INTERNATIONAL STANDARD

ISO 6155

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Machine tools — Test conditions for horizontal spindle turret and single spindle automatic lathes — Testing of the accuracy

Machines-outils — Conditions d'essai des tours à tourelle revolver à broche horizontale et des tours automatiques monobroche — Contrôle de la précision

Reference number
ISO 6155:1998(E)

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Foreword

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

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

International Standard ISO 6155 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

This first edition of ISO 6155 cancels and replaces ISO 6155-1:1981 and ISO 6155-2:1986 which have been combined in this technical revision.

Annex A of this International Standard is for information only.

Introduction

ISO/TC 39/SC 2 recognized the fact that machines described in this International Standard represent obsolescent technology. Nevertheless, there is no Standard available for machines that represent current technology. Therefore, ISO/TC 39/SC2 responded to the request for revision of this Standard by combining ISO 6155 parts 1 and 2 into a single standard and adding positioning tests.

Machine tools — Test conditions for horizontal spindle turret and single spindle automatic lathes — Testing of the accuracy

1 Scope

This International Standard describes, with reference to ISO 230-1 and ISO 230-2, geometric tests, machining tests and tests for accuracy and repeatability of numerically-controlled positioning axes on general purpose and normal accuracy turret and single spindle automatic lathes. It also specifies the applicable tolerances corresponding to the above-mentioned tests.

This International Standard applies only to lathes with a multi-tool turret. This turret can be manually indexed, semi-automatically indexed by motion of the turret slide or automatically indexed by an independent control including numerical control. Lathes with sliding headstock are excluded from the scope, but lathes with numerical control are included as far as the contents of this International Standard are applicable.

This International Standard deals only with the verification of accuracy of the machine. It does not apply to the operational testing 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 standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 68-1:—[1)], *ISO general purpose screw threads — Basic profile — Part 1: Metric screw threads.*

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

ISO 230-2:1997, *Test code for machine tools — Part 2: Determination of accuracy and repeatability of positioning of numerically controlled axes.*

ISO 1101:—[2)], *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Generalities, definitions, symbols, indication on drawings.*

ISO 3442:1991, *Self-centring chucks for machine tools with two-piece jaws (tongue and groove type) — Sizes for interchangeability and acceptance test specifications.*

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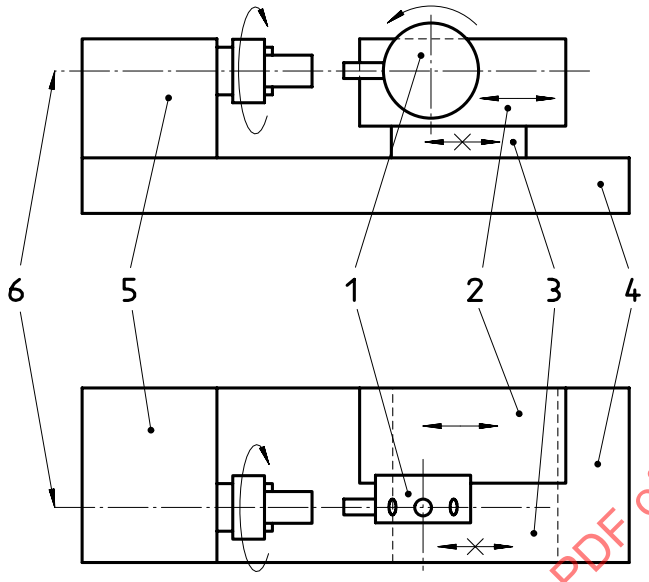
1) To be published. (Partial revision of ISO 68:1973)

2) To be published. (Revision of ISO 1101:1983)

3 Definitions

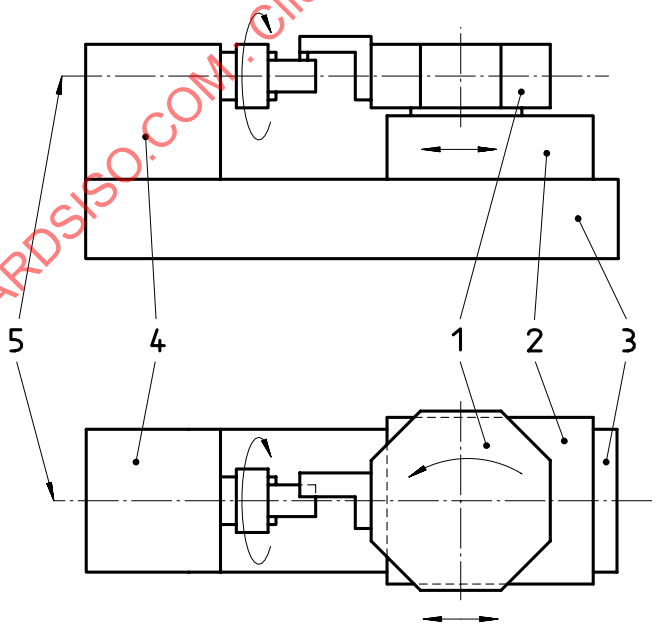
Some possible machine architectures referred to this International Standard are given in the following figures.



