INTERNATIONAL STANDARD

ISO
8636-2
First edition
1988-12-01

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Acceptance conditions for plano-milling machines — Testing of the accuracy —

Part 2:
Gantry-type machines

Conditions de réception des machines à fraiser à portique — Contrôle de la précision —

Partie 2: Machines à portique mobile

Reference number
ISO 8636-2: 1988 (E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8636-2 was prepared by Technical Committee ISO/TC 39, *Machine tools.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Printed in Switzerland

Acceptance conditions for plano-milling machines — Testing of the accuracy —

Part 2 : Gantry-type machines

1 Scope and field of application

This part of ISO 8636 specifies, with reference to ISO 230-1, the preliminary tests, geometrical tests and practical tests for gantry-type plano-milling machines, and the corresponding deviations which apply to general purpose, normal accuracy, machines, excluding machines for machining light alloy panels (for aircraft).

This part of ISO 8636 deals only with the verification of the machine accuracy. It does not apply to the testing of the running of the machine (vibration, abnormal noise, stick-slip motion of components, etc.) nor to the checking of machine characteristics (speeds, feeds, etc.) which should generally be checked before the accuracy is tested.

This part of ISO 8636 gives the nomenclature used for the principal parts of the machine and the designation of the axes.

NOTE — In addition to terms used in the three official ISO languages (English, French and Russian), this part of ISO 8636 gives the equivalent terms in the German and Italian languages in an annex; these have been included at the request of Technical Committee ISO/TC 39 and are published under the responsibility of the member bodies for Germany, F.R. (DIN) and Italy (UNI). However, only terms given in the official languages can be considered as ISO terms.

2 References

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

ISO 7572, *Conditions of acceptance and installation for work-holding fixed tables of machine tools.*

ISO 8636-1, *Acceptance conditions for plano-milling machines — Testing of the accuracy — Part 1: Portal-type machines.*

3 Preliminary observations

3.1 In this part of ISO 8636, all dimensions and deviations are expressed in millimetres and inches.

3.2 To apply this part of ISO 8636, reference should be made to ISO 230-1, especially for the installation of the machine before testing, warming up of the spindle and other moving parts, description of measuring methods and recommended accuracy of test equipment.

3.3 The temperature conditions during the tests shall be specified by agreement between manufacturer and user.

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

3.5 When inspecting a machine, it is not always necessary to carry out all the tests given in this part of ISO 8636. It is up to the user to choose, in agreement with the manufacturer, those tests relating to the properties which are of interest to him, but these tests are to be clearly stated when ordering a machine.

3.6 Practical tests shall be carried out with finishing cuts and not with roughing cuts which are liable to generate appreciable cutting forces.

3.7 When establishing the tolerance for a measuring range different from that given in this part of ISO 8636 (see subclause 2.311 of ISO 230-1), it should be borne in mind that the minimum tolerance value is 0,005 mm (0.000 2 in).

3.8 For reasons of simplicity, the diagrams in this part of ISO 8636 are based on one single machine type.

4 Definitions and description

4.1 Definitions of the machining processes that can be carried out

4.1.1 Milling operations

These are mainly end milling operations carried out using "face cutters" or "end mills", and sometimes milling operations on two or three faces using end mills or side and face cutters. The tools are mounted either on the spindle taper or on the spindle front face.

4.1.2 Boring operations

Boring consists of machining the diameters of cylindrical, conical, blind or through holes, to the required size.

4.1.3 Drilling and tapping operations

These operations consist of drilling and/or tapping blind or through holes.

4.2 Definition of gantry-type plano-milling machines and main types

4.2.1 Definition

gantry-type plano-milling machines: Machines with one fixed workpiece clamping table and two beds provided with slideways on either side of the table, which are independent or not of the table. The gantry, composed of a left-hand column and a right-hand column supported by respective column slides and made integral with a fixed top bridge, is moved along the bed slideways. The gantry supports a horizontal cross-rail, movable or fixed in the vertical plane, on which one or more milling heads are mounted with vertical or inclinable spindle axes.

4.2.2 Main types

In general these machines are classified into two types characterized by their particular configuration:

— gantry-type plano-milling machines with fixed cross-rail;

— gantry-type plano-milling machines with movable cross-rail.

4.3 Description

See the nomenclature given in 5.1 for an explanation of the numerals.

4.3.1 Table and beds

The table (1) is a rigid fixed part placed between the beds (3) and (4). The beds are rigid parts, made integral with the table if required, which comprise horizontal slideways on which the movable gantry slides.

NOTE — The table may possibly be replaced by a floorplate.

4.3.2 Columns, top bridge and cross-rail

The columns (9) and (10) are rigid parts with vertical greater axes and which either slide on the beds or are fixed rigidly to column slides (7) and (8) which slide horizontally on the beds.

The top bridge (11) is a fixed part connecting the two columns near their upmost end.

The cross-rail (14) is a part whose greater axis is parallel to the plane of the table. In the case of machines with fixed cross-rails, the cross-rail is made integral with the columns and may be used as a top bridge; in the case of machines with movable cross-rails, the cross-rail slides vertically on the slideways of the columns (12) and (13).

The cross-rail is provided with horizontal slideways on which one or more milling heads with vertical or inclinable spindle axes are mounted.

4.3.3 Milling heads

Milling heads (16) are parts which move on the cross-rail slideways.

