INTERNATIONAL STANDARD

ISO 1701-2

Second edition
2004-08-15

Test conditions for milling machines with table of variable height — Testing of accuracy —

Part 2: Machines with vertical spindle

Conditions d'essai des machines à fraiser à table de hauteur variable — Contrôle de la précision —

Partie 2: Machines à broche verticale

Reference number
ISO 1701-2:2004(E)

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

Published in Switzerland

Contents

Page

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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 1701-2 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

This second edition of ISO 1701-2 as well as ISO 1701-1:2004 cancels and replaces ISO 1701-0:1984, ISO 1701-2:1997 and ISO 1701-3:1997, which have been revised only editorially. The relevant sections of ISO 1701-0 have been incorporated into this part of ISO 1701.

ISO 1701 consists of the following parts, under the general title *Test conditions for milling machines with table of variable height — Testing of accuracy:*

— *Part 1: Machines with horizontal spindle*

— *Part 2: Machines with vertical spindle*

Test conditions for milling machines with table of variable height — Testing of accuracy —

Part 2: Machines with vertical spindle

1 Scope

This part of ISO 1701 specifies, with reference to ISO 230-1, both geometric and machining tests on general purpose, normal accuracy, vertical-spindle milling machines with table of variable height. It also specifies the applicable tolerances corresponding to the above-mentioned tests.

NOTE Milling machines with table of fixed height are covered by ISO 1984.

This part of ISO 1701 deals only with the verification of accuracy of the machine, and it does not apply to the testing of the running of the machine (vibration, abnormal noise, stick-slip motion of components, etc.) or to machine characteristics (such as speeds, feeds, etc.), which should generally be carried out before testing the accuracy.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 3855, *Milling cutters — Nomenclature*

3 Terminology, designation of axes and milling operations

3.1 Terminology and designation of axes

See Figures 1 and 2 and Tables 1 and 2.

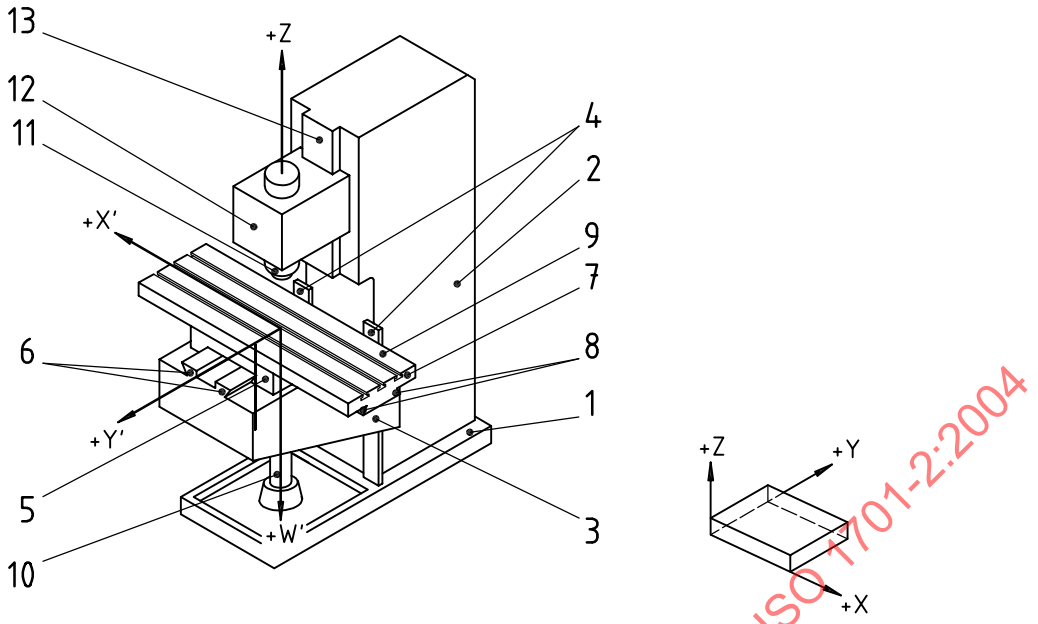


Figure 1 — Milling machine with table of variable height, with vertical spindle and a sliding vertical saddle spindle head

