
**Test conditions for vertical surface
type broaching machines — Testing of
accuracy**

*Conditions de réception des machines verticales à brocher les
extérieurs — Contrôle de l'exactitude*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This second edition cancels and replaces the first edition (ISO 6481:1981), which has been technically revised. The main changes compared to the previous edition are as follows:

- the title has been changed;
- the document's format has been aligned with new published ISO/TC 39/SC 2 documents;
- some terms have been changed and equivalent non-formal terms in more languages have been added to [Annex A](#);
- all diagrams have been regenerated;
- old references to ISO/R 230:1961 have been changed to ISO 230-1:2012 and all observations have been updated accordingly;
- levelling test, G01, has been deleted and relevant explanations have been added to [Clause 5](#);
- test items G2 and G3 have been merged into one; consequently, a new tolerance has been applied;
- [Clause 7](#) has been created to provide considerations to machining tests to be agreed between manufacturer/supplier and user;
- imperial units of measurements have been deleted and only metric units are now used.

In addition to terms given in the official ISO languages (English and French), this document gives the equivalent terms in German, Italian and Persian. These are published under the responsibility of the member bodies for Germany (DIN), Iran (ISIRI) and Italy (UNI) and are given for information only. Only the terms given in the official languages can be considered as ISO terms.

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Introduction

The object of this document is to supply information as wide and comprehensive as possible on tests on vertical surface type broaching machines which can be carried out for comparison, acceptance, maintenance or any other purposes.

This document also establishes the tolerances for the test results corresponding to general purpose and normal accuracy vertical surface type broaching machines.

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Test conditions for vertical surface type broaching machines — Testing of accuracy

1 Scope

This document specifies, with reference to ISO 230-1, the geometric tests on surface type broaching machines with vertical Z-axis providing the main cutting motion.

It also specifies the applicable tolerances corresponding to the tests mentioned above for normal-accuracy vertical surface type broaching machines.

This document explains different concepts or configurations and common features of vertical surface type broaching machines. It also provides related terminology and designation of axes.

This document deals only with the verification of the accuracy of the broaching machine.

It does not apply to the operational testing of the broaching machine (e.g. vibration, abnormal noise, stick-slip motion of components), nor to broaching machine characteristics (e.g. speeds, feeds) as such checks are generally carried out before testing the accuracy.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 230-1:2012, *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or quasi-static conditions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 230-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

surface broaching operation

machining process in which a broach is pushed over an external surface to remove material by linear cutting

Note 1 to entry: Principal cutting motion is a relative translation of broach against the non-rotating workpieces and where the cutting energy is brought by the broach or workpiece motion.

3.2

broach

cutting tool that has multiple transverse cutting edges each with progressively increased size

