भारतीय मानक
Indian Standard

IS/ISO 1701-1 : 2004
[Superseding IS 2200 (Part 2) : 2002]

परिवर्ती ऊँचाई वाली टेबल मिलिंग मशीनों की परीक्षण शर्तें — परिशुद्धता का परीक्षण

भाग 1 क्षैतिज तर्कु वाली मशीनें

Test Conditions for Milling Machines with Table of Variable Height — Testing of the Accuracy

Part 1 Machines with Horizontal Spindle

ICS 25.080.20

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली-110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.org.in www.standardsbis.in

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Machine Tools, Machine Tool Elements and Holding Devices Sectional Committee, PGD 35

NATIONAL FOREWORD

This Indian Standard (Part 1) which is identical with ISO 1701-1 : 2004 'Test conditions for milling machines with table of variable height — Testing of the accuracy — Part 1: Machines with horizontal spindle' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Machine Tools, Machine Tool Elements and Holding Devices Sectional Committee and approval of the Production and General Engineering Division Council.

This standard was first published in 1962 and subsequently revised in 1973, 1994 and in 2002 as IS 2200 (Part 2) : 2002 which was identical with ISO 1701-2 : 1997. The committee has now decided to adopt this standard as IS/ISO 1701-1 : 2004 to align with the latest international practices by superseding IS 2200 (Part 2) : 2002 'Test conditions for milling machines with table of variable height — Testing of accuracy : Part 2 Machines with horizontal spindle'. Therefore, with the publication of this standard, IS 2200 (Part 2) : 2002 shall be treated as withdrawn.

This standard is published in two parts. The other part of this series is:

Part 2 Machines with vertical spindle

The text of ISO Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to the following International Standard for which Indian Standard also exists. The corresponding Indian Standard which is to be substituted in its place is listed below along with its degree of equivalence for the edition indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 230-1 : 1996 Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or finishing conditions	IS 2063 (Part 1) : 2002 Test code for machine tools : Part 1 Geometric accuracy of machines operating under no-load or finishing conditions (*second revision*)	Identical

The technical committee has reviewed the provisions of the following International Standard referred in this adopted standard and has decided that it is acceptable for use in conjunction with this standard:

International Standard	*Title*
ISO 3855[1)]	Milling cutters — Nomenclature

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

[1)] Since published in 1977.

Indian Standard

TEST CONDITIONS FOR MILLING MACHINES WITH TABLE OF VARIABLE HEIGHT — TESTING OF THE ACCURACY

PART 1 MACHINES WITH HORIZONTAL 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, horizontal-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. 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 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.

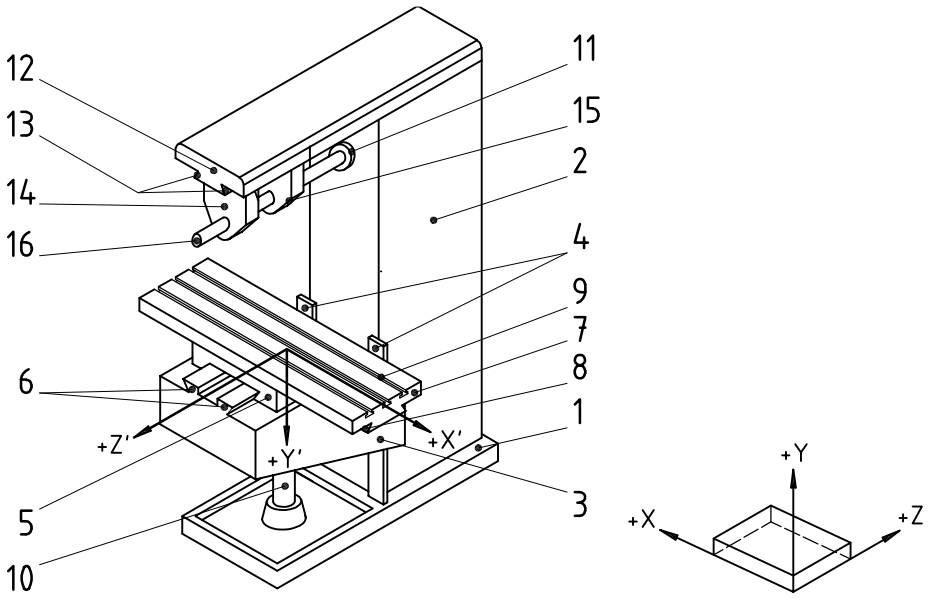


Figure 1 — Milling machine with table of variable height, with fixed horizontal spindle

Table 1 — Terminology

Key	English
1	Base-plate with tray
2	Column
3	Knee
4	Knee slideways
5	Saddle
6	Saddle slideways
7	Table
8	Table slideways
9	Table surface
10	Vertical feed-screw
11	Spindle nose
12	Overarm
13	Overarm slideways
14	Front arbor support
15	Rear arbor support
16	Arbor