Key

1 Indexable turret
2 Small slide
3 Saddle with manual operation
4 Bed
5 Fixed headstock
6 Spindle axis

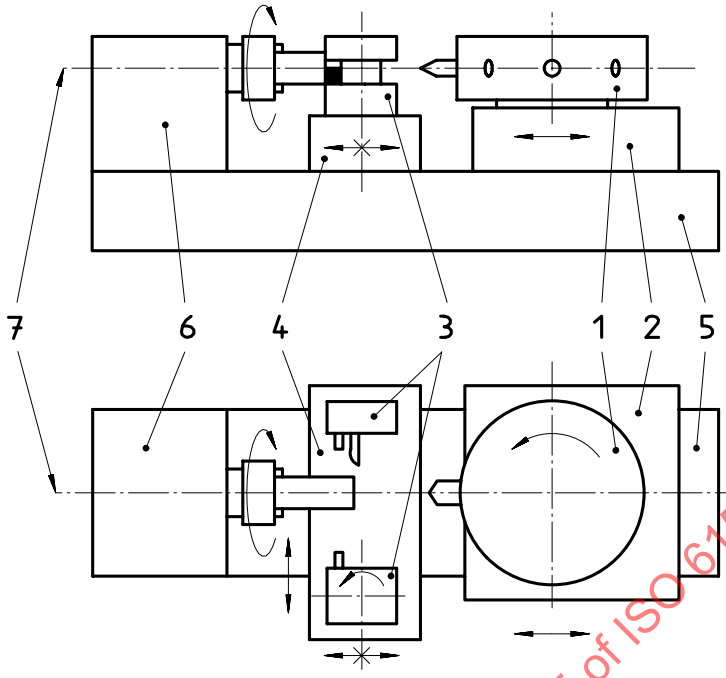
Figure 1 — Capstan Lathe



Key

1 Turret
2 Saddle
3 Bed
4 Fixed headstock
5 Spindle axis

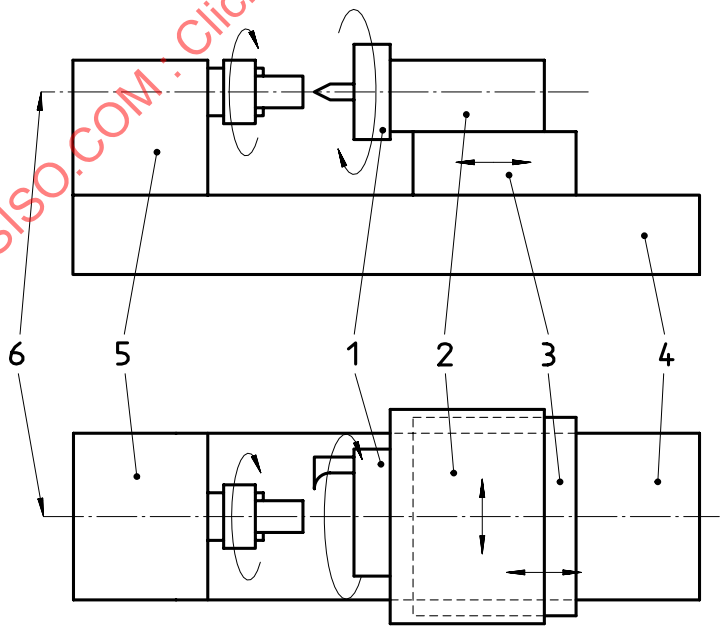
Figure 2 — Turret lathe



Key

1	Indexing turret	5	Bed
2	Saddle of turret	6	Fixed headstock
3	Small turret or tool holder	7	Spindle axis
4	Cross-slide saddle		

