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**Test conditions for die sinking electro-  
discharge machines (die sinking  
EDM) — Testing of the accuracy —**

**Part 1:  
Single-column machines (cross-slide  
table type and fixed-table type)**

*Conditions d'essai des machines d'électroérosion en plongée (EDM en  
plongée) — Contrôle de l'exactitude —*

*Partie 1: Machines à un montant (à bancs en croix et table fixe)*



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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](http://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](http://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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: [Foreword — Supplementary information](#).

The committee responsible for this document is ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

This second edition cancels and replaces the first edition (ISO 11090-1:1998), which has been technically revised.

ISO 11090 consists of the following parts, under the general title *Test conditions for die sinking electro-discharge machines (die sinking EDM) — Testing of the accuracy*:

- *Part 1: Single-column machines (cross-slide table type and fixed table type)*
- *Part 2: Double-column machines (slide-head type)*

## Introduction

The purpose of this part of ISO 11090 is to standardize methods of testing normal accuracy and general-purpose die sinking electro-discharge machines (die sinking EDM).

In this part of ISO 11090, the tolerances for G1, G2, G3, G4, G5, G14, P1, P2, P3, and P4 have been changed from those in ISO 11090-1:1998. The following tests in ISO 11090-1:1998 are deleted due to the limited availability of the reference T-slot in typical machines in today's market: G9 (Checking of straightness of the reference T-slot or reference surface of the table) and G10 (Checking of parallelism between the reference T-slot or reference surface of the table and the x-axis motion).

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# Test conditions for die sinking electro-discharge machines (die sinking EDM) — Testing of the accuracy —

## Part 1: Single-column machines (cross-slide table type and fixed-table type)

### 1 Scope

This part of ISO 11090 specifies, with reference to ISO 230-1 and ISO 230-2, geometric and machining tests and tests for checking accuracy and repeatability of numerically controlled positioning axes for normal accuracy and general-purpose die sinking electro-discharge machines (die sinking EDM). It also specifies the applicable tolerances corresponding to the above-mentioned tests.

This part of ISO 11090 is also applicable to single-column machines of cross-slide table type and fixed table type.

This part of ISO 11090 deals only with the verification of accuracy of the machine. It does not apply to the testing of the machine operation (vibrations, abnormal noises, stick-slip motion of components, etc.) or to the checking of its characteristics (such as speeds, feeds, etc.), which should generally be checked before the testing of the accuracy.

This part of ISO 11090 provides the terminology used for the principal components of the machine and the designation of the axes with reference to ISO 841:2001.

**NOTE** In addition to the terms used in the official ISO languages (English and French), [Annex A](#) of this part of ISO 11090 gives the equivalent terms in the Dutch, German, Italian, Swedish, Persian, and Japanese languages. These are published under the responsibility of the national member bodies for Netherlands (NEN), Germany (DIN), Italy (UNI), Sweden (SIS), Iran (ISIRI), and Japan (JISC). However, only the terms given in the official languages can be considered as ISO terms.

### 2 Normative references

The following referenced documents, in whole or in part, are normatively referenced in this document and are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 230-2:2014, *Test code for machine tools — Part 2: Determination of accuracy and repeatability of positioning of numerically controlled axes*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply

3.1  
electro-discharge machines

machine tools for the removal of material in dielectric fluid by electro-discharges which are separated in time and randomly distributed in space between two electrically conductive electrodes (the tool electrode and the workpiece electrode) and where the energy in the discharge is controlled

3.2  
die sinking electro-discharge machines

machine tools for the removal of material by electro-discharge machining through the application of a tool electrode whose geometry matches (defines) the desired shape of the workpiece feature

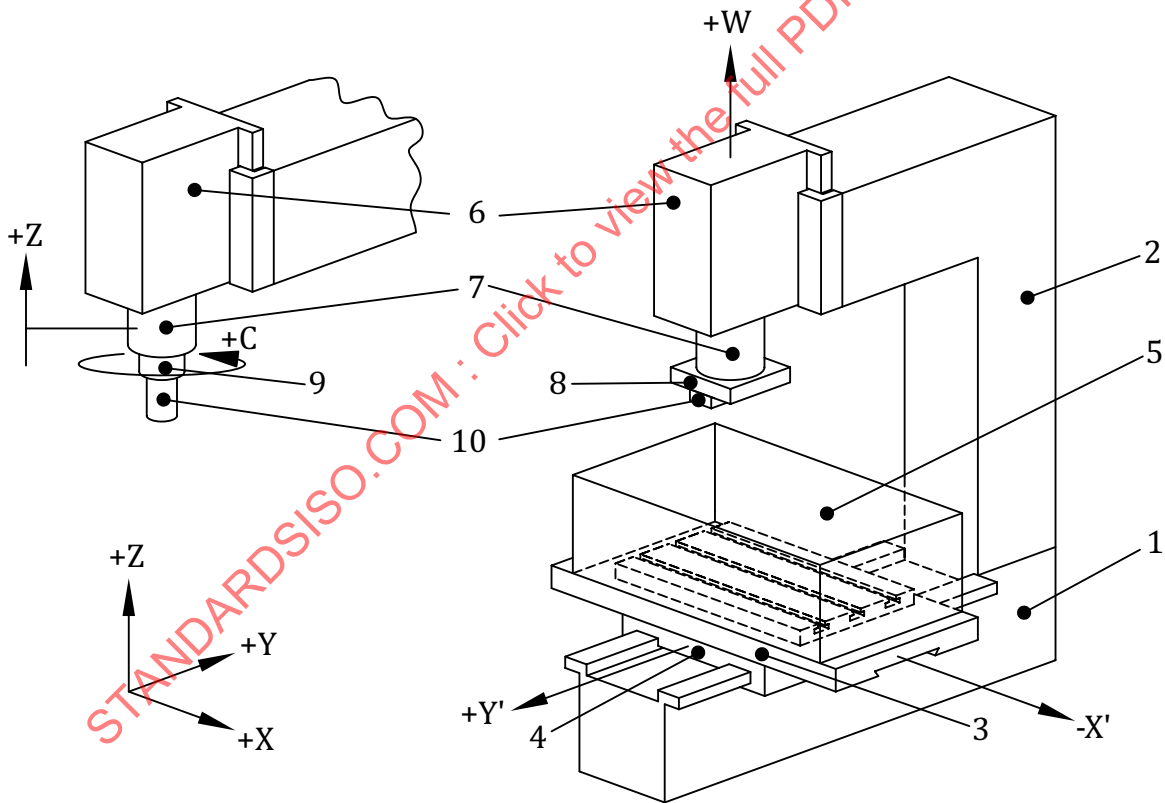
3.3  
wire electro-discharge machines

machine tools for the removal of material by electro-discharge machining through the application of a wire electrode to produce prismatic and more complex shapes in a workpiece

4 Terminology and designation of axes

4.1 Cross-slide table type

See [Figure 1](#) and [Table 1](#).