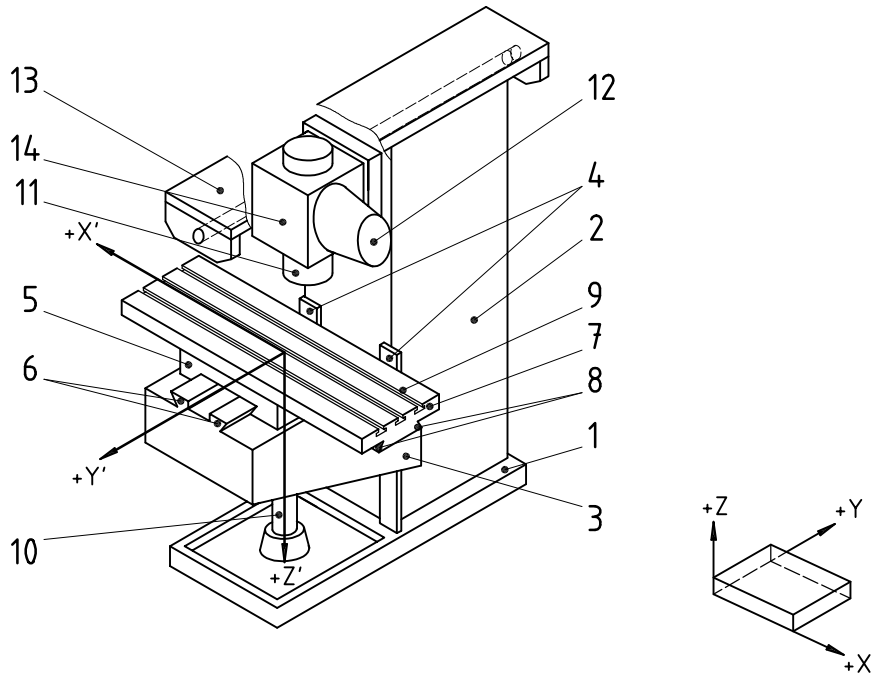


Figure 2 — Milling machine with table of variable height, with a movable head, with horizontal or vertical spindle

Table 2 — Terminology

Key	English
1	Base-plate with tray
2	Column
3	Knee
4	Knee slideways
5	Saddle
6	Saddle slideways
7	Table
8	Table slideways
9	Table surface
10	Vertical feed-screw
11	Vertical spindle nose
12	Horizontal spindle nose
13	Horizontal milling attachment
14	Movable head

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 are 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).

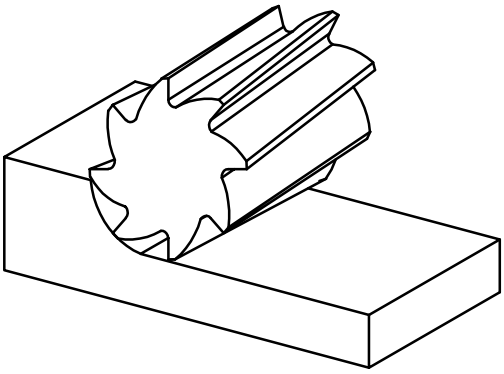


Figure 3 — Slab milling operation

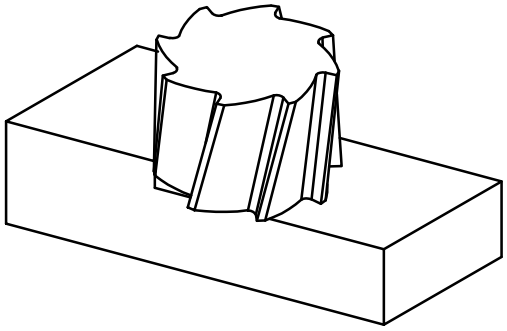


Figure 4 — Face milling operation

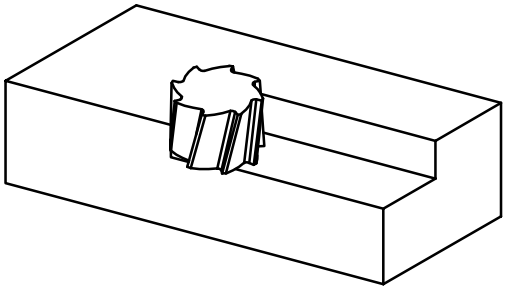


Figure 5 — End milling operation

3.3 Description of machines

In milling machines with table of variable height with horizontal 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 horizontal.