Table 1 — Terminology

Key	Designation		
	English	French	Russian
1	Base-plate with tray	Socle	Основание
2	Column	Montant	Стойка
3	Knee	Console	Консоль
4	Knee slideways	Glissières de la console	Направляющие консоли
5	Saddle	Chariot transversal	Салазки
6	Saddle slideways	Glissières du mouvement transversal de la table	Направляющие салазок
7	Table	Table porte-pièce	Стол
8	Table slideways	Glissières du mouvement longitudinal de la table	Направляющие стола
9	Table surface	Surface utile de la table	Рабочая поверхность стола
10	Vertical feed-screw	Vis verticale	Винт вертикального перемещения
11	Spindle nose	Nez de broche	Конец вертикального шпинделя
12	Spindle head	Tête porte-broche	Шпиндельная бабка
13	Spindle head slideways	Glissière du mouvement vertical de la tête porte-broche	Направляющие шпиндельной бабки

NOTE In addition to terms used in the three official ISO languages (English, French and Russian), this part of ISO 1701 gives in Annex A the equivalent terms in German, Spanish, Italian, Dutch and Swedish; these are published under the responsibility of the member committees for Germany (DIN), Spain (AENOR), Italy (UNI), the Netherlands (NEN) and Sweden (SIS). However, only the terms and definitions given in the official languages can be considered as ISO terms and definitions.

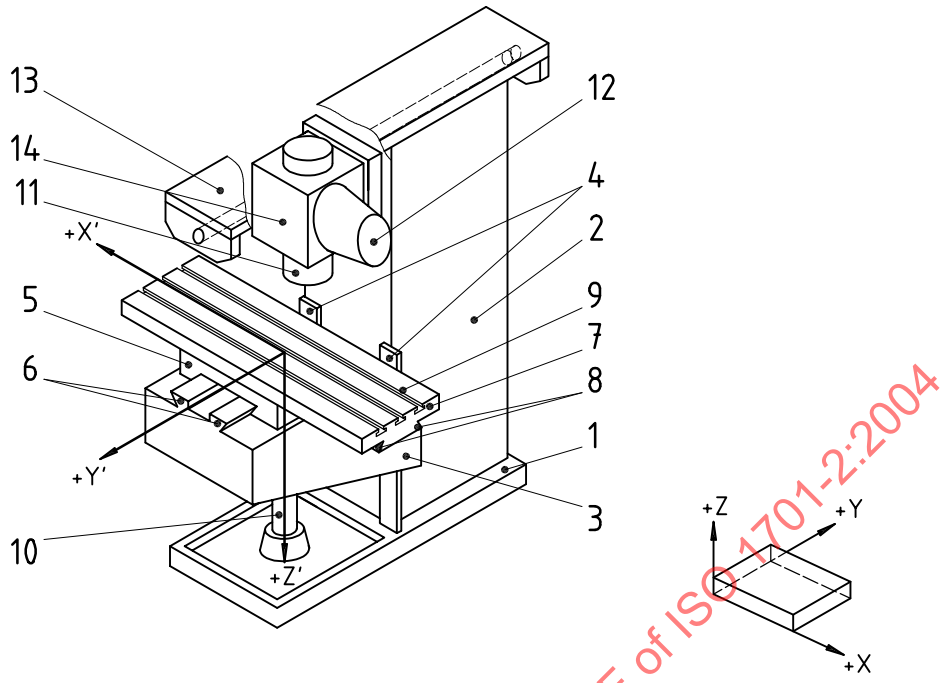


Figure 2 — Milling machine with table of variable height, with a movable head, with horizontal or vertical spindle

Table 2 — Terminology

Key	Designation		
	English	French	Russian
1	Base-plate with tray	Socle	Основание
2	Column	Montant	Стойка
3	Knee	Console	Консоль
4	Knee slideways	Glissières de la console	Направляющие консоли
5	Saddle	Chariot transversal	Салазки
6	Saddle slideways	Glissières du mouvement transversal de la table	Направляющие салазок
7	Table	Table porte-pièce	Стол
8	Table slideways	Glissières du mouvement longitudinal de la table	Направляющие стола
9	Table surface	Surface utile de la table	Рабочая поверхность стола
10	Vertical feed-screw	Vis verticale	Винт вертикального перемещения
11	Vertical spindle nose	Nez de broche verticale	Конец вертикального шпинделя
12	Horizontal spindle nose	Nez de broche horizontale	Конец горизонтального шпинделя
13	Horizontal milling attachment	Dispositif de fraisage horizontal	Ползун
14	Movable head	Tête amovible	Поворотная головка

NOTE In addition to terms used in the three official ISO languages (English, French and Russian), this part of ISO 1701 gives in Annex B the equivalent terms in German, Spanish, Italian, Dutch and Swedish; these are published under the responsibility of the member committees for Germany (DIN), Spain (AENOR), Italy (UNI), the Netherlands (NEN) and Sweden (SIS). However, only the terms and definitions given in the official languages can be considered as ISO terms and definitions.