The portion in direct contact with the cross-rail slideways is called the bottom slide (15). The milling head may be mounted so that it slides on the bottom slide in the direction of the spindle axis; it is then called a ram. The spindle may be mounted in a quill sliding in the milling head in the direction of the spindle axis. Some parts of the head may be inclinable.

4.3.4 Cutting and feed movements

4.3.4.1 Cutting motions

Cutting movements are generated by the spindle motors and kinematic chain of the milling heads driving the milling spindles.

4.3.4.2 Feed motions

The following feed movements with continuous or discontinuous speed variation may exist on certain machines:

— horizontal movement of the movable gantry;

— vertical movement of the movable cross-rail;

— horizontal movements of the milling heads;

— vertical movements of rams, if any;

— vertical movements of quills, if any;

— rotational movements (tilt movements of milling heads), if any.

NOTES

1 In general rapid traverse is available in addition to feed movement of the driven parts.

2 The vertical movement of the movable cross-rail may be either a feed movement (in which case the cross-rail is said to be movable when working) or a movement of displacement between two fixed working positions (the cross-rail is then said to be movable when being positioned).

5 Nomenclature and designation of axes

5.1 Nomenclature

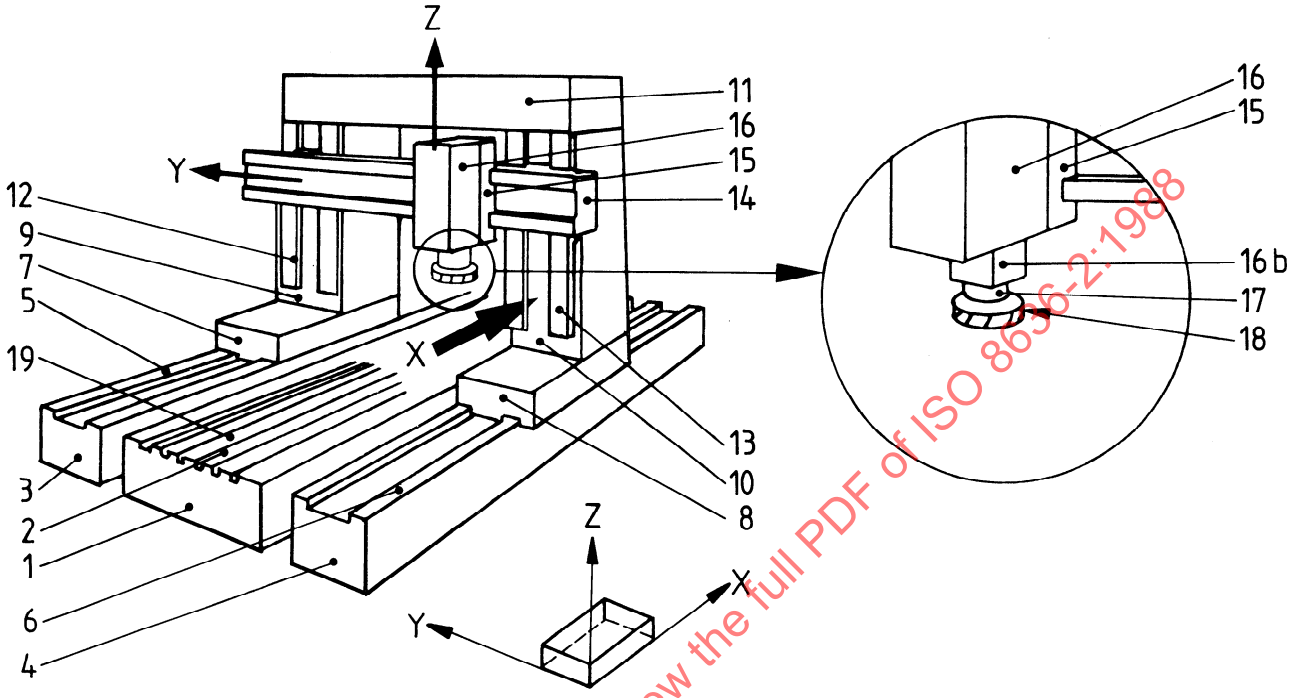


Figure 1 — Gantry-type plano-milling machine with variable height cross-rail

Reference	Designation		
	English	French	Russian
1	Table (or floorplate)	Table (ou taque)	Стол (или плита основания)
2	Clamping surface	Surface de bridage	Рабочая поверхность
3	Left-hand bed	Banc gauche	Левая станина
4	Right-hand bed	Banc droit	Правая станина
5	Left-hand bed slideways	Glissières du banc gauche	Направляющие левой станины
6	Right-hand bed slideways	Glissières du banc droit	Направляющие правой станины
7	Left-hand column slide	Chariot porte-montant gauche	Каретка левой стойки
8	Right-hand column slide	Chariot porte-montant droit	Каретка правой стойки
9	Left-hand column	Montant gauche	Левая стойка
10	Right-hand column	Montant droit	Правая стойка
11	Top bridge	Entretoise	Поперечная балка
12	Left-hand slideways column	Glissières du montant gauche	Направляющие левой стойки
13	Right-hand slideways column	Glissières du montant droit	Направляющие правой стойки
14	Cross-rail (movable, fixed)	Traverse (mobile, fixe)	Траверса (подвижная, неподвижная)
15	Bottom slide	Cuirasse	Каретка суппорта
16	Vertical milling head	Tête de fraisage verticale	Головка вертикально- фрезерная
16b	Ram (quill)	Coulant (fourreau)	Ползун (втулка)
17	Milling spindle	Broche porte-fraise	Шпиндель фрезы
18	Tool (milling cutter)	Outil (fraise)	Инструмент (фреза)
19	Reference T-slot	Rainure de référence	Базовый паз

