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JIS B 6336-2 : 2002
(JMTBA/JSA)

**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)**

ICS 25.040.10; 25.080.01

Reference number : JIS B 6336-2 : 2002 (E)

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from the Japan Machine Tool Builders' Association (JMTBA)/the Japanese Standards Association (JSA), with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

By this establishment, **JIS B 6336 : 1986** and **JIS B 6338 : 1985** were withdrawn and replaced with **JIS B 6336** group.

This Standard has been made based on **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)* for the purposes of making easy to prepare Japanese Industrial Standard conforming with International Standard and to propose a draft of International Standard which is based on Japanese Industrial Standard.

JIS B 6336 group consists of the following 11 parts with 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 deformation (to be published)*
- Part 11 : Evaluation of the noise emission (to be published)*

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the original JIS is to be the final authority.

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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)

Introduction This Standard has been made based on **ISO 10791-2** *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)* published in 2001 without modifying the technical contents.

The portions underlined with dots in this Standard are the matters not included in the original International Standard.

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 this Standard 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.

This Standard specifies, by reference to the relevant parts of **JIS B 6191**, 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. This Standard also establishes the tolerances or maximum acceptable values for the test results corresponding to general purpose and normal accuracy machining centres.

This Standard 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.

1 Scope This Standard specifies, with reference to **JIS B 6191**, 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 Standard 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 Standard.

This Standard describes geometric tests for optional horizontal spindles as well as for three 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 Standard 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 **JIS B 6336**.

Remarks: The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

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)* (MOD)

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 6191 *Machine tools—Geometric accuracy tests and practical tests—Test methods*

Remarks: **ISO 230-1** : 1996 *Test code for machine tools—Part 1 : Geometric accuracy of machines operating under no-load or finishing conditions* is equivalent to the said standard.

JIS B 6337 *Workholding pallets for machine tools—Dimensions*

Remarks: **ISO 8526-1** : 1990 *Modular units for machine tools—Workholding pallets—Part 1 : Workholding pallets up to 800 mm nominal size* and **ISO 8526-2** : 1990 *Modular units for machine tools—Workholding pallets—Part 2 : Workholding pallets of nominal size greater than 800 mm* are equivalent to the said standard.

3 Preliminary remarks

3.1 Measuring units In this Standard, 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 (e.g. 0.00x/1 000), but, in some cases for the sake of clarity, microradians (μrad) 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 JIS B 6191 To apply this Standard, reference shall be made to **JIS B 6191**, 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 **JIS B 6191**, the instructions described in clause 4 and notes in annexes A to C are followed by a reference to the corresponding clauses in **JIS B 6191**.

3.3 Test sequence The sequence in which the tests are presented in this Standard 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 Standard. When the tests are required for acceptance purposes, it is up to the user to choose, in agreement with the supplier/manufacturer, those tests relating to the components and/or the properties of the machine which are of interest. These tests shall be clearly stated when ordering a machine. The mere reference to this Standard 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 Standard illustrate only one type 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 Standard 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⁽¹⁾.

Note ⁽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 Standard 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”.

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 Standard;
- 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 **JIS B 6336-2** type V07

3.11 Minimum tolerance When establishing the tolerance for a measuring length different from that given in this Standard (see **2.311** of **JIS B 6191**), it shall be taken into consideration that the minimum value of tolerance is 0.005 mm.