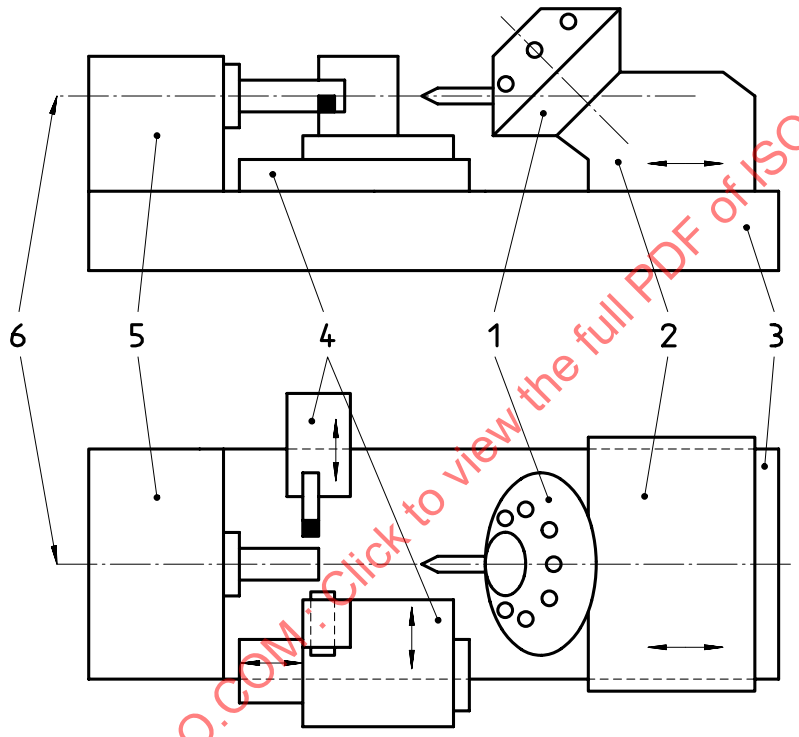
Figure 3 — Combination turret lathe



Key

1	Indexing turret	4	Bed
2	Turret holder slide	5	Fixed headstock
3	Saddle	6	Spindle axis

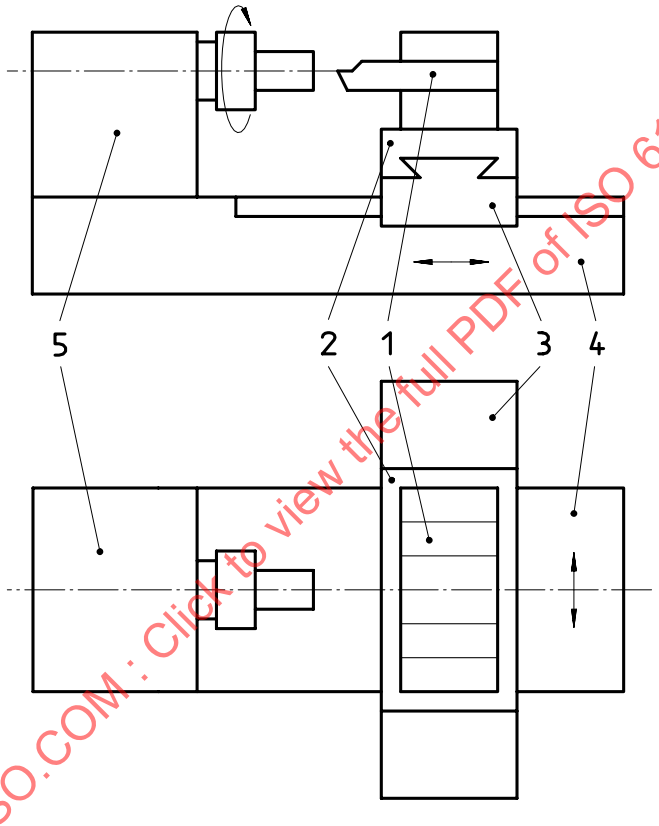
Figure 4 — Cross-feeding turret lathe



Key

1 Indexing turret	4 Independent cross-slides
2 Turret holder saddle	5 Fixed headstock
3 Bed	6 Spindle axis

Figure 5 — Single spindle automatic lathe



Key

1 Linear turret
2 Cross slide
3 Saddle
4 Bed
5 Fixed headstock

Figure 6 — Linear turret lathe

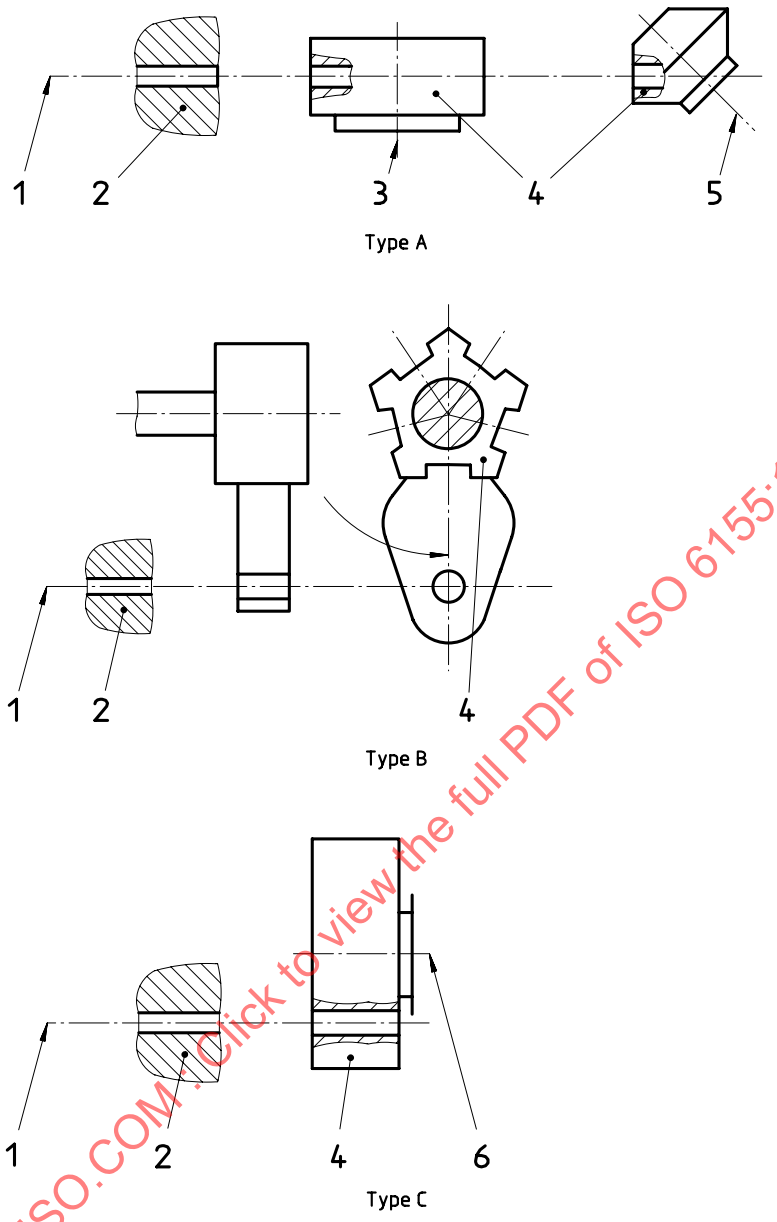
All these types of lathe are manufactured with a variety of turret configurations. The most common types of configurations are designated types A, B, C (see figure 7) and D and are described below.

Turret type A: Circular or multi-sided turret whose axis of rotation intersects the work spindle axis. Whether or not the turret axis is perpendicular to the work spindle axis, the axis of each turret bore must align with the work spindle axis in its working position. Tools may be located in the bore or recess, attached to the flat turret face or located and clamped in the bore itself.

Turret type B: Multi-sided turret whose axis of rotation does not intersect the work spindle axis but is parallel or at a right angle to it. Special toolholders mounted and located on the turret sides (faces) are required.

Turret type C: Circular (drum or disc type) turret whose axis of rotation is parallel to the work spindle axis. Tools are located in turret bores, which are parallel to the turret axis, and the turret axis is arranged so that the work spindle axis aligns with the axes of the turret bores in their working positions.

Turret type D: Linear turret where tools are set on the cross slide. The necessary tool comes to the working position by the cross slide linear movement (see figure 6).



Key

1	Spindle axis	4	Turrets
2	Spindle	5	Oblique turret axis
3	Perpendicular turret axis	6	Parallel turret axis

Figure 7 — Different types of turret

4 Machine size range

The machines are classified into three ranges, on the basis of the criteria indicated in table 1.

Table 1 — Criteria and ranges

Criteria	Range 0	Range 1	Range 2
Swing diameter over the bed	$\leqslant 250$	$250 < D \leqslant 400$	$400 < D \leqslant 800$
Nominal bar diameter	$\leqslant 25$	$25 < d \leqslant 63$	$63 < d$
Nominal chuck diameter as defined in ISO 3442	$\leqslant 125$	$125 < d \leqslant 250$	$250 < d$
NOTE — The choice of the criterion is at the supplier/manufacturer's discretion.			

5 Preliminary remarks

5.1 Measuring units

In this International Standard, all linear dimensions, deviations and corresponding tolerances are expressed in millimeters; angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerances are expressed in ratios but in some cases microradians or arcseconds may be used for clarification purposes. The equivalence of the following expressions should always be kept in mind.

$0{,}010/1\,000 = 10 \times 10^{-6} = 10\ \mu\text{rad} \approx 2''$

5.2 Reference to ISO 230-1

To apply this International Standard, 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 the following sections, 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.

5.3 Testing sequence

The sequence in which the tests are presented in this International Standard 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.

5.4 Tests to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests described in this International Standard. 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 International Standard for the acceptance tests, without specifying the tests to be carried out, and without agreement on the relevant expenses, can not be considered as binding for any contracting party.