3.3

broaching machine

machine tool in which broaching operation is executed

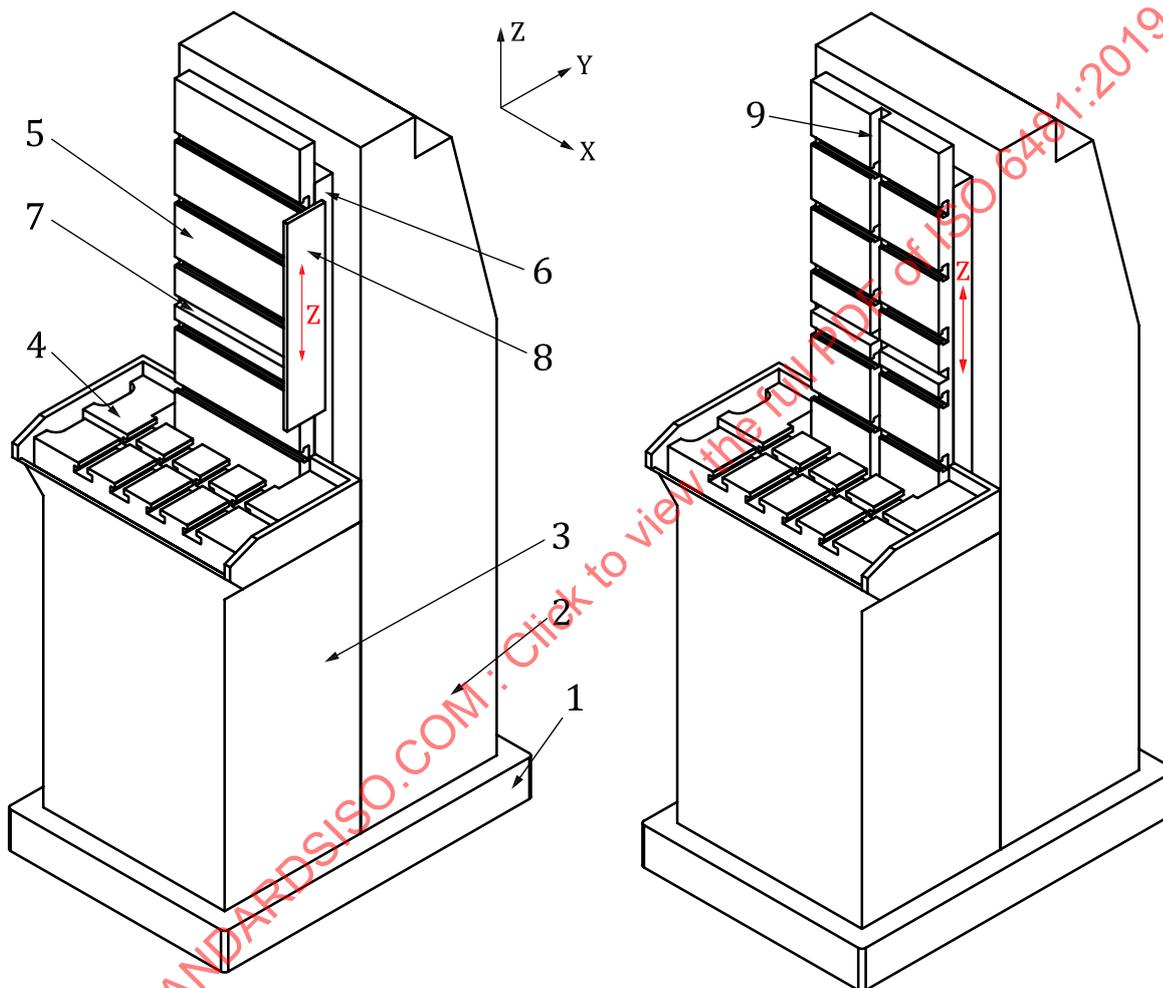
3.4 vertical surface type broaching machine

vertical broaching machine in which its broach is pushed or pulled over an external surface of the workpiece to remove material

Note 1 to entry: A vertical broaching machine is understood to be a broaching machine whose main cutting axis (Z-axis) is vertical.

4 Terminology and designation of axes

See [Figure 1](#).



Key

English	French
1 bed	bâti
2 column	bâti arrière
3 table base	bâti avant
4 table	table
5 broach holder (Z-axis)	porte-broche (axe Z)
6 Z-axis guide	guide de l'axe Z
7 cross tenon	clavette d'entraînement
8 broach positioner	règle de dégauchissage
9 vertical keyway	rainure de dégauchissage

NOTE For languages other than official ISO languages, see [Table A.1](#).

NOTE Machines have either a broach positioner (Key item 8) or a vertical keyway (Key item 9).

Figure 1 — Typical example of a vertical surface type broaching machine

5 Preliminary remarks

5.1 Measurement units

In this document, all linear dimensions, deviations and corresponding tolerances are expressed in millimetres and angular dimensions are expressed in degrees. Angular deviations and the corresponding tolerances are expressed in ratios as the primary method. However, in some cases, microradians or arcseconds may be used for clarification purposes. [Formula \(1\)](#) should be used for conversion of the units of angular deviations or tolerances:

$$0,010 / 1\,000 = 10 \mu\text{rad} \approx 2'' \quad (1)$$

5.2 Reference to the ISO 230 series

To apply this document, reference shall be made to ISO 230-1, especially for the installation and levelling of the machine before testing, warming up of the moving components, description of measuring methods and recommended uncertainty of testing equipment.

In the “Observations” block of the tests described in the following clauses, the instructions are followed by a reference to the corresponding clause in ISO 230-1:2012, in cases where the test concerned is in line with the specifications of ISO 230-1.

5.3 Testing sequence

The sequence in which the tests are presented in this document does not define 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

Prior to conducting tests on a vertical surface type broaching machine, the machine should be levelled according to the recommendations of the manufacturer/supplier (see ISO 230-1:2012, 6.1.2).

