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ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 1701

TEST CONDITIONS FOR MILLING MACHINES WITH TABLE OF VARIABLE HEIGHT, WITH HORIZONTAL OR VERTICAL SPINDLE

TESTING OF THE ACCURACY

1st EDITION

April 1970

For each individual country the only valid standard is the national standard of that country.

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BRIEF HISTORY

The ISO Recommendation R 1701, *Test conditions for milling machines with table of variable height, with horizontal or vertical spindle – Testing of the accuracy*, was drawn up by Technical Committee ISO/TC 39, *Machine tools*, the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question led to the adoption of Draft ISO Recommendation No. 1701 which was circulated to all the ISO Member Bodies for enquiry in August 1968. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	India	Spain
Belgium	Iran	Sweden
Brazil	Israel	Switzerland
Czechoslovakia	Italy	Thailand
Finland	Korea, Rep. of	Turkey
France	Netherlands	U.A.R.
Germany	New Zealand	United Kingdom
Greece	Romania	
Hungary	South Africa, Rep. of	

The following Member Body opposed the approval of the Draft :

Japan

This Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in April 1970, to accept it as an ISO RECOMMENDATION.

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ISO Recommendation R 1701 April 1970

TEST CONDITIONS FOR MILLING MACHINES WITH TABLE OF VARIABLE HEIGHT, WITH HORIZONTAL OR VERTICAL SPINDLE

TESTING OF THE ACCURACY

1. SCOPE

This ISO Recommendation describes, with reference to ISO Recommendation R 230, *Machine tool test code*, both geometrical and practical tests on milling machines with table of variable height and with horizontal or vertical spindle, and gives the permissible deviations corresponding to general purpose and normal accuracy machines.

It deals only with the verification of accuracy of the machine and does not apply to the testing of the running (vibrations, abnormal noises, stick-slip motion of components, etc.), or to characteristics (speeds, feeds, etc.) which should generally be checked before testing accuracy.

2. PRELIMINARY REMARKS

2.1 In this ISO Recommendation, all the dimensions are expressed in millimetres in section 3 and in inches in section 4.

2.2 To apply this ISO Recommendation, reference should be made to ISO Recommendation R 230, especially for the installation of the machine before testing, warming up of spindles and other moving parts, description of measuring methods and recommended accuracy of testing equipment.

2.3 The sequence in which the geometrical tests are given is related to the sub-assemblies of the machine, and this in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests may be applied in any order.

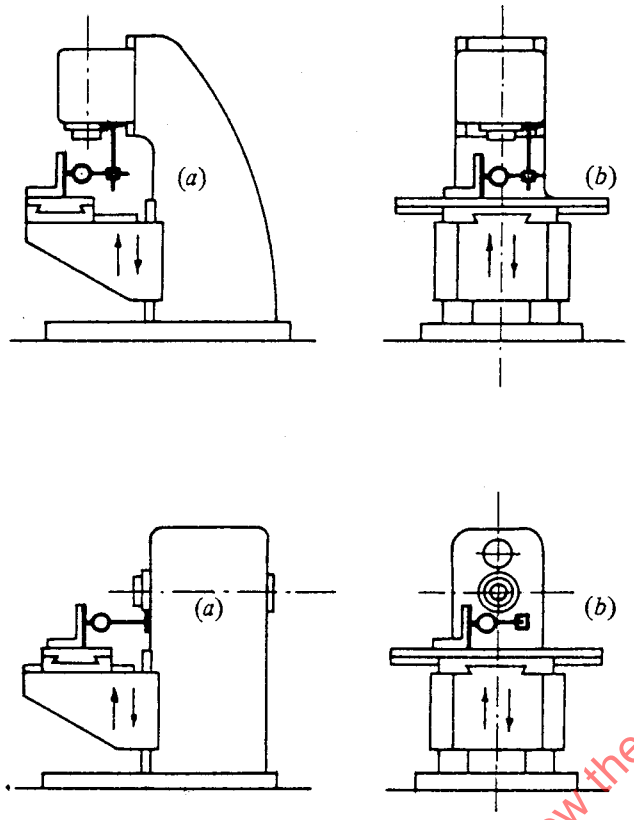
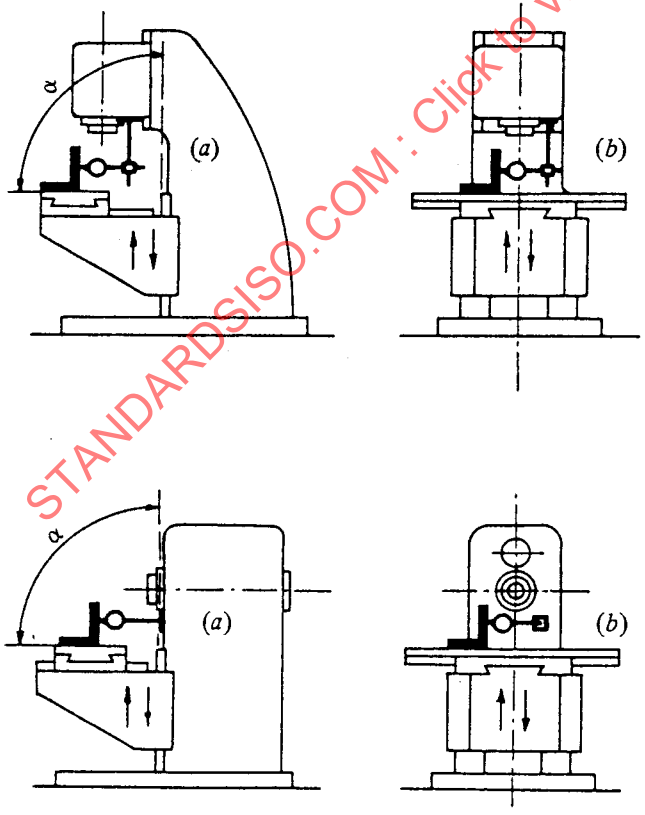
2.4 When inspecting a machine, it is not always necessary to carry out all the tests described in this ISO Recommendation. It is up to the user to choose, in agreement with the manufacturer, those relating to the properties which are of interest to him, but these tests are to be clearly stated when ordering a machine.

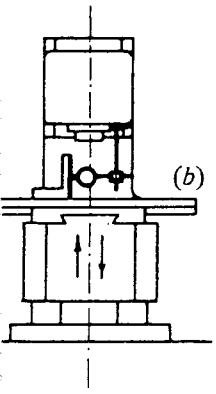
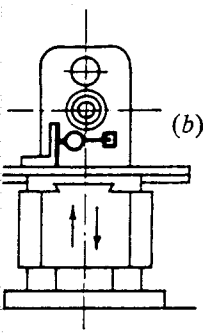
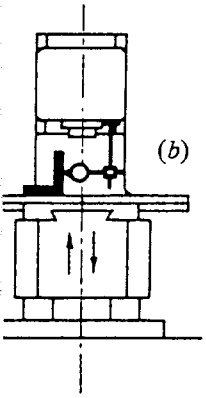
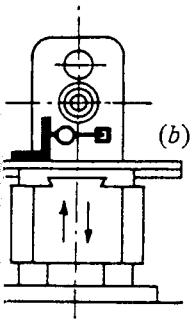
2.5 Practical tests should be made with finishing cuts – for instance : depth = 0.1 mm (0.004 in), feed per tooth = 0.1 mm (0.004 in) – and not with roughing cuts which are liable to generate appreciable cutting forces.

2.6 When establishing the tolerance for a measuring range different from that given in this ISO Recommendation (see clause 2.311 in ISO Recommendation R 230), it should be taken into consideration that the minimum value of tolerance is 0.01 mm (0.0004 in).