5.5 Measuring instruments

The measuring instruments indicated in the tests described in the following sections 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 millimeters or better.

5.6 Machining tests

Machining tests shall be made with finishing cuts only, not with roughing cuts which are liable to generate appreciable cutting forces.

5.7 Machine levelling

Prior to conducting tests on a machine, the machine should be levelled according to the recommendations of the supplier/manufacturer. (See 3.11 of ISO 230-1:1996.)

6 Geometric tests

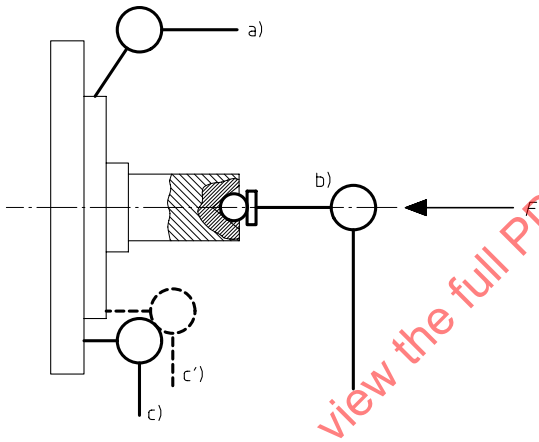
6.1 Work spindle

Object **G 1**

Checking of work spindle nose:

a) Run-out of the centring diameter on the spindle nose;
b) Periodic axial slip;
c) Camming of the spindle face.

Diagram



Tolerance

	Range 0	Range 1	Range 2	(Measured deviation)
a)	0,010	0,010	0,015	a)
b)	0,008	0,010	0,010	b)
c)	0,012	0,015	0,020	c)

Measuring instruments

Dial gauge and possible special device

Observations and references to ISO 230-1

A force *F*, specified by the supplier/manufacturer of the machine, shall be exerted towards the housing. When preloaded bearings are used, no force need be applied to the spindle.

a) 5.612.2
When the surface is conical, the stylus of the dial gauge shall be normal to the conical surface.

b) 5.622.1 and 5.622.2

c) 5.632
Spindle face may be at spindle nose c') depending upon the design of the machine.

Object **G2**

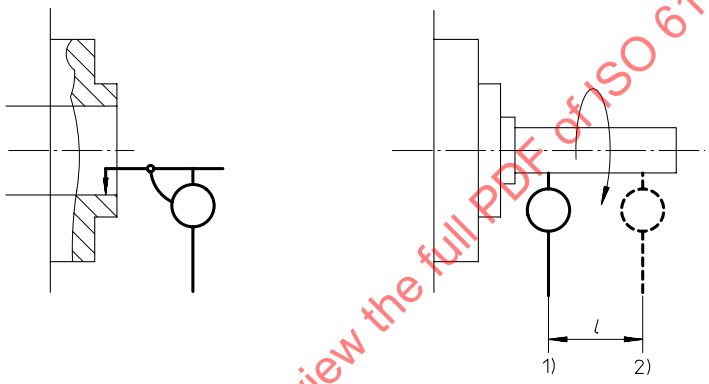
Checking of work spindle internal bore:

a) Run-out of the spindle locating bore.
(This test applies only to machines with a locating bore for work holding fixture.)

b) Run-out of the work spindle internal taper.
1) at the spindle nose;
2) at a distance of 300 mm from the spindle nose.

(This test applies only to machines with internal taper spindle bore.)

Diagram



Tolerance		Range 0	Range 1	Range 2	**(Measured deviation)**
a)		0,008	0,010	0,015	a)
b)	1)	0,008	0,010	0,020	b) 1)
	2)	0,012	0,015	0,030	2)

Measuring instruments

Dial gauge

Observations and references to ISO 230-1

a) and b) 5.612.3

Object **G3**

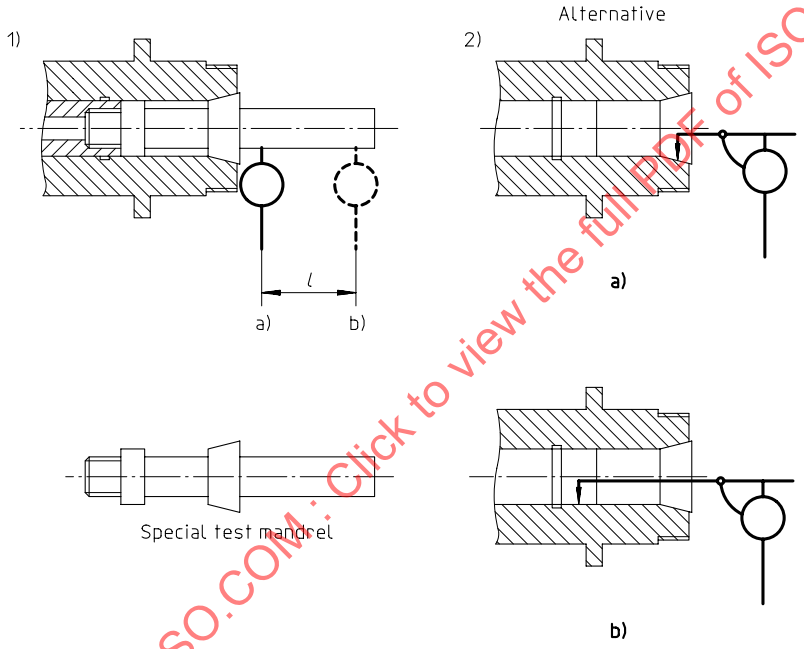
Checking of run-out of the collet housing in the spindle nose (for draw-back collets):

1) Using a special test mandrel
   a) at the spindle nose;
   b) at a distance of *l* mm.

Alternative

2) By touching directly,
   a) the front seating cone;
   b) the back register.

