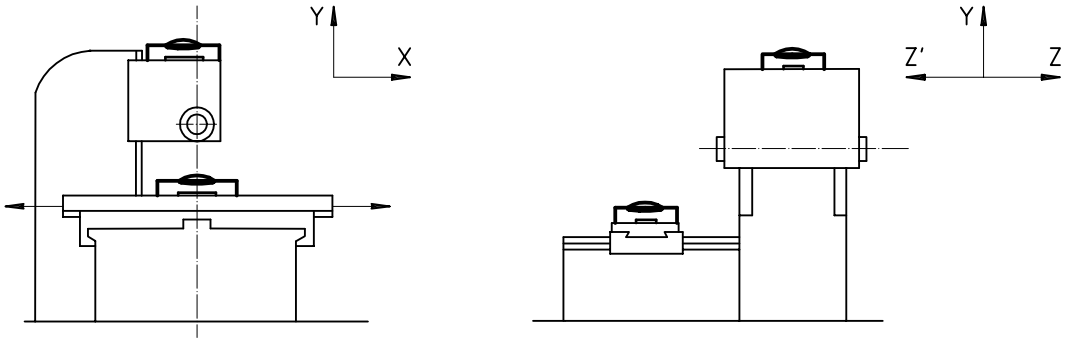
Object **G3**

Checking of angular deviation of the table in its longitudinal movement (X-axis):

a) in the vertical XY-plane (pitch ECX);

b) in the vertical YZ-plane (roll EAX).

Diagram



a) b)

Tolerance

a) $X \leqslant 1\,000$ 0,06/1 000 (or 60 μrad or 12 '')

$X > 1\,000$ 0,10/1 000 (or 100 μrad or 20 '')

b) 0,03/1 000 (or 30 μrad or 6 '')

Measured deviation

For X = . . .

a)

b)

Measuring instruments

Precision level

Observations and references to ISO 230-1:1996

The level shall be placed in the centre of the table:

a) longitudinally;

b) transversely.

When the 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.

The reference level (when used) shall be located on the column or the spindle head and the spindle head shall be in the middle of its travel range.

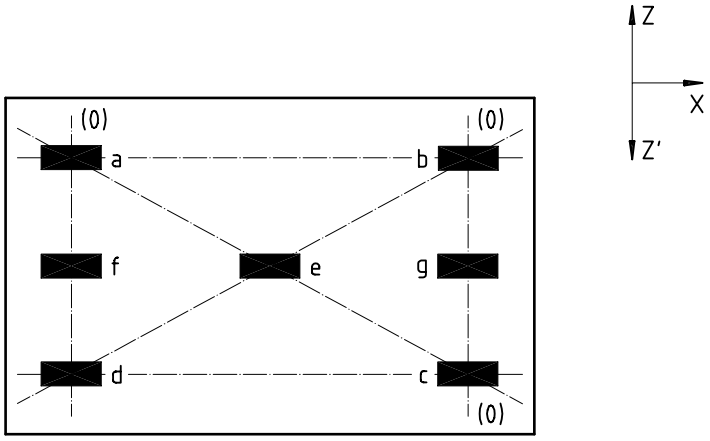
Measurements shall be taken at a number of positions equally spaced (200 mm or 250 mm) along the travel direction.

The difference between the maximum and the minimum readings of both directions of movement shall not exceed the tolerance.

5.2 Table

Object	**G4**
Checking of flatness of the table surface.	

Diagram



Tolerance	**Measured deviation**
0,04 up to 1 000 concave only For each 1 000 mm increase in table length, add 0,005 to the preceding tolerance Maximum tolerance: 0,05 Local tolerance: 0,02 for any measuring length of 300	

Measuring instruments

Precision level or straightedge and gauge blocks

Observations and references to ISO 230-1:1996 5.322 and 5.323

Table (X-axis) and cross-slide (Z'-axis) or spindle head (Z-axis) in central position, table not locked, cross-slide locked.

NOTE The alphabetical references on the diagram correspond to those used in Figure 28 of ISO 230-1:1996.