NOTE See keys in [Table 1](#).

Figure 1 — Single-column machine with cross-slide table

Table 1 — Keys for [Figure 1](#)

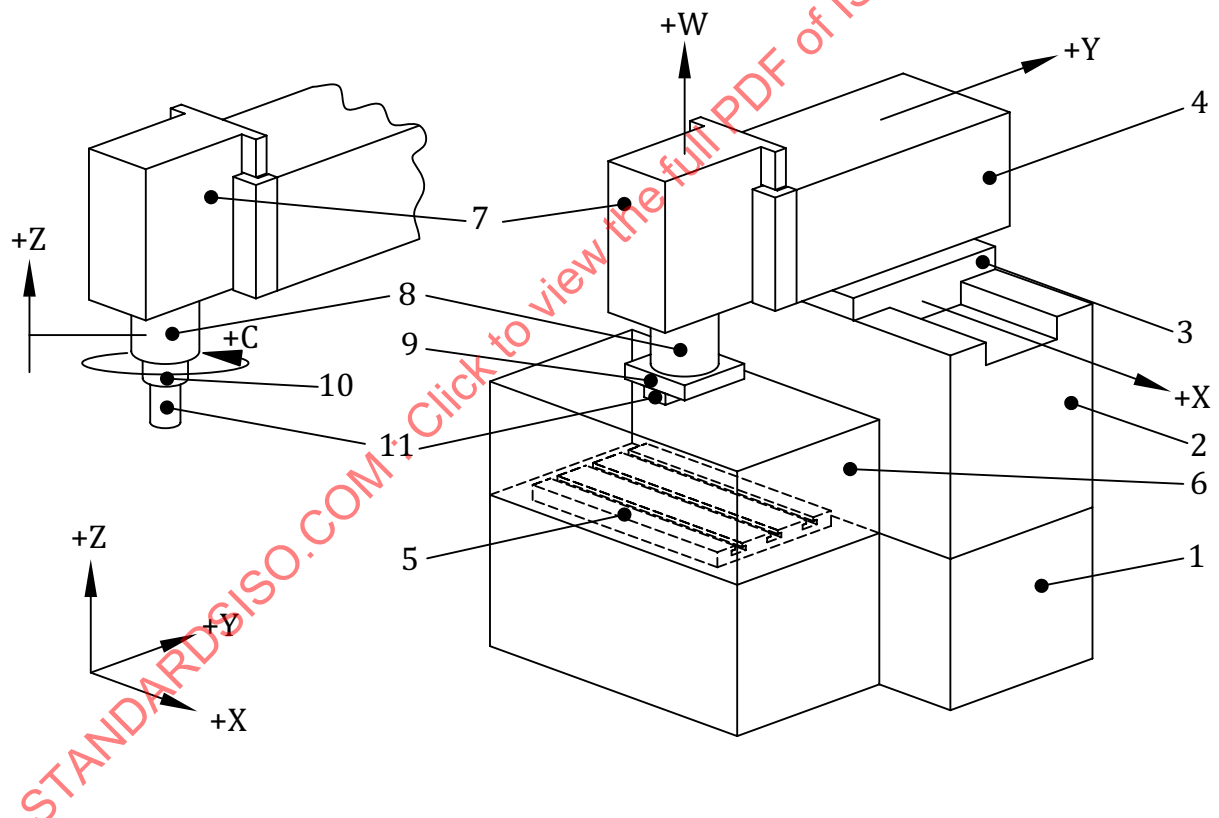
| Key | English | French |
|-----|---------|--------|
| 1   | bed     | banc   |

Table 1 (continued)

| Key | English          | French                      |
|-----|------------------|-----------------------------|
| 2   | column           | montant                     |
| 3   | table (X-axis)   | table (axe X)               |
| 4   | saddle (Y-axis)  | chariot transversal (axe Y) |
| 5   | work tank        | réservoir de travail        |
| 6   | head (W-axis)    | tête de travail (axe W)     |
| 7   | quill (Z-axis)   | coulisse (axe Z)            |
| 8   | electrode platen | porte-électrode             |
| 9   | spindle (C-axis) | broche (axe C)              |
| 10  | electrode        | electrode                   |

## 4.2 Fixed table type

See [Figure 2](#) and [Table 2](#).



NOTE See keys in [Table 2](#).

Figure 2 — Single-column machine with fixed table

Table 2 — Keys for [Figure 2](#)

| Key | English         | French                       |
|-----|-----------------|------------------------------|
| 1   | bed             | banc                         |
| 2   | column          | montant                      |
| 3   | saddle (X-axis) | chariot longitudinal (axe X) |

**Table 2** (continued)

| Key | English          | French                  |
|-----|------------------|-------------------------|
| 4   | ram (Y-axis)     | coulant (axe Y)         |
| 5   | table            | table                   |
| 6   | work tank        | réservoir de travail    |
| 7   | head (W-axis)    | tête de travail (axe W) |
| 8   | quill (Z-axis)   | coulisse (axe Z)        |
| 9   | electrode platen | porte-électrode         |
| 10  | spindle (C-axis) | broche (axe C)          |
| 11  | electrode        | electrode               |

## 5 Preliminary remarks

### 5.1 Measurement units

In this part of ISO 11090, all linear dimensions, deviations, and corresponding tolerances are expressed in millimetres, angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerances are expressed primarily in ratios, but in some cases, microradians or arcseconds can be used for clarification purposes. The following expression should be used for the conversion of angular deviations or tolerances:

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

### 5.2 Reference to ISO 230-1

For the application of this part of ISO 11090, 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 parts, the description of measuring methods, and recommended accuracy of testing equipment.

In the "Observations" block of the tests described in [Clauses 6, 7, and 8](#), the instructions are preceded by a reference to the corresponding clause/subclause in ISO 230-1 in cases where the test concerned is in compliance with the specifications. Tolerances are given for each geometric test (see G1 to G12).

### 5.3 Machine levelling

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

### 5.4 Testing sequence

The sequence in which the geometric tests are given in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, the tests may be performed in any order.

### 5.5 Tests to be performed

When testing a machine tool, it is not always necessary or possible to carry out all the tests given in this part of ISO 11090. When the tests are required for acceptance purposes, the choice of tests relating to the components and/or the properties of the machine of interest is at the discretion of the user, in agreement with the manufacturer/supplier. The tests to be used are to be clearly stated when ordering a machine tool. A mere reference to this part of ISO 11090 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 parties.