3.2 Milling operations

Milling is a machining operation, which consists of removing material by means of a rotary tool called a “milling cutter” of which there is several different types.

The usual operations of milling can be divided into three categories:

— slab milling operations (see Figure 3);

— face milling operations (see Figure 4);

— end milling operations (see Figure 5).

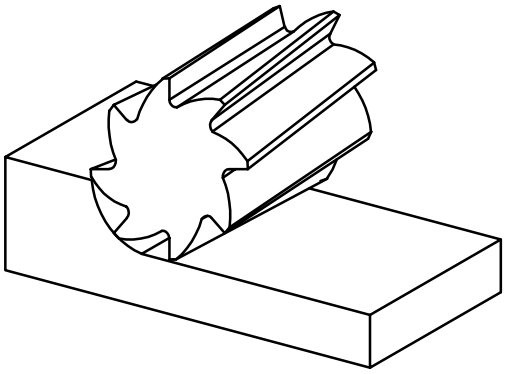


Figure 3 — Slab milling operation

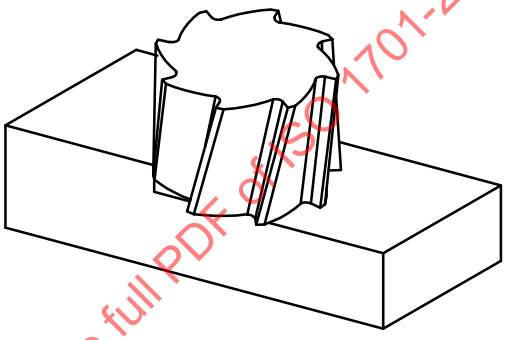


Figure 4 — Face milling operation

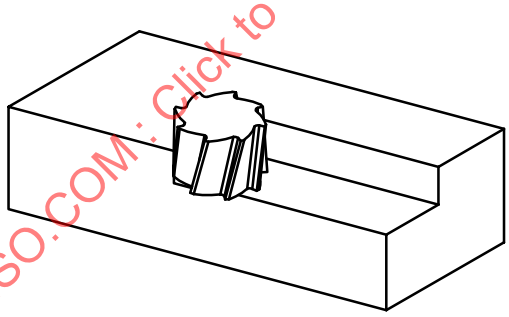


Figure 5 — End milling operation

3.3 Description of machines

In milling machines with table of variable height with vertical spindle, the base-plate is rigidly fixed to the column (see Figures 1 and 2).

In this type of machine, the cutting movement is given by the spindle, the axis of which is vertical.

The feed movements are as follows:

a) **Milling machine with vertical spindle** (see Figure 1)

— The X axis of motion constitutes the longitudinal movement of the table.

— The Y axis of motion constitutes the vertical movement of the table.

— The Z axis of motion is parallel to the spindle axis and constitutes the vertical movement of the spindle head.

— The W axis of motion constitutes the vertical movement of the table.

b) **Milling machine with movable head with horizontal or vertical spindle axis** (see Figure 2)

— The X axis of motion constitutes the longitudinal movement of the table.

— The Y axis of motion constitutes the transverse movement of the table.

— The Z axis of motion constitutes the vertical movement of the table.

NOTE All these feed movements may be carried out by a rapid traverse of the element in question.

4 Preliminary remarks

4.1 Measuring units

In this part of ISO 1701, 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 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 1701, reference shall be made to ISO 230-1, especially for the installation of the machine before testing, warming up of the spindle and other moving components, description of measuring methods and recommended accuracy of testing equipment.

In the “Observations” block of the tests described in Clauses 5 and 6, the instructions are followed by a reference to the corresponding clause in ISO 230-1 in cases, where the test concerned is in compliance with the specifications of that part of ISO 230.