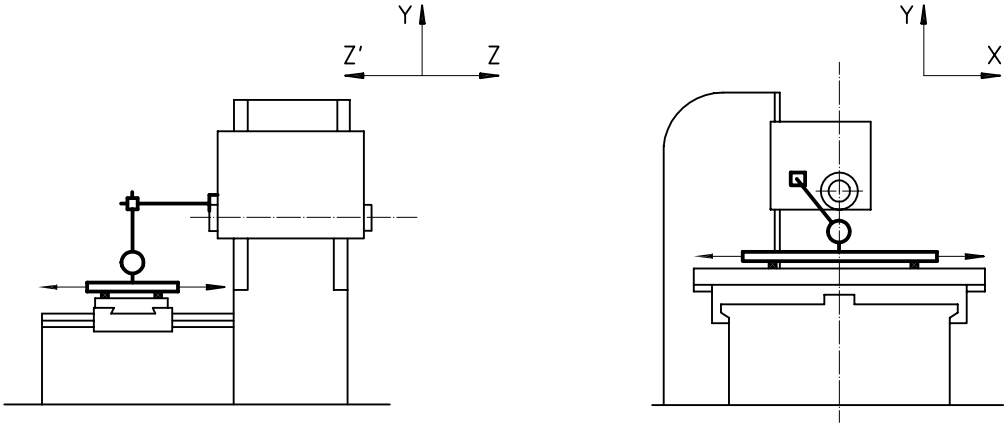
Object **G5**

Checking of parallelism between the table surface and

a) the transverse cross-slide movement (Z'-axis), or the spindle-head movement (Z-axis), in the vertical YZ-plane;

b) its longitudinal movement (X-axis), in the vertical XY-plane.

Diagram



a) **b)**

Tolerance	**Measured deviation**
For a) and b) 0,025 for a measuring length of 300 Maximum tolerance: 0,05	a) b)

Measuring instruments

Straightedge and dial gauge

Observations and references to ISO 230-1:1996 5.422.21

The stylus of the dial gauge shall be placed approximately at the working position of the tool.

The measurement may be made on a straightedge laid parallel to the table surface.

If the table length is greater than 1 600 mm, carry out the inspection by successive movements of the straightedge.

Spindle-head slideways (Y-axis) locked;

a) table (X-axis) locked,

b) cross-slide (Z'-axis) or spindle head (Z-axis) locked.

If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge shall be placed on a fixed part of the spindle head.

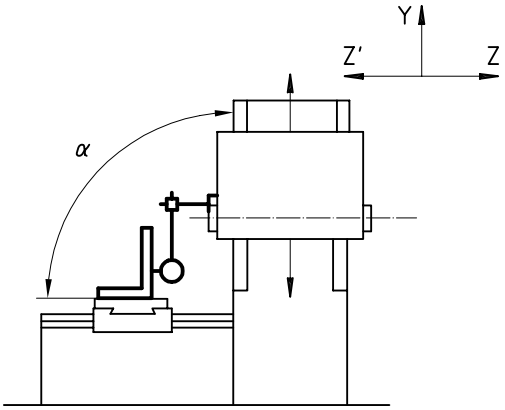
Object **G6**

Checking of squareness between the table surface and the vertical movement of the spindle-head slide (Y-axis):

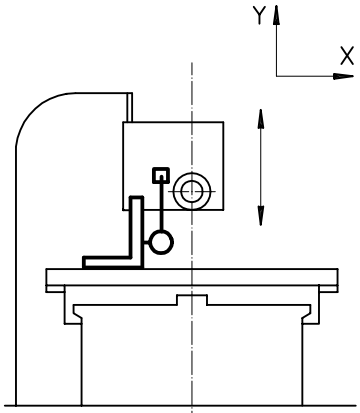
a) in the YZ-plane;

b) in the XY-plane.

Diagram



a)



b)

Tolerance	**Measured deviation**
a) 0,025 for a measuring length of 300 with $\alpha \leqslant 90^{o}$	a)
b) 0,025 for a measuring length of 300	b)

Measuring instruments

Dial gauge and square

Observations and references to ISO 230-1:1996 5.522.2

Table in central position:

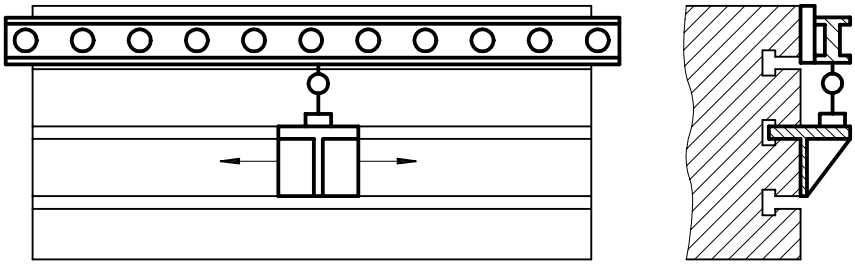
a) cross-slide (Z'-axis) or spindle head (Z-axis) locked;

b) table (X-axis) locked.