3. TEST CONDITIONS AND PERMISSIBLE DEVIATIONS

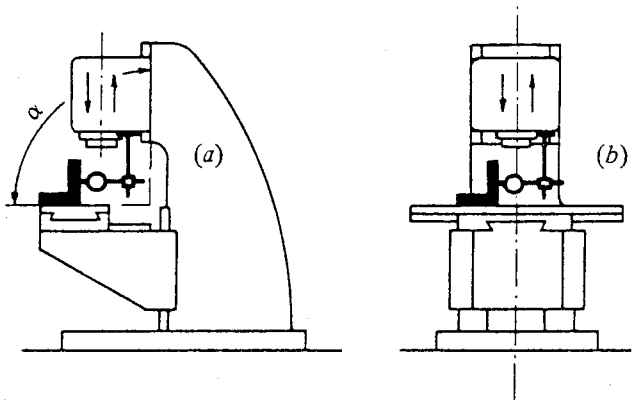
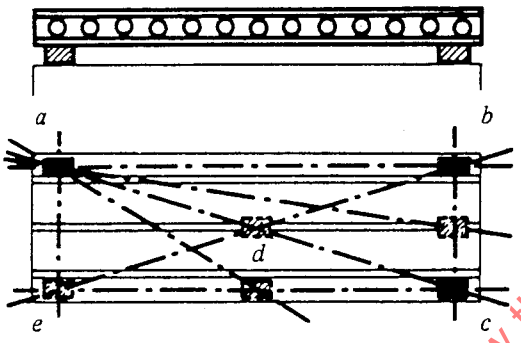
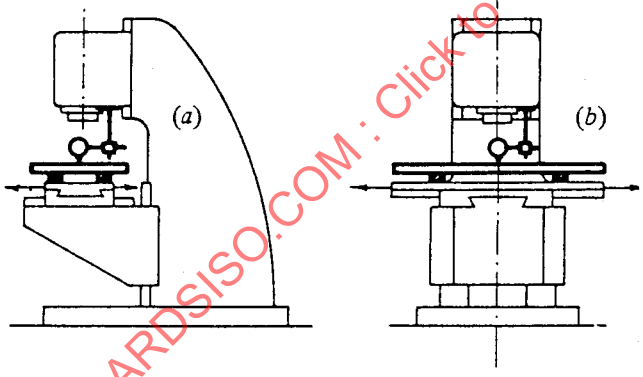
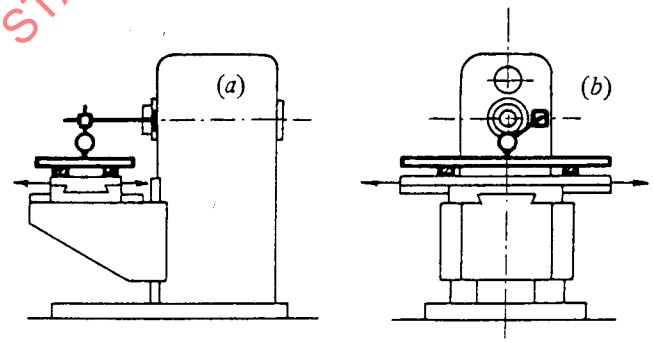
3.1 Geometrical tests

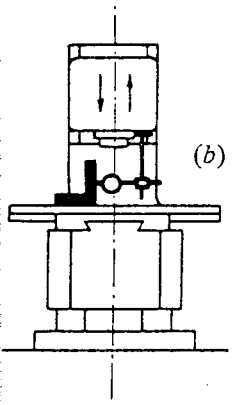
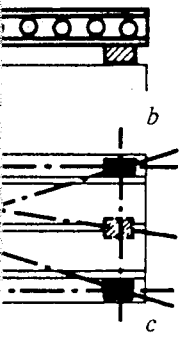
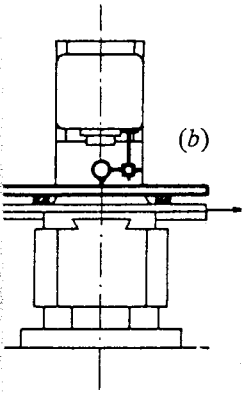
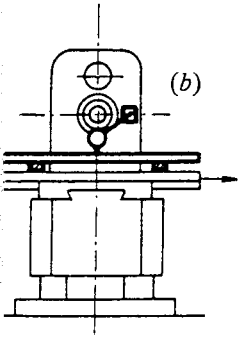
No.	Diagram	Object
G 1		Checking of straightness of the vertical movement of the knee : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.
G 2		Checking of squareness of the table surface to the column ways for knee (in three positions : in the middle and near the extremities of the travel) : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.

	Object	Permissible deviation	Measuring instruments
	Checking of straightness of the vertical movement of the knee : (a) in the vertical plane of symmetry of the machine or transverse vertical plane; (b) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.	(a) 0.025 for a measuring length of 300 (b) 0.025 for a measuring length of 300	Dial gauge and square
			
	Checking of squareness of the table surface to the column ways for knee (in three positions : in the middle and near the extremities of the travel) : (a) in the vertical plane of symmetry of the machine or transverse vertical plane; (b) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.	(a) 0.025/300 with $\alpha \leqslant 90°$ (b) 0.025/300	Dial gauge and square
			

Dimensions in millimetres

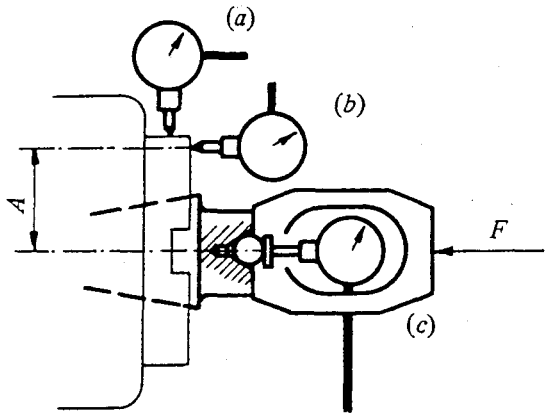
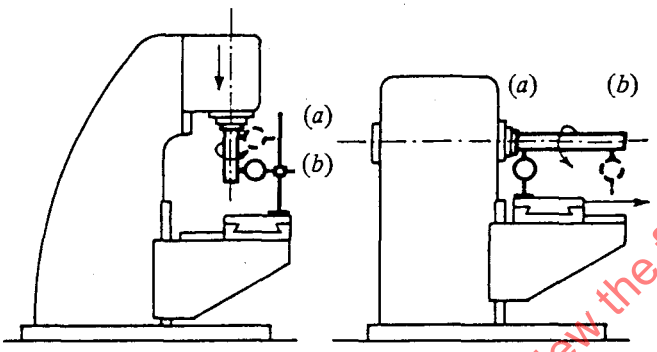
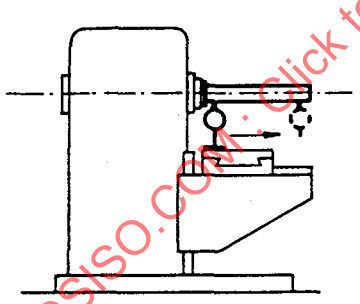
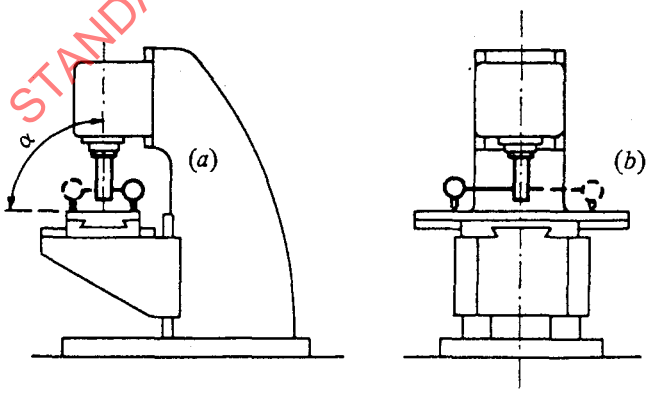
	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
e vertical move-			Clause 5.232.1 Instead of a straightedge, use the vertical arm of a square.
symmetry of the tical plane;	(*a*) 0.025 for a measuring length of 300	Dial gauge and square	Table in central position, table and cross slide locked, knee not locked.
ar to the vertical the machine or	(*b*) 0.025 for a measuring length of 300		If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge should be placed on a fixed part of the machine.
table surface to three positions : tremities of the			Clause 5.522.2 Table in central position, table and cross slide locked.
symmetry of the tical plane;	(*a*) 0.025/300 with $\alpha \leqslant 90^\circ$	Dial gauge and square	Knee locked when taking measurements.
ar to the vertical the machine or	(*b*) 0.025/300		If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge should be placed on a fixed part of the machine.

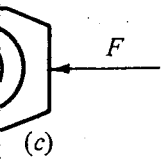
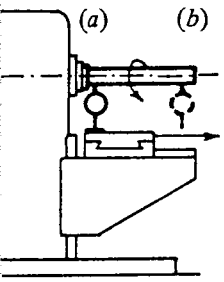
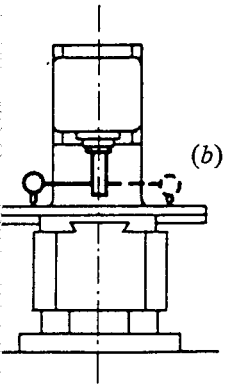
No.	Diagram	Object
G 3		Checking of squareness of the table surface to the vertical movement of the spindle head slide : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.
G 4		Checking of flatness of the table surface.
G 5	 	Checking of parallelism of the table surface to its movement : (*a*) transversely; (*b*) longitudinally.