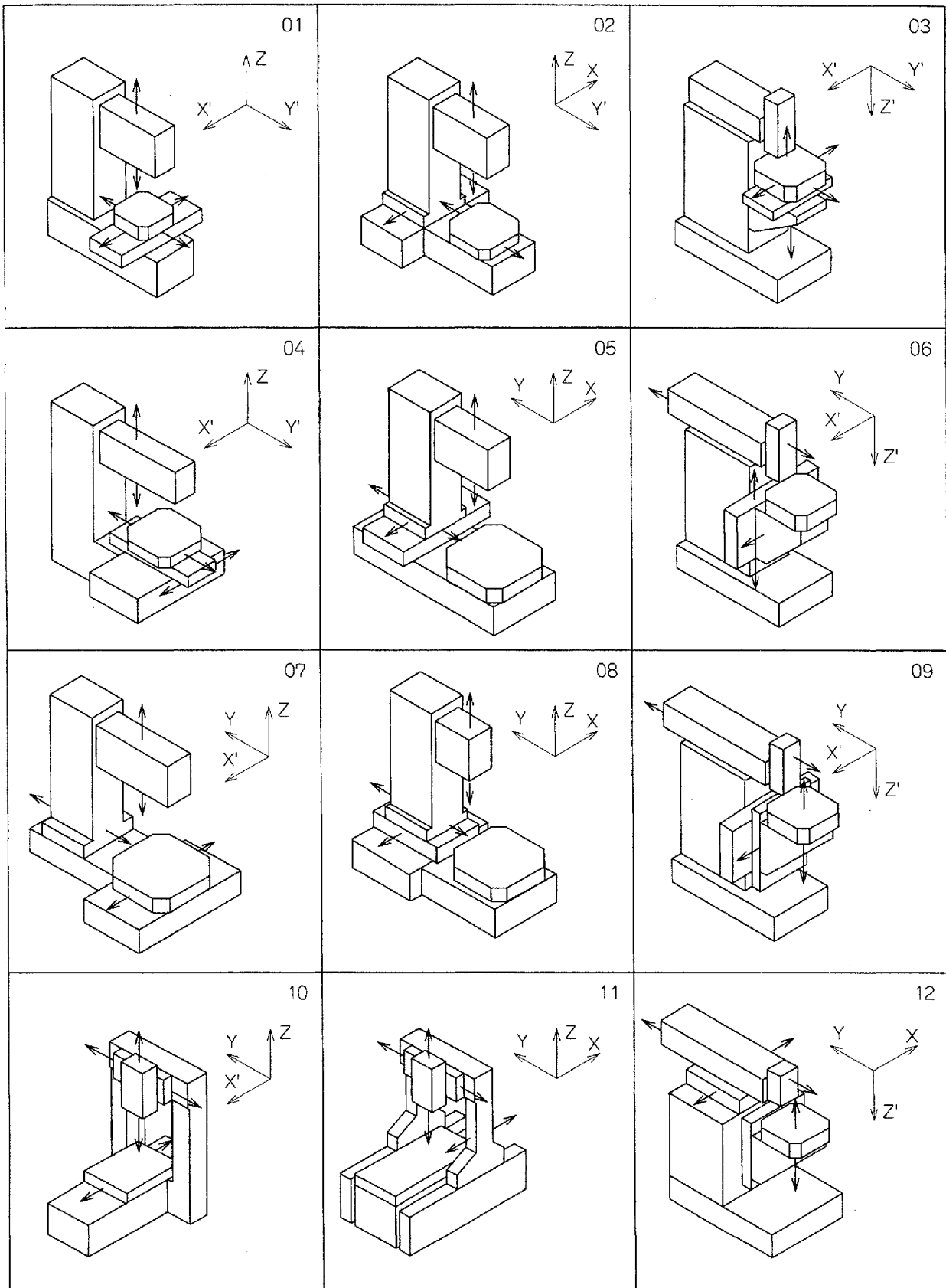


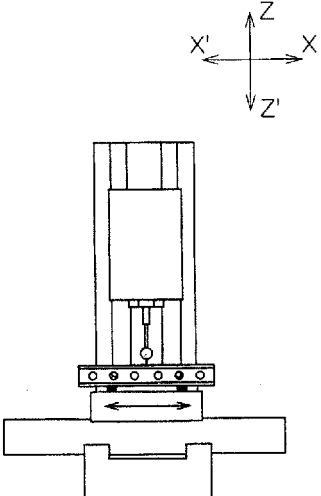
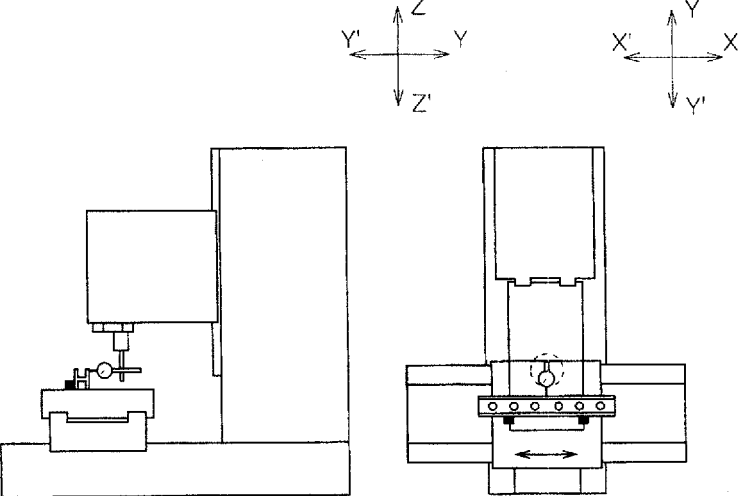
Figure 1