If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge shall be placed on a fixed part of the spindle head.

Object	**G7**
Checking of straightness of the median or reference T-slot of the table.	

Diagram



Tolerance	**Measured deviation**
0,01 for a measuring length of 500 Maximum tolerance: 0,03	

Measuring instruments

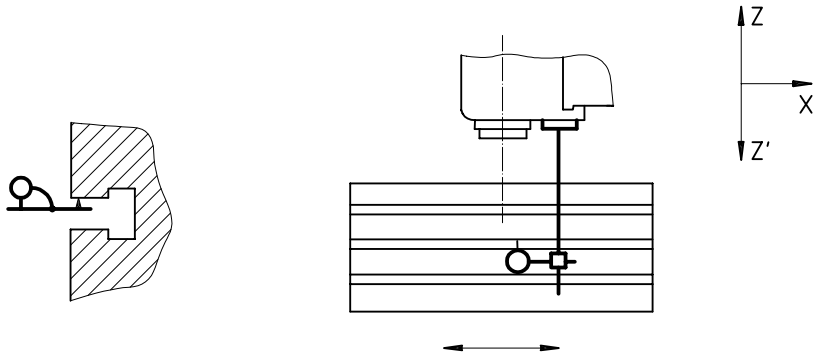
Straightedge and dial gauge

Observations and references to ISO 230-1:1996 5.212, 5.212.1, 5.212.3 or 5.232

The straightedge may be placed directly on the table.

Object	**G8**
Checking of parallelism between the median or reference T-slot and the longitudinal movement of the table (X-axis).	

Diagram



Tolerance	**Measured deviation**
0,015 for a measuring length of 300 Maximum tolerance: 0,04	

Measuring instruments

Dial gauge.

Observations and references to ISO 230-1:1996 5.422.1 and 5.422.21

Cross-slide (Z'-axis) or spindle head (Z-axis) and spindle-head slide (Y-axis) locked.

If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge shall be placed on a fixed part of the spindle head.

5.3 Spindle

Object **G9**

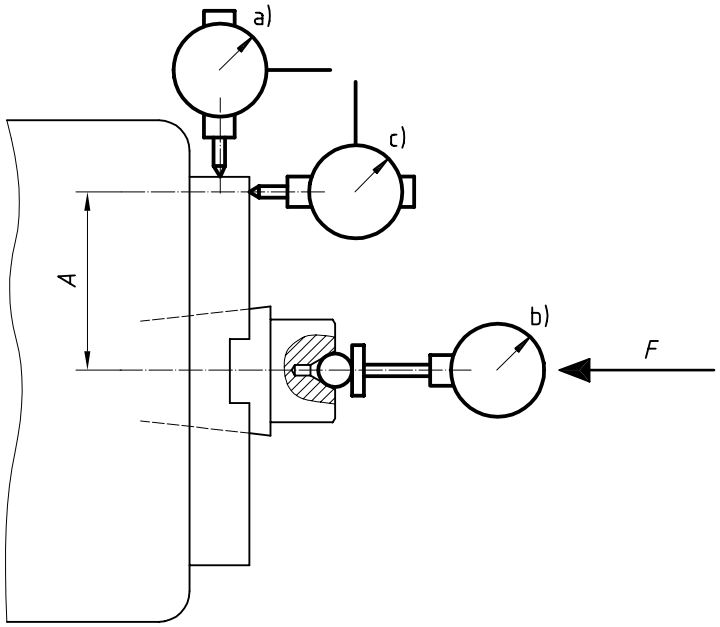
Checking of

a) run-out of the external centring surface on the spindle nose (for machines having this feature),

b) periodic axial slip,

c) camming of the face of the spindle nose (including periodic axial slip).