5.2 Designation of axes

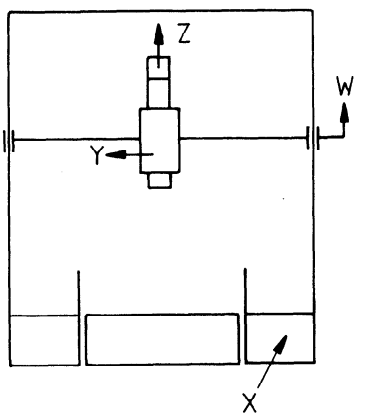


Figure 2 — Type 1: Machine with one milling head on a movable cross-rail

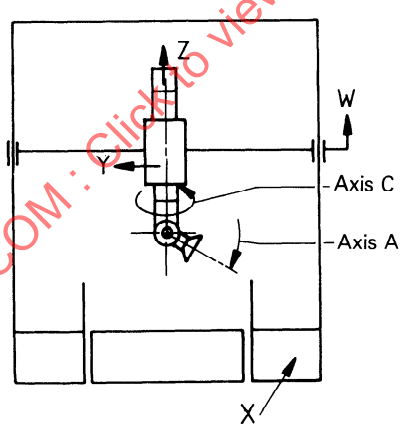


Figure 3 — Type 2: Machine with one milling head on a movable cross-rail and an additional milling head swivelling on axes C and A

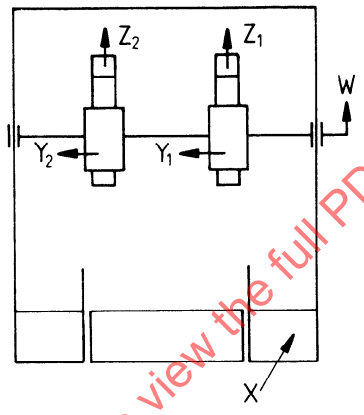
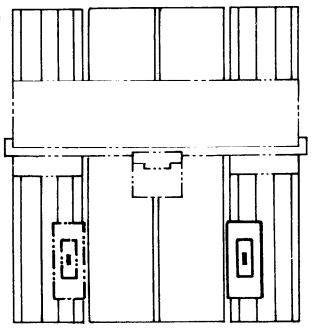
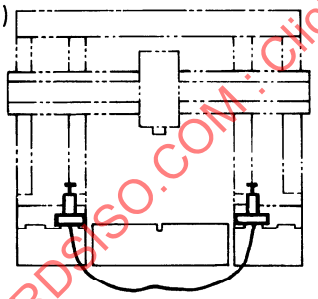
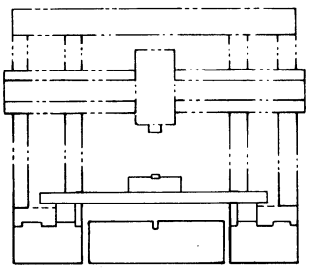


Figure 4 — Type 3: Machine with two milling heads on a movable cross-rail

6 Acceptance conditions and permissible deviations

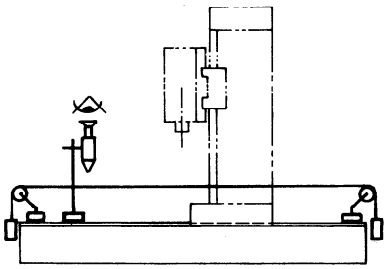
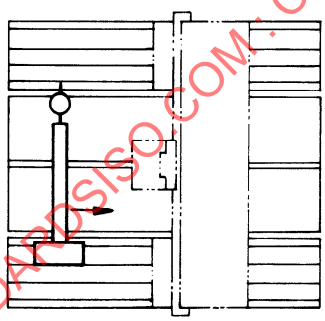
6.1 Geometrical tests

No.	Diagram	Object
G01	a)  b)  **Alternative** 	**A — Bed** Checking of levelling of bed slideways[1]: a) checking of slideway straightness in the vertical plane; b) checking of slideway parallelism in the vertical plane.

Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
a)			
0,05 for L[2] $\leqslant$ 15 000	0.002 for L[2] $\leqslant$ 590		
0,06 for 15 000 $<$ L $\leqslant$ 25 000	0.002 4 for 590 $<$ L $\leqslant$ 984		Gantry not in place. Subclauses 3.1 and 3.2 Place level in longitudinal direction on the slideways at various points equally spaced over the whole length.
0,08 for 25 000 $<$ L $\leqslant$ 35 000	0.003 1 for 984 $<$ L $\leqslant$ 1 378		
0,1 for L $>$ 35 000	0.003 9 for L $>$ 1 378	Precision level, straightedge or optical measurement instruments and water level micrometer	
Local tolerance:			
0,02 over any measured length of 1 000	0.000 8 40		Subclause 5.412.7 Such checks are to be carried out when mounting the machine.
b)			
0,02 over any measured length of 1 000	0.000 8 40		
Maximum permissible deviation:			
0,08 whatever the distance between slideways	0.003 1		

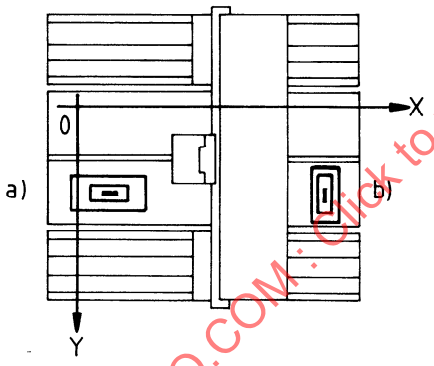
1) The shape characteristics of the bed basic plane from which the permissible deviation is measured shall be supplied by the manufacturer as a drawing or a written description.

