

---

---

**Test conditions for machining centres —**

Part 2:

**Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis)**

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

*Conditions d'essai des centres d'usinage —*

*Partie 2: Essais géométriques des machines à broche verticale ou à têtes universelles à axe principal de rotation verticale (axe Z vertical)*

[ISO 10791-2:2001](https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-43fd14a405a0/iso-10791-2-2001)

<https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-43fd14a405a0/iso-10791-2-2001>



**PDF disclaimer**

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

ISO 10791-2:2001

<https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-43fd14a405a0/iso-10791-2-2001>

© ISO 2001

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Case postale 56 • CH-1211 Geneva 20  
Tel. + 41 22 749 01 11  
Fax + 41 22 749 09 47  
E-mail [copyright@iso.ch](mailto:copyright@iso.ch)  
Web [www.iso.ch](http://www.iso.ch)

Printed in Switzerland

# Contents

Page

Foreword.....	iv
Introduction.....	v
1 Scope .....	1
2 Normative references .....	1
3 Preliminary remarks .....	2
3.1 Measuring units .....	2
3.2 Reference to ISO 230-1.....	2
3.3 Testing sequence.....	2
3.4 Tests to be performed .....	2
3.5 Measuring instruments .....	2
3.6 Diagrams.....	2
3.7 Pallets .....	2
3.8 Software compensation .....	3
3.9 Machine configurations .....	3
3.10 Designation .....	3
3.11 Minimum tolerance .....	3
4 Geometric tests.....	6
4.1 Straightness of linear motions .....	6
4.2 Angular deviations of linear motions .....	9
4.3 Squareness between linear motions .....	12
4.4 Spindle .....	15
4.5 Table or pallet.....	20
4.6 Supplementary axis (W-axis) parallel to the Z-axis.....	24
Annex A (normative) Optional horizontal spindles .....	26
Annex B (normative) Rotary heads .....	32
Annex C (normative) Swivel heads .....	34
Bibliography.....	41

iTech STANDARD PREVIEW

(standards.itech.ai)

ISO 10791-2:2001

[https://standards.itech.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-](https://standards.itech.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-431814605692-iso-10791-2-2001)[431814605692-iso-10791-2-2001](https://standards.itech.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-431814605692-iso-10791-2-2001)

## 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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

Attention is drawn to the possibility that some of the elements of this part of ISO 10791 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10791-2 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

ISO 10791 consists of the following parts, under the general title *Test conditions for machining centres*:

- *Part 1: Geometric tests for machines with horizontal spindle and with accessory heads (horizontal Z-axis)*
- *Part 2: Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis)*
- *Part 3: Geometric tests for machines with integral indexable or continuous universal heads (vertical Z-axis)*
- *Part 4: Accuracy and repeatability of positioning of linear and rotary axes*
- *Part 5: Accuracy and repeatability of positioning of work-holding pallets*
- *Part 6: Accuracy of feeds, speeds and interpolations*
- *Part 7: Accuracy of a finished test piece*
- *Part 8: Evaluation of the contouring performance in the three coordinate planes*
- *Part 9: Evaluation of the operating times of tool change and pallet change*
- *Part 10: Evaluation of the thermal distortions*
- *Part 11: Evaluation of the noise emission*

Annexes A, B and C form a normative part of this part of ISO 10791.

## Introduction

A machining centre is a numerically controlled machine tool capable of performing multiple machining operations, including milling, boring, drilling and tapping, as well as automatic tool changing from a magazine or similar storage unit in accordance with a machining programme.

The purpose of ISO 10791 is to supply information as wide and comprehensive as possible on tests and checks which can be carried out for comparison, acceptance, maintenance or any other purpose.

ISO 10791 specifies, by reference to the relevant parts of ISO 230, *Test code for machine tools*, several families of tests for machining centres with horizontal or vertical spindle or with universal heads of different types, standing alone or integrated in flexible manufacturing systems. ISO 10791 also establishes the tolerances or maximum acceptable values for the test results corresponding to general purpose and normal accuracy machining centres.

ISO 10791 is also applicable, totally or partially, to numerically controlled milling and boring machines, when their configuration, components and movements are compatible with the tests described herein.

## iTeh STANDARD PREVIEW (standards.iteh.ai)

[ISO 10791-2:2001](https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-43fd14a405a0/iso-10791-2-2001)

<https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-43fd14a405a0/iso-10791-2-2001>

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

ISO 10791-2:2001

<https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-43fd14a405a0/iso-10791-2-2001>

# Test conditions for machining centres —

## Part 2:

# Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis)

## 1 Scope

This part of ISO 10791 specifies, with reference to ISO 230-1, the geometric tests for machining centres (or numerically controlled milling machines, boring machines, etc., where applicable) with vertical spindle (that is vertical Z-axis).