Diagram



Tolerance			**Measured deviation**
a) 0,01	b) 0,01	c) 0,02	a) b) c)

Measuring instruments

Dial gauge.

Observations and references to ISO 230-1:1996

a) 5.612.2.

b) 5.622.1 and 5.622.2

A force F, specified by the supplier/manufacturer of the machine, can be exerted by pressing towards the housing for tests b) and c).

c) 5.632

The distance A of dial gauge from the spindle axis shall be as large as possible.

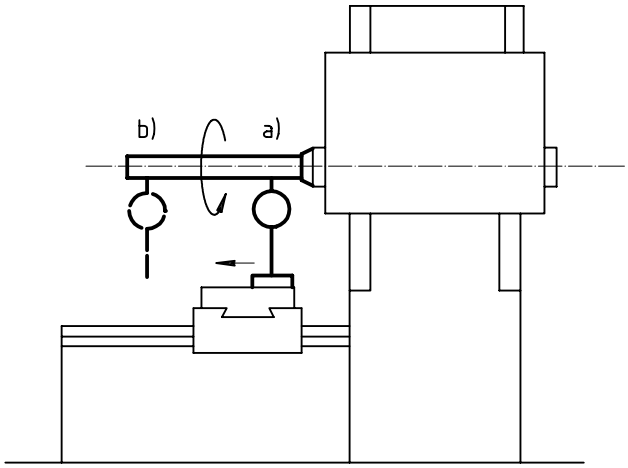
Object **G10**

Checking of run-out of the internal taper of the spindle:

a) at the spindle nose;

b) at a distance of 300 mm from the spindle nose.

Diagram



Tolerance	**Measured deviation**
a) 0,01 b) 0,02	a) b)

Measuring instruments

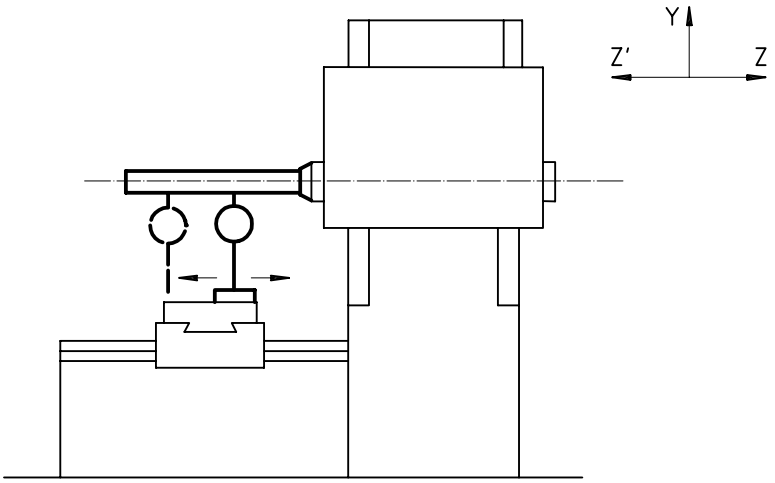
Dial gauge and test mandrel.

Observations and references to ISO 230-1:1996 5.612.3

Object **G11**

Checking of parallelism between the spindle axis and the table surface.

Diagram



Tolerance	**Measured deviation**
0,025 for a measuring length of 300 (free end of the test mandrel inclined downwards)	

Measuring instruments

Dial gauge and test mandrel.

Observations and references to ISO 230-1:1996 5.412.4

Table (X-axis) and cross-slide (Z'-axis) or spindle head (Z-axis) not locked, spindle-head slide (Y-axis) locked.

The measurement shall be repeated after rotating the test mandrel through 180°.