The feed movements are as follows:

a) **Milling machine with horizontal 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 transverse 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 in principle 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

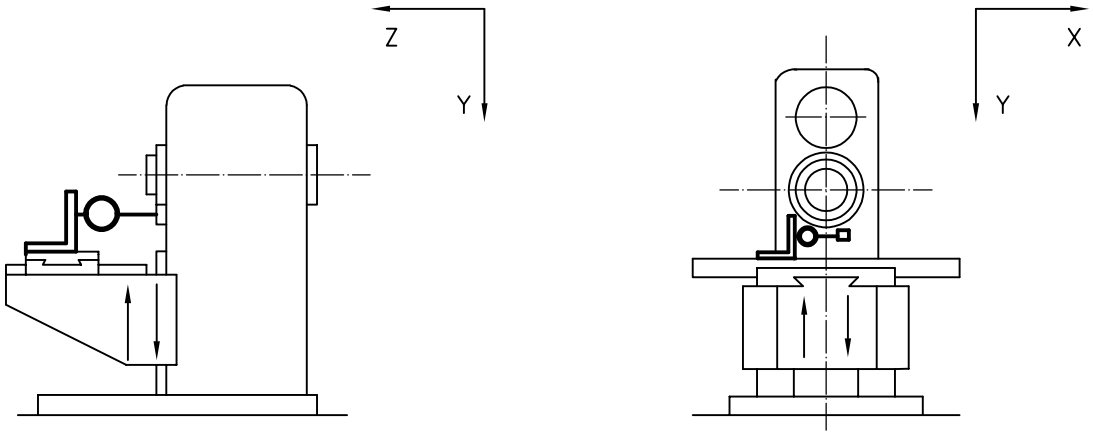
Object **G1**

Checking of straightness of the vertical movement of the knee (Y 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 (XY plane).

Diagram



a) b)

Tolerance	**Measured deviation**
For a) and b) 0,02 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 so that straightness deviation can be calculated as the maximum difference of dial gauge readings.

Table in central position:

a) saddle (Z axis) locked;

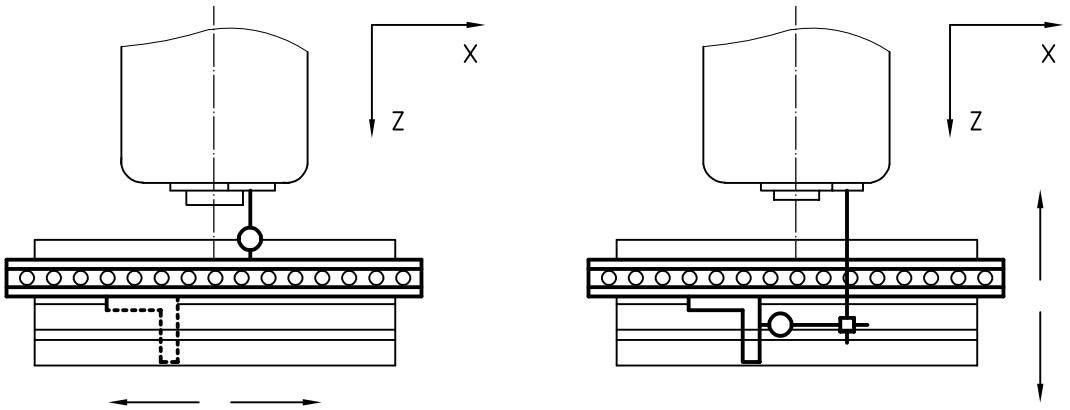
b) table (X axis) locked.

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 machine.

Object **G2**

Checking of squareness between the transverse cross-slide movement (Z 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 (Y 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 be performed as well without the straightedge, aligning the long arm of the square parallel to the X axis.

b) The saddle movement (Z 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.

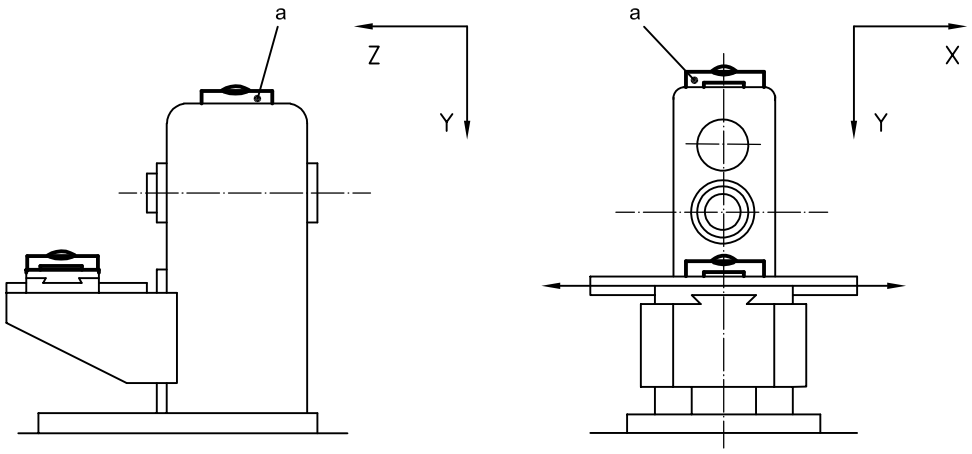
Object **G3**

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 XY plane parallel to the table movement (pitch ECX).