## 5.6 Measuring instruments

The measuring instruments indicated in the tests described in [Clauses 6](#) to [8](#) are examples only. Other instruments measuring the same quantities and having the same or smaller measurement uncertainty can be used.

## 5.7 Software compensation

When built-in software facilities are available for compensating geometric, positioning, contouring, and/or thermal deviations, their use during these tests shall be based on agreement between the manufacturer/supplier and the user with due consideration to the machine tool's intended use.

When the software compensation is used, this shall be stated in the test reports.

It shall be noted that when software compensation is used, axes shall not be locked for test purposes.

## 5.8 Minimum tolerance

When the tolerance for a geometric test is established for a measuring length different from that given in this part of ISO 11090, the tolerance can be determined by means of the law of proportionality (see ISO 230-1:2012, 4.1.2). It shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

## 5.9 Machining test

Machining test shall be made under finishing conditions.

## 5.10 Positioning tests and reference to ISO 230-2

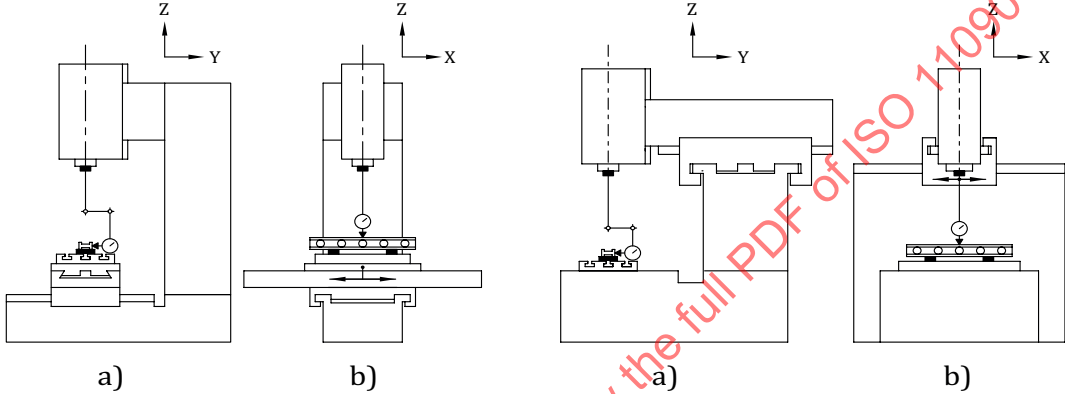
Tests P1 to P4 are applied only to numerically controlled electro-discharge machines.

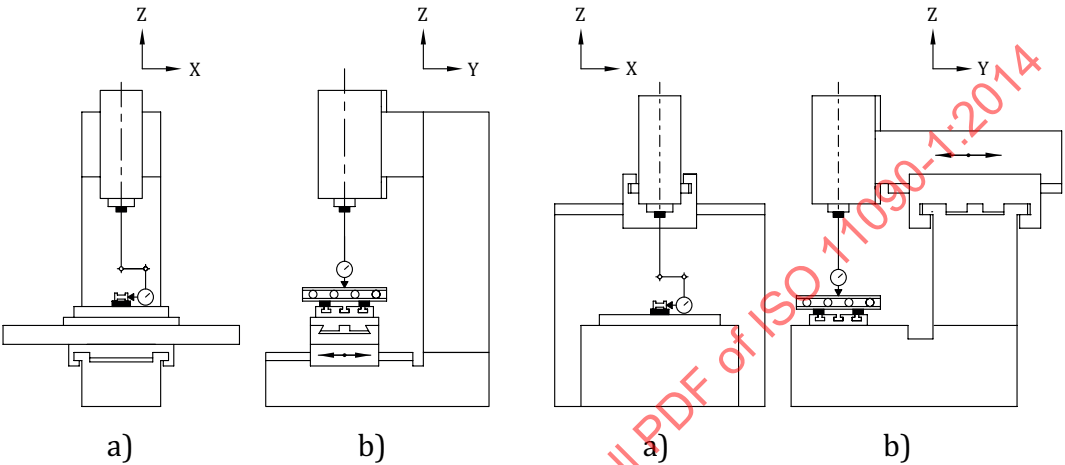
To apply these tests, reference shall be made to ISO 230-2, especially for the environmental conditions, warming up of the machine, measuring methods, evaluation, and interpretation of the results.

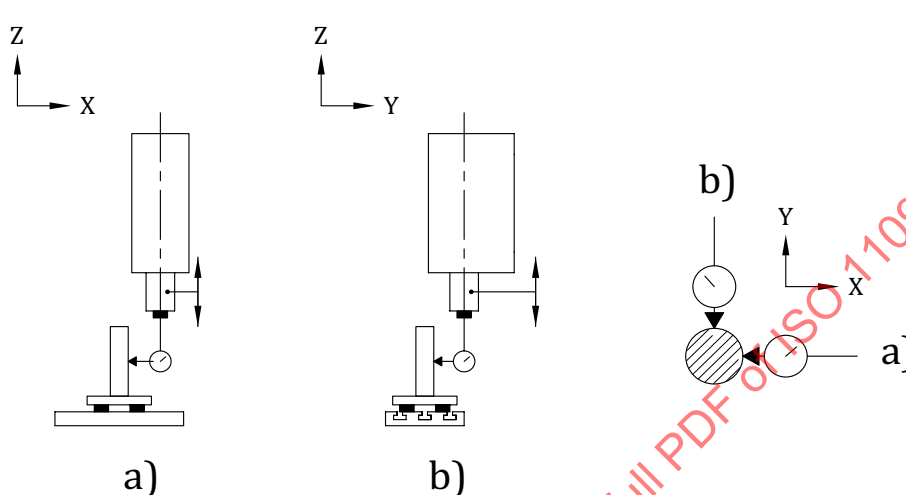
Checking of the W-axis is not included because the W movement is used for adjusting the head position. When required, it shall be done in the same way as the checking of the Z-axis.