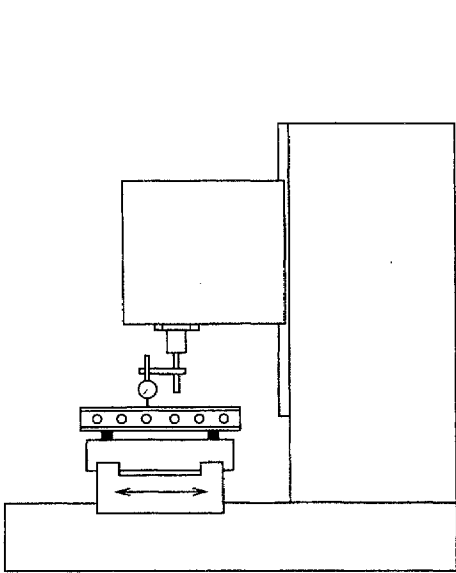
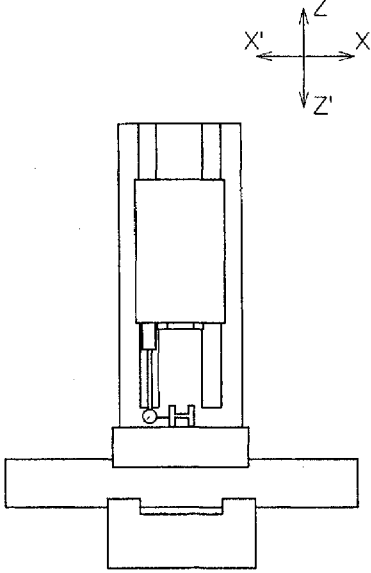
Table 1 Classification of configurations of vertical spindle machining centres

	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

Object Checking of straightness of the X-axis motion: a) in the vertical ZX plane (EZ _X); b) in the horizontal XY plane (EY _X).	G1								
Diagram  a)  b)									
Tolerance For a) and b) <table style="margin-left: 40px;"> <tr> <td>$X \leq 500$</td><td>0.010</td></tr> <tr> <td>$500 < X \leq 800$</td><td>0.015</td></tr> <tr> <td>$800 < X \leq 1\,250$</td><td>0.020</td></tr> <tr> <td>$1\,250 < X \leq 2\,000$</td><td>0.025</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	Measured deviation For $X = \dots$ 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								
Measuring instruments a) Straightedge and dial gauge or optical methods b) Straightedge and dial gauge or microscope and taut wire or optical methods									
Observations and references to JIS B 6191 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.									

Object Checking of straightness of the Y-axis motion: a) in the vertical YZ plane (EZY); b) in the horizontal XY plane (EXY).	G2								
Diagram  a)  b)									
Tolerance For a) and b) <table style="margin-left: 40px;"> <tr> <td>$Y \leq 500$</td><td>0.010</td></tr> <tr> <td>$500 < Y \leq 800$</td><td>0.015</td></tr> <tr> <td>$800 < Y \leq 1\,250$</td><td>0.020</td></tr> <tr> <td>$1\,250 < Y \leq 2\,000$</td><td>0.025</td></tr> </table> Local tolerance: 0.007 for a measuring length of 300	$Y \leq 500$	0.010	$500 < Y \leq 800$	0.015	$800 < Y \leq 1\,250$	0.020	$1\,250 < Y \leq 2\,000$	0.025	Measured deviation For $Y = \dots$ a) b)
$Y \leq 500$	0.010								
$500 < Y \leq 800$	0.015								
$800 < Y \leq 1\,250$	0.020								
$1\,250 < Y \leq 2\,000$	0.025								
Measuring instruments a) Straightedge and dial gauge or optical methods b) Straightedge and dial gauge or microscope and taut wire or optical methods									
Observations and references to JIS B 6191 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.									