When testing a machine tool, it is not always necessary or possible to carry out all the tests described in this document. When the tests are required for acceptance purposes, it is up to the user to choose, in agreement with the manufacturer/supplier, those tests relating to the components and/or the properties of the machine tool which are of interest. These tests are to be clearly stated when ordering a machine tool. A mere reference to this document for the acceptance tests, without specifying the tests to be carried out, and without agreement on the relevant expenses, cannot be considered as binding for any contracting party.

5.5 Tolerances and minimum tolerance

In this document, all tolerance values (see ISO 230-1:2012, 4.1) are guidelines. When they are used for acceptance purposes, other values can be agreed on between the user and the manufacturer/supplier. The required/agreed tolerance values are to be clearly stated when ordering the machine.

When establishing the tolerance for a measuring length different from that given in this document (see ISO 230-1:2012, 4.1.2), it shall be taken into consideration that the minimum value of tolerance is 0,010 mm.

5.6 Measuring instruments

Measuring instruments indicated in the tests described in the following clauses are examples only. Other instruments capable of measuring the same quantities and having the same or a smaller measurement uncertainty may be used. Reference shall be made to ISO 230-1:2012, Clause 5, which indicates the relationship between measurement uncertainties and the tolerances.

When a “dial gauge” is referred to, it can mean not only dial test indicators (DTI) but any type of linear displacement sensor such as analogue or digital dial gauges, linear variable differential transformer (LVDTs), linear scale displacement gauges, or non-contact sensors, when applicable to the test concerned (see ISO 230-1:2012, Clause 4).

Similarly, when a “straightedge” is referred to, it can mean any type of straightness reference artefact, such as a granite or ceramic or steel or cast iron straightedge, one arm of a square, one generating line on a cylindrical square, any straight path on a reference cube, or a special, dedicated artefact manufactured to fit in the T-slots or other references.

In the same way, when a “square” is mentioned, it can mean any type of squareness reference artefact, such as a granite or ceramic or steel or cast-iron square, a cylindrical square, a reference cube, or, again, a special, dedicated artefact.

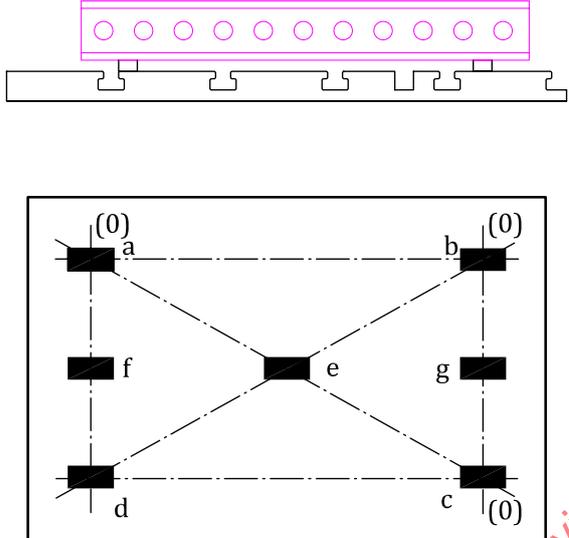
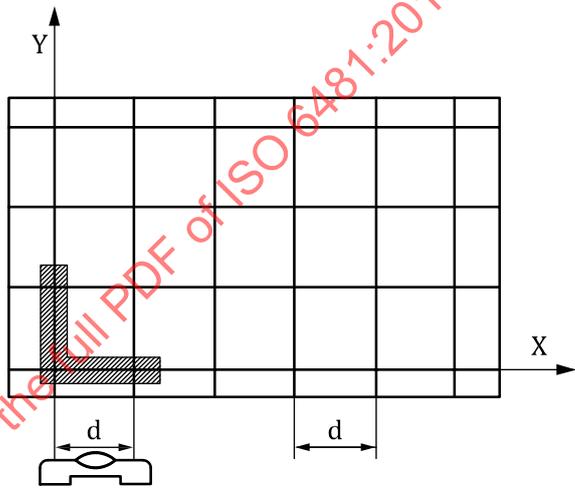
5.7 Diagrams