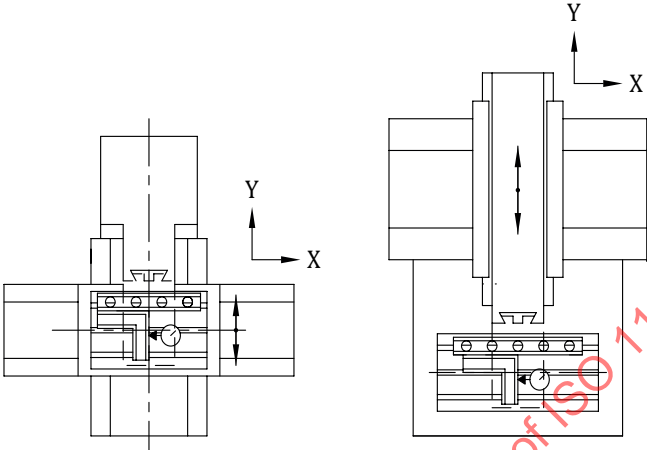
## 6 Geometric tests

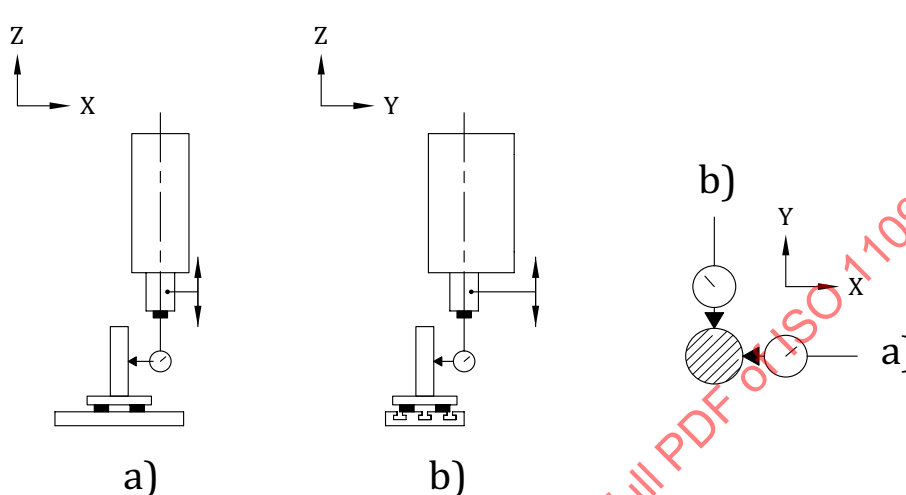
### 6.1 Linear axes of motion

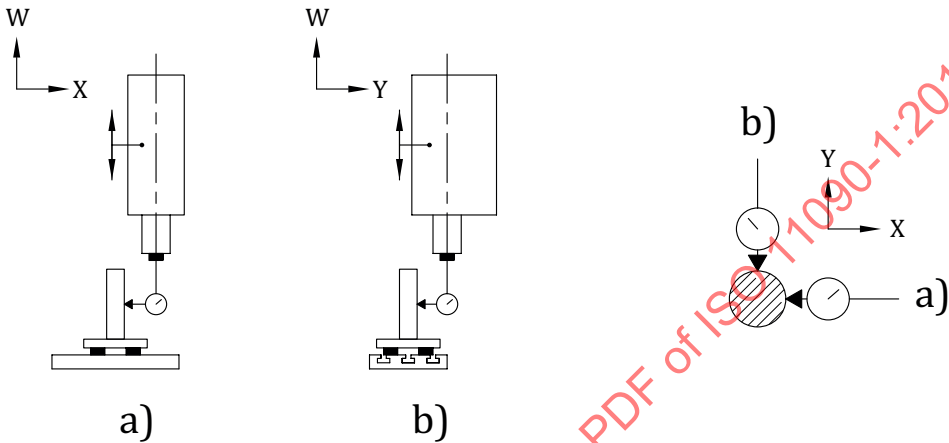
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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------------------------------------|
| <b>Object</b><br>Checking of straightness of the x-axis motion:<br>a) in the horizontal XY plane ( $E_{YX}$ );<br>b) in the vertical ZX plane ( $E_{ZX}$ ).                                                                                                                                                                                                                                                        |  | <b>G1</b>                              |
| <b>Diagram</b><br>                                                                                                                                                                                                                                                                                                              |  |                                        |
| <b>Tolerance</b><br>for a) and b)<br>0,010 for any measuring length of 500                                                                                                                                                                                                                                                                                                                                         |  | <b>Measured deviations</b><br>a)<br>b) |
| <b>Measuring instruments</b><br>Straightness reference artefact and linear displacement sensor or optical measuring instruments                                                                                                                                                                                                                                                                                    |  |                                        |
| <b>Observations and reference to ISO 230-1:2012, 3.4.8, 8.2.2.1, and 8.2.3</b><br>a) Mount the linear displacement sensor on the quill (head).<br>b) Set the straightness reference artefact parallel to the x-axis in the XY plane and set the linear displacement sensor against it. Feed the x-axis through the measuring length and note the readings.<br>c) Repeat the check in the same way in the ZX plane. |  |                                        |

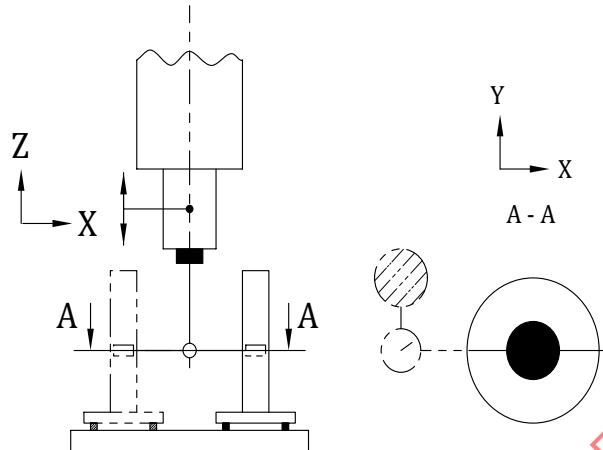
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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                          | <b>G2</b>                                  |
| Checking of straightness of the y-axis motion:<br>a) in the horizontal XY plane ( $E_{XY}$ );<br>b) in the vertical YZ plane ( $E_{ZY}$ ).                                                                                                                                                                                                                                                                             |                                            |
| <b>Diagram</b>                                                                                                                                                                                                                                                                                                                       |                                            |
| <b>Tolerance</b><br><br>for a) and b)<br><br>0,010 for any measuring length of 500                                                                                                                                                                                                                                                                                                                                     | <b>Measured deviations</b><br><br>a)<br>b) |
| <b>Measuring instruments</b>                                                                                                                                                                                                                                                                                                                                                                                           |                                            |
| Straightness reference artefact, linear displacement sensor, and gauge blocks or optical measuring instruments                                                                                                                                                                                                                                                                                                         |                                            |
| <b>Observations and reference to ISO 230-1:2012, 3.4.8, 8.2.2.1, and 8.2.3</b><br><br>a) Mount the linear displacement sensor on the quill (head).<br>b) Set the straightness reference artefact parallel to the y-axis in the XY plane and set the linear displacement sensor against it. Feed the y-axis through the measuring length and note the readings.<br>c) Repeat the check in the same way in the YZ plane. |                                            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>G3</b>                              |
| Checking of straightness of the quill (Z-axis) motion:<br>a) in the ZX plane ( $E_{XZ}$ );<br>b) in the YZ plane ( $E_{YZ}$ ).                                                                                                                                                                                                                                                                                                                                                                                                |                                        |
| <b>Diagram</b><br>                                                                                                                                                                                                                                                                                                                                                                                                                         |                                        |
| <b>Tolerance</b><br>for a) and b)<br>0,010 for any measuring length of 300                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Measured deviations</b><br>a)<br>b) |
| <b>Measuring instruments</b><br>Straightness reference artefact, surface plate, adjustable blocks, and linear displacement sensor                                                                                                                                                                                                                                                                                                                                                                                             |                                        |
| <b>Observations and reference to ISO 230-1:2012, 3.4.8, 8.2.2.1, and 8.2.3</b><br>a) Mount the surface plate on the table.<br>b) Mount the linear displacement sensor on the quill.<br>c) Set the straightness reference artefact parallel to the Z-axis in the ZX plane and set the linear displacement sensor against the straightness reference artefact in the X-direction. Move the quill in the Z-direction through the measuring length and note the readings.<br>d) Repeat the check in the same way in the YZ plane. |                                        |