4.3 Testing sequence

The sequence in which the tests are presented in this part of ISO 1701 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 1701. 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 1701 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 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 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 1701 (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

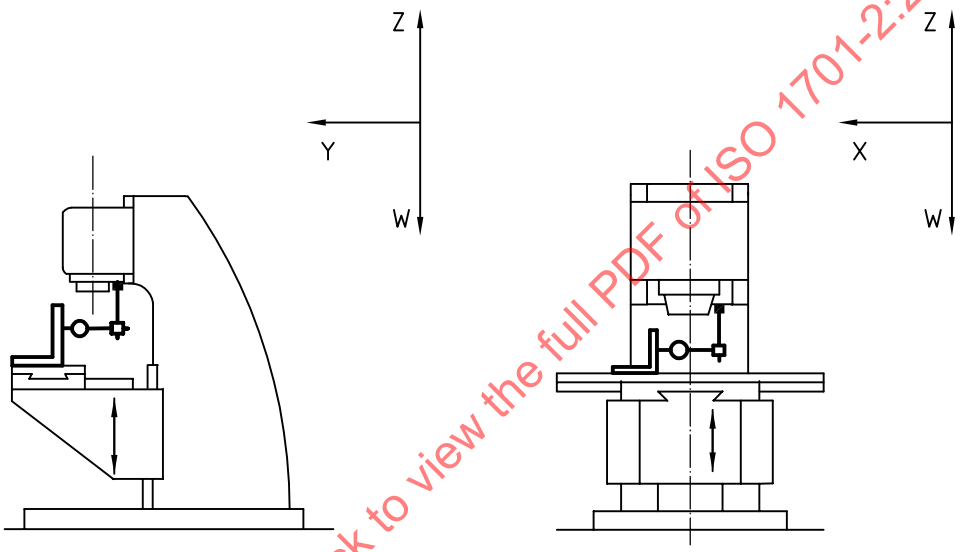
Object **G1**

Checking of straightness of the vertical movement of the knee (W axis):

a) in the vertical plane of symmetry of the machine (YZ plane);

b) in the plane perpendicular to the vertical plane of symmetry of the machine (ZX plane).

Diagram



a) b)

Tolerance	**Measured deviation**
For a) and b) 0,020 for any measuring length of 300	a) b)

Measuring instruments

Dial gauge and square.

Observations and references to ISO 230-1:1996 5.232.11

Instead of a straightedge, use the vertical arm of the square.

Adjust the square to obtain similar readings at both ends of its measuring length, then the maximum difference of dial gauge readings gives straightness deviation.

Table in central position:

a) saddle is) locked;

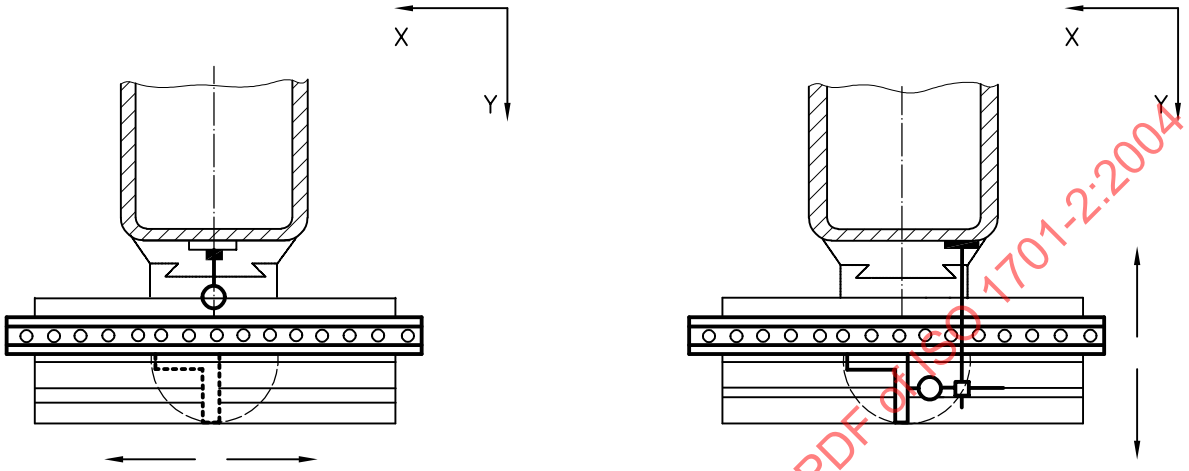
b) table (X axis) locked.

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 machine.

Object **G2**

Checking of squareness between the transverse saddle movement (Y axis) and the longitudinal table movement (X axis).

Diagram



a) b)

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

Knee (W axis) locked.

a) 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.

b) The transverse saddle movement (Y axis) shall then be checked.

If the spindle can be locked, then 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 machine.