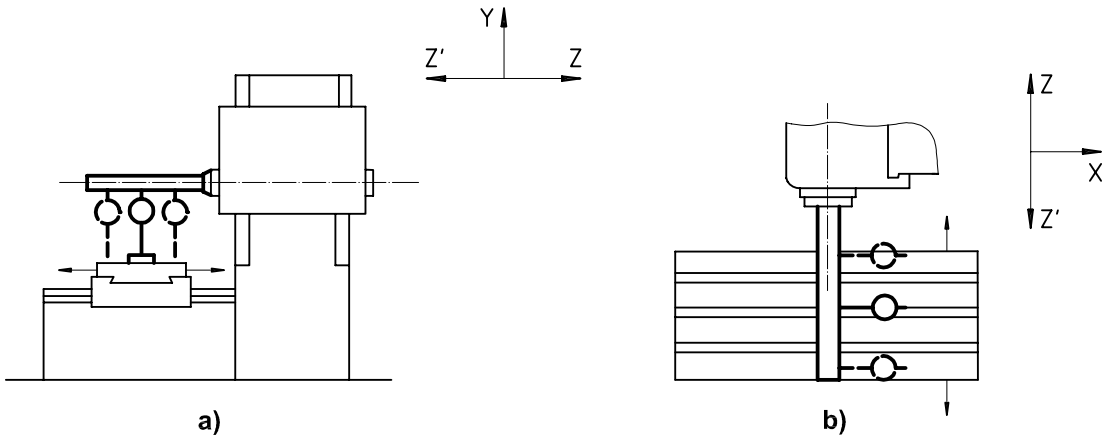
Object	**G12**

Checking of parallelism between the spindle axis and the transverse cross-slide movement (Z'-axis), or the spindle-head movement (Z-axis):

a) in the vertical YZ-plane;

b) in the horizontal ZX-plane.

Diagram



a) **b)**

Tolerance	**Measured deviation**
a) 0,025 for a measuring length of 300 (free end of the test mandrel inclined downward)	a)
b) 0,025 for a measuring length of 300	b)

Measuring instruments

Dial gauge and test mandrel

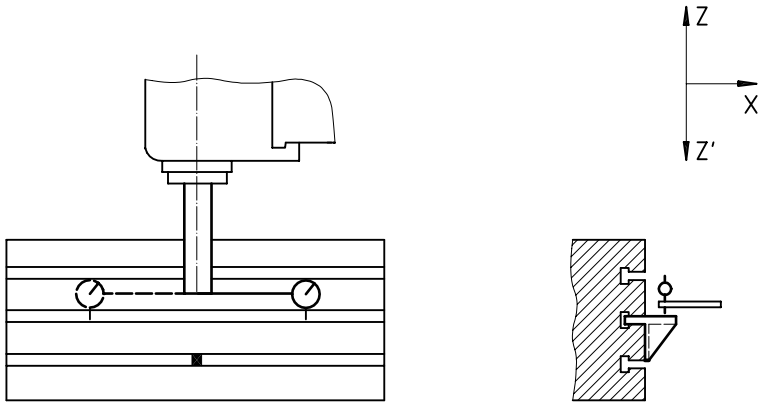
Observations and references to ISO 230-1:1996 5.422.3

Table (X-axis) in central position.

Spindle head slide (Y-axis) locked.

Object	**G13**
Checking of squareness between the spindle axis and the median or reference T-slot of the table.	

Diagram



Tolerance	**Measured deviation**
0,02/300[a]	

[a] Distance between the two points touched.

Measuring instruments

Dial gauge.

Observations and references to ISO 230-1:1996 5.512.1 and 5.512

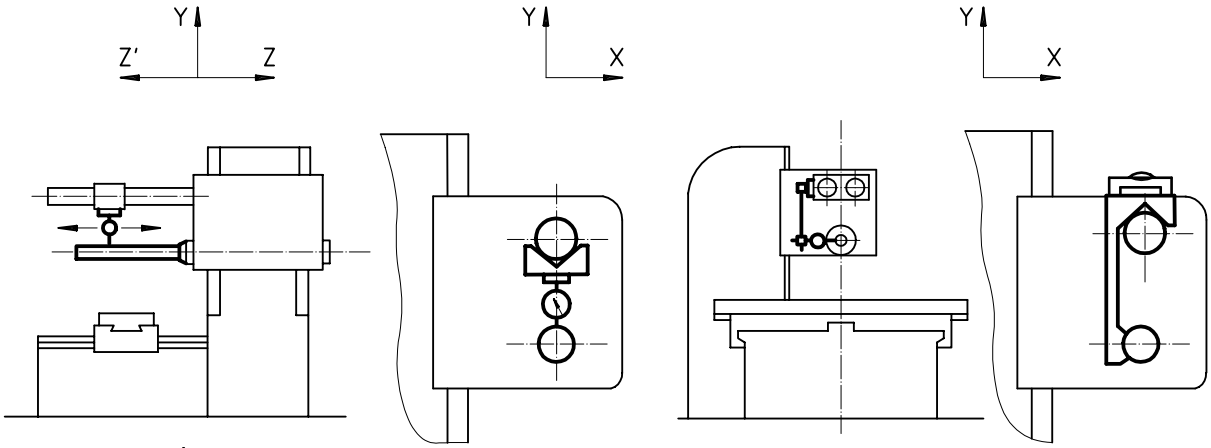
Table (X-axis) in central position.