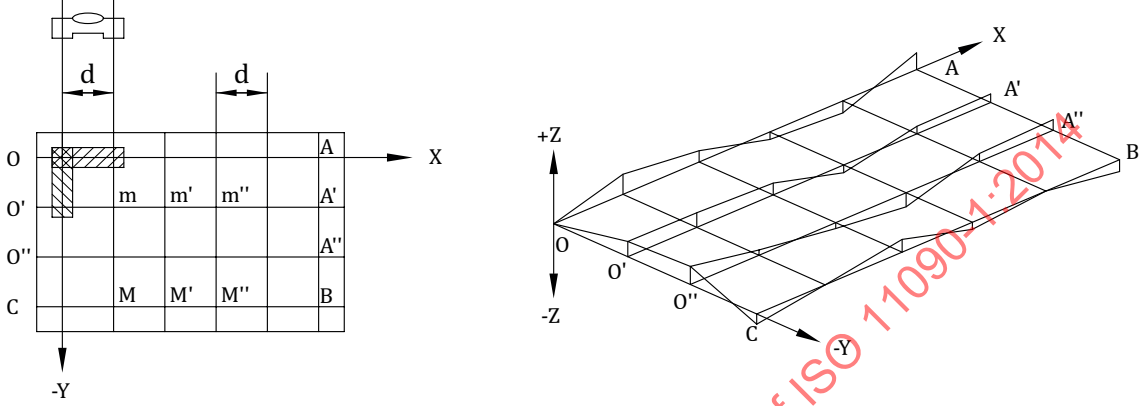
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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>G4</b>                  |
| Checking of squareness of y-axis to x-axis motion ( $E_{C(0X)Y}$ ).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                            |
| <b>Diagram</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                            |
| <b>Tolerance</b><br><br>0,033 / 1 000 (0,010 / 300)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Measured deviations</b> |
| <b>Measuring instruments</b><br>Straightness reference artefact, squareness reference artefact, and linear displacement sensor or optical measuring instruments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                            |
| <b>Observations and reference to ISO 230-1:2012, 3.6.7, 10.3.2.2, and 10.3.2.5</b> <p>a) Align the straightness reference artefact on the table so as to be parallel to the x-axis motion and press the squareness reference artefact against it.</p> <p>b) Mount the linear displacement sensor on the quill (head) and set it against the squareness reference artefact. Feed the y-axis through the measuring length and note the readings at several positions. The inclination of the reference straight line of the trajectory of the readings is the squareness error and shall be reported (see ISO 230-1:2012, 3.6.7).</p> <p>c) Using the squareness reference artefact only is also possible. In this case</p> <ol style="list-style-type: none"> <li>1) set the squareness reference artefact so that the long arm is parallel to the x-axis motion, and</li> <li>2) check the parallelism of the y-axis motion with the short arm.</li> </ol> |                            |