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 (Y axis) is clamped on the column.

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

a) transversely;

b) longitudinally.

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

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

The reference level shall be located on the column.

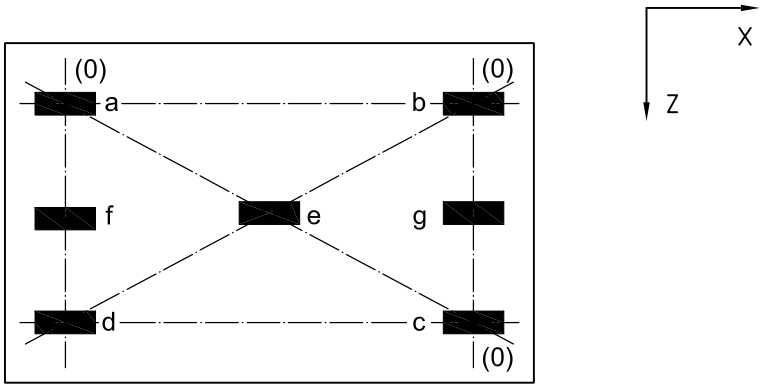
The difference between the maximum and minimum readings (excluding the above angular contribution) of both directions of movement shall not exceed the tolerance.

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 (Z axis) in central position, table not locked, knee and saddle locked.

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

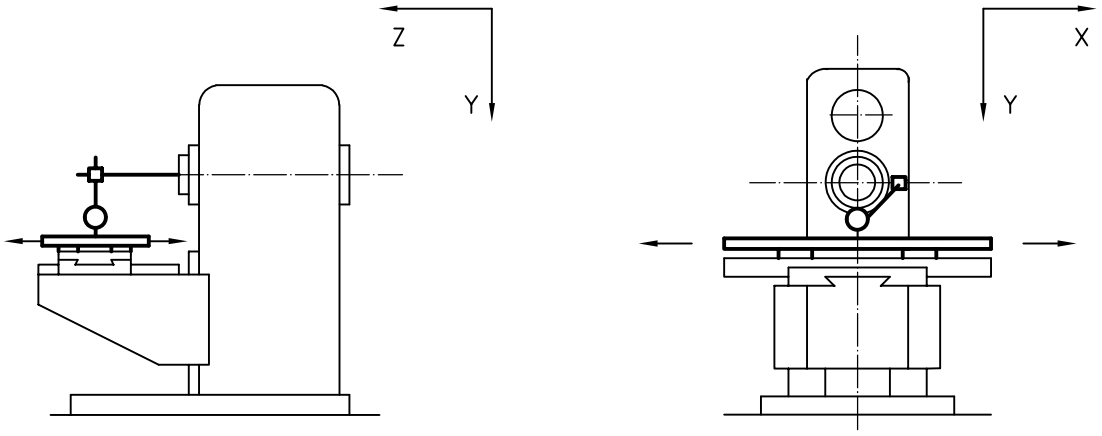
Object **G5**

Checking of parallelism between the table surface and

a) the saddle 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 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 at approximately 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.

Knee (Y axis) locked:

a) table (X axis) locked;

b) saddle (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 machine.

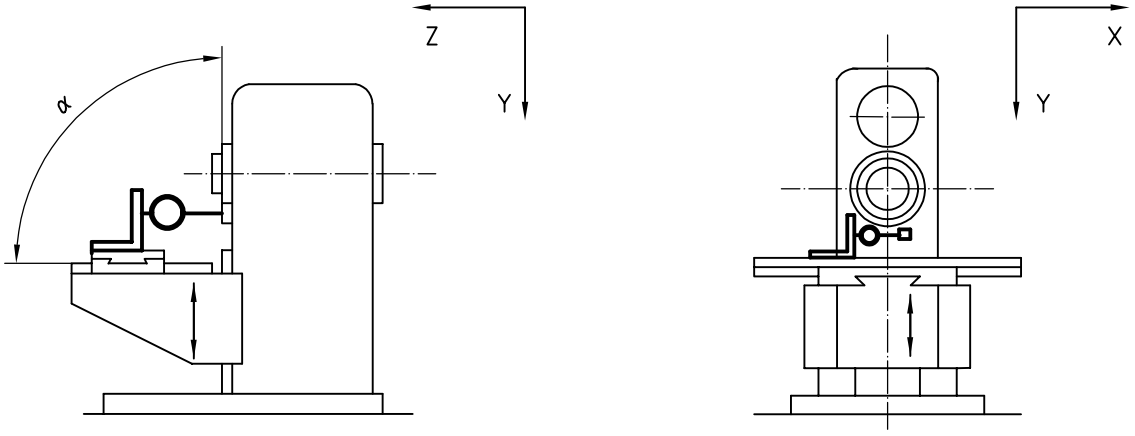
Object **G6**

Checking of squareness between the table surface and the vertical movement of the knee (Y axis) (in three positions: in the middle and near the extremities of the 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 (XY 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 (Y axis) locked when taking measurements:

a) saddle (Z axis) locked;