Diagram



Tolerance		Range 0	Range 1	Range 2	**(Measured deviation)**
1)	a)	0,010	0,015	0,015	1) a)
	b)	0,015	0,030	0,030	b)
		l = 50	*l* = 100	*l* = 100	
2) a) and b)		0,008	0,010	0,010	2) a) and b)

Measuring instruments

1) Test mandrel and dial gauge
2) Dial gauge

Observations and references to ISO 230-1 5.612.3

Object **G4**

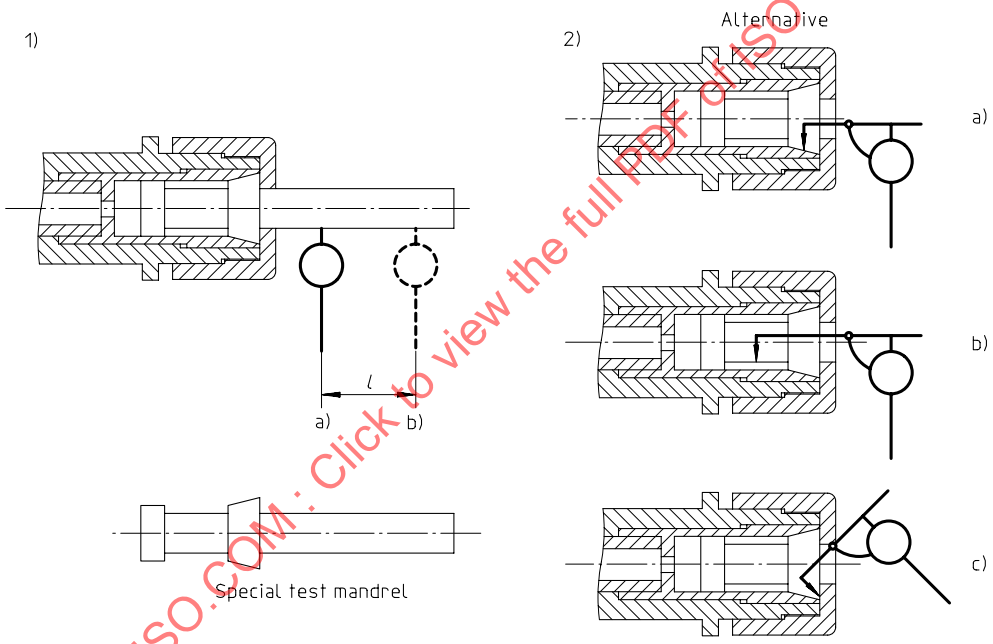
Checking of run-out of the collet internal seating in the spindle (for closing sleeve type collets):

1) Using a special test mandrel
   a) at the spindle nose;
   b) at a distance of *l* mm.

Alternative

2) By touching directly,
   a) the front seating cone;
   b) the back register;
   c) internal surface of the nut.

Diagram



Tolerance **(Measured deviation)**

		Range 0	Range 1	Range 2
1)	a)	0,015	0,02	0,02
	b)	0,02	0,04	0,04
		l = 50	*l* = 100	*l* = 100
2) a) and b)		0,008	0,01	0,015
	c)	0,012	0,015	0,02

1) a)
   b)

2) a) and b)
   c)

Measuring instruments

1) Test mandrel and dial gauge
2) Dial gauge

Observations and references to ISO 230-1 5.612.3

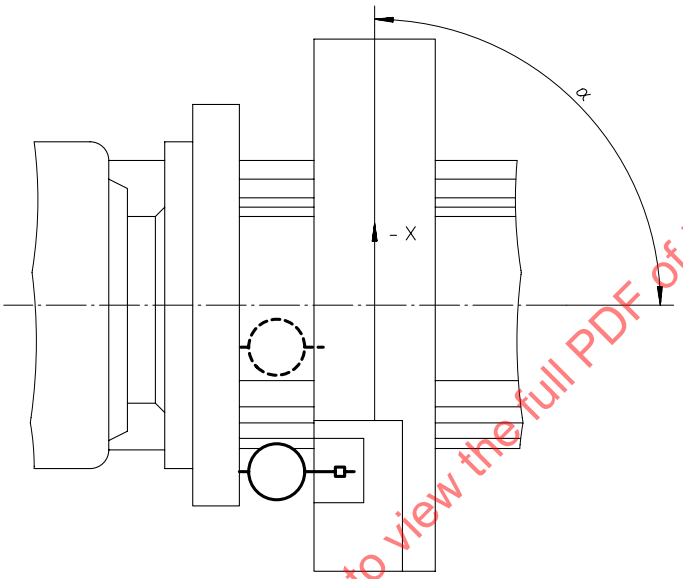
6.2 Slide bases

Object **G5**

Checking of squareness of the transverse movement (X-axis) of the cross slide to the spindle axis.

(Machining test M2 may be used as an alternative to this test.)

Diagram



Tolerance	**(Measured deviation)**
For all ranges 0,01 for a measuring length of 100 For slides with one tool holder only $\alpha \geqslant 90^{\circ}$	

Measuring instruments

Dial gauge and flat disc or straightedge

Observations and references to ISO 230-1 5.522.3

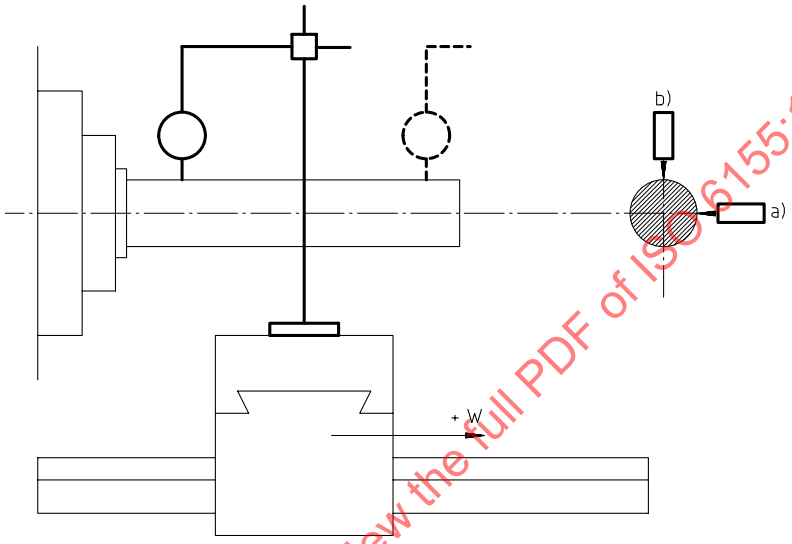
The dial gauge is mounted on the cross-slide.

Object **G6**

Checking of the parallelism of the W-axis movement of the intermediate carriage to the work spindle axis:

a) in a horizontal plane;
b) in a vertical plane.