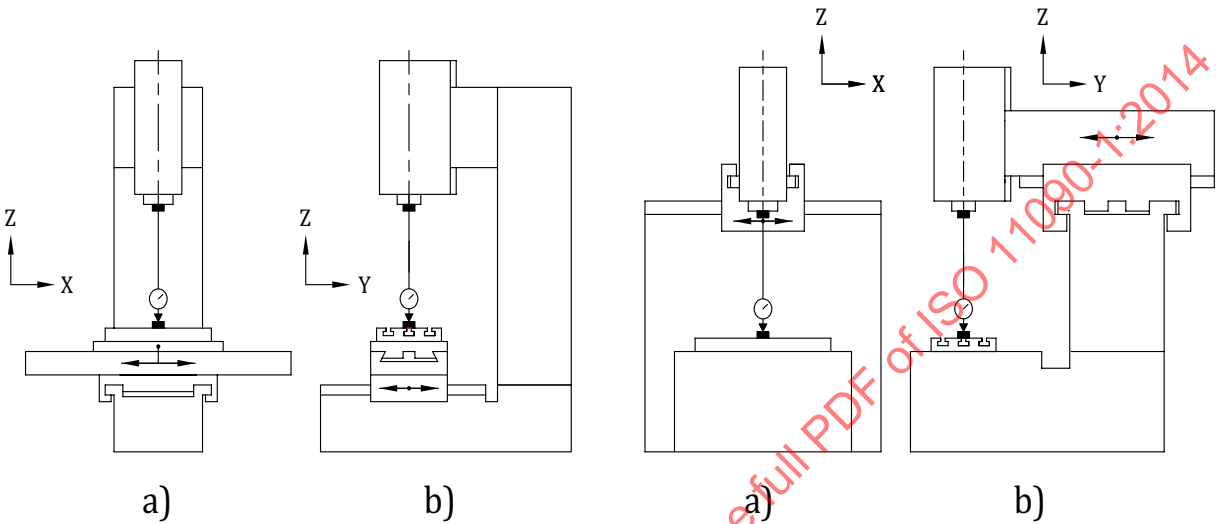
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>G5</b>                              |
| Checking of squareness between the vertical movement of the quill (Z-axis) and the following: <ul style="list-style-type: none"> <li>a) the x-axis motion (<math>E_{B(0X)Z}</math>);</li> <li>b) the y-axis motion (<math>E_{A(0Y)Z}</math>).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                        |
| <b>Diagram</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                        |
| <b>Tolerance</b><br><br>for a) and b)<br>$0,050 / 1\,000 (0,015 / 300)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Measured deviations</b><br>a)<br>b) |
| <b>Measuring instruments</b><br>Squareness reference artefact, surface plate, adjustable blocks, and linear displacement sensor or optical measuring instruments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |
| <b>Observations and reference to ISO 230-1:2012, 3.6.7, 10.3.2.2, and 10.3.2.5</b> <ul style="list-style-type: none"> <li>a) Mount the surface plate on the table and adjust it so that the surface is parallel to both the X- and Y-axes. Place the squareness reference artefact on the surface plate. Mount the linear displacement sensor on the quill.</li> <li>b) Set the linear displacement sensor against the squareness reference artefact in the X-direction and move the quill in the Z-direction through the measuring length and note the readings at several positions. The inclination of the reference straight line of the trajectory of the readings is the squareness error and shall be reported (see ISO 230-1:2012, 3.6.7).</li> <li>c) Repeat the check in the same way in the Y-direction.</li> </ul> |                                        |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>G6</b>                              |
| Checking of squareness between the vertical movement of the head (W-axis) and the following: <ul style="list-style-type: none"> <li>a) the x-axis motion (<math>E_{B(0X)W}</math>);</li> <li>b) the y-axis motion (<math>E_{A(0Y)W}</math>).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                        |
| <b>Diagram</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                        |
| <b>Tolerance</b><br><br>for a) and b)<br>$0,050 / 1\,000$ ( $0,015 / 300$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Measured deviations</b><br>a)<br>b) |
| <b>Measuring instruments</b><br>Squareness reference artefact, surface plate, adjustable blocks, and linear displacement sensor or optical measuring instruments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                        |
| <b>Observations and reference to ISO 230-1:2012, 3.6.7, 10.3.2.2, and 10.3.2.5</b> <ul style="list-style-type: none"> <li>a) Mount the surface plate on the table and adjust it so that the surface is parallel to both the X- and Y-axes. Place the squareness reference artefact on the surface plate. Mount the linear displacement sensor on the head.</li> <li>b) Set the linear displacement sensor against the squareness reference artefact in the X-direction. Move the head in the W-direction through the measuring length and note the readings at several positions. The inclination of the reference straight line of the trajectory of the readings is the squareness error and shall be reported (see ISO 230-1:2012, 3.6.7).</li> <li>c) Repeat the check in the same way in the Y-direction.</li> </ul> |                                        |

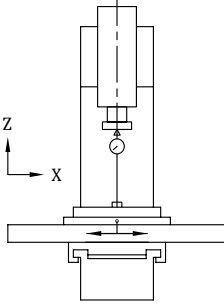
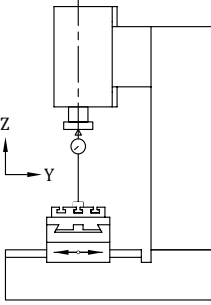
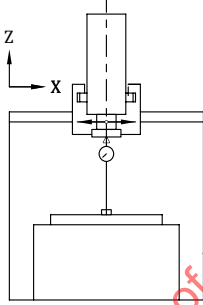
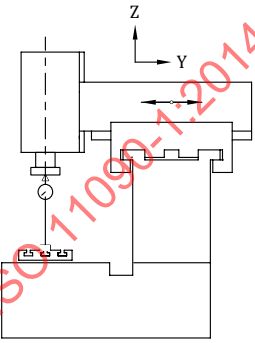
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>G7</b>                  |
| Checking of angular deviation of the Z-axis motion (quill) [the W-axis motion (head)] in the XY plane (roll, $E_{CZ}$ , or $E_{CW}$ ).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                            |
| <b>Diagram</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                            |
| <b>Tolerance</b><br>0,060/1 000 (0,012 / 200)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Measured deviations</b> |
| <b>Measuring instruments</b><br>Straightness reference artefact, surface plate, adjustable blocks, and linear displacement sensor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                            |
| <b>Observations and reference to ISO 230-1:2012, 3.4.16, 8.4.2.1, 8.4.2.2, and 8.4.3</b> <p>a) Mount the surface plate on the table. Place the straightness reference artefact on the surface plate approximately parallel to the Z-axis. Set the stylus of a linear displacement sensor to sense the Y-direction mounted on a special arm against the straightness reference artefact. Note the readings and mark the corresponding heights on the straightness reference artefact.</p> <p>b) Move the table along the x-axis and move the linear displacement sensor to the other side of the quill (head) so that the stylus can touch the straightness reference artefact again along the same line. The linear displacement sensor shall be zeroed again and the new measurements shall be taken at the same heights as the previous ones and noted.</p> <p>c) For each measurement height, calculate the difference of the two readings. The maximum and the minimum of these differences shall be selected and the value given by:</p> $(\text{Maximum difference} - \text{minimum difference}) / d$ <p>where "d" is the distance between the two positions of the linear displacement sensor, is the angular error and shall be recorded.</p> <p>d) The possible roll deviation of the x-axis motion shall be measured and taken into account.</p> |                            |