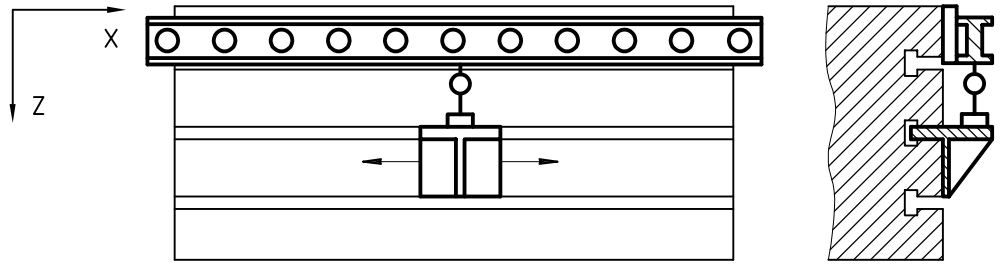
b) table (X axis) locked.

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 machine.

Object **G7**

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

Diagram



Tolerance	**Measured deviation**
0,01 for any measuring length of 300 Maximum tolerance: 0,03	

Measuring instruments

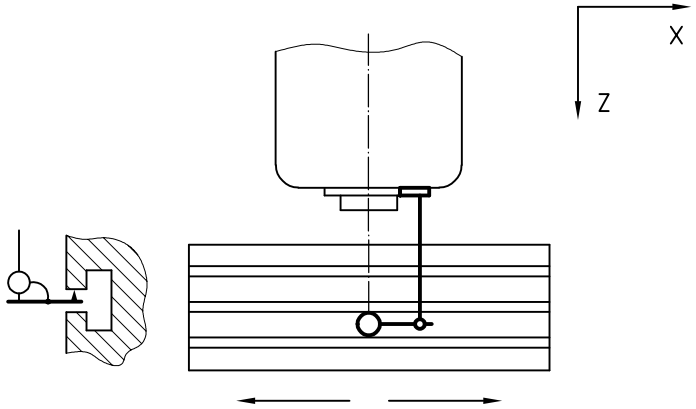
Straightedge and dial gauge or gauge blocks, or taut wire and microscope, or autocollimator

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	**G8**
Checking of parallelism between the median or reference T-slot and the longitudinal movement of the table.	

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 (Z axis) and knee (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.

5.3 Spindle

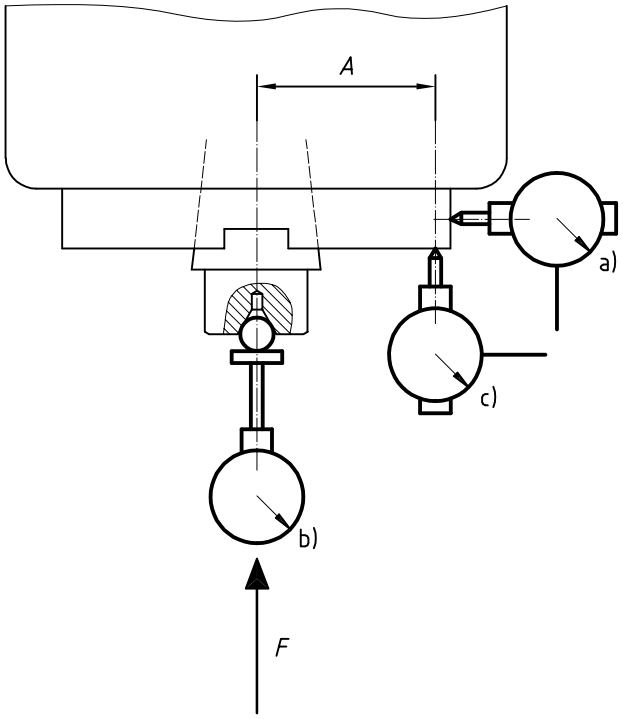
Object **G9**

a) Checking of run-out of the external centering 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 toward the housing for 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.

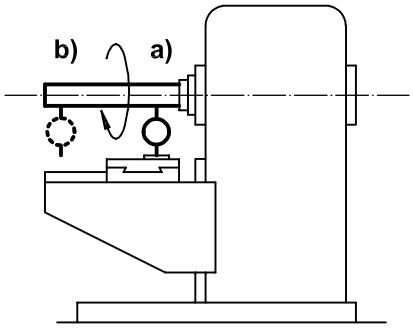
Object **G10**

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

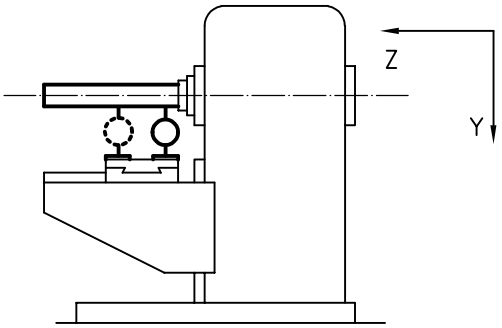
Dial gauge and test mandrel

Observations and references to ISO 230-1:1996 5.612.3

Object **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 saddle (Z axis) not locked, knee (Y axis) locked.