2) L is the length of the slideways.

No.	Diagram	Object
G02		a) Checking of straightness of reference slideway in the horizontal plane.
		b) Checking of parallelism of reference slideways in the horizontal plane (for machines having two reference slideways).

Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
a)		Microscope and taut wire or other optical instrument, special support or measuring carriage	Subclauses 5.212.3 and 5.222 Gantry not in place. Subclauses 5.212.3 and 5.222 Fix taut wire to each end of slideway, stretch and orientate it. Fix and orientate special support and microscope on slideway at various points equally spaced and read indication variation.
0,05 for L[1] $\leqslant$ 15 000	0.002 for L[1] $\leqslant$ 590		
0,06 for 15 000 $< L \leqslant$ 25 000	0.002 4 for 590 $< L \leqslant$ 984		
0,08 for 25 000 $< L \leqslant$ 35 000	0.003 1 for 984 $< L \leqslant$ 1 378		
0,1 for $L >$ 35 000	0.003 9 for $L >$ 1 378		
Local tolerance:			
0,015	0.000 6		
over any measured length of			
1 000	40		
b)		Special support or measuring carriage, dial gauge or optical method	Subclause 5.412.6 Place the special support on one reference slideway and the opposite slideway. Move special support along slideways through various equally-spaced points. Record dial gauge indication variation. The operation G02 may be carried out checking straightness on one slideway and parallelism on the other.
0,02	0.000 8		
over any measured length of			
1 000	40		
Maximum permissible deviation:			
0,08	0.003 1		
whatever the distance between slideways			

1) L is the length of the slideways.

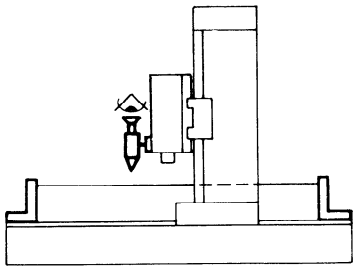
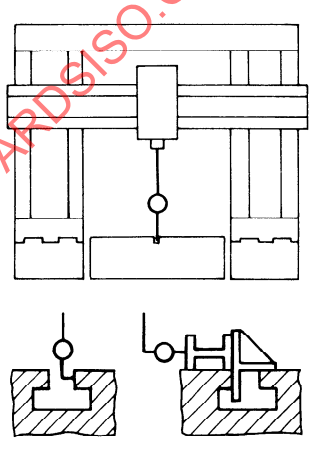
No.	Diagram	Object
G1		**B — Table** Checking of flatness of table surface. 1) For large machines a) straightness in the longitudinal direction (X axis); b) straightness in the transverse direction (Y axis). (For machines with a table only. [1]) 2) For small machines

Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
			Subclause 5.323
1)			1) Place the level (straightedge) successively in the longitudinal direction at a), then in the traverse direction at b) on the table surface and move it through various equally-spaced positions. Read indication variation.
For Y axis dimensions greater than			
2 000	83		
a)			
0,06 for x[2] ⩽ 10 000	0.002 4 for x[2] ⩽ 394		
0,08 for 10 000 < x ⩽ 20 000	0.003 1 for 394 < x ⩽ 787		
0,1 for 20 000 < x ⩽ 30 000	0.003 9 for 787 < x ⩽ 1 181		
0,12 for x > 30 000	0.004 7 for x > 1 181		
Local tolerance:			
0,02	0.000 8		
over any measured length of			
1 000	40		
b)			
0,03 for y[3] ⩽ 2 000	0.001 2 for y[3] ⩽ 79	Precision level and straightedge	
For each additional 500 mm (20 in) over 2 000 mm (79 in) increase the tolerance by			
0,005	0.000 2		
Maximum permissible deviation:			
0,06	0.002 4		
Local tolerance:			
0,02	0.000 8		
over any measured length of			
1 000	40		
2)			2) The shape characteristics of the table basic plane from which the permissible deviation is measured shall be supplied by the manufacturer as a drawing or a written description.
For Y axis dimensions less than or equal to			
2 000	83		
0,03	0.001 2		
Local tolerance:			
0,02	0.000 8		
over any measured length of			
1 000	40		

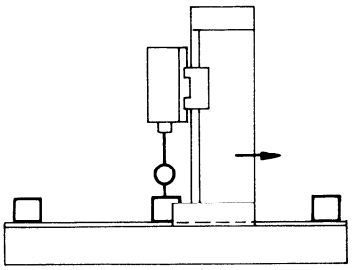
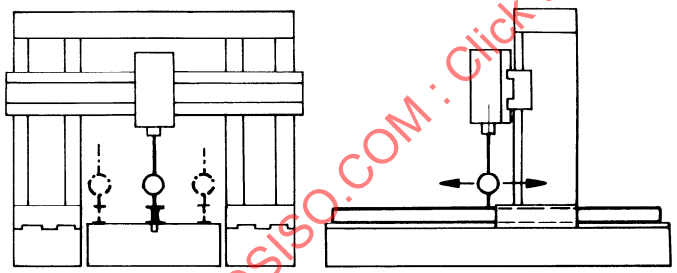
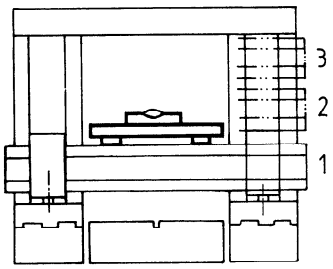
1) To verify the block, see ISO 7572.