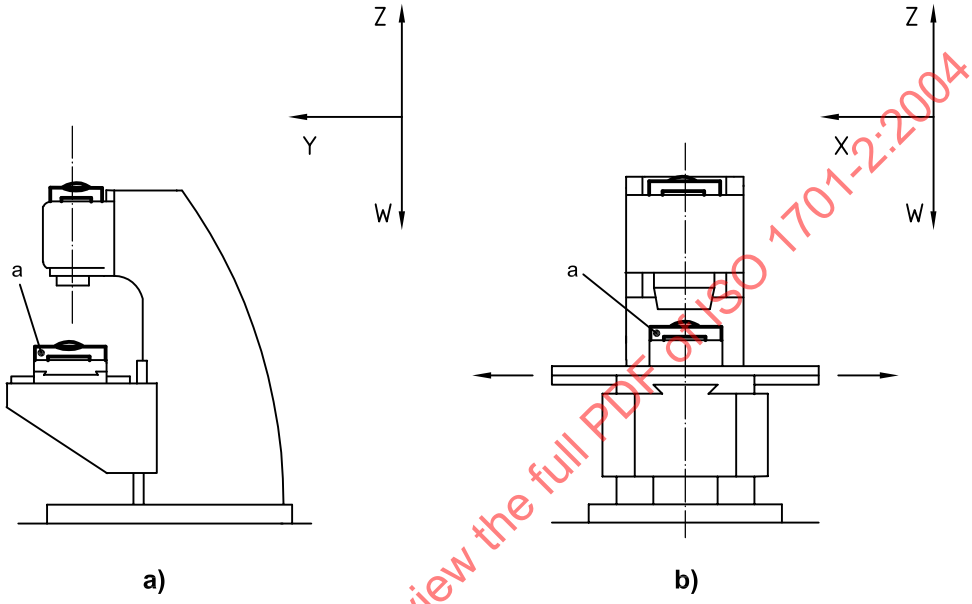
Object **G3**

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

a) in the vertical YZ plane perpendicular to the table movement (roll EAX);

b) in the vertical ZX plane parallel to the table movement (pitch EBX).

Diagram



a) b)

[a] Reference level.

Tolerance	**Measured deviation**
a) 0,04/1 000 (or 40 µrad or 8")	a)
b) $X \leqslant 1\,000$ 0,08/1 000 (or 80 µrad or 16")	b)
$X > 1\,000$ 0,12/1 000 (or 120 µrad or 24")	

Measuring instruments

Precision level

Observations and references to ISO 230-1:1996 5.232.2

These tests should only be performed when the knee (W axis) is clamped on the column.

The level shall be placed in centre of the table

a) transversely;

b) longitudinally.

The reference level shall be located on the spindle head, and the spindle head shall be in the middle of the travel range.

When X axis motion causes an angular movement of both the spindle head and work holding table, differential measurements of the two angular movements shall be made and this shall be stated.

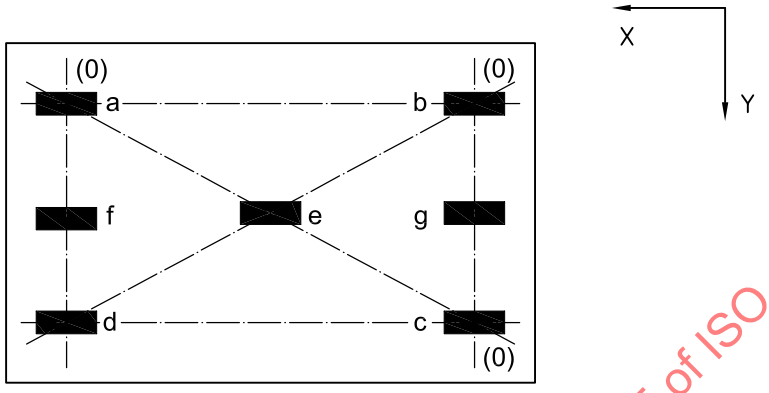
Measurements shall be taken at several positions, moving the table by 200 or 250 mm steps.

The difference between the maximum and minimum readings (excluding the above angular contribution) 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 for a measuring length up to 1 000 (concave only) For each 1 000 mm increase in table length, add 0,005 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 saddle (Y axis) in the central position, table not locked, knee and cross slide locked.

NOTE The alphabetical references on the diagram correspond to those used in Figure 41 of ISO 230-1:1996.