This part of ISO 10791 applies to machining centres having basically three numerically controlled axes, that is three linear axes (X, Y and Z) of up to 2 000 mm length, but also refers to supplementary motions, such as rotary axes (A', B' and C'), those of rams, quill, or universal heads. Motions other than those mentioned are considered as special features and the relevant tests are not included in this part of ISO 10791.

This part of ISO 10791 describes geometric tests for optional horizontal spindles as well as for two possible types of universal heads in the following annexes:

- annex A: optional horizontal spindles (tests AG1 to AG6);
- annex B: rotary heads, with one numerically controlled rotary axis (tests BG1 and BG2);
- annex C: swivel heads, with two numerically controlled rotary axes perpendicular to each other (tests CG1 to CG7).

This part of ISO 10791 deals only with the verification of the accuracy of the machine. It does not apply to the testing of the machine operation, which should be checked separately. Some tests concerning the performance of the machine operating under no-load or finishing conditions are included in other parts of ISO 10791.

## 2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this part of ISO 10791. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10791 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 8526-1:1990, *Modular units for machine tools — Workholding pallets — Part 1: Workholding pallets up to 800 mm nominal size.*

ISO 8526-2:1990, *Modular units for machine tools — Workholding pallets — Part 2: Workholding pallets of nominal size greater than 800 mm.*

### 3 Preliminary remarks

#### 3.1 Measuring units

In this part of ISO 10791, 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 in ratios, but, in some cases for the sake of clarity, microradians or arcseconds are used. The equivalence of the following expressions should always be kept in mind:

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

#### 3.2 Reference to ISO 230-1

To apply this part of ISO 10791, reference shall be made to ISO 230-1, especially for the installation of the machine before testing, warming up of the spindle and other moving components, description of measuring methods and recommended accuracy of testing equipment.

When the operation concerned is in accordance with the specifications of ISO 230-1, the instructions in the "Observations" box of the operations described in clause 4 and annexes A to C are followed by a reference to the corresponding paragraph in ISO 230-1.

#### 3.3 Testing sequence

The sequence in which the tests are presented in this part of ISO 10791 in no way defines the practical order of testing. With a view to making the mounting of instruments or gauging easier, tests may be performed in any order.

#### 3.4 Tests to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests described in this part of ISO 10791. When the tests are required for acceptance purposes, it is up to the user to choose, in agreement with the supplier/manufacturer, those tests relating to the components and/or the properties of the machine which are of interest. These tests shall be clearly stated when ordering a machine. The mere reference to this part of ISO 10791 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 of the contracting parties.

#### 3.5 Measuring instruments

The measuring instruments indicated in the tests described in clause 4 and annexes A to C are examples only. Other instruments measuring the same quantities and having at least the same accuracy may be used. Dial gauges shall have a resolution of at least 0,001 millimetres.

#### 3.6 Diagrams

For reasons of simplicity, the diagrams in this part of ISO 10791 illustrate only a few types of machines.

#### 3.7 Pallets

For the machines working with several pallets, the tests concerning the intrinsic geometric features or their behaviour related to the axes of the machine (tests G15 to G20) shall be performed on only one representative pallet clamped in position, unless otherwise specified by a written agreement between the user and the supplier/manufacturer.



### 3.8 Software compensation

When software facilities are available for compensating some geometric deviations, based on an agreement between the user and the supplier/manufacturer, the relevant tests may be carried out with or without these compensations. When the software compensations are used, this shall be stated in the test results.

### 3.9 Machine configurations

The machines considered in this part of ISO 10791 are divided into 12 families based on their architecture and the components moving along the linear axes. These families are identified by means of numbers from 01 to 12, as shown in Figure 1. The classification for these families is shown in Table 1<sup>1)</sup>.

### 3.10 Designation

A designation is also supplied in order to define the architecture of a machining centre, using a short code; this designation is given by the following elements, in the given order:

- a) "Machining centre";
- b) the reference to this part of ISO 10791, that is ISO 10791-2;
- c) the letter V for "vertical spindle";
- d) the number indicated in the relevant box of Figure 1 and the left-hand column of Table 1.

EXAMPLE A machining centre, vertical spindle type, with the table moving along the X-axis, the column moving along the Y-axis and the spindle head moving along the Z-axis is designated as follows:

**Machining centre ISO 10791-2 type V07**

[ISO 10791-2:2001](https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-43fd14a405a0/iso-10791-2-2001)

<https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-8583-43fd14a405a0/iso-10791-2-2001>

### 3.11 Minimum tolerance

When establishing the tolerance for a measuring length different from that given in this part of ISO 10791 (see 2.311 of ISO 230-1:1996), it shall be taken into consideration that the minimum value of tolerance is 0,005 mm.