2) For x, dimensions along X axis.

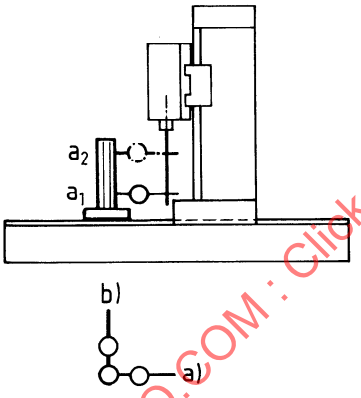
3) For y, dimensions along Y axis.

No.	Diagram	Object
		C — Gantry
G2		Checking of straightness of gantry movement in the horizontal plane.
G3		Checking of parallelism of longitudinal displacement of gantry (X axis) to reference T-slot (if any) in the horizontal plane. (For machines with a table only.)

Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
0,05 for $L^{1)} \leqslant 10\,000$ 0,06 for $10\,000 < L \leqslant 20\,000$ 0,08 for $20\,000 < L \leqslant 30\,000$ 0,1 for $L > 30\,000$ Local tolerance: 0,02 over any measured length of 1 000	0.002 for $L^{1)} \leqslant 394$ 0.002 4 for $394 < L \leqslant 787$ 0.003 1 for $787 < L \leqslant 1\,181$ 0.003 9 for $L > 1\,181$ 0.000 8 40	Taut wire and microscope or other optical devices	Subclause 5.232.2 Fix taut wire to the extremities of the table (or floorplate), stretch it and orientate it. Place milling head in mid-position on cross-rail. Fix microscope on milling head and orientate it. Move gantry through various equally-spaced points and record indications. 1) L is the gantry stroke.
0,05 for $L^{1)} \leqslant 10\,000$ 0,06 for $10\,000 < L \leqslant 20\,000$ 0,08 for $20\,000 < L \leqslant 30\,000$ 0,1 for $L > 30\,000$ Local tolerance: 0,02 over any measured length of 1 000	0.002 for $L^{1)} \leqslant 394$ 0.002 4 for $394 < L \leqslant 787$ 0.003 1 for $787 < L \leqslant 1\,181$ 0.003 9 for $L > 1\,181$ 0.000 8 40	Dial gauge support, dial gauge, T-square and straightedge or optical device	Subclause 5.422.22 Place cross-rail in lower position on gantry. Fix dial gauge support and dial gauge on milling head. Place dial gauge stylus in contact with reference T-slot and move gantry along slot length. Record indication. 1) L is the gantry stroke.

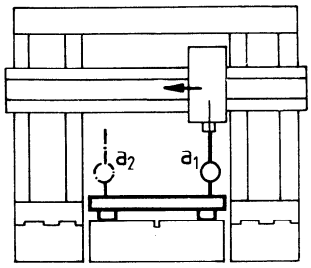
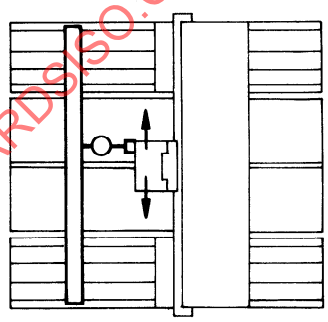
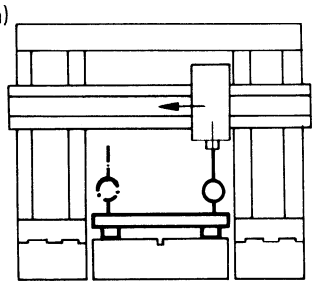
No.	Diagram	Object
G4		a) Checking of parallelism of gantry displacement to table surface in the vertical plane (for machines with a table).
		b) Checking of straightness of gantry longitudinal displacement in the vertical plane (for machines with a floorplate).
G5		Checking of the slope variation in the vertical plane of the movable cross-rail during its displacement **1**: in the lower position, **2**: in the medium position, **3**: in the higher position, a) in the case of a fixed cross-rail when working without mechanical indexing; b) other cases.

Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
a) or b)		Dial gauge support, dial gauge and gauge blocks	Place cross-rail in lower position on column and milling head in mid-position on cross-rail. Fix dial gauge support and dial gauge on milling head. Subclause 5.422.22 a) Place gauge blocks on table at various points at equal distances of 1 000 mm (40 in). Place dial gauge stylus against the surface of one block; move gantry until stylus is in contact with another block and read indication variation. 1) L is the gantry stroke.
0,05 for L[1] $\leq$ 10 000 0,06 for 10 000 $<$ L $\leq$ 20 000 0,08 for 20 000 $<$ L $\leq$ 30 000 0,1 for L $>$ 30 000	0.002 for L[1] $\leq$ 394 0.002 4 for 394 $<$ L $\leq$ 787 0.003 1 for 787 $<$ L $\leq$ 1 181 0.003 9 for L $>$ 1 181		
Local tolerance: 0,015 over any measured length of 1 000	0.000 6 40	Dial gauge support, dial gauge, straightedge and gauge blocks or optical devices	Subclause 5.232.2 b) Place straightedge on the floorplate and orientate it in the longitudinal direction parallel to gantry longitudinal displacement. Place dial gauge stylus against straightedge and move gantry through milling stroke. Read indication at every 1 000 mm (40 in). Repeat operation at two positions of milling head symmetrical to preceding position. 1) L is the gantry stroke.
a) 0,03/1 000 b) 0,02/1 000	0.001 2/40 0.000 8/40	Precision level, straightedges and gauge blocks or optical methods	Subclause 5.212.2 or 5.212.21 or 5.212.22 Place level in mid-position on appropriate face of cross-rail and read indications in quoted positions. Place milling heads symmetrically. Lock cross-rail at each position.

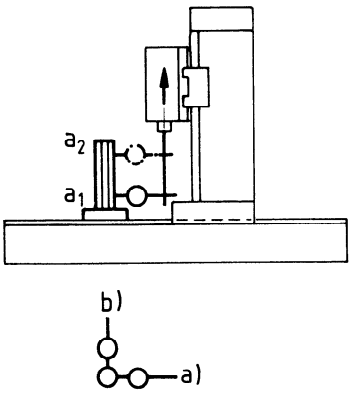
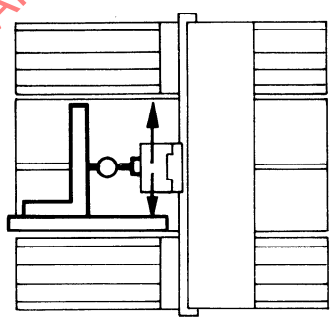
No.	Diagram	Object
G6		Checking of squareness of movable cross-rail vertical displacement to reference plane a) in the longitudinal plane (X axis); b) in the transverse plane (Y axis).

Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
a) and b)			Subclause 5.522.2 Place gantry and milling head at mid-stroke. Fix dial gauge support and dial gauge on milling head. Lock milling head on cross-rail. Place square cylinder on a surface plate oriented parallel to the reference plane defined by the gantry longitudinal displacement and the milling head transverse displacement; then place dial gauge stylus in the longitudinal plane at point $\mathbf{a}_1$ on the square cylinder. Move cross-rail to point $\mathbf{a}_2$ and read indication. Rotate square cylinder 180° and repeat the checking in the same order. Calculate the average value of the deviations determined. Then check in the transverse plane at points $\mathbf{b}_1$ and $\mathbf{b}_2$. For large machines, checking may be carried out at the mid-position and in two extreme positions of the milling head on the cross-rail.
0,02/500 for L [1] $\leqslant$ 1 500 0,03/500 for L > 1 500	0.000 8/20 for L [1] $\leqslant$ 59 0.001 2/20 for L > 59	Dial gauge support, dial gauge, square cylinder and surface plate or straightedge	

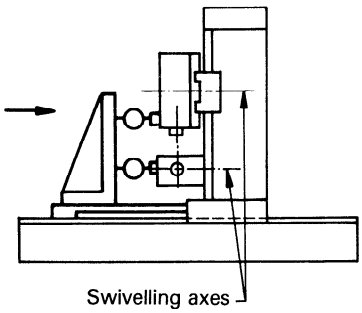
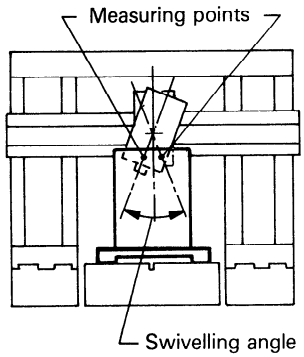
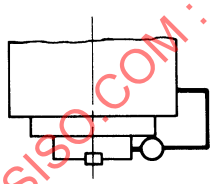
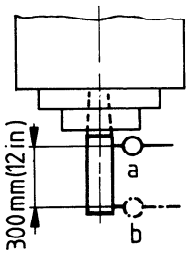
1) L is the cross-rail stroke.

No.	Diagram	Object
G7		**D — Milling head** Checking of parallelism in a vertical plane of the milling head transverse displacement to the table surface a) in the case of a fixed cross-rail when working without mechanical indexing; b) in other cases. NOTE — For machines with a table only.
G8	a)  b) 	Checking of straightness of the milling head transverse displacement on the cross-rail a) in the horizontal plane (for all machine types); b) in the vertical plane (for machines with a floorplate only).