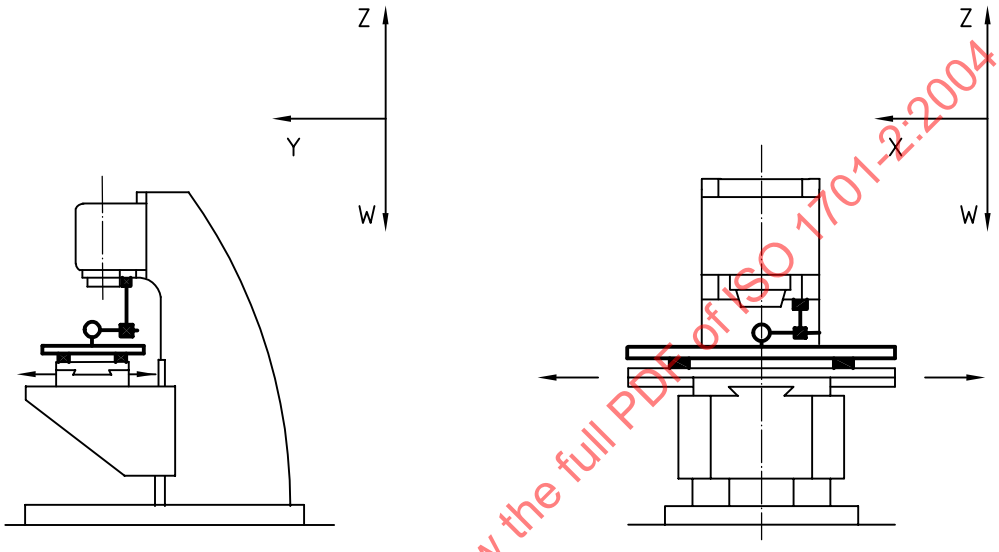
Object **G5**

Checking of parallelism between the table surface and:

a) the transverse saddle movement (Y axis), in the vertical YZ plane;

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

Diagram



a) b)

Tolerance	**Measured deviation**
For a) and b) 0,025 for any 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 succesive movements of the straightedge.

Knee (W axis) locked:

a) table (X axis) locked;

b) saddle (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 machine.

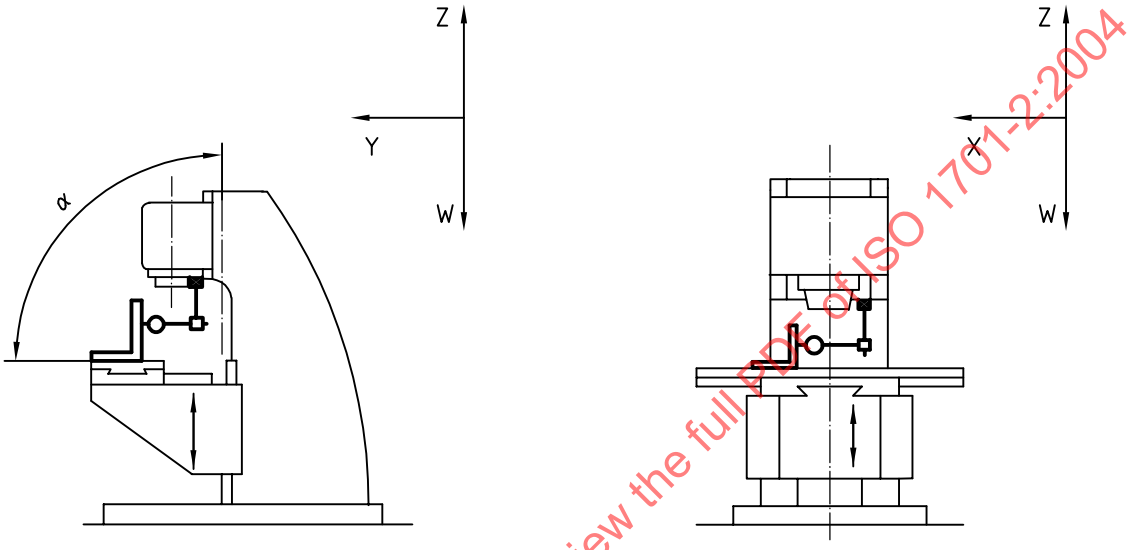
Object **G6**

Checking of squareness between the table surface and the vertical movement of the knee (W axis) (in three positions: in the middle and near the extremities of travel):

a) in the vertical plane of symmetry of the machine (YZ plane);

b) in the plane perpendicular to the vertical plane of symmetry of the machine (ZX plane).

Diagram



a) b)

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

Measuring instruments

Dial gauge and square.

Observations et références à l'ISO 230-1:1996 5.522.2

Table in central position, knee (W axis) locked when taking measurements;

a) saddle (Y 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 machine.