---

1) Some vertical machining centres are built with an architecture similar to type V10 (portal type) or V11 (gantry type) but with only one column. This part of ISO 10791 is applicable to them as well. In this case, and when necessary, the text should be modified by replacing the terms "portal" or "gantry" with "column", and "cross rail" with "arm".

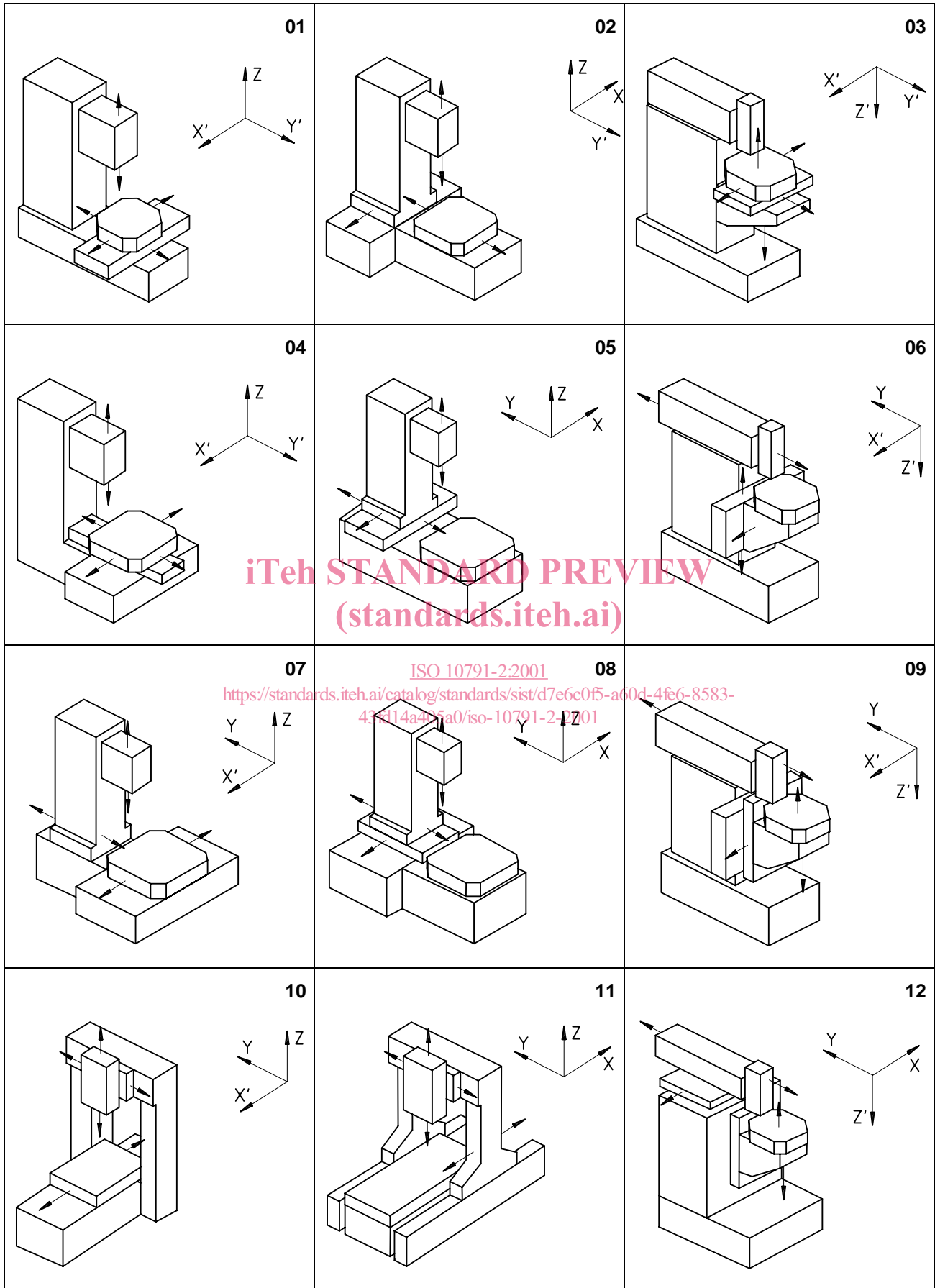


Figure 1

Table 1 — Classification of configurations of vertical spindle machining centres

	X	X'	Y	Y'	Z	Z'
01		Table on its saddle		Table saddle on the bed	Spindle head on the column	
02	Column on the bed			Table on the bed	Spindle head on the column	
03		Table on its saddle		Table saddle on the knee		Knee on the column
04		Table saddle on the bed		Table on its saddle	Spindle head on the column	
05	Column on its saddle		Column saddle on the bed		Spindle head on the column	
06		Knee on its saddle	Spindle head on the column			Knee saddle on the column
07		Table on the bed	Column on the bed		Spindle head on the column	
08	Column saddle on the bed		Column on its saddle		Spindle head on the column	
09		Knee saddle on the column	Spindle head on the column			Knee on its saddle
10		Table on the bed	Spindle head slide on the cross rail		Spindle head on its slide	
11	Gantry on the bed		Spindle head slide on the cross rail		Spindle head on its slide	
12	Spindle head slide on the column		Spindle head on its slide			Knee on the column