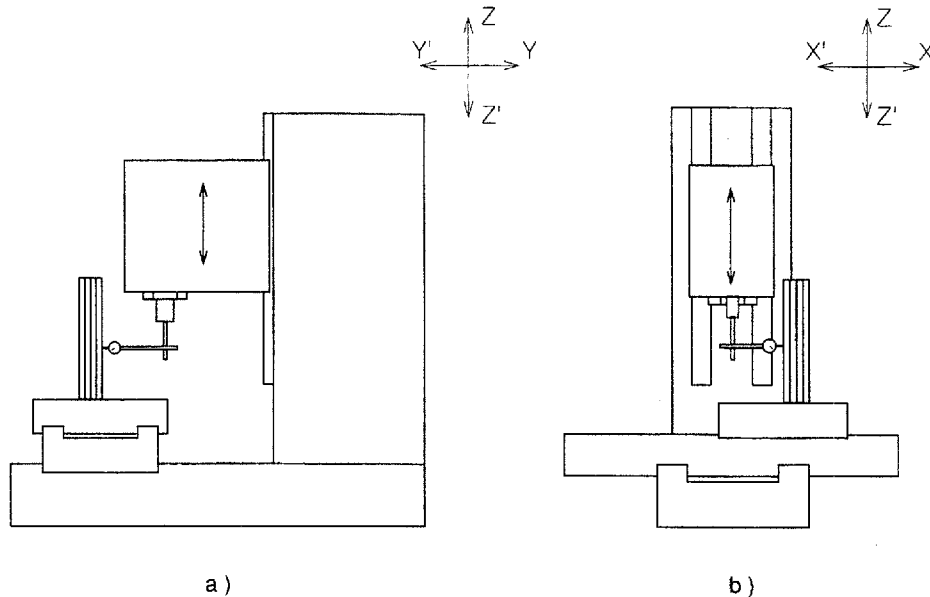
Object

G3

Checking of straightness of the Z-axis motion:

- a) in the vertical YZ plane (EYZ) parallel to the Y-axis;
- b) in the vertical ZX plane (EXZ) parallel to the X-axis.

Diagram



Tolerance

For a) and b)

$Z \leq 500$	0.010
$500 < Z \leq 800$	0.015
$800 < Z \leq 1\,250$	0.020
$1\,250 < Z \leq 2\,000$	0.025

Local tolerance: 0.007 for a measuring length of 300

Measured deviation

For $Z = \dots$

- a)
- b)

Measuring instruments

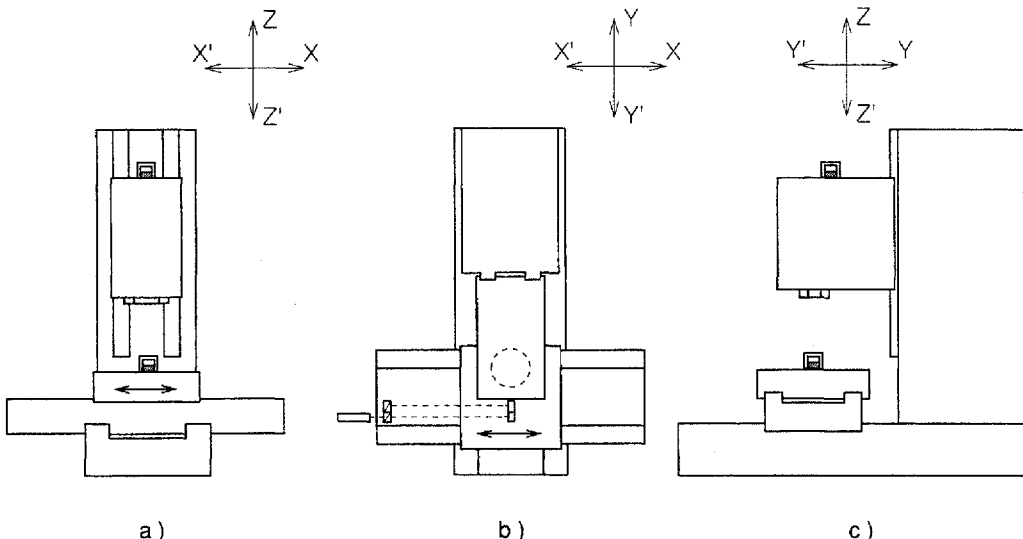
For a) and b): Square and dial gauge or optical methods or microscope and taut wire

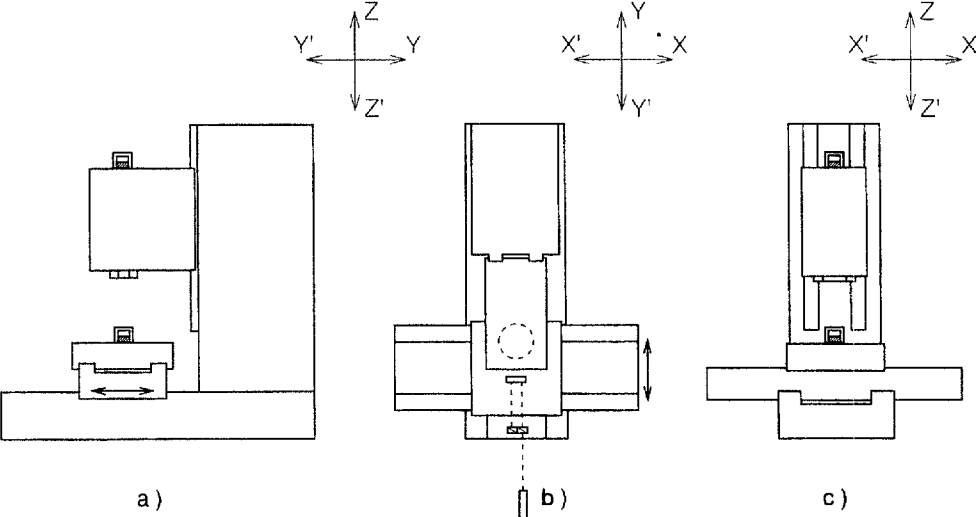
Observations and references to JIS B 6191