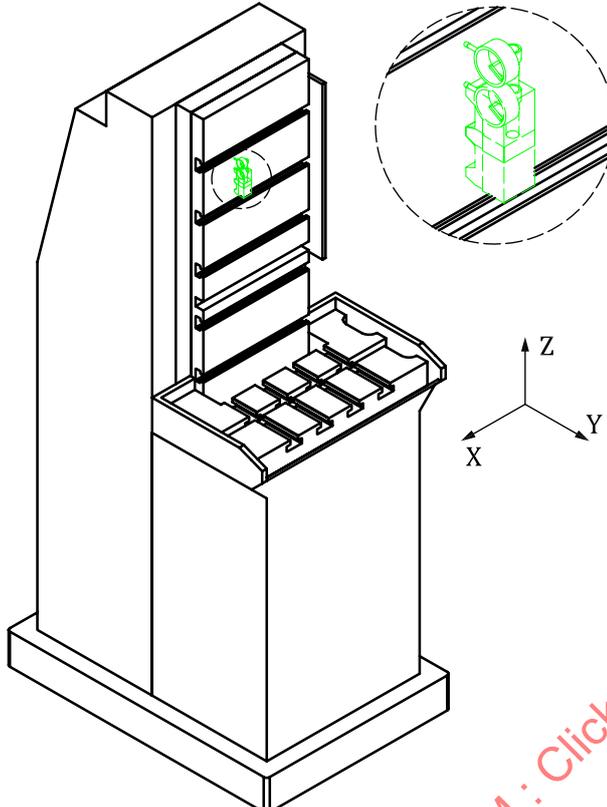
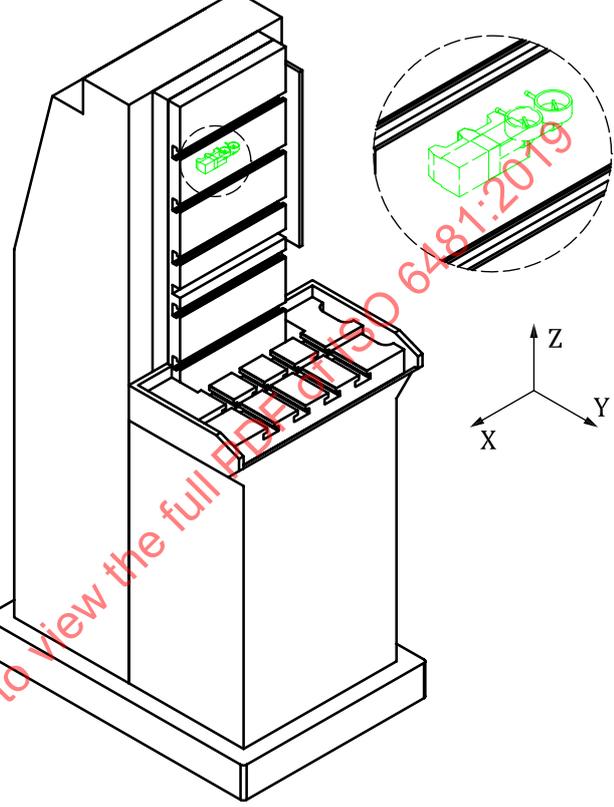
For reasons of simplicity, diagrams in this document illustrate only one type of machine.