The measurement shall be at the mean position of rotation; i.e., measure at a position of spindle rotation and then repeat the measurement after rotating the spindle with mandrel 180° and take the mean value of the two measurements.

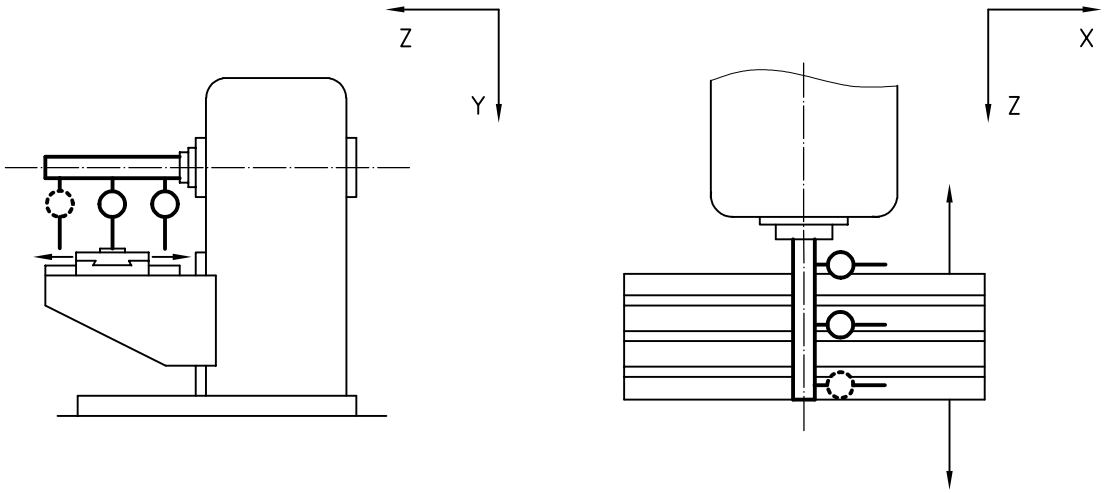
Object **G12**

Checking of parallelism between the spindle axis and the transverse movement of the table (saddle 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 downwards)	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.

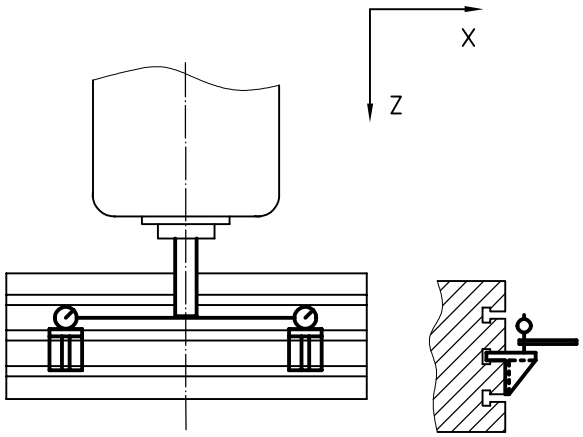
Knee (Y axis) locked.

The measurement shall be at the mean position of rotation; i.e., measure at a position of spindle rotation and then repeat the measurement after rotating the spindle with mandrel 180° and take the mean value of the two measurements.

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] 300 is the distance between the two measuring points touched.