Table (X-axis), cross-slide (Z'-axis) or spindle head (Z-axis) and spindle head (Y-axis) locked.

5.4 Arbor Support

Object	**G14**
Checking of parallelism between the arbor support guide on the over arm(s) and the spindle axis: a) in the vertical YZ-plane; b) in the horizontal ZX-plane.	

Diagram



a) b)

Tolerance	**Measured deviation**
a) 0,02 for a measuring length of 300 (over arm inclined downwards)	a)
b) 0,02 for a measuring length of 300	b)

Measuring instruments

Dial gauge or precision level.

Observations and references to ISO 230-1:1996 5.412.5 or 5.412.3 and 5.412.1 5.422.4

Over arm(s) locked.

Object

G14

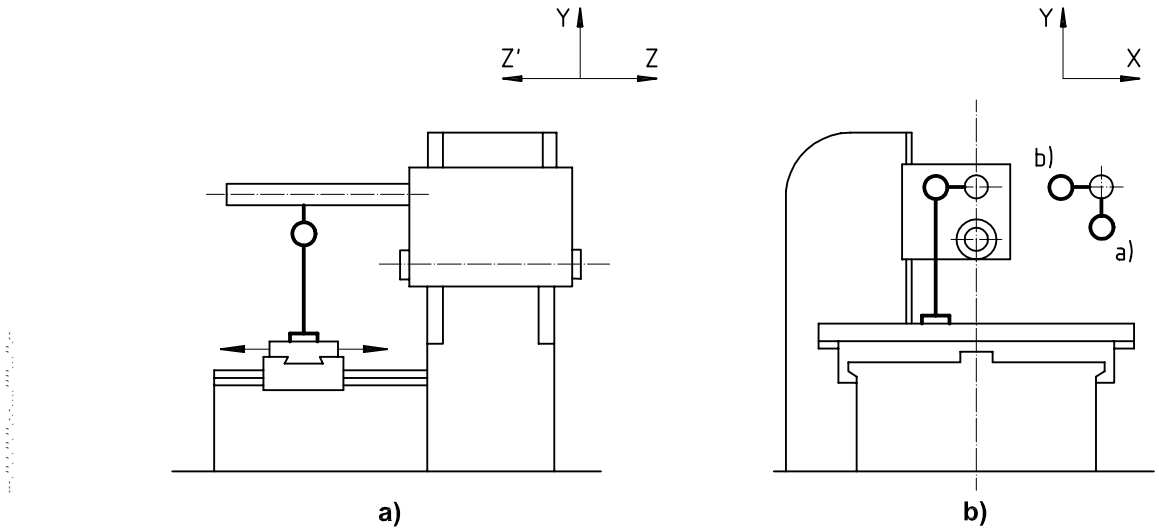
Alternative

Checking of parallelism between the arbor support guide on the over arm(s) and the transverse cross-slide movement (Z'-axis), or the spindle-head movement (Z-axis):

a) in the vertical YZ-plane;

b) in the horizontal ZX-plane.

Diagram



a) b)

Tolerance	**Measured deviation**
a) 0,02 for a measuring length of 300 (over arm inclined downwards)	a)
b) 0,02 for a measuring length of 300	b)

Measuring instruments

Dial gauge or precision level.

Observations and references to ISO 230-1:1996 5.412.5 or 5.412.3 and 5.412.1 5.422.4

Over arm(s) locked.