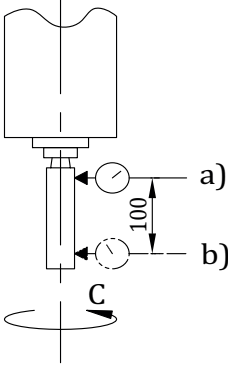
## 6.2 Table

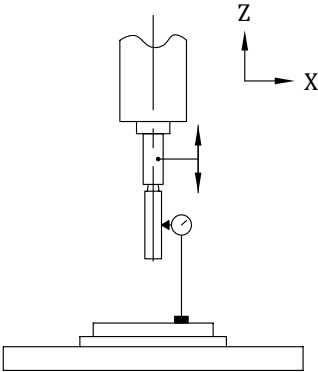
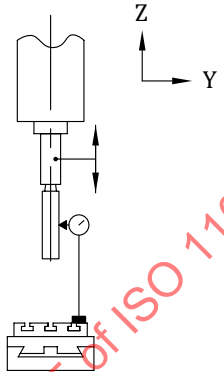
| Object                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | G8                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Checking of flatness of the table surface.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                   |
| <p><b>Diagram</b></p>  <p>The diagram consists of two parts. The left part is a top-down view of a grid. A vertical line with a cross-section of a level is shown at the top, with a distance 'd' indicated. The grid has points labeled O, O', O'', C in the first column; m, m', m'' in the second; M, M', M'' in the third; and A, A', A'', B in the fourth. An X-axis points to the right from point A, and a Y-axis points downwards from point O. The right part is a 3D perspective view of the surface. It shows a grid of points O, O', O'', C, A, A', A'', B. A Z-axis points upwards from point O, and a Y-axis points downwards from point C. The surface is shown as a series of connected points, illustrating its flatness or deviation from a plane.</p> |                                   |
| <p><b>Tolerance</b></p> <p>0,03 for a measuring length up to 1 000<br/> add 0,01 for any further 1 000 increase in length<br/> NOTE Measuring length means the longer length of O-X and O-Y.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <p><b>Measured deviations</b></p> |
| <p><b>Measuring instruments</b></p> <p>Precision level or straightness reference artefact and linear displacement sensor, or optical or other equipment</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                   |
| <p><b>Observations and reference to ISO 230-1:2012, 12.2.4.2, and 12.2.5</b></p> <p>a) Set the table at the centre of x-axis and y-axis motion. Place the precision level on the table surface and move it in X- and Y-directions in the steps corresponding to its length and record the readings. The method of the measurement of angles along each direction is based on ISO 230-1:2012, 12.1.3.</p> <p>b) Measuring shall start from the point O, O',..... and C and be implemented on the line OA, line O'A',... and line CB in the direction of x-axis, and then start from the point O and be implemented on the line OC in the Y-direction.</p> <p>c) The flatness error shall be calculated according to ISO 230-1:2012, 12.2.4.2 and reported.</p>                                                                                              |                                   |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>G9</b>                              |
| Checking of parallelism between the table surface (Table) and the following:<br>a) the x-axis motion ( $E_{B(0X)Table}$ );<br>b) the y-axis motion ( $E_{A(0Y)Table}$ ).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                        |
| <b>Diagram</b><br>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |
| <b>Tolerance</b><br><br>for a) and b)<br>0,015 for any measuring length of 300<br>Maximum tolerance: 0,04                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Measured deviations</b><br>a)<br>b) |
| <b>Measuring instruments</b><br>Linear displacement sensor and straightness reference artefact                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                        |
| <b>Observations and reference to ISO 230-1:2012, 3.6.5, and 12.3.2.5</b><br>a) Mount the linear displacement sensor on the quill (head).<br>b) The stylus of the linear displacement sensor shall touch the table surface. Feed the x-axis through the measuring length and note the readings.<br>c) Repeat the check in the same way in the Y-direction.<br>d) The measurement shall be done approximately along the centrelines of the table in X- and Y-directions when possible.<br>e) When the direct measurement of table surface is difficult due to, for example, T-slots, a straightness reference artefact set on the table can be used (see ISO 230-1:2012, 12.3.2.5.2). |                                        |

### 6.3 Head, quill and spindle

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>G10</b>                                 |
| Checking of parallelism between the electrode platen (Platen) and the following: <ul style="list-style-type: none"> <li>a) the x-axis motion (EB(0X)Platen);</li> <li>b) the y-axis motion (EA(0Y)Platen).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                            |
| <b>Diagram</b> <div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;">  <p>a)</p> </div> <div style="text-align: center;">  <p>b)</p> </div> <div style="text-align: center;">  <p>a)</p> </div> <div style="text-align: center;">  <p>b)</p> </div> </div> |                                            |
| <b>Tolerance</b><br><br>for a) and b)<br><br>0,010 for any measuring length of 200                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Measured deviations</b><br><br>a)<br>b) |
| <b>Measuring instruments</b><br>Linear displacement sensor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |
| <b>Observations and reference to ISO 230-1:2012, 3.6.5, and 12.3.2.5.2</b> <ul style="list-style-type: none"> <li>a) Place the linear displacement sensor on the table.</li> <li>b) Set the linear displacement sensor against the electrode platen surface.</li> <li>c) Feed the x-axis through the measuring length and note the readings at several positions. The maximum difference of the readings is the parallelism error and shall be reported.</li> <li>d) Repeat the check in the same way in the Y-direction.</li> </ul>                                                                                                                            |                                            |

|                                                                                                                                                                                                                                                                                                                                                                                               |                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                 | <b>G11</b>                             |
| Checking of run-out of the spindle bore:<br>a) near the spindle nose;<br>b) at a distance of 100 mm.                                                                                                                                                                                                                                                                                          |                                        |
| <b>Diagram</b><br>                                                                                                                                                                                                                                                                                           |                                        |
| <b>Tolerance</b><br>a) 0,005<br>b) 0,01                                                                                                                                                                                                                                                                                                                                                       | <b>Measured deviations</b><br>a)<br>b) |
| <b>Measuring instruments</b><br>Test mandrel and linear displacement sensor                                                                                                                                                                                                                                                                                                                   |                                        |
| <b>Observations and reference to ISO 230-1:2012, 3.9.7, and 12.5.3</b><br>a) Attach the test mandrel to the spindle.<br>b) Mount the linear displacement sensor on the machine table.<br>c) Set the linear displacement sensor against the test mandrel near the spindle nose, turn the spindle, and note the readings.<br>d) Repeat the check in the same way at a distance of 100 mm apart. |                                        |

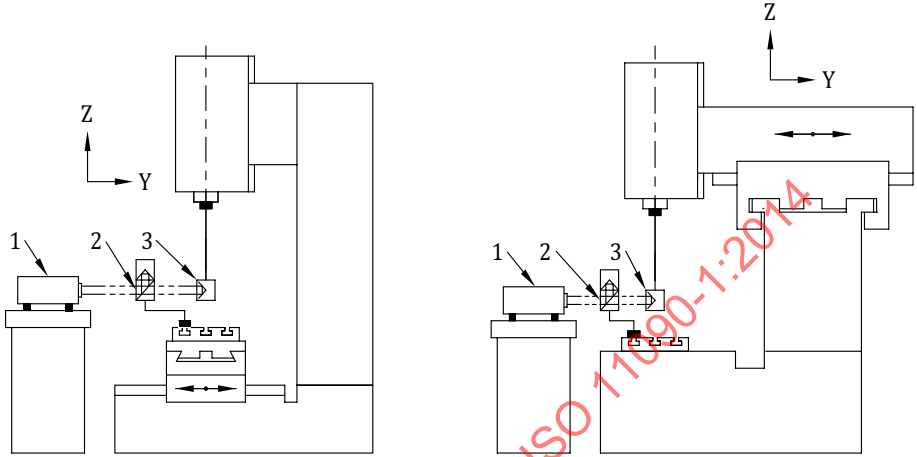
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| <b>Object</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>G12</b>                                 |
| Checking of parallelism between the spindle axis and the Z-axis motion:<br>a) in the ZX plane ( $E_{B(0Z)C}$ );<br>b) in the YZ plane ( $E_{A(0Z)C}$ ).                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |
| <b>Diagram</b> <div style="display: flex; justify-content: space-around; align-items: center;">   </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <span>a)</span> <span>b)</span> </div>                                                                                                                                                             |                                            |
| <b>Tolerance</b><br><br>for a) and b)<br>$0,1 / 1\,000\ (0,01 / 100)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Measured deviations</b><br><br>a)<br>b) |
| <b>Measuring instruments</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                            |
| Test mandrel and linear displacement sensor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                            |
| <b>Observations and reference to ISO 230-1:2012, 3.6.4, and 10.1.4.3</b><br>a) Mount the linear displacement sensor on the machine table.<br>b) Set the linear displacement sensor against the test mandrel in the ZX plane and find the mean position of the spindle by rotating it. Move the quill in the Z-direction and note the readings at several positions. The inclination of the reference straight line of the trajectory of the readings is the parallelism error and shall be reported.<br>c) Repeat the check in the same way in the YZ plane. |                                            |