Measuring instruments

Dial gauge

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

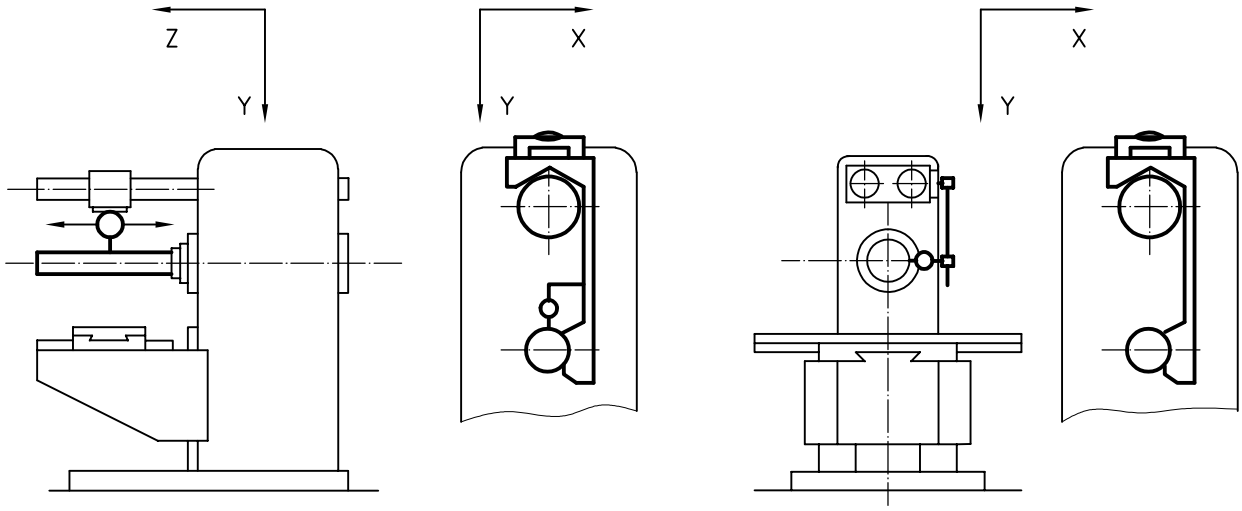
Table (X axis) in central position.

Table (X axis), saddle (Z axis) and knee (Y axis) locked.

5.4 Arbor support

Object	**G14**
Checking of parallelism between the arbor support guide on the overarm(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 (overarm inclined downwards)	a)
b) 0,02 for a measuring length of 300	b)

Measuring instruments

Dial gauge and possibly precision level with special fixture

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

Overarm(s) locked.

Object

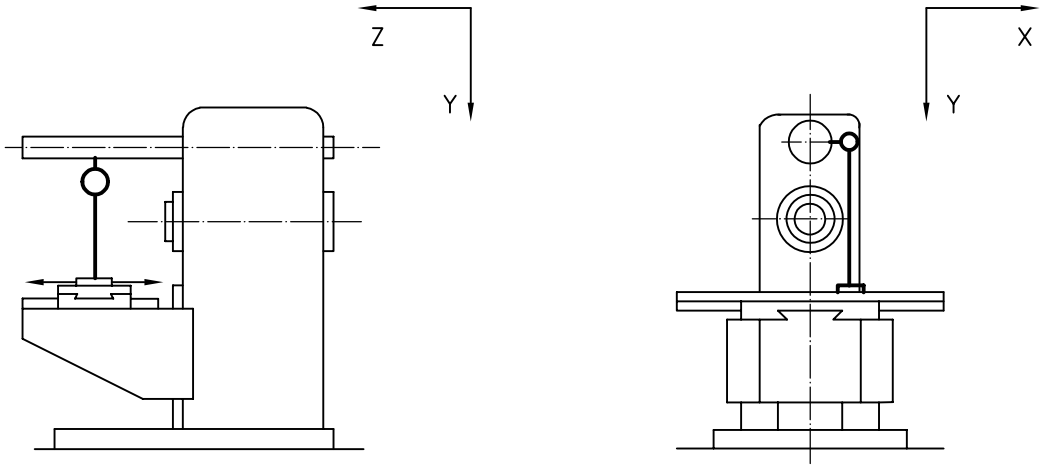
G14
(alternative)

Checking of parallelism between the arbor support guide on the overarm(s) and the transverse movement of the table (saddle 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 (overarm inclined downwards)	a)
b) 0,02 for a measuring length of 300	b)

Measuring instruments

Dial gauge

Observations and references to ISO 230-1:1996 5.422.3 and 5.422.4

Overarm(s) locked.

Object **G15**

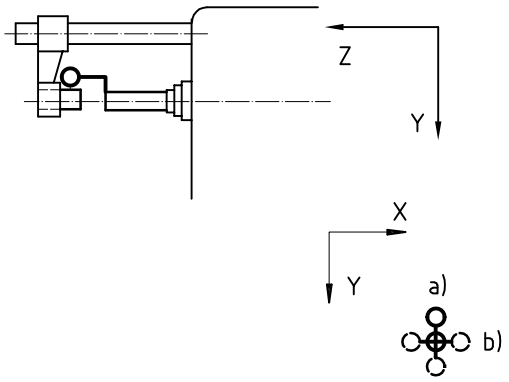
Checking of coincidence of the axis of the bore of the arbor support with the spindle axis:

a) in the vertical YZ plane;

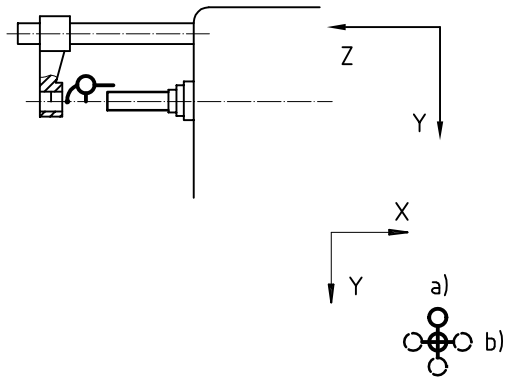
b) in the horizontal ZX plane.