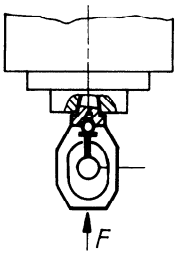
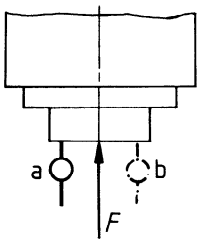
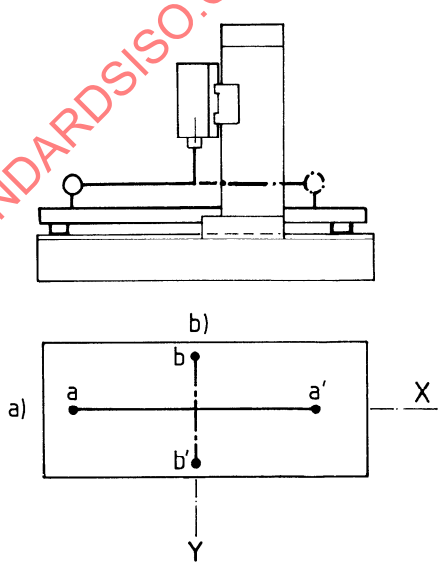
Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
a)		Dial gauge support, dial gauge, straightedge and gauge blocks	Subclause 5.422.22 Gantry at mid-stroke. Fix the dial gauge support and dial gauge on the milling head. Place straightedge and orientate it in the transverse direction. Place dial gauge stylus to point a_1 on straightedge. Move milling head to point a_2 and read indication variation. Repeat this operation in lower cross-rail position. For any additional milling head, repeat testing as previously. For large machines checking may be carried out at the mid-position and two extreme positions of the gantry. 1) L is the milling head stroke.
0,03	0.001 2		
for $L^{1)} \leqslant 1\,000$	for $L^{1)} \leqslant 40$		
for every additional 500 mm (20 in) above 1 000 mm (40 in), increase this tolerance by			
0,01	0.000 4		
b)			
0,02	0.000 8		
for $L \leqslant 1\,000$	for $L \leqslant 40$		
For every additional 500 mm (20 in) above 1 000 mm (40 in), increase this tolerance by			
0,01	0.000 4		
a) and b)			
Local tolerance:			
0,02	0.000 8		
over any measured length of			
1 000	40		
Maximum permissible deviation:			
0,06	0.002 4		
for $L \leqslant 5\,000$	for $L \leqslant 197$		
The tolerances shall be defined by agreement between manufacturer and purchaser			
for $L > 5\,000$	for $L > 197$		
a) and b)		Dial gauge support, dial gauge, straightedge or optical methods and water level micrometer	Subclauses 5.212.3 and 5.222 Place gantry at mid-position of longitudinal stroke and milling head at mid-position of vertical stroke. Fix dial gauge support and dial gauge on milling head. Orientate straightedge in the transverse direction of the table. Place dial gauge stylus in contact with straightedge and move the milling head through the measured length. Read indications. 1) L is the milling head stroke.
0,02	0.000 8		
for $L^{1)} \leqslant 1\,000$	for $L^{1)} \leqslant 40$		
1 000	40		
For every additional 1 000 mm (40 in) above 1 000 mm (40 in), increase this tolerance by			
0,01	0.000 4		
Local tolerance:			
0,02	0.000 8		
over any measured length of			
1 000	40		
Maximum permissible deviation:			
0,06	0.002 4		
for $L \leqslant 5\,000$	for $L \leqslant 197$		
The tolerances shall be defined by agreement between manufacturer and purchaser			
for $L > 5\,000$	for $L > 197$		

No.	Diagram	Object
G9		Checking of squareness of milling head vertical displacement to reference plane a) in the longitudinal plane (X axis); b) in the transverse plane (Y axis).
G10		Checking of squareness of milling carriage transverse displacement on cross-rail to gantry displacement in a horizontal plane.

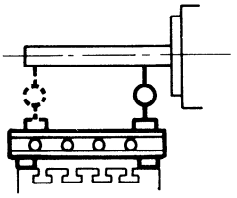
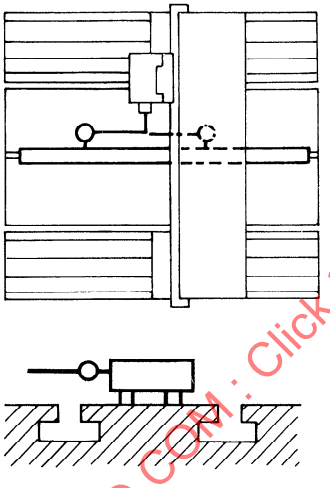
Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
a) and b) 0,02/500	0.000 8/20	Dial gauge support, dial gauge, square cylinder and surface plate or straightedge	Subclause 5.522.2 Place gantry and milling head at mid-stroke. Fix dial gauge support and dial gauge on milling head. Lock cross-rail on column. Place square cylinder on surface plate oriented parallel to the reference plane defined by gantry longitudinal displacement and milling head transverse displacement, then place dial gauge stylus in a longitudinal plane at point $\mathbf{a}_1$ on square cylinder. Move milling head to point $\mathbf{a}_2$ and read indication. Rotate square cylinder 180° and repeat checking in the same order. Calculate the average value of the deviations determined. Then carry out checking in a transverse plane at points $\mathbf{b}_1$ and $\mathbf{b}_2$. For large machines, checking may be carried out at the mid-position and in two extreme positions of the milling head on the cross-rail.
0,02/1 000	0.000 8/40	Square, dial gauge support, dial gauge or optical methods and straightedge	Subclause 5.522.4 Place gantry in mid-position, orientate one arm of square parallel to gantry displacement (X axis). Fix dial gauge support and dial gauge on milling head. Place dial gauge stylus against the other arm of the square. Move milling head along cross-rail and read indication. Rotate square 180° and repeat checks in the same order and calculate the average value of the deviations determined. For large machines, repeat the operation in two extreme gantry positions.