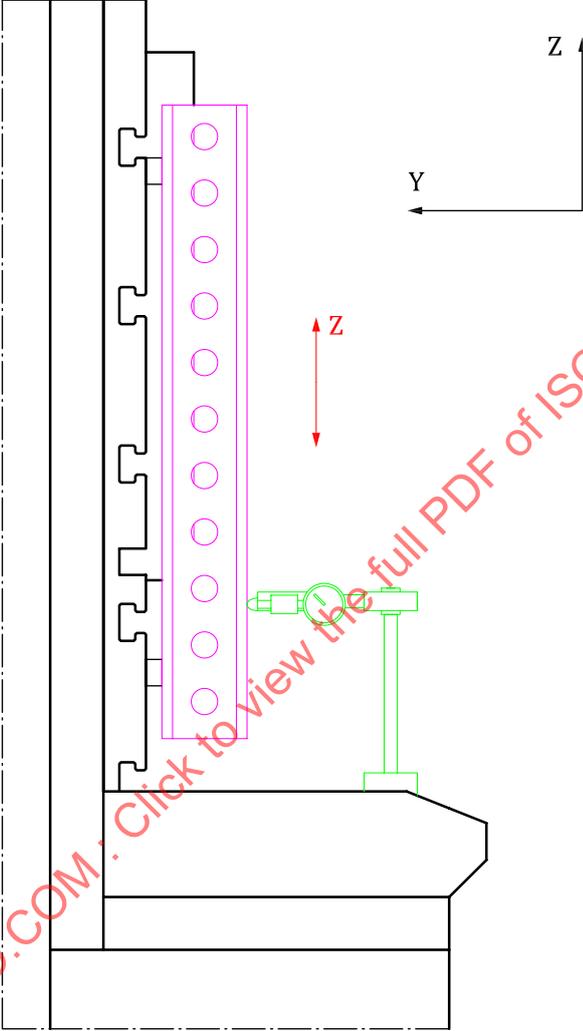
5.8 Axes not under test

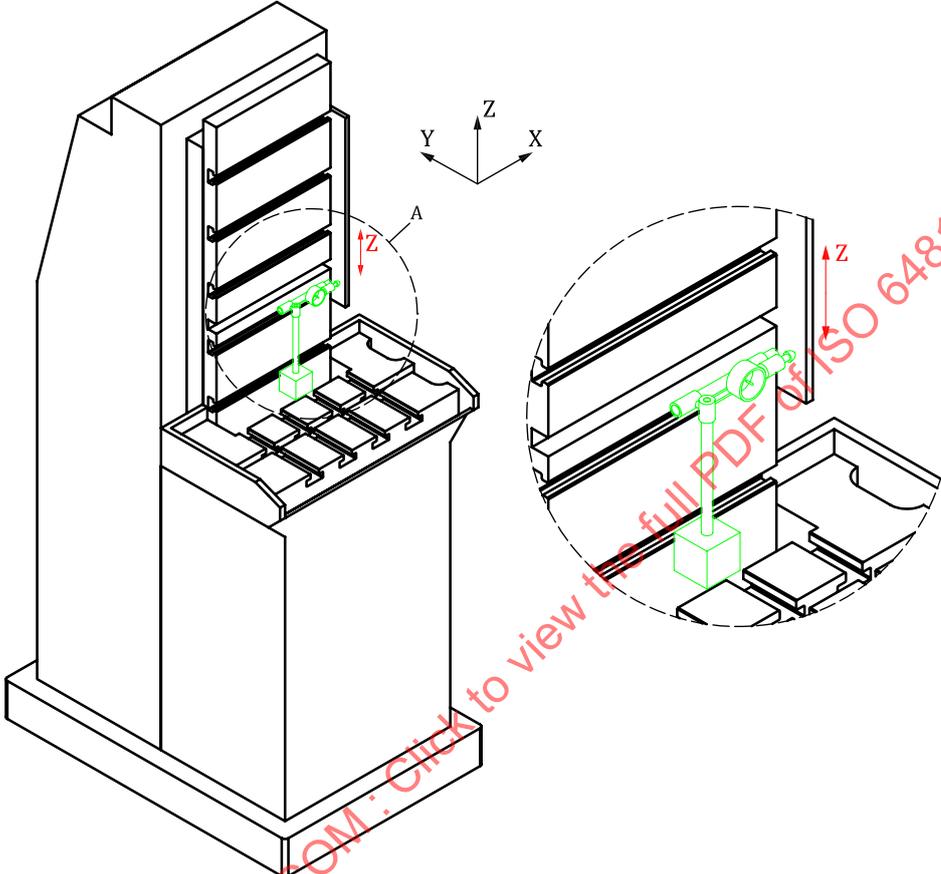
During the execution of some geometric tests on one axis of motion, the position of the other axes, not under test, may affect the results. Therefore, the positions of these axes, as well as the offsets on the tool side and on the workpiece side, are to be recorded in the test report.

6 Geometric tests

Object Checking of flatness of the table	G1
Diagram Method A by straightedge and series of gauge blocks  Method B by precision level 	
Tolerance 0,040 for a measuring length of up to 1 000	
Measured deviation	
Measuring instruments Method A: Straightedge and gauge blocks; or Method B: precision level or optical instruments.	
Observations and references to ISO 230-1:2012, 12.2.3.1, 12.2.4 and 12.2.5 For implementing flatness measurement by straightedge and series of gauge blocks (method A), refer to ISO 230-1:2012, 12.2.3.1. For implementing the test by precision level or optical instruments (method B), measurements shall be carried out at a number of positions equally spaced with measuring distance, d . For more details and interpretation of obtained results, refer to ISO 230-1:2012, 12.2.4 and 12.2.5, for precision level and optical instruments respectively.	