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.

Overarm locked and arbor support not connected to the knee.

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

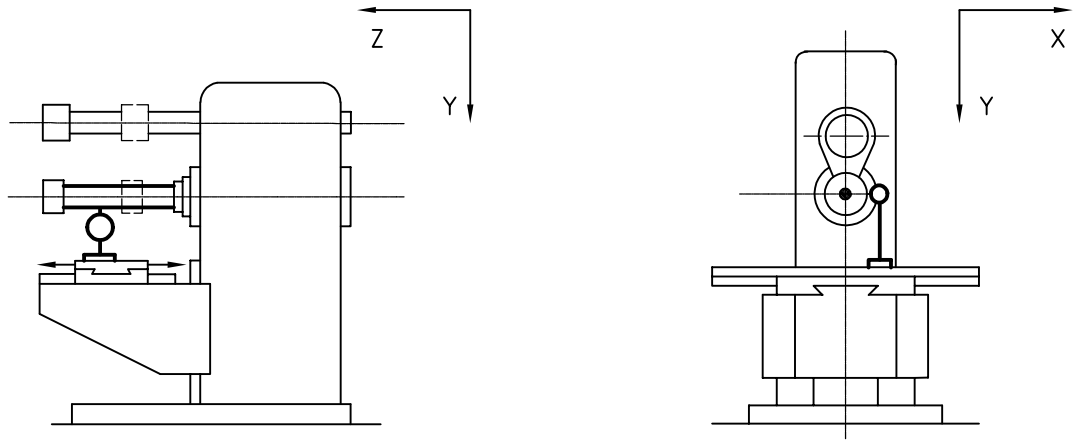
G15 (alternative)

Checking of coincidence of the axis of the bore of the arbor support with the spindle axis [parallelism between the supported arbor and the transverse movement of the table (saddle 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 downwards on the bore end of the arbor support)	a)
b) 0,03 for a measuring length of 300	b)

Measuring instruments

Dial gauge and test mandrel

Observations and references to ISO 230-1:1996 5.442

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

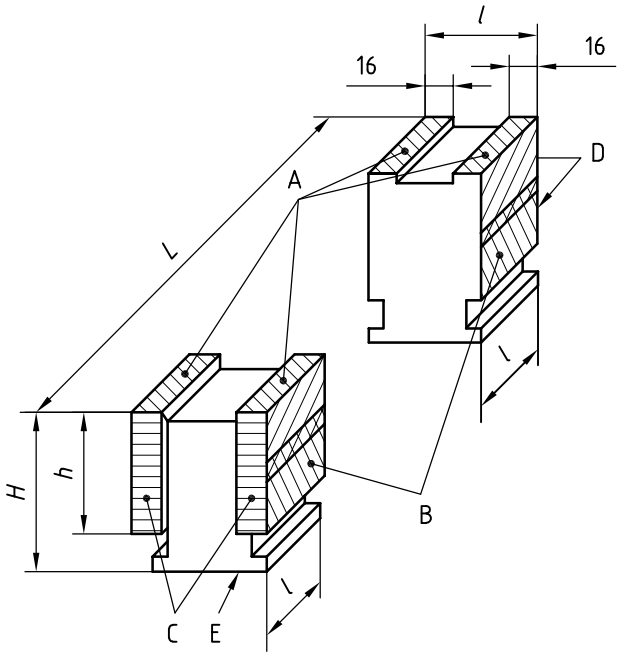
b) The arbor support is positioned midway along the mandrel or cutter arbor.

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 knee, in two cuts overlapping 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 knee and manual transverse movement of the saddle.

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 the longitudinal travel.

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

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

is 150 mm: for 500 mm $< L \leqslant$ 1 000 mm

is 200 mm: for $L >$ 1 000 mm

$l_{min.}$ is 50 mm

NOTE 1 Longitudinal travels of $\geqslant$ 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 of $<$ 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 to the nearest 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 to the nearest 0,02/100.	b_1)
b_2) The height H of the block(s) shall be constant to the nearest 0,03.	b_2)

Measuring instruments

a) Straightedge and gauge blocks or amplifier	b_1) Square and gauge blocks	b_2) Micrometer callipers

Observations and references to ISO 230-1:1996 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 along 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 841:2001 , *Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature*

[2] ISO 1701-2, *Test conditions for milling machines with table of variable height — Testing of the accuracy — Part 2: Machines with vertical spindle*

[3] ISO 1984-1, *Test conditions for manually controlled milling machines with table of fixed height — Testing of the accuracy — Part 1: Machines with horizontal spindle*

[4] ISO 1984-2, *Test conditions for manually controlled milling machines with table of fixed height — Testing of the accuracy — Part 2: Machines with vertical spindle*

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Headquarters:

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