	Object	Permissible deviation	Measuring instrument
	Checking of squareness of the table surface to the vertical movement of the spindle head slide : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.	(*a*) 0.025/300 with $\alpha \leqslant 90°$ (*b*) 0.025/300	Dial gauge and square
	Checking of flatness of the table surface.	0.04 up to 1 000 For each 1 000 increase in table length, add 0.005 Maximum permissible deviation : 0.05 Local tolerance : 0.02 for any 300 length	Precision level or straig edge and slip gauges
	Checking of parallelism of the table surface to its movement : (*a*) transversely;	(*a*) 0.025 for any 300 length	Straightedge and dial gau
	(*b*) longitudinally.	(*b*) 0.025 for any 300 length Maximum permissible deviation : 0.05	

Dimensions in millimetres

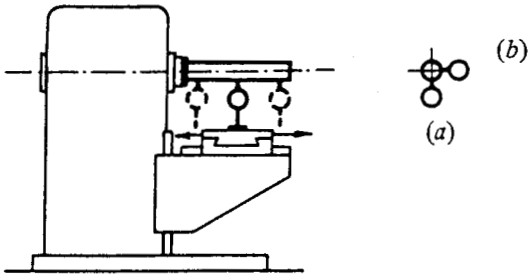
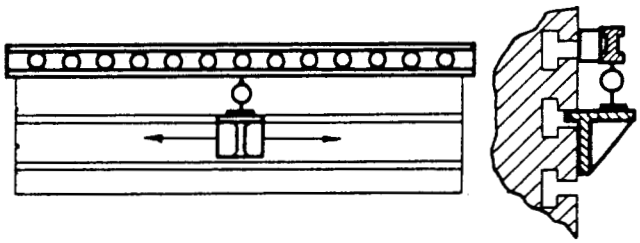
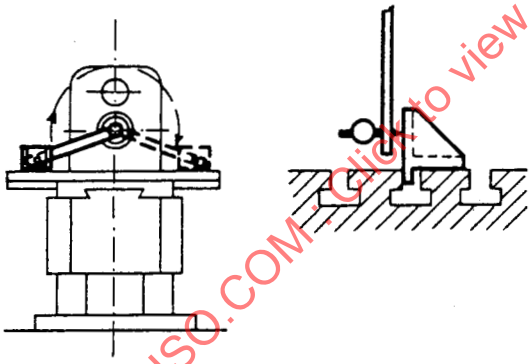
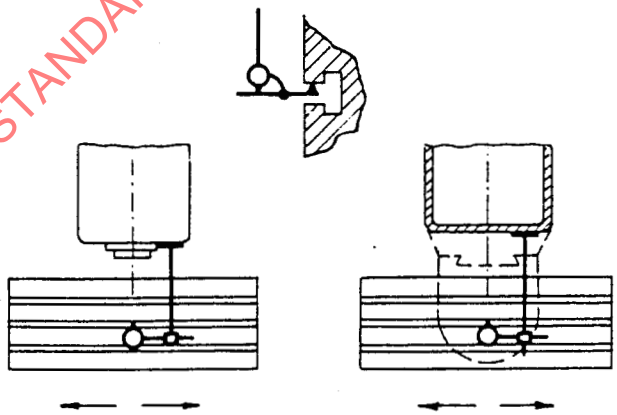
	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
e table surface to indle head slide : symmetry of the rtical plane; ar to the vertical the machine or	(*a*) 0.025/300 with $\alpha \leqslant 90°$ (*b*) 0.025/300	Dial gauge and square	Clause 5.522.2 Table in central position, knee and table locked. Spindle head slide locked when taking measurements. If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked the dial gauge should be placed on the spindle head slide of the machine.
e table surface.	0.04 up to 1 000 For each 1 000 increase in table length, add 0.005 Maximum permissible deviation : 0.05 Local tolerance : 0.02 for any 300 length	Precision level or straightedge and slip gauges	Clauses 5.322 and 5.323 Table and cross slide in central position, table not locked, knee and cross slide locked. NOTE. – The alphabetical references on the diagram correspond to those used in Figure 19 of ISO Recommendation R 230.
e table surface to	(*a*) 0.025 for any 300 length (*b*) 0.025 for any 300 length Maximum permissible deviation : 0.05	Straightedge and dial gauge	Clause 5.422.21 The stylus of the dial gauge to 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 1600 mm, carry out the inspection by successive movements of the straightedge. Knee locked. If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge should be placed on a fixed part of the machine. (*a*) Table and spindle head slide locked; (*b*) Cross slide and spindle head slide locked.

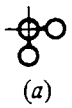
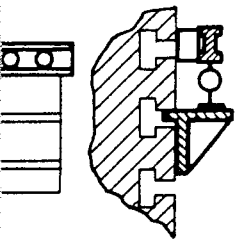
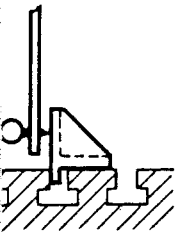
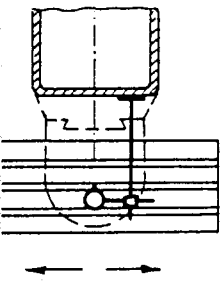
No.	Diagram	Object
G 6		(a) Measurement of run-out of the external centring surface on the spindle nose (for machines having this feature). (b) Measurement of camming of the face of the spindle nose (including periodic axial slip). (c) Measurement of periodic axial slip.
G 7		Measurement of run-out of the internal taper of the spindle : (a) at the mouth of taper; (b) at a distance of 300 from the spindle nose.
G 8		Checking of parallelism of the spindle axis to the table surface.
G 9		Checking of squareness of the spindle axis to the table surface : (a) in the vertical plane of symmetry of the machine or transverse vertical plane; (b) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.

	Object	Permissible deviation	Measuring instrument
	(*a*) Measurement of run-out of the external centring surface on the spindle nose (for machines having this feature). (*b*) Measurement of camming of the face of the spindle nose (including periodic axial slip). (*c*) Measurement of periodic axial slip.	(*a*) 0.01 (*b*) 0.02 (*c*) 0.01	Dial gauge
	Measurement of run-out of the internal taper of the spindle : (*a*) at the mouth of taper; (*b*) at a distance of 300 from the spindle nose.	(*a*) 0.01 (*b*) 0.02	Dial gauge and test mand
	Checking of parallelism of the spindle axis to the table surface.	0.025 for a measuring length of 300 (free end of the test mandrel inclined downwards)	Dial gauge and test mand
	Checking of squareness of the spindle axis to the table surface : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.	(*a*) 0.025/300 with $\alpha \leqslant 90^\circ$ (*b*) 0.025/300	Dial gauge