No.	Diagram	Object
G11	 **View along arrow** 	For tilting milling heads. Checking of parallelism of milling head swivelling axes to reference plane when milling heads swivel. (For swivelling axes parallel to longitudinal displacement of gantry or parallel to transverse displacement of milling head on cross-rail.)
G12		**E — Milling spindle** Measurement of run-out of external diameter of milling spindle nose.
G13		Measurement of run-out of internal taper of milling spindle.

Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
0,02 for α [1] $\leqslant$ 10° 0,03 for 10° < $\alpha \leqslant$ 20° 0,04 for α > 20°	0.000 8 0.001 2 0.001 6	Dial gauge support, dial gauge, square, surface plate and gauge blocks	Subclause 5.422.22 Fix dial gauge support to milling head; orientate square parallel to displacement concerned and touch the face of the square. Place dial gauge at 500 mm (20 in) from milling head swivelling axis. Rotate inclinable milling head and read indication. Remark : This operation allows a check of parallelism of swivelling inclinable milling head axes to the reference plane of the machine. This plane is defined by the gantry longitudinal displacement and the milling head transverse displacement. NOTE — For machines fitted with C axis, coincidence of C and Z axes may be checked using a square aligned with the Z axis and a dial gauge touching a test mandrel rotated through the C axis. This check is then to be repeated in two perpendicular planes. 1) α is the tilt angle.
0,01 for D [1] $\leqslant$ 200 0,015 for D > 200	0.000 4 for D [1] $\leqslant$ 8 0.000 6 for D > 8	Dial gauge support and dial gauge	Subclause 5.612.2 Fix dial gauge support and dial gauge on milling head. Place dial gauge stylus against generator line of the spindle. Rotate milling spindle and read indication. Check each milling spindle of the machine. 1) D is the spindle nose diameter.
a : 0,01 for D [1] $\leqslant$ 200 0,015 for D > 200 b : 0,02 for $D \leqslant$ 200 0,03 for D > 200	a : 0.000 4 for D [1] $\leqslant$ 8 0.000 6 for D > 8 b : 0.000 8 for $D \leqslant$ 8 0.001 2 for D > 8	Dial gauge support, dial gauge and test mandrel	Subclause 5.612.3 Fix dial gauge support and dial gauge on milling head and insert test mandrel. Place dial gauge stylus as close as possible to spindle at point **a**, rotate spindle and read indication. Repeat the same operation at point **b** at a distance of 300 mm (12 in). Check each milling spindle of the machine. 1) D is the spindle nose diameter.

No.	Diagram	Object
G14		Measurement of periodic axial slip of milling spindle.
G15		Measurement of camming of spindle nose face.
G16		Checking of squareness of vertical axis of rotation of the milling spindle to reference plane [1)] a) in a longitudinal plane (X axis); b) in a transverse plane (Y axis). (For milling head, tilting or not.)

Permissible deviation		Measuring instruments	Observations and references to the ISO 230-1 acceptance code
mm	in		
0,01 for D[1] $\leqslant$ 200 0,015 for D > 200	0.000 4 for D[1] $\leqslant$ 8 0.000 6 for D > 8	Dial gauge support, dial gauge or other auxiliary means	Subclauses 5.622.1 and 5.622.2 Fix dial gauge support and dial gauge on milling head. Insert steel ball in spindle centring. Position dial gauge stylus, rotate spindle and read indication. Check each spindle of the machine. The value and direction of application of force F shall be specified by the manufacturer (if required). 1) D is the spindle nose diameter.
0,01 for D[1] $\leqslant$ 200 0,015 for D > 200	0.000 4 for D[1] $\leqslant$ 8 0.000 6 for D > 8	Dial gauge support and dial gauge	Subclause 5.632 Fix dial gauge support and dial gauge on a fixed part of the machine. Place dial gauge stylus as close as possible to outside edge of flat face at point **a**, rotate the spindle and read indication. Repeat the same operation at point **b** after having rotated dial gauge 180°. Determine average value. The value and direction of application of force F shall be specified by the manufacturer (if required). 1) D is the spindle nose diameter.
a) and b) 0,03/500[2]	0,001 2/20[2]	Support arm, dial gauge, straightedge, and gauge blocks or surface plate	Subclauses 5.512.1 and 5.512.42 Place gantry at mid-stroke, with milling head at mid-position on cross-rail (or in symmetrical positions if several heads are available). Fix support arm and dial gauge on spindle. Place dial gauge stylus at point **a** on the straightedge surface and read indication (straightedge to be parallel to longitudinal displacement of gantry). Rotate support arm 180°, place dial gauge stylus at point **a'** and read new indication. Take the difference between the two readings. Carry out test at point **b** (straightedge to be parallel to transverse displacement of milling head) in the same way as above. 1) The reference plane is defined by the longitudinal displacement of the gantry and the transverse displacement of the milling head. 2) Distance between the two points traversed.

No.	Diagram	Object
G17		Checking of parallelism of horizontal axis of rotation of the milling spindle with reference plane. (For milling heads with horizontal spindle axes, tilting or not.)
G18		Checking of squareness of horizontal axis of rotation of milling spindle to gantry longitudinal displacement. (For milling heads with horizontal spindle axes, tilting or not.)