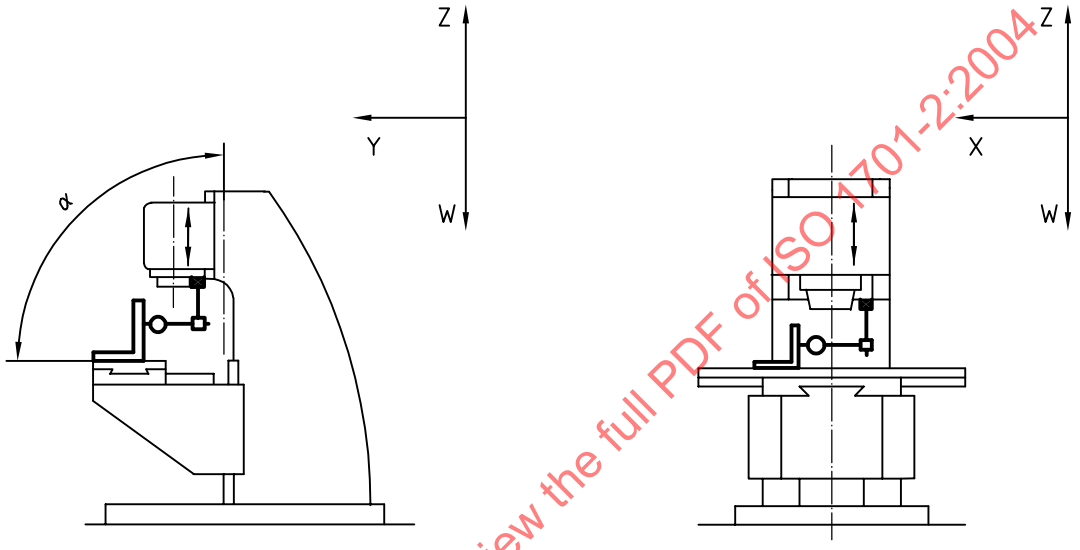
Object **G7**

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

a) in the vertical plane of symmetry of the machine (YZ plane);

b) in the plane perpendicular to the vertical plane of symmetry of the machine (ZX plane).

Diagram



a) b)

Tolerance	**Measured deviation**
a) 0,025 for a measuring length of 300 with $\alpha \leqslant 90°$	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, knee (W axis) locked;

Spindle head slide (Z axis) locked when taking measurements;

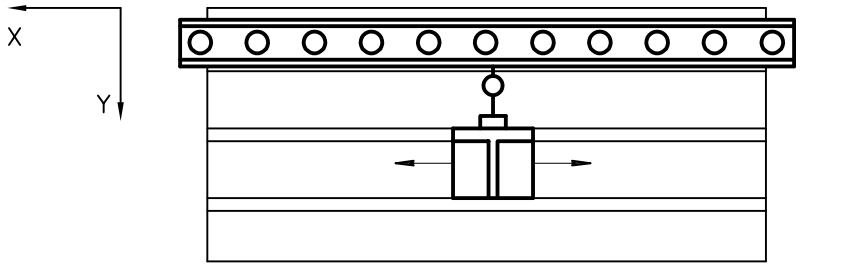
a) saddle (Y axis) locked;

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 the spindle head slide of the machine.

Object	**G8**
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

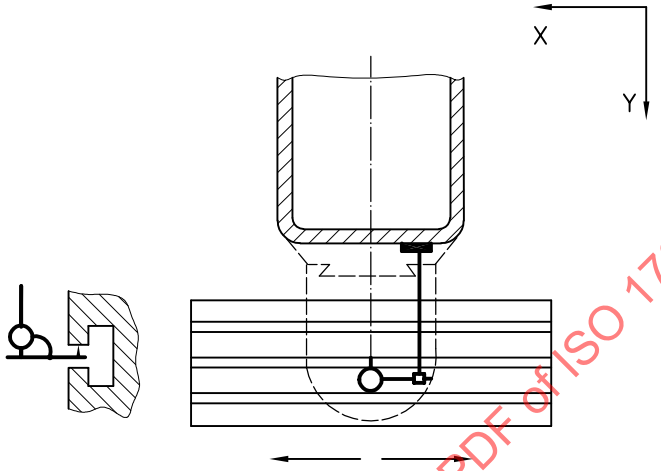
Straightedge and dial gauge or gauge blocks, or taut wire and microscope, or autocollimator.

Observations and references to ISO 230-1:1996 5.212, 5.212.1 and 5.212.23

The straightedge may be placed directly on the table.

Object	G9
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

Saddle (Y axis) and knee (W 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 machine.