Diagram



Tolerance	**(Measured deviation)**
For all ranges	
a) 0,005 for a measuring length of 100 (free end of mandrel forward only)	a)
b) 0,007 for a measuring length of 100 (free end of mandrel upward only)	b)

NOTE — For Range 0 machines with a stroke of less than 100 mm, the tolerance remains the same.

Measuring instruments

Dial gauge and test mandrel

Observations and references to ISO 230-1 5.422.3

The dial gauge is mounted on the cross-slide.

6.3 Turret

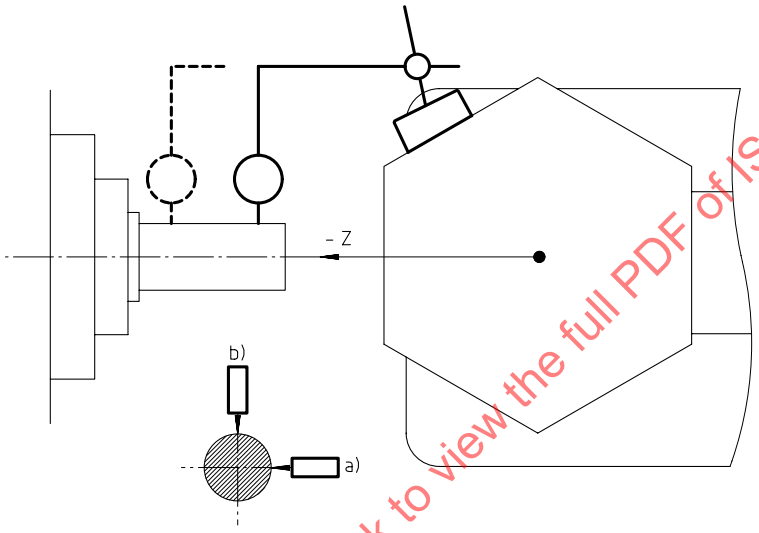
Object **G7**

Checking of parallelism of the turret movement on the bed (Z-axis) to the work spindle axis:

a) in a horizontal plane;
b) in a vertical plane.

(This test applies only to turret lathes.)

Diagram



Tolerance For both a) and b)

Range 0	0,01 for a measuring length of 150
Range 1	0,02 for a measuring length of 300
Range 2	0,02 for a measuring length of 300

NOTE — For machines with a stroke of less than the above measuring lengths, tolerances remain the same.

(Measured deviation)
a) b)

Measuring instruments

Dial gauge and test mandrel

Observations and references to ISO 230-1 5.422.3

Dial gauge is mounted on the turret.

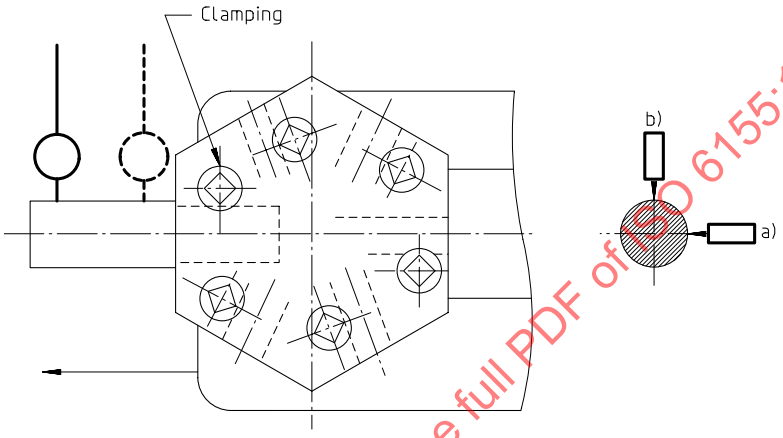
Object **G8**

Checking of parallelism of the turret bores with the turret movement (Z-axis):

a) in a horizontal plane;
b) in a vertical plane.

(This test does not apply to machines with turret type B or to those without tool shank clamping facilities.)

Diagram



Tolerance	a) and b)	**(Measured deviation)** a) b)
Range 0	0,01 for a measuring length of 50	
Range 1 and 2	0,015 for a measuring length of 100	

Measuring instruments

Dial gauge and test mandrel

Observations and references to ISO 230-1 5.422.3

The test mandrel shall not be clamped in the turret but be a tight fit. Where the turret bores are relieved, the test mandrel shall be tightly clamped using the locking mechanism.

The test shall be repeated for each turret bore.

Object **G9**

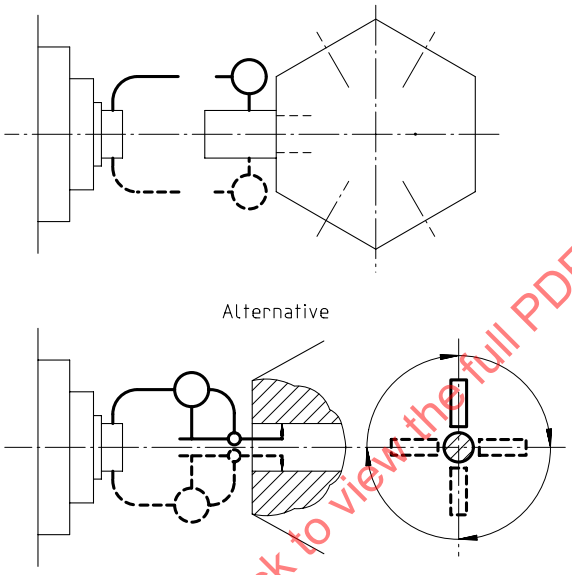
Checking alignment of the work spindle axis with the turret bore axes.

Alternative

Checking by direct measurement of the turret bores.

(This test does not apply to machines with a turret configuration type B.)

Diagram



Tolerance	**(Measured deviation)**
For all ranges 0,015	

Measuring instruments

Dial gauge with or without test mandrel

Observations and references to ISO 230-1 5.442

The dial gauge shall be placed as close as possible to the turret face and the spindle shall be rotated through 360°.

The test mandrel shall not be clamped in the turret but be a tight fit. Where the turret bores are relieved, the test mandrel shall be tightly clamped using the locking mechanism.

The test shall be repeated for each turret bore.

NOTE — Divide the total dial gauge reading by two before comparing to tolerance.