Dimensions in millimetres

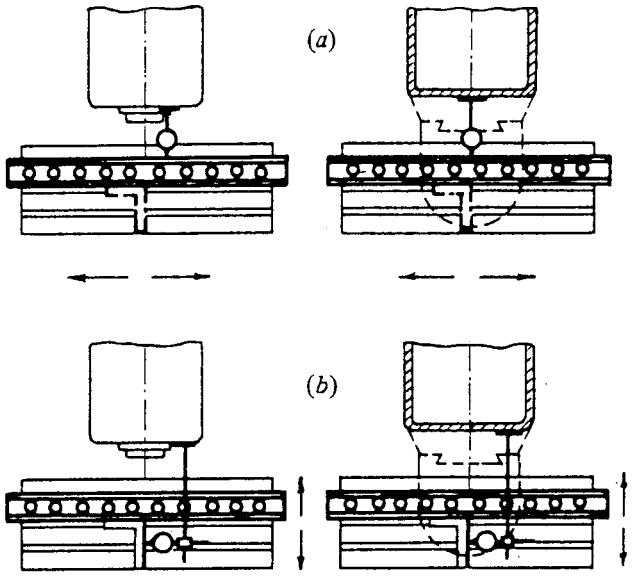
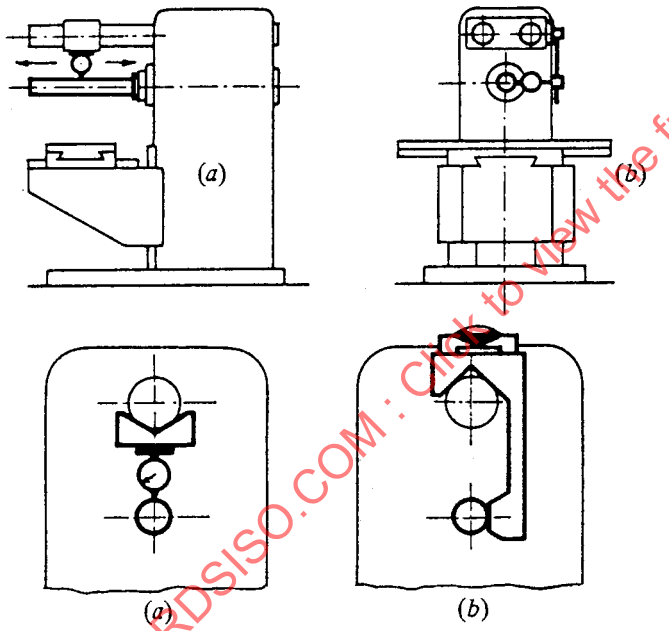
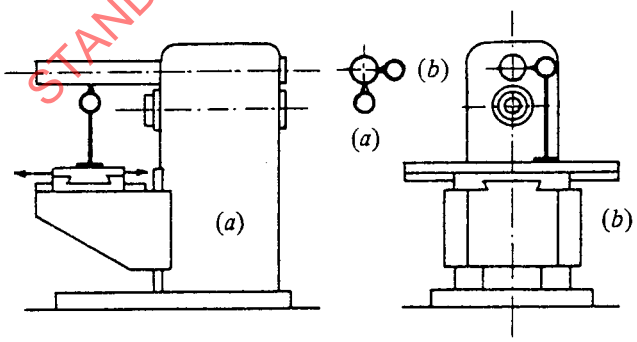
	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
t of the external spindle nose (for ture).	(*a*) 0.01		(*a*) Clause 5.612.2
ng of the face of ling periodic axial	(*b*) 0.02	Dial gauge	(*b*) Clause 5.632 The distance *A* of dial gauge (*b*) from the spindle axis should be as large as possible.
: axial slip.	(*c*) 0.01		(*c*) Clauses 5.662.1 and 5.622.2 A force *F*, specified by the manufacturer of the machine, should be exerted by pressing towards the housing for tests (*b*) and (*c*).
the internal taper from the spindle	(*a*) 0.01 (*b*) 0.02	Dial gauge and test mandrel	Clause 5.612.3
the spindle axis	0.025 for a measuring length of 300 (free end of the test mandrel inclined downwards)	Dial gauge and test mandrel	Clause 5.412.4. Table and cross slide not locked, knee locked.
pindle axis to the symmetry of the rtical plane; ar to the vertical the machine or	(*a*) 0.025/300 with $\alpha \leqslant 90°$ (*b*) 0.025/300	Dial gauge	Clauses 5.512.1 and 5.512.42 Spindle head slide, table, cross slide and knee locked.

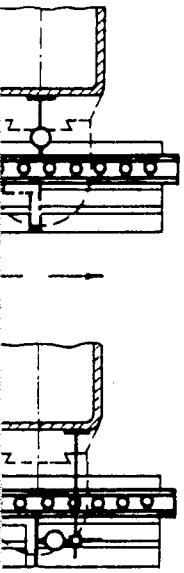
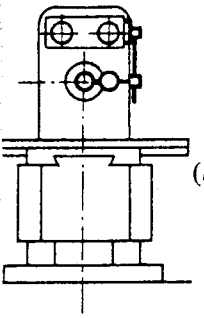
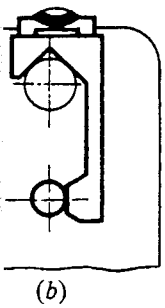
No.	Diagram	Object
G 10		Checking of parallelism of the spindle axis to the transverse movement of the table : (*a*) in the vertical plane; (*b*) in the horizontal plane.
G 11		Checking of straightness of the median or reference tee slot of the table.
G 12		Checking of squareness of the spindle axis to the median or reference tee slot of the table.
G 13		Checking of parallelism of the median or reference tee slot to the longitudinal movement of the table.

	Object	Permissible deviation	Measuring instrument
 (b) (a)	Checking of parallelism of the spindle axis to the transverse movement of the table : (a) in the vertical plane; (b) in the horizontal plane.	(a) 0.025 for a measuring length of 300 (free end of the test mandrel inclined downwards) (b) 0.025 for a measuring length of 300	Dial gauge and test manc
	Checking of straightness of the median or reference tee slot of the table.	0.01 for any 500 length Maximum permissible deviation : 0.03	Straightedge and dial gai or slip gauges, or taut w and microscope
	Checking of squareness of the spindle axis to the median or reference tee slot of the table.	0.02/300 *	Dial gauge
	Checking of parallelism of the median or reference tee slot to the longitudinal movement of the table.	0.015 for any 300 length Maximum permissible deviation : 0.04	Dial gauge

Dimensions in millimetres

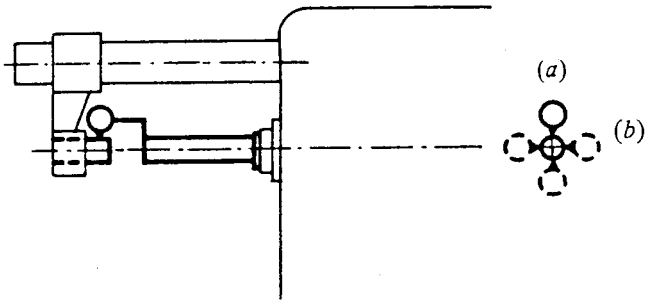
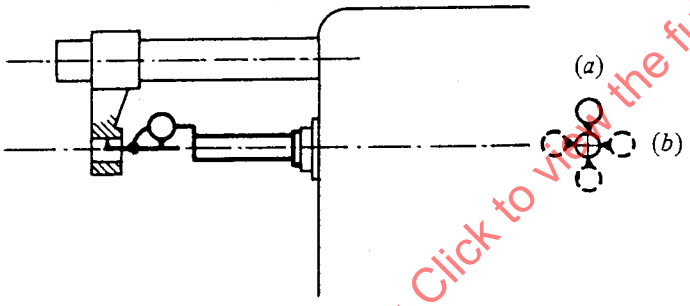
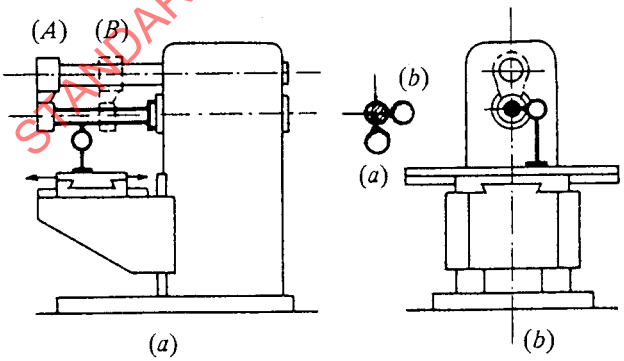
	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
spindle axis to the able :	(*a*) 0.025 for a measuring length of 300 (free end of the test mandrel inclined downwards) (*b*) 0.025 for a measuring length of 300	Dial gauge and test mandrel	Clause 5.422.3. Table in central position. Knee locked.
f the median or	0.01 for any 500 length Maximum permissible deviation : 0.03	Straightedge and dial gauge or slip gauges, or taut wire and microscope	Clauses 5.212, 5.212.1, 5.212.3 or 5.232 The straightedge may be placed directly on the table.
spindle axis to the ot of the table.	0.02/300 *	Dial gauge	Clauses 5.512.1 and 5.512.52 Table in central position. Table, cross slide and knee locked. * Distance between the two points touched.
e median or referinal movement of	0.015 for any 300 length Maximum permissible deviation : 0.04	Dial gauge	Clauses 5.422.1 and 5.422.21 Cross slide and knee locked. If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge should be placed on a fixed part of the machine.

No.	Diagram	Object
G 14		Checking of squareness of the movement of the table transversely to its longitudinal movement.
G 15		Checking of parallelism of arbor support guide on the over arm (or arms) to the spindle axis : (*a*) in the vertical plane; (*b*) in the horizontal plane.
		**Alternative** Checking of parallelism of arbor support guide on the over arm (or arms) to the transverse movement of the table : (*a*) in the vertical plane; (*b*) in the horizontal plane.