Object **G15**

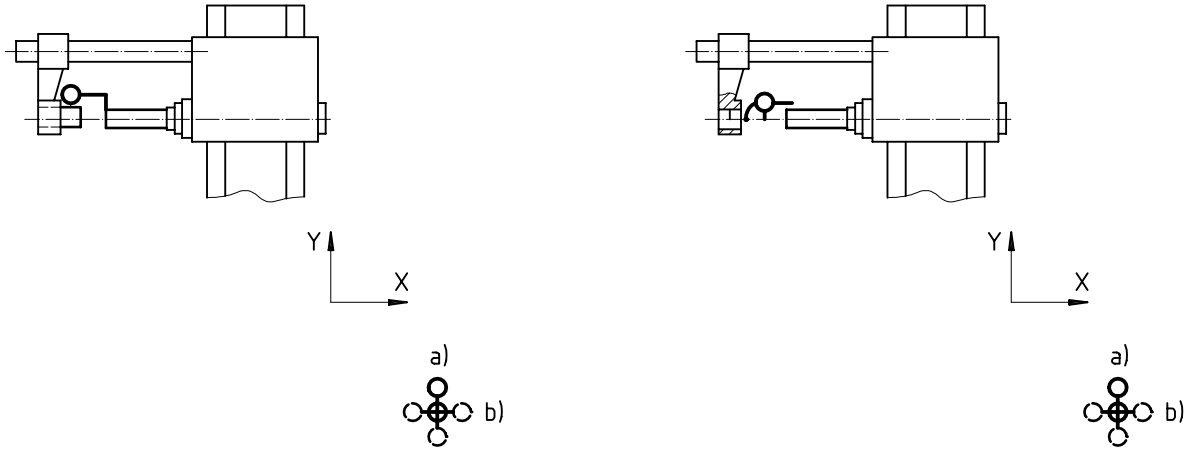
Checking of coincidence of the axis of the bore of the arbor support with the spindle axis:

a) in the vertical YZ-plane;

b) in the horizontal ZX-plane.

Diagram

1) First method **2) Alternative**



Tolerance	**Measured deviation**
a) 0,03(axis of the bore of the arbor support lower than the spindle axis)	a)
b) 0,03	b)

Measuring instruments

Dial gauge and test mandrel.

Observations and references to ISO 230-1:1996 5.442

Arbor support located 300 mm away from the spindle nose.

The measurement shall be made:

1) in the case of the first method, as close as possible to the arbor support;

2) in the case of the alternative, close to the middle of the arbor support bore.

The reading on the dial gauge shall be divided by 2 to be compared with the tolerance.

Object

G15

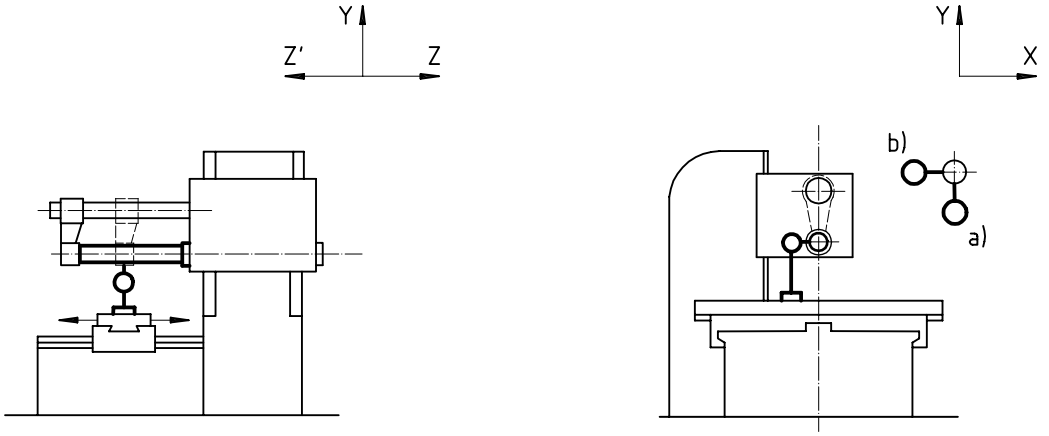
Alternative

Checking the coincidence of the axis of the bore of the arbor support with the spindle axis (parallelism between the supported arbor and the transverse cross slide movement (Z'-axis), or the spindle head movement (Z-axis):

a) in the vertical YZ-plane;

b) in the horizontal ZX-plane.