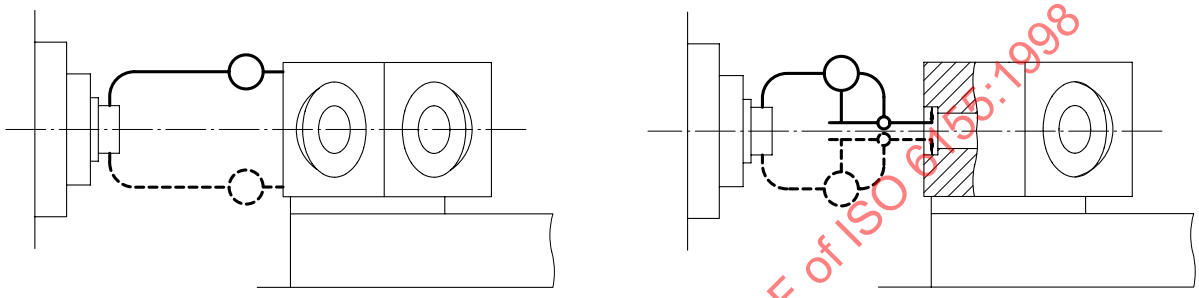
Object **G10**

Checking of:

1) Squareness of the turret faces to the work spindle axis;
2) Alignment of the turret recess axes to the work spindle axis.

(These tests apply only to machines with turret configuration type A.)

Diagram



Tolerance	Range 0	Range 1	Range 2	**(Measured deviation)**
1)	—	0,015/100	0,015/100	1)
2)	—	0,015	0,015	2)

Measuring instruments

1) Dial gauge in rigid spindle nose mounting
2) Dial gauge in rigid spindle nose mounting and as close as possible to the spindle nose

Observations and references to ISO 230-1

1) 5.512.1 and 5.512.4
The dial gauge should be mounted as close as possible to the spindle nose.
The test shall be repeated for each turret face.

2) 5.442
The turret should be in the forward position or as near to the spindle as possible.
The test shall be repeated for each turret recess.

NOTE — For test 2, divide the total dial gauge reading by two before comparing to tolerance.

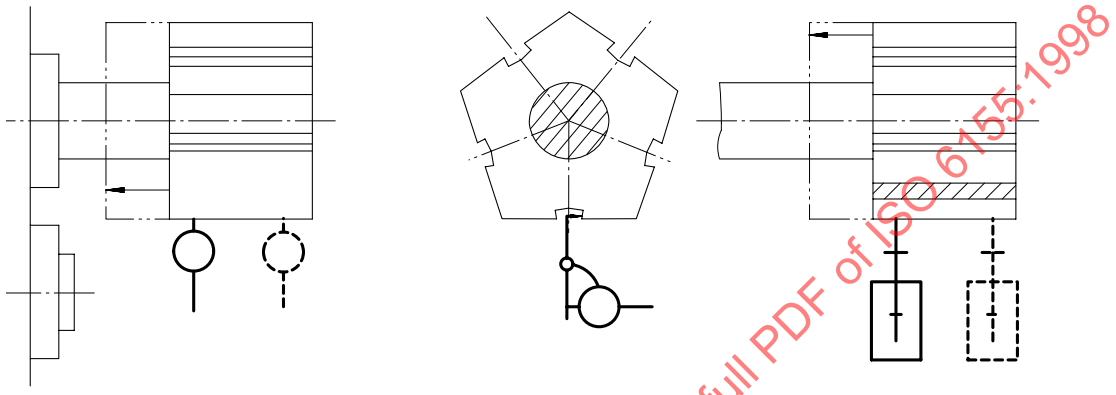
Object **G11**

Checking of:

1) Parallelism of the turret faces with the turret movement.
2) Parallelism of the turret tool holder location slot (or tenon) to the turret movement.

(These tests apply only to machines with turret configuration type B.)

Diagram



Tolerance	1) and 2)	**(Measured deviation)** 1) and 2)
Range 0	Range 1 and Range 2	
—	0,015 for any measuring length of 100	

Measuring instruments

Dial gauge and special device if specified by the supplier/manufacturer

Observations and references to ISO 230-1 5.422.21

Both 1) and 2),

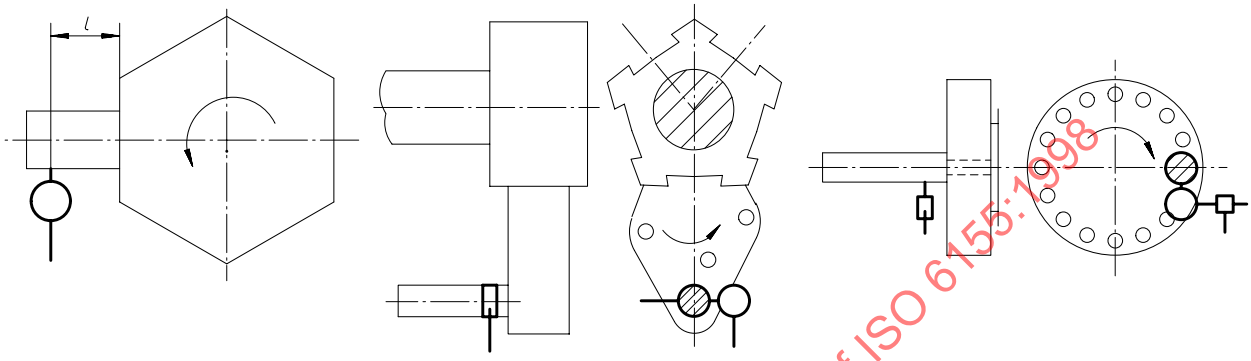
The test, made over the whole cutting stroke, shall be repeated for each turret face, in the indexing position.

Object **G12**

Checking of repeatability of the turret indexing.

(Machining test M1 c) may be used as an alternative to this test.)

Diagram



Type A Type B Type C

Tolerance **(Measured deviation)**

	Type	Range 0	Range 1 and 2
Turret lathe	A	0,01 at / = 50	0,01 at / = 100
Single spindle Automatic lathe	A	0,01 at / = 50	0,01 at / = 100
	B	—	0,01
	C	0,01	0,01

NOTE — In case of type B and type C, measure as close as possible to the tool holder.