5.3 Spindle

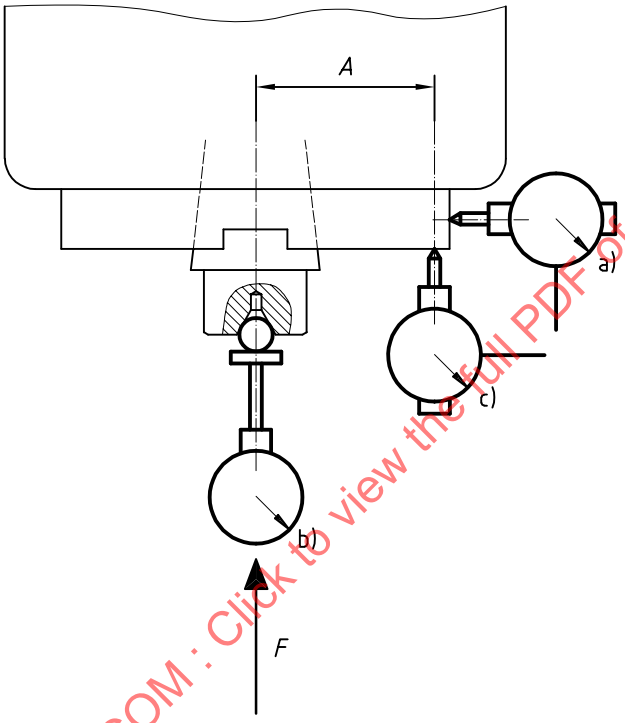
Object **G10**

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

b) Checking of periodic axial slip.

c) Checking of 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 during tests b) and c).

c) 5.632

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

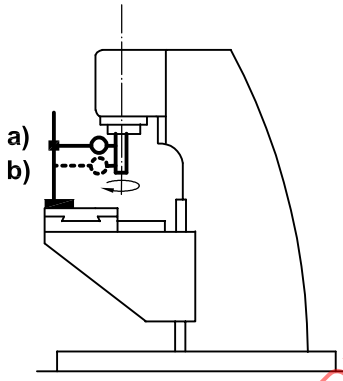
Object **G11**

Checking of the 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

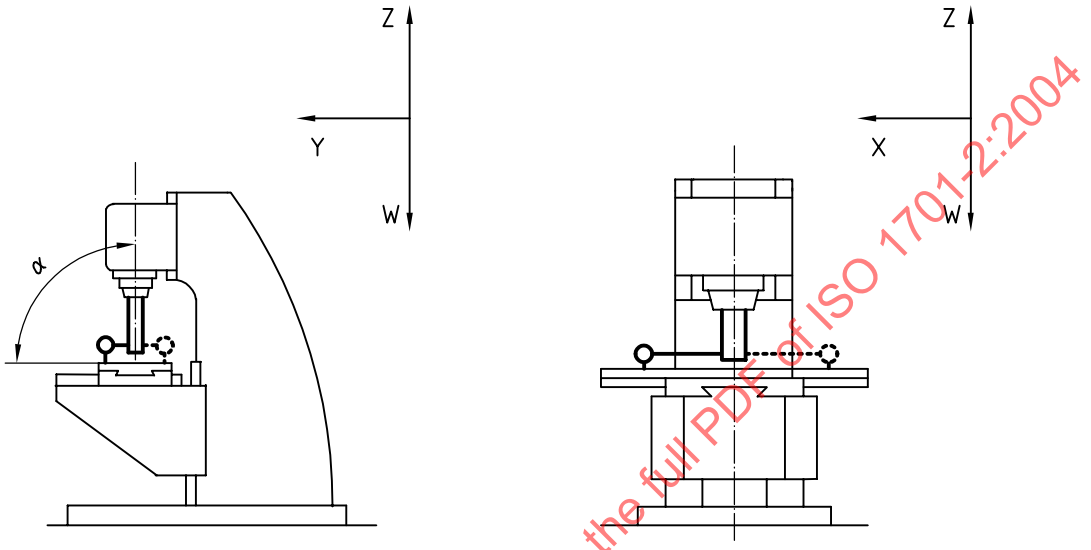
Object **G12**

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

a) in the vertical plane of symmetry of the machine (YZ plane);

b) in the plane perpendicular to the vertical plane of symmetry of the machine (ZX plane).

Diagram



a) b)

Tolerance	**Measured deviation**
a) 0,025/300 with $\alpha \leqslant 90°$	a)
b) 0,025/300	b)

Measuring instruments

Dial gauge and test mandrel.

Observations and references to ISO 230-1:1996 5.512.1 and 5.512.42

Table (X axis), saddle (Y axis), spindle head slide (Z axis) and knee (W axis) locked.