	Object	Permissible deviation	Measuring instruments
	Checking of squareness of the movement of the table transversely to its longitudinal movement.	0.02/300	Straightedge, dial gauge and square
 (*b*)	Checking of parallelism of arbor support guide on the over arm (or arms) to the spindle axis : (*a*) in the vertical plane; (*b*) in the horizontal plane.	(*a*) 0.02 for a measuring length of 300 (over arm inclined downwards) (*b*) 0.02 for a measuring length of 300	Dial gauge and precision level.
 (*b*)	**Alternative** Checking of parallelism of arbor support guide on the over arm (or arms) to the transverse movement of the table : (*a*) in the vertical plane; (*b*) in the horizontal plane.	(*a*) 0.02 for a measuring length of 300 (over arm inclined downwards) (*b*) 0.02 for a measuring length of 300	

Dimensions in millimetres

	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
ovement of the nal movement.	0.02/300	Straightedge, dial gauge and square	Clause 5.522.4 Knee locked. (*a*) The straightedge should be set parallel to the table longitudinal movement; then the square should be placed against the straightedge. The table should then be locked in central position. (*b*) The transverse movement of the table should then be checked. If the spindle can be locked, then the dial gauge may be mounted on it after locking the spindle head slide. If the spindle cannot be locked the dial gauge should be placed on a fixed part of the machine.
support guide spindle axis :	(*a*) 0.02 for a measuring length of 300 (over arm inclined downwards) (*b*) 0.02 for a measuring length of 300	Dial gauge and precision level.	Clause 5.412.5 or Clauses 5.412.3 and 5.412.1 Clause 5.422.4.
support guide the transverse	(*a*) 0.02 for a measuring length of 300 (over arm inclined downwards) (*b*) 0.02 for a measuring length of 300		Over arm(s) locked.

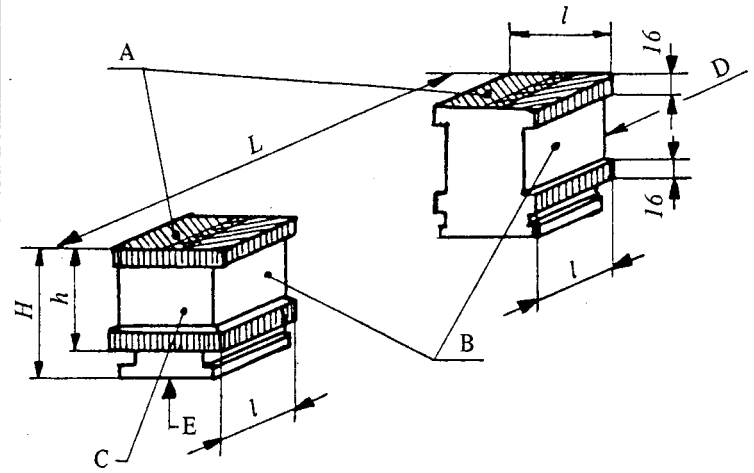
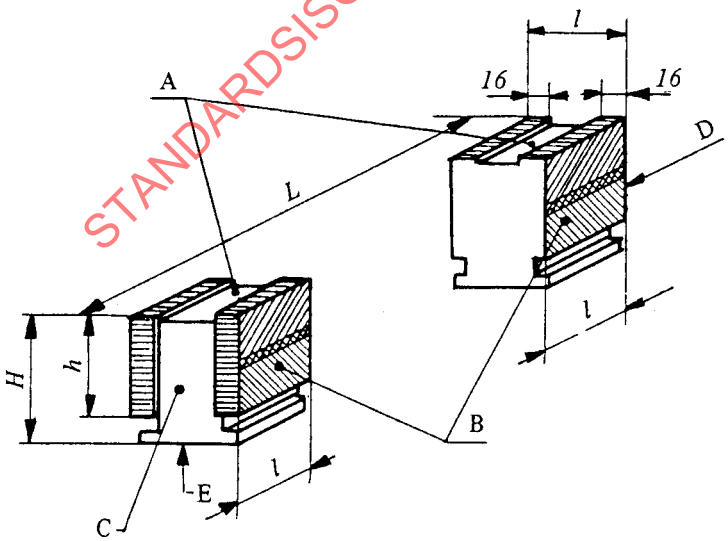
No.	Diagram	Object
G 16	 **First alternative**  **Second alternative** 	Checking of coincidence of the axis of the bore of the arbor support with the spindle axis : (a) in the vertical plane; (b) in the horizontal plane.

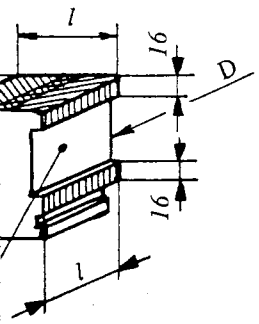
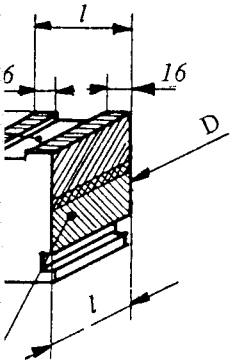
	Object	Permissible deviation	Measuring instruments
(a) (b)		(a) 0.03 (Axis of the bore of the arbor support lower than the spindle axis)	
	Checking of coincidence of the axis of the bore of the arbor support with the spindle axis :	(b) 0.03	
(a) (b)	(a) in the vertical plane;		Dial gauge and test mandre
	(b) in the horizontal plane.		
(b)		**Second alternative** (a) 0.04 for a measuring length of 300 (Mandrel inclined downwards on the side of the bore of the arbor support) (b) 0.025 for a measuring length of 300	

Dimensions in millimetres

	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
			Clauses 5.422.4 and 5.442 Arbor support located 300 away from the spindle nose. The measurement should be made as near as possible to the arbor support. Over arm locked and arbor support not connected to the knee.
xis of the bore spindle axis :	(*a*) 0.03 (Axis of the bore of the arbor support lower than the spindle axis) (*b*) 0.03	Dial gauge and test mandrel	**First alternative** It is unnecessary to follow the test code ISO/R 230. The dial gauge is mounted on the spindle and the stylus touches the bore of the arbor support. The reading observed on the dial gauge must be divided by 2 for comparison with the permissible deviation.
	Second alternative (*a*) 0.04 for a measuring length of 300 (Mandrel inclined downwards on the side of the bore of the arbor support) (*b*) 0.025 for a measuring length of 300		**Second alternative** (*A*) The end of the mandrel or cutter arbor is held by the arbor support. (*B*) The arbor support is positioned mid-way along the mandrel or cutter arbor. The reading observed on the dial gauge must not be divided by 2.

3.2 Practical test

No.	Diagram and test piece dimensions	Nature of test	Cutti conditi
P 1	 L (length of the test piece or distance between the opposite faces of two test pieces) $= \frac{1}{2}$ longitudinal travel $l = h$ $= \frac{1}{8}$ longitudinal travel l max. = 100 for $L \leqslant 500$ 150 for $500 < L \leqslant 1000$ 200 for $L > 1000$ l min. = 50 NOTES (concerning vertical and horizontal milling machines) 1. Longitudinal travels $\geqslant 400$: one or two test pieces can be used and they should be machined in the longitudinal direction over a length l at each end. 2. Longitudinal travels < 400 : one test piece is used and it should be machined over its entire length. 3. Material : cast iron. 	*A* **Vertical milling machines** Milling of surface A by automatic longitudinal movement of the table and manual transverse movement of the cross slide, in two cuts overlapping by about 5 to 10 mm. Milling of strips of surfaces B, C and D by automatic longitudinal movement of the table, automatic transverse movement of the cross slide and manual vertical movement of the knee. *B* **Horizontal milling machines** 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 to 10 mm. Milling of strips 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 cross slide.	With a s end mil Slab mill with the cutter. With a sl end mill. Slab milli with the s cutter.