Diagram



a) **b)**

Tolerance	**Measured deviation**
a) 0,04 for a measuring length of 300 (mandrel inclined downward on the side of the bore of the arbor support) b) 0,025 for a measuring length of 300	a) b)

Measuring instruments

Dial gauge and test mandrel.

Observations and references to ISO 230-1

a) The end of the mandrel or cutter arbor is held by the arbor support.

b) The arbor support is positioned midway along the mandrel or cutter arbor.

The reading on the dial gauge shall not be divided by 2.

6 Machining Test

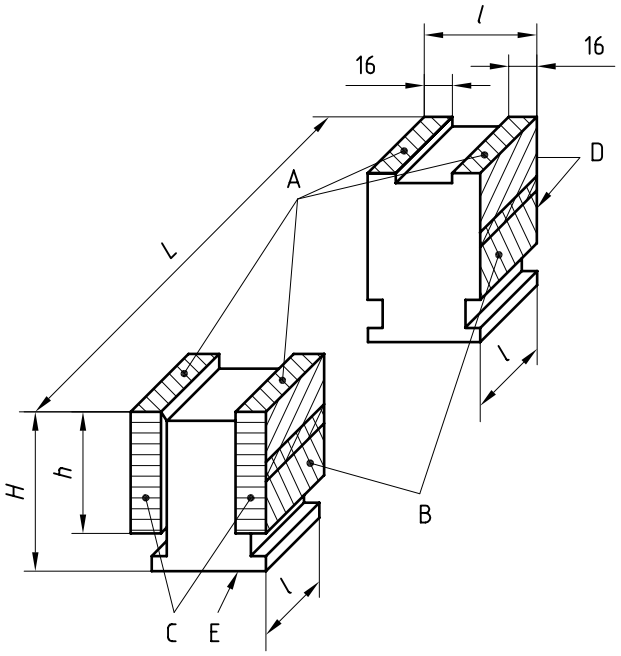
Object **M1**

a) Milling of surface B by automatic longitudinal movement of the table and manual vertical movement of the spindle-head slide, in two cuts over-lapping by about 5 mm to 10 mm.

b) Milling of surfaces A, C and D by automatic longitudinal movement of the table, automatic vertical movement of the spindle-head slide and manual transverse movement of the cross-slide.

Diagram

Dimensions in millimetres



L is the length of the test piece or distance between the opposite faces of two test pieces, and is equal to 1/2 longitudinal travel.

l is equal to h, and corresponds to 1/8 longitudinal travel.

l_{max} is 100 mm for $L \leqslant 500$ mm

is 150 mm for 500 mm $< L \leqslant$ 1000 mm

is 200 mm for $L >$ 1000 mm

l_{min} is 50 mm

NOTE 1 Longitudinal travels $\geqslant$ 400 mm; one or two test pieces, machined in the longitudinal direction over a length l at each end, can be used.

NOTE 2 Longitudinal travels $<$ 400 mm: one test piece, machined over its entire length, shall be used.

NOTE 3 Material: cast iron.

Tolerance	**Measured deviation**
a) Surface B on each block shall be flat within 0,02.	a)
b_1) The planes containing the surfaces A, C and D shall be perpendicular to each other and each one perpendicular to the surface B within 0,02/100.	b_1)
b_2) The height H of the block(s) shall be constant within 0,03.	b_2)

Measuring instruments

a) Straight edge and gauge blocks or amplifier. b_1) Square and gauge block b_2) Micrometer callipers

Observations and references to ISO 230-1:1996 3.1 and 3.22 4.1 and 4.2

Cutting conditions:

a) with a shell-end mill;

b) slab milling with the same cutter.

Before beginning the test, surface E shall be flat.

Test pieces shall be placed in the longitudinal axis of the table so that the length L is equally distributed on either side of the table centre.

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

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

1) run-out:
$\leqslant$ 0,02

2) camming:
$\leqslant$ 0,03.

All non-operating slides shall be locked during cutting.

Bibliography

[1] ISO 841:—[1)], *Industrial automation systems — Numerical control of machines — Coordinate system and motion nomenclature.*

[2] ISO 10791-1:1998, *Test conditions for machining centres — Part 1: Geometric tests for machines with horizontal spindle and with accessory heads (horizontal Z-axis).*

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

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