4 Geometric tests

4.1 Straightness of linear motions

<b>Object</b>		G1								
Checking of straightness of the X-axis motion: a) in the vertical ZX plane (EZX); b) in the horizontal XY plane (EYX).										
<b>Diagram</b>										
<b>Tolerance</b>		<b>Measured deviation</b>								
For a) and b) <table style="margin-left: 20px; border: none;"> <tr> <td style="padding-right: 10px;"><math>X \leq 500</math></td> <td style="padding-right: 10px;"><math>0,010</math></td> </tr> <tr> <td style="padding-right: 10px;"><math>500 &lt; X \leq 800</math></td> <td style="padding-right: 10px;"><math>0,015</math></td> </tr> <tr> <td style="padding-right: 10px;"><math>800 &lt; X \leq 1\ 250</math></td> <td style="padding-right: 10px;"><math>0,020</math></td> </tr> <tr> <td style="padding-right: 10px;"><math>1\ 250 &lt; X \leq 2\ 000</math></td> <td style="padding-right: 10px;"><math>0,025</math></td> </tr> </table> Local tolerance: 0,007 for a measuring length of 300		$X \leq 500$	$0,010$	$500 < X \leq 800$	$0,015$	$800 < X \leq 1\ 250$	$0,020$	$1\ 250 < X \leq 2\ 000$	$0,025$	For X = .... a) b)
$X \leq 500$	$0,010$									
$500 < X \leq 800$	$0,015$									
$800 < X \leq 1\ 250$	$0,020$									
$1\ 250 < X \leq 2\ 000$	$0,025$									
<b>Measuring instruments</b>										
a) Straightedge and dial gauge or optical methods b) Straightedge and dial gauge or microscope and taut wire or optical methods										
<b>Observations and references to ISO 230-1:1996</b>										
5.211, 5.23, 5.231.2, 5.232.1 and 5.233.1 For all machine configurations, either the straightedge, the taut wire or the straightness reflector shall be placed on the table. If the spindle can be locked, either the dial gauge, the microscope or the interferometer may be mounted on it; if the spindle cannot be locked, the instrument shall be placed on the spindle head of the machine.  The measuring line should pass as close to the centre of the table as possible.										

<b>Object</b>		<b>G2</b>																
Checking of straightness of the Y-axis motion: a) in the vertical YZ plane (EZY); b) in the horizontal XY plane (EXY).																		
<b>Diagram</b>																		
iTeh STANDARD PREVIEW (standards.iteh.ai)																		
a) <span style="margin-left: 200px;">b)</span>																		
ISO 10791-2:2001																		
<b>Tolerance</b>	<a href="https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-43fd14a405a0/iso-10791-2-2001">https://standards.iteh.ai/catalog/standards/sist/d7e6c0f5-a60d-4fe6-43fd14a405a0/iso-10791-2-2001</a>	<b>Measured deviation</b>																
For a) and b)	<table border="0"> <tr> <td>Y</td> <td>≤</td> <td>500</td> <td>0,010</td> </tr> <tr> <td>500 &lt; Y</td> <td>≤</td> <td>800</td> <td>0,015</td> </tr> <tr> <td>800 &lt; Y</td> <td>≤</td> <td>1 250</td> <td>0,020</td> </tr> <tr> <td>1 250 &lt; Y</td> <td>≤</td> <td>2 000</td> <td>0,025</td> </tr> </table>	Y	≤	500	0,010	500 < Y	≤	800	0,015	800 < Y	≤	1 250	0,020	1 250 < Y	≤	2 000	0,025	for Y = ....
Y	≤	500	0,010															
500 < Y	≤	800	0,015															
800 < Y	≤	1 250	0,020															
1 250 < Y	≤	2 000	0,025															
	Local tolerance: 0,007 for a measuring length of 300	a) b)																
<b>Measuring instruments</b>																		
a) Straightedge and dial gauge or optical methods b) Straightedge and dial gauge or microscope and taut wire or optical methods																		
<b>Observations and references to ISO 230-1:1996</b>																		
5.211, 5.23, 5.231.2, 5.232.1 and 5.233.1																		
For all machine configurations, either the straightedge, the taut wire or the straightness reflector shall be placed on the table. If the spindle can be locked, either the dial gauge, the microscope or the interferometer may be mounted on it; if the spindle cannot be locked, the instrument shall be placed on the spindle head of the machine.																		
The measuring line should pass as close to the centre of the table as possible.																		