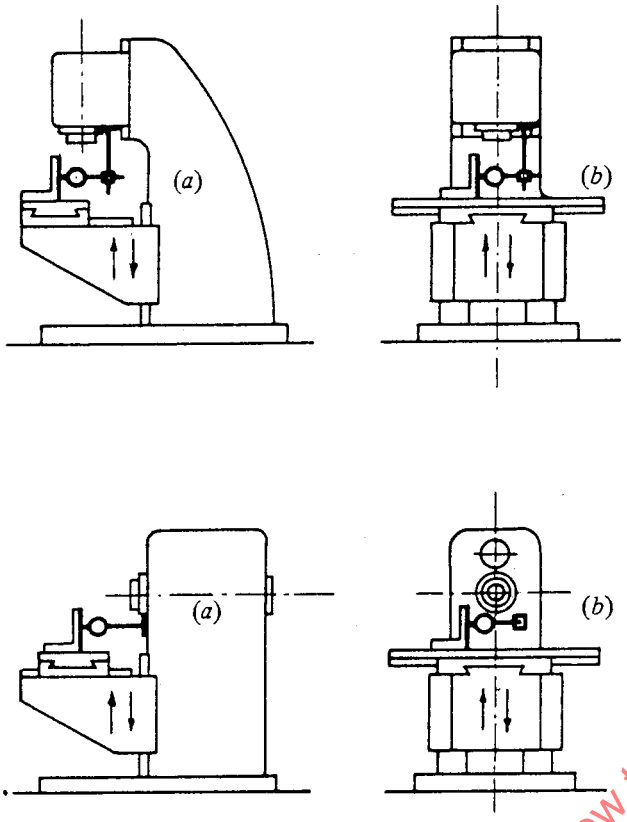
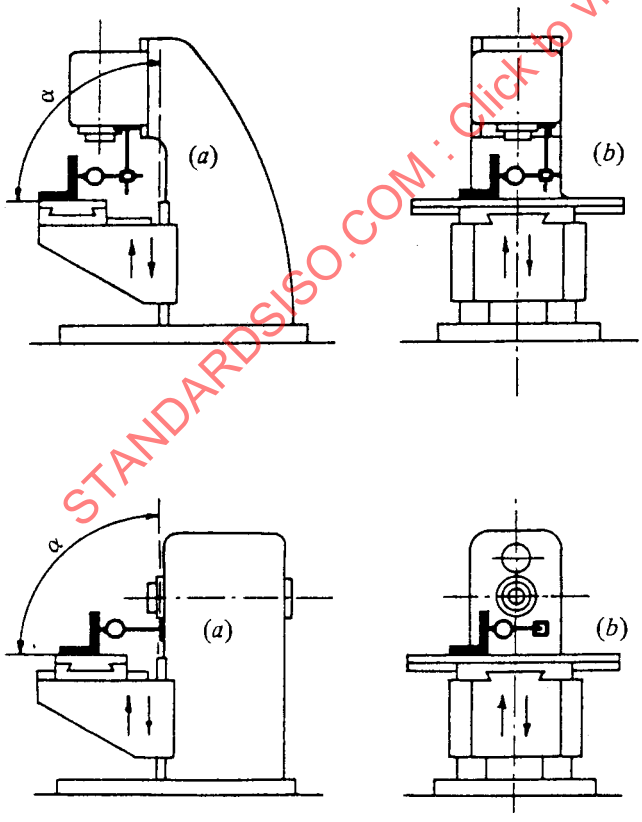
ensions	Nature of test	Cutting conditions	Checks to be applied	Permissible deviation	Me inst
	*A* **Vertical milling machines**				
	Milling of surface A by automatic longitudinal movement of the table and manual transverse movement of the cross slide, in two cuts overlapping by about 5 to 10 mm.	With a shell end mill.	(*a*) Surface A on each block should be flat.	0.02	Straig and sl or mi callip
			(*b*) The height *H* of the block (or blocks) should be constant.	0.03	
ance between the	Milling of strips of surfaces B, C and D by automatic longitudinal movement of the table, automatic transverse movement of the cross slide and manual vertical movement of the knee.	Slab milling with the same cutter.	The planes containing the strips of surfaces B, C and D should be perpendicular to each other and each one perpendicular to the surface A.	0.02/100	Squar slip ga
l milling machines) st pieces can be used linal direction over a is used and it should	*B* **Horizontal milling machines**				
	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 to 10 mm.	With a shell end mill.	Surface B on each block should be flat.	0.02	Straigh and sli or mic callipe
	Milling of strips 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 cross slide.	Slab milling with the same cutter.	(*a*) The planes containing the strips of surfaces C, A and D should be perpendicular to each other and each one perpendicular to the surface B.	0.02/100	Square slip gau
			(*b*) The height *H* of the block (or blocks) should be constant.	0.03	

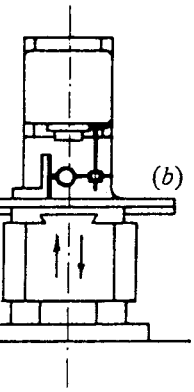
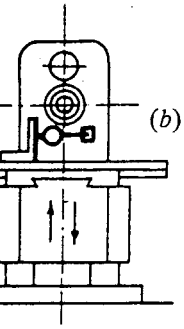
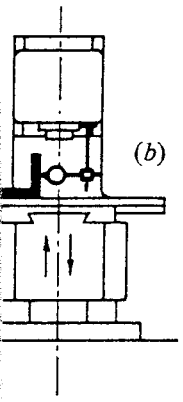
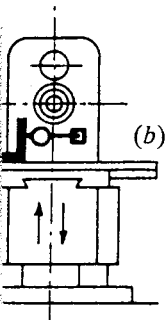
Dimensions in millimetres

	Cutting conditions	Checks to be applied	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
toma- of the sverse de, in about	With a shell end mill.	(*a*) Surface A on each block should be flat. (*b*) The height *H* of the block (or blocks) should be constant.	0.02 0.03	Straightedge and slip gauges or micrometer callipers	Clauses 3.1 and 3.22. Clauses 4.1 and 4.2. Before beginning the test make sure that surface E is flat.
; B, C idinal toma- of the rtical	Slab milling with the same cutter.	The planes containing the strips of surfaces B, C and D should be perpendicular to each other and each one perpendicular to the surface A.	0.02/100	Square and slip gauges	Test pieces should 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 manufacturer, the form of 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.
toma- of the nove- cuts 5 to	With a shell end mill.	Surface B on each block should be flat.	0.02	Straightedge and slip gauges or micrometer callipers	The cutter should be sharpened on its arbor and when mounted should conform to the following tolerances: 1. Out of round $\leqslant 0.02$
A, C dinal auto- f the verse slide.	Slab milling with the same cutter.	(*a*) The planes containing the strips of surfaces C, A and D should be perpendicular to each other and each one perpendicular to the surface B. (*b*) The height *H* of the block (or blocks) should be constant.	0.02/100 0.03	Square and slip gauge	2. Run-out $\leqslant 0.02$ 3. Camming $\leqslant 0.03$ All non-operating slides should be locked during cutting.

4. TEST CONDITIONS AND PERMISSIBLE DEVIATIONS

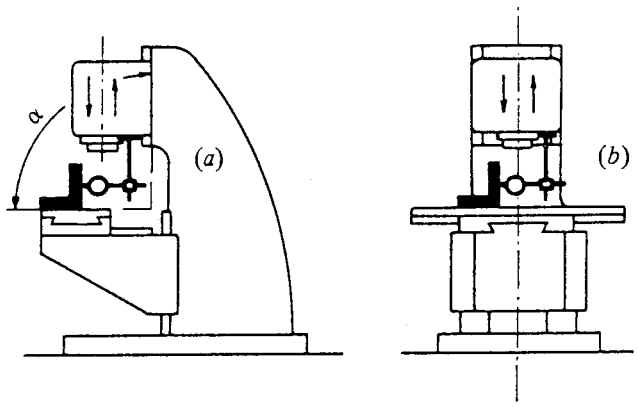
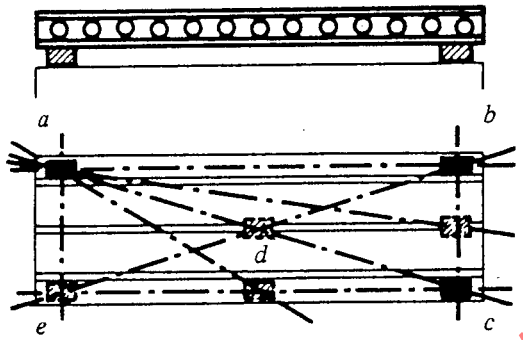
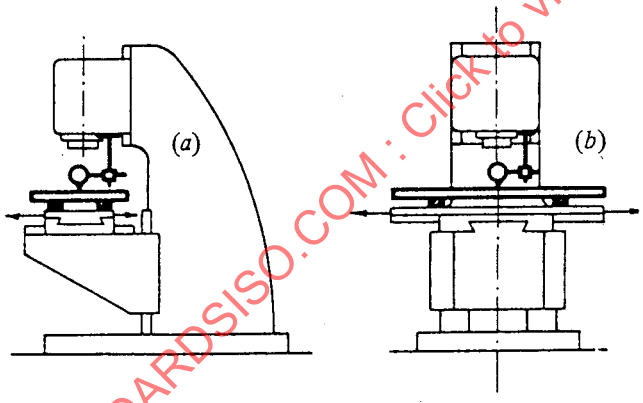
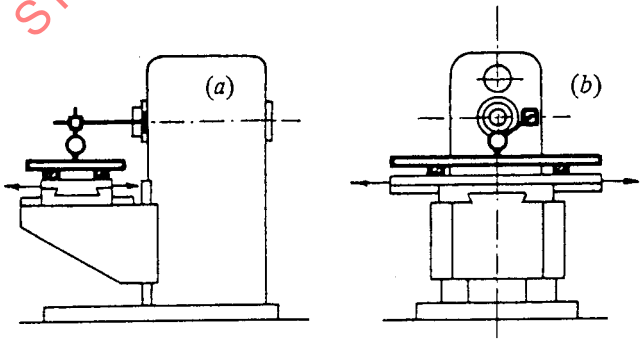
4.1 Geometrical tests