<p>Object</p>	<p>G2</p>
<p>Checking of flatness of the surface of broach holder</p>	
<p>Diagram First step of measurement in vertical direction</p>	<p>Second step of measurement in horizontal direction</p>
	
<p>Tolerance 0,025 for a measuring length of up to 500 Total tolerance: 0,040</p>	
<p>Measured deviation</p>	
<p>Measuring instruments Dial gauge with metrological carriage.</p>	
<p>Observations and references to ISO 230-1:2012, 12.1.3.5 and 12.2 In order to determine flatness of the rectangular surface which is a vertical plane, a dial gauge with a special base is used. In the first step, measurements shall be carried out at a number of positions equally spaced in horizontal directions. In the second step, measurements are performed in vertical directions by the same dial gauge with its special base with equally spaced measuring distances. For more details and interpretation of obtained results, refer to ISO 230-1:2012, 12.2.4.</p>	

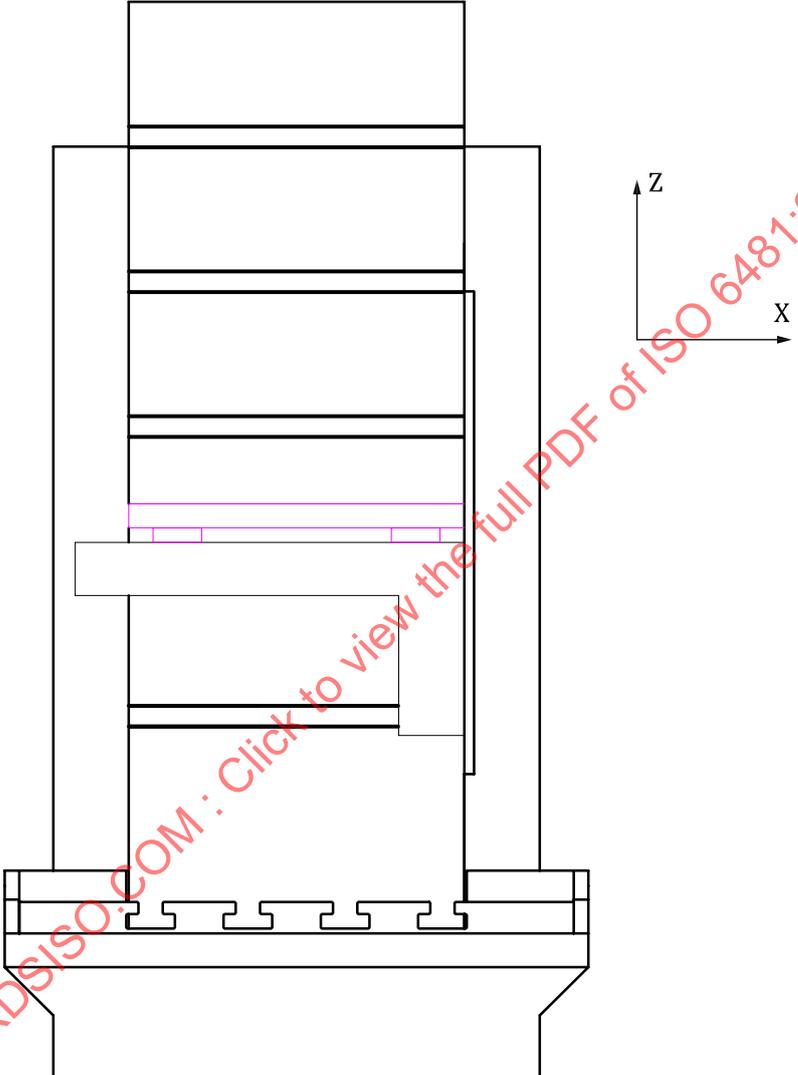
Object	G3
Checking of parallelism error of the broach holder movement (Z-axis) to the surface of broach holder	
<p>Diagram</p> 	
<p>Tolerance</p> <p>Local tolerance: 0,025 over a measuring length of 1 000</p> <p>Total tolerance: 0,050</p>	
<p>Measured deviation</p>	
<p>Measuring instruments</p> <p>Straightedge, gauge blocks and dial gauge.</p>	
<p>Observations and references to ISO 230-1:2012, 12.3.2.5.1</p> <p>Fix the dial gauge base on the table of the machine. By two equal-size gauge blocks, fix the straightedge on the broach holder. Contact the stylus to the front surface of straightedge. Move the broach holder along Z-axis in front of dial gauge and record the variations of the dial gauge.</p> <p>The parallelism error is the difference between the maximum and the minimum readings of the dial gauge.</p>	