## 7 Positioning tests for numerically controlled axes

To apply these tests, reference shall be made to ISO 230-2 especially for the environmental conditions, warming up of the machine, description of measuring methods, evaluation, and interpretation of the results.

Checking the W-axis is not included because W movement is used for adjusting the head position. When required, it shall be done in the same way as the checking of the Z-axis.

| Object                                                                                                                                               |                             |                  |               |               | P1                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|------------------|---------------|---------------|--------------------|
| Checking of accuracy, repeatability, and reversal value of positioning of the x-axis motion ( $E_{xx}$ )                                             |                             |                  |               |               |                    |
| <b>Diagram</b><br><b>Key</b><br>1 laser head<br>2 interferometer<br>3 reflector                                                                      |                             |                  |               |               |                    |
|                                                                                                                                                      |                             |                  |               |               |                    |
| Tolerance                                                                                                                                            |                             | Measuring length |               |               | Measured deviation |
|                                                                                                                                                      |                             | $\leq 500$       | $\leq 1\,000$ | $\leq 2\,000$ |                    |
| Bidirectional accuracy of positioning                                                                                                                | $E_{xx,A}$                  | 0,012            | 0,016         | 0,020         |                    |
| Unidirectional repeatability of positioning                                                                                                          | $E_{xx,R1}$ and $E_{xx,R2}$ | 0,005            | 0,008         | 0,010         |                    |
| Bidirectional repeatability                                                                                                                          | $E_{xx,R}$                  | 0,010            | 0,012         | 0,016         |                    |
| Reversal value of axis                                                                                                                               | $E_{xx,B}$                  | 0,008            | 0,010         | 0,013         |                    |
| Mean reversal value                                                                                                                                  | $E_{xx,\bar{B}}$            | 0,004            | 0,005         | 0,006         |                    |
| Bidirectional systematic deviation of positioning                                                                                                    | $E_{xx,E}$                  | 0,010            | 0,012         | 0,016         |                    |
| Mean bi-directional positional deviation of the axis                                                                                                 | $E_{xx,M}$                  | 0,006            | 0,008         | 0,010         |                    |
| <b>Measuring instruments</b>                                                                                                                         |                             |                  |               |               |                    |
| Laser measurement equipment or linear scale                                                                                                          |                             |                  |               |               |                    |
| <b>Observations and references to ISO 230-1:2012, 8.3 and ISO 230-2:2014</b>                                                                         |                             |                  |               |               |                    |
| Linear scale of length or beam axis of laser measurement equipment shall be set parallel to the axis under test.                                     |                             |                  |               |               |                    |
| Rapid feed is used for positioning in principle, but arbitrary feed speed may be used with agreement between the manufacturer/supplier and the user. |                             |                  |               |               |                    |

|                                                                                                                                                      |                                             |                         |               |               |                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-------------------------|---------------|---------------|---------------------------|
| <b>Object</b>                                                                                                                                        |                                             |                         |               |               | <b>P2</b>                 |
| Checking of accuracy, repeatability, and reversal value of positioning of the y-axis motion ( $E_{YY}$ ).                                            |                                             |                         |               |               |                           |
| <b>Diagram</b>                                                                                                                                       |                                             |                         |               |               |                           |
| <b>Key</b><br>1 laser head<br>2 interferometer<br>3 reflector                                                                                        |                                             |                         |               |               |                           |
|                                                                    |                                             |                         |               |               |                           |
| <b>Tolerance</b>                                                                                                                                     |                                             | <b>Measuring length</b> |               |               | <b>Measured deviation</b> |
|                                                                                                                                                      |                                             | $\leq 500$              | $\leq 1\,000$ | $\leq 2\,000$ |                           |
| Bidirectional accuracy of positioning                                                                                                                | $E_{YY,A}$                                  | 0,012                   | 0,016         | 0,020         |                           |
| Unidirectional repeatability of positioning                                                                                                          | $E_{YY,R\uparrow}$ and $E_{YY,R\downarrow}$ | 0,005                   | 0,008         | 0,010         |                           |
| Bidirectional repeatability                                                                                                                          | $E_{YY,R}$                                  | 0,010                   | 0,012         | 0,016         |                           |
| Reversal value of axis                                                                                                                               | $E_{YY,B}$                                  | 0,008                   | 0,010         | 0,013         |                           |
| Mean reversal value                                                                                                                                  | $E_{YY,\bar{B}}$                            | 0,004                   | 0,005         | 0,006         |                           |
| Bidirectional systematic deviation of positioning                                                                                                    | $E_{YY,E}$                                  | 0,010                   | 0,012         | 0,016         |                           |
| Mean bi-directional positional deviation of the axis                                                                                                 | $E_{YY,\bar{E}}$                            | 0,006                   | 0,008         | 0,010         |                           |
| <b>Measuring instruments</b>                                                                                                                         |                                             |                         |               |               |                           |
| Laser measurement equipment or linear scale                                                                                                          |                                             |                         |               |               |                           |
| <b>Observations and references to ISO 230-1:2012, 8.3 and ISO 230-2:2014</b>                                                                         |                                             |                         |               |               |                           |
| Linear scale of length or beam axis of laser measurement equipment shall be set parallel to the axis under test.                                     |                                             |                         |               |               |                           |
| Rapid feed is used for positioning in principle, but arbitrary feed speed may be used with agreement between the manufacturer/supplier and the user. |                                             |                         |               |               |                           |