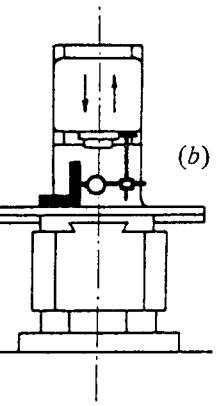
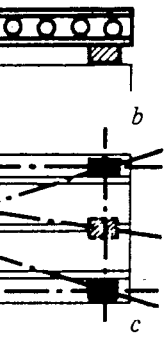
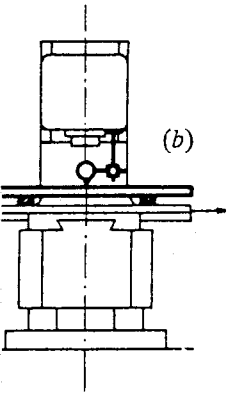
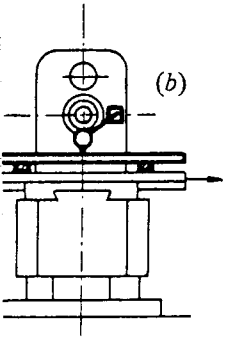
No.	Diagram	Object
G 1		Checking of straightness of the vertical movement of the knee : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.
G 2		Checking of squareness of the table surface to the column ways for knee (in three positions : in the middle and near the extremities of the travel) : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.

	Object	Permissible deviation	Measuring instruments
	Checking of straightness of the vertical movement of the knee :		
	(a) in the vertical plane of symmetry of the machine or transverse vertical plane;	(a) 0.001 for a measuring length of 12	Dial gauge and square
	(b) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.	(b) 0.001 for a measuring length of 12	
	Checking of squareness of the table surface to the column ways for knee (in three positions : in the middle and near the extremities of the travel) :		
	(a) in the vertical plane of symmetry of the machine or transverse vertical plane;	(a) 0.001 /12 with $\alpha \leqslant 90°$	Dial gauge and square
	(b) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.	(b) 0.001 /12	

Dimensions in inches.

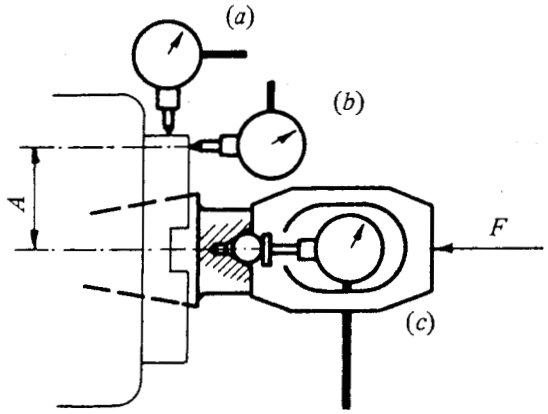
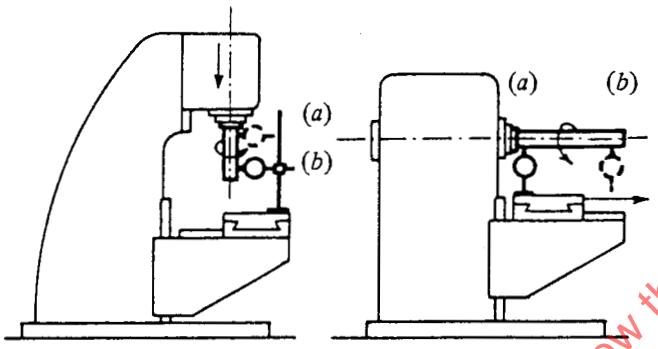
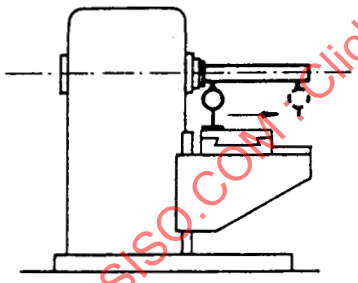
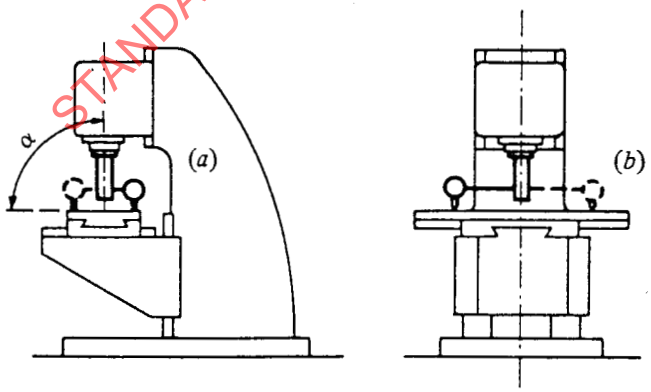
	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
ertical move-			Clause 5.232.1 Instead of a straightedge, use the vertical arm of a square.
metry of the l plane;	(*a*) 0.001 for a measuring length of 12	Dial gauge and square	Table in central position, table and cross slide locked, knee not locked.
o the vertical machine or	(*b*) 0.001 for a measuring length of 12		If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge should be placed on a fixed part of the machine.
ble surface to ee positions : emities of the			Clause 5.522.2 Table in central position, table and cross slide locked.
metry of the l plane;	(*a*) 0.001 /12 with $\alpha \leqslant 90^\circ$	Dial gauge and square	Knee locked when taking measurements.
o the vertical machine or	(*b*) 0.001 /12		If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge should be placed on a fixed part of the machine.

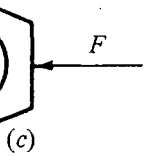
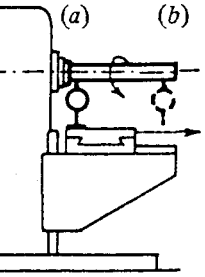
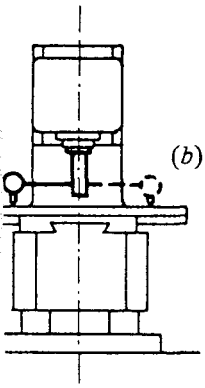
No.	Diagram	Object
G 3		Checking of squareness of the table surface to the vertical movement of the spindle head slide : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.
G 4		Checking of flatness of the table surface.
G 5	 	Checking of parallelism of the table surface to its movement : (*a*) transversely; (*b*) longitudinally.

	Object	Permissible deviation	Measuring instruments
	Checking of squareness of the table surface to the vertical movement of the spindle head slide : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.	(*a*) 0.001 /12 with $\alpha \leqslant 90°$ (*b*) 0.001 /12	Dial gauge and square
	Checking of flatness of the table surface.	0.0016 up to 40 For each 40 increase in table length, add 0.0002 Maximum permissible deviation : 0.002 Local tolerance : 0.0008 for any 12 length	Precision level or straigh edge and slip gauges
	Checking of parallelism of the table surface to its movement: (*a*) transversely;	(*a*) 0.001 for any 12 length	Straightedge and dial gaug
	(*b*) longitudinally.	(*b*) 0.001 for any 12 length Maximum permissible deviation : 0.002	