Object	G4
Checking of parallelism of the broach holder movement (Z-axis) to the broach positioner.	
NOTE This test also applies to machines with a vertical keyway.	
Diagram	
	
Tolerance	
Local tolerance: 0,025 over a measuring length of 1 000	
Total tolerance: 0,050	
Measured deviation	
Measuring instruments	
Dial gauge.	
Observations and references to ISO 230-1:2012, 12.3.2.5.1	
Fix the dial gauge base on the table of the machine. Contact the stylus of the dial gauge to the surface of broach positioner in YZ plane. Move broach positioner downward along Z-axis and record the variations of the dial gauge.	
The parallelism error is the difference between the maximum and minimum readings of the dial gauge.	

Object	G5
<p>Checking of squareness of the broach holder/positioner movement (Z-axis) to the table:</p> <p>a) in the longitudinal direction (along Y direction);</p> <p>b) in the transverse direction (along X direction).</p>	
<p>Diagram</p> <div style="display: flex; justify-content: space-around;"> <div data-bbox="193 521 766 1261"> <p>a)</p> </div> <div data-bbox="766 521 1485 1261"> <p>b)</p> </div> </div>	
<p>Tolerance</p> <p>For a and b) 0,040 / 300 (0,135 / 1 000) or 27"</p> <p>α shall be less than 90°</p>	

Measured deviation	
a)	b)
Measuring instruments	
Square and dial gauge.	
Observations and references to ISO 230-1:2012, 12.4.5	
For a)	
<p>Fix a square on the table while one measuring side of the square is oriented along Y direction. Set the base of the dial gauge on the broach holder. Fix the dial gauge with its stylus oriented along Y direction touching the square. Move broach holder (Z-axis) with the dial gauge attached along the square. Record the variations of the dial gauge and also the first and the last positions of Z-axis. The squareness error is the difference between the readings at the top and bottom of the square divided by the predetermined stroke of Z-axis at those positions.</p>	
For b)	
<p>Fix a square on the table while one measuring side of the square is oriented along X direction. Set the base of the dial gauge on the broach positioner. Fix the dial gauge with its stylus oriented along X direction touching the square. Move broach positioner (Z-axis) with the dial gauge attached along the square. Record the variations of the dial gauge and also the first and the last positions of Z-axis. The squareness error is the difference between the readings at the top and bottom of the square divided by the predetermined stroke of Z-axis at those positions.</p>	

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Object	G6
<p>Checking of squareness of the lower face of the cross tenon to the broach positioner.</p> <p>NOTE This test also applies to machines with a vertical keyway.</p>	
<p>Diagram</p> 	
<p>Tolerance 0,030 / 300 (0,100 / 1 000) or 20"</p>	
<p>Measured deviation</p>	
<p>Measuring instruments Square and gauge blocks; or Square and dial gauge.</p>	

Observations and references to ISO 230-1:2012, 12.4.2

Fix one of measuring sides of the square to the broach positioner along Z direction. Insert gauge blocks between lower face of cross tenon and the other measuring side of the square along X direction at one end of the square. Repeat the same process for another end of the square by inserting gauge blocks. The squareness error is the difference between size of gauge blocks at two ends divided by the longitudinal distance between those locations.

Instead of using gauge blocks, a dial gauge can be moved along the broach positioner (along Z direction) or along the square (along X direction).

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Object	G7
Checking of squareness of the table front-to-back slots to the broach holder.	
Diagram	
Tolerance	
0,025 over a measuring length of 300	
Measured deviation	
Measuring instruments	
Square and gauge blocks.	
Observations and references to ISO 230-1:2012, 12.4.2	
<p>Fix one of measuring sides of the square to the broach holder along X direction. Insert gauge blocks between right face of the table slot and the other measuring side of the square along Y direction at one end of the square. Repeat the same process for another end of the square by inserting gauge blocks. The squareness error is the difference between the size of gauge blocks at two ends while the distance between two gauge blocks is set to 300.</p>	