Measuring instruments

Dial gauge and test mandrel

Observations and references to ISO 230-1

The test mandrel shall be held in the bore of a tool holder which is mounted on to the turret and set on the spindle centre line. The dial gauge is mounted on a fixed part of the machine.

With the turret in mid position of the stroke, position the dial gauge against the mandrel. Take the first reading.

Then, withdraw the turret, index through 360° and re-position (under automatic cycle, if any). Note the new reading.

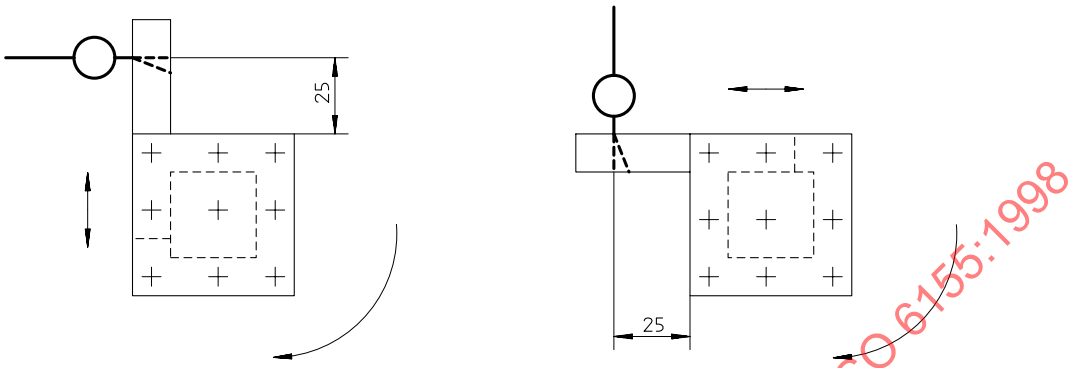
Repeat the procedure at least three times at each turret station.

The measured deviation is represented by the difference between maximum and minimum readings.

Object **G13**

Checking of repeatability of indexing of square turret on the cross slide.

Diagram



Tolerance	**(Measured deviation)**
0,02	

Measuring instruments

Dial gauge and block

Observations and references to ISO 230-1 6.42

The block shall be mounted in the square turret to simulate a tool. The dial gauge shall be mounted on a fixed part of the machine. Take the first reading.

The turret to be pushed back along the axis perpendicular to the direction of the dial gauge stylus.

Then index the turret through 360° and reposition to the measuring position. Note the new reading.

Repeat the procedure at least three times for each turret face.

The measured deviation is represented by the difference between maximum and minimum readings.

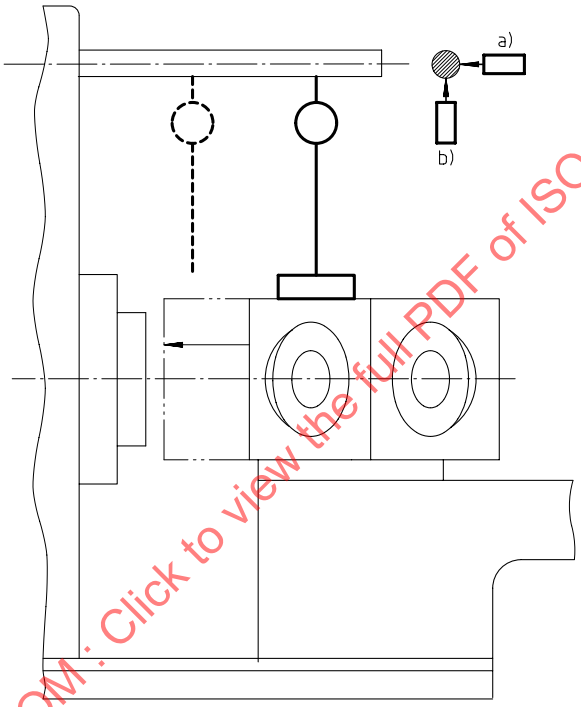
Object **G14**

Checking of parallelism of the steady bar with the turret movement (Z-axis):

a) in a horizontal plane;
b) in a vertical plane.

Diagram

On some machines the steady bar is fixed to the headstock; on others it is fixed to the turret.



Tolerance	**(Measured deviation)**
For a) and b) 0,02 for any measuring length of 300	a) b)

Measuring instruments

Dial gauge

Observations and references to ISO 230-1 5.422.3

Object **G15**

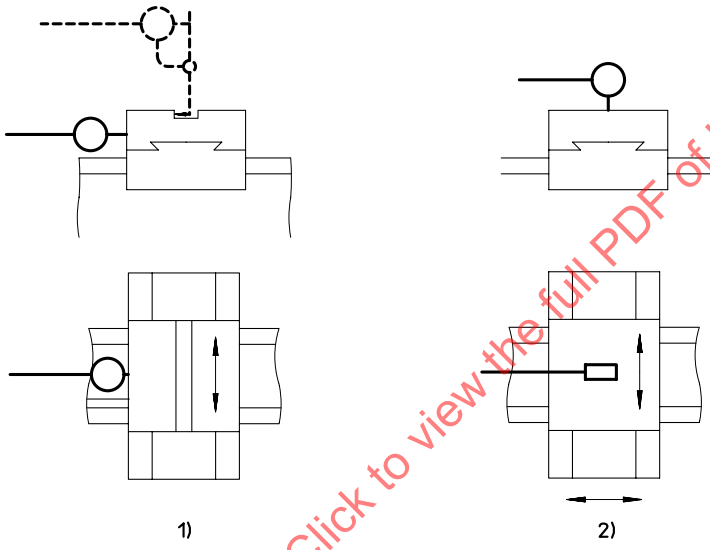
1) Checking of parallelism of the reference slot or reference side face of the cross slide to its transverse movement (X-axis).

2) Checking of parallelism of the tool mounting surface of the cross slide to:

a) longitudinal movement of the cross slide carriage (Z-axis);
b) transverse movement of the cross slide (X-axis).

(These tests apply only to machines with turret configuration type D [linear turret].)

Diagram



Tolerance		**(Measured deviation)**
1):	0,03 for any measuring length of 300	1)
2): a) and b);	0,04 for any measuring length of 300	2) a) and b)

Measuring instruments

Dial gauge

Observations and references to ISO 230-1

a) and b): 5.422.21