Dimensions in inches

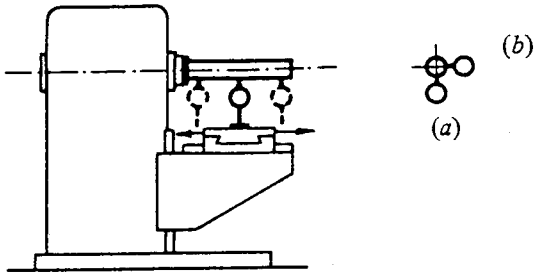
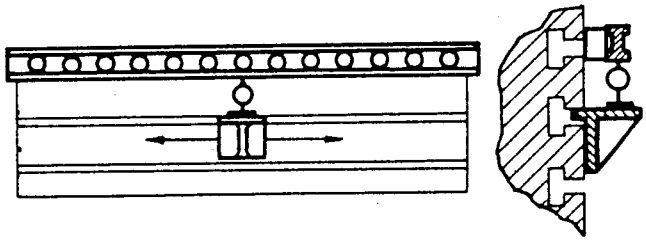
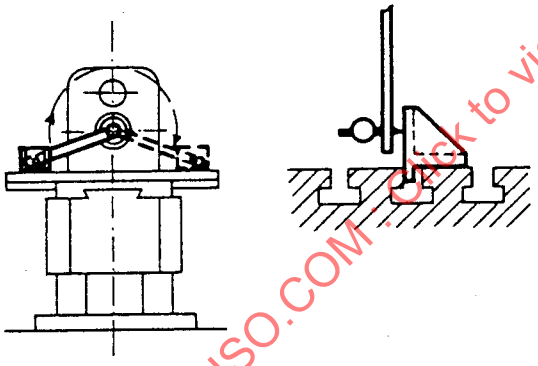
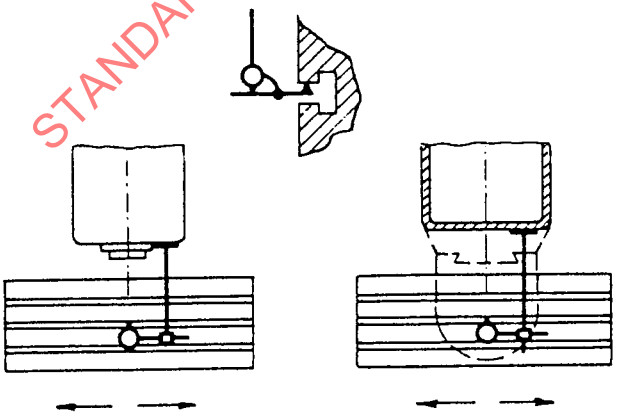
	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
table surface to idle head slide : symmetry of the cal plane; to the vertical he machine or	(*a*) 0.001 /12 with $\alpha \leqslant 90^\circ$ (*b*) 0.001 /12	Dial gauge and square	Clause 5.522.2 Table in central position, knee and table locked. Spindle head slide locked when taking measurements. If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked the dial gauge should be placed on the spindle head slide of the machine.
table surface.	0.0016 up to 40 For each 40 increase in table length, add 0.0002 Maximum permissible deviation : 0.002 Local tolerance : 0.0008 for any 12 length	Precision level or straightedge and slip gauges	Clauses 5.322 and 5.323 Table and cross slide in central position, table not locked, knee and cross slide locked. NOTE. – The alphabetical references on the diagram correspond to those used in Figure 19 of ISO Recommendation R 230.
table surface to	(*a*) 0.001 for any 12 length (*b*) 0.001 for any 12 length Maximum permissible deviation : 0.002	Straightedge and dial gauge	Clause 5.422.21 The stylus of the dial gauge to 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 64 in, carry out the inspection by successive movements of the straightedge. Knee locked. If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge should be placed on a fixed part of the machine. (*a*) Table and spindle head slide locked; (*b*) Cross slide and spindle head slide locked.

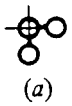
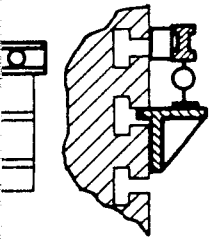
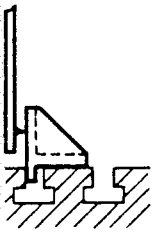
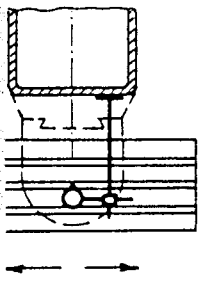
No.	Diagram	Object
G 6		(a) Measurement of run-out of the external centring surface on the spindle nose (for machines having this feature). (b) Measurement of camming of the face of the spindle nose (including periodic axial slip). (c) Measurement of periodic axial slip.
G 7		Measurement of run-out of the internal taper of the spindle : (a) at the mouth of taper; (b) at a distance of 12 from the spindle nose.
G 8		Checking of parallelism of the spindle axis to the table surface.
G 9		Checking of squareness of the spindle axis to the table surface : (a) in the vertical plane of symmetry of the machine or transverse vertical plane; (b) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.

	Object	Permissible deviation	Measuring instruments
	(*a*) Measurement of run-out of the external centring surface on the spindle nose (for machines having this feature). (*b*) Measurement of camming of the face of the spindle nose (including periodic axial slip). (*c*) Measurement of periodic axial slip.	(*a*) 0.0004 (*b*) 0.0008 (*c*) 0.0004	Dial gauge
	Measurement of run-out of the internal taper of the spindle : (*a*) at the mouth of taper; (*b*) at a distance of 12 from the spindle nose.	(*a*) 0.0004 (*b*) 0.0008	Dial gauge and test mandre
	Checking of parallelism of the spindle axis to the table surface.	0.001 for a measuring length of 12 (free end of the test mandrel inclined downwards)	Dial gauge and test mandrel
	Checking of squareness of the spindle axis to the table surface : (*a*) in the vertical plane of symmetry of the machine or transverse vertical plane; (*b*) in the plane perpendicular to the vertical plane of symmetry of the machine or transverse vertical plane.	(*a*) 0.001 /12 with $\alpha \leqslant 90^\circ$ (*b*) 0.001 /12	Dial gauge

Dimensions in inches

	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
f the external ndle nose (for e).	(*a*) 0.0004	Dial gauge	(*a*) Clause 5.612.2
of the face of periodic axial	(*b*) 0.0008		(*b*) Clause 5.632 The distance *A* of dial gauge (*b*) from the spindle axis should be as large as possible.
ial slip.	(*c*) 0.0004		(*c*) Clauses 5.662.1 and 5.622.2 A force *F*, specified by the manufacturer of the machine, should be exerted by pressing towards the housing for tests (*b*) and (*c*).
internal taper n the spindle	(*a*) 0.0004 (*b*) 0.0008	Dial gauge and test mandrel	Clause 5.612.3
spindle axis	0.001 for a measuring length of 12 (free end of the test mandrel inclined downwards)	Dial gauge and test mandrel	Clause 5.412.4. Table and cross slide not locked, knee locked.
dle axis to the nmetry of the al plane; to the vertical e machine or	(*a*) 0.001 /12 with $\alpha \leqslant 90^\circ$ (*b*) 0.001 /12	Dial gauge	Clauses 5.512.1 and 5.512.42 Spindle head slide, table, cross slide and knee locked.

No.	Diagram	Object
G 10		Checking of parallelism of the spindle axis to the transverse movement of the table : (*a*) in the vertical plane; (*b*) in the horizontal plane.
G 11		Checking of straightness of the median or reference tee slot of the table.
G 12		Checking of squareness of the spindle axis to the median or reference tee slot of the table.
G 13		Checking of parallelism of the median or reference tee slot to the longitudinal movement of the table.

	Object	Permissible deviation	Measuring instruments
 (b) (a)	Checking of parallelism of the spindle axis to the transverse movement of the table : (a) in the vertical plane; (b) in the horizontal plane.	(a) 0.001 for a measuring length of 12 (free end of the test mandrel inclined downwards) (b) 0.001 for a measuring length of 12	Dial gauge and test mandr
	Checking of straightness of the median or reference tee slot of the table.	0.0004 for any 20 length Maximum permissible deviation : 0.0012	Straightedge and dial gaug or slip gauges, or taut wir and microscope
	Checking of squareness of the spindle axis to the median or reference tee slot of the table.	0.0008 /12*	Dial gauge
	Checking of parallelism of the median or reference tee slot to the longitudinal movement of the table.	0.0006 for any 12 length Maximum permissible deviation : 0.0016	Dial gauge

Dimensions in inches

	Permissible deviation	Measuring instruments	Observations and references to the test code ISO/R 230
dle axis to the :	(*a*) 0.001 for a measuring length of 12 (free end of the test mandrel inclined downwards) (*b*) 0.001 for a measuring length of 12	Dial gauge and test mandrel	Clause 5.422.3. Table in central position. Knee locked.
ae median or	0.0004 for any 20 length Maximum permissible deviation : 0.0012	Straightedge and dial gauge or slip gauges, or taut wire and microscope	Clauses 5.212, 5.212.1, 5.212.3 or 5.232 The straightedge may be placed directly on the table.
dle axis to the of the table.	0.0008 /12*	Dial gauge	Clauses 5.512.1 and 5.512.52 Table in central position. Table, cross slide and knee locked. * Distance between the two points touched.
edian or refer- movement of	0.0006 for any 12 length Maximum permissible deviation : 0.0016	Dial gauge	Clauses 5.422.1 and 5.422.21 Cross slide and knee locked. If the spindle can be locked, the dial gauge may be mounted on it. If the spindle cannot be locked, the dial gauge should be placed on a fixed part of the machine.