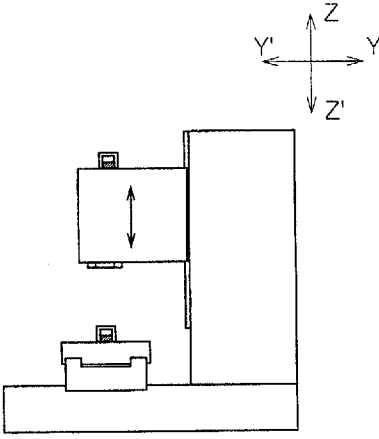
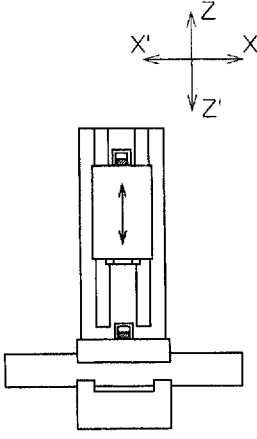
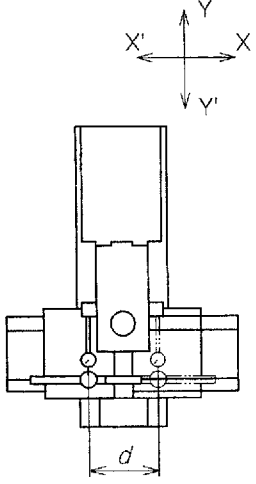
5.211, 5.23, 5.231.2, 5.232.1 and 5.233.1

For all machine configurations, either the square or the taut wire shall be placed as close to the centre of the table as possible. 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.

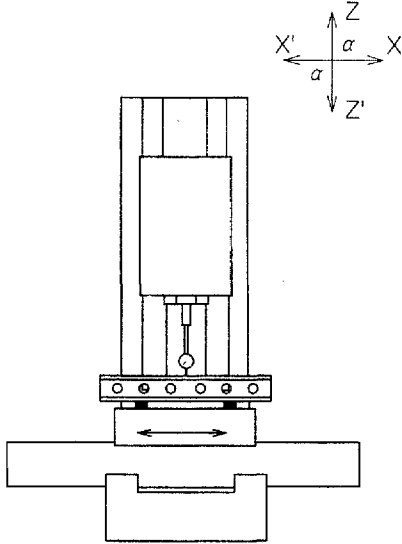
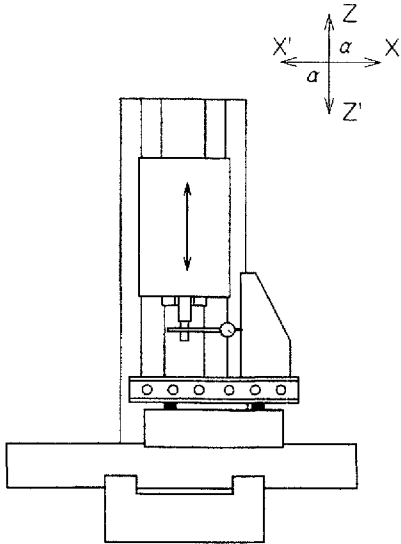
4.2 Angular deviations of linear motions

Object Checking of angular deviations of the X-axis motion: a) in the vertical ZX plane parallel to the axis movement (pitch, EBX); b) in the horizontal XY plane (yaw, ECX); c) in the vertical YZ plane perpendicular to the axis movement (roll, EAX).	G4
Diagram  a) b) c)	
Tolerance For a), b) and c) 0.060/1 000 (or 60 μrad or 12")	Measured deviation - a) - b) - c)
Measuring instruments a) (pitch, EBX) Precision level or optical angular deviation measuring instruments b) (yaw, ECX) Optical angular deviation measuring instruments c) (roll, EAX) Precision level	
Observations and references to JIS B 6191 5.231.3, 5.232.2 and 5.233.2 The measuring instrument shall be placed on the moving component (spindle head or workholding table): a) (pitch, EBX) longitudinally b) (yaw, ECX) horizontally c) (roll, EAX) transversely When X-axis motion causes an angular movement of both the spindle head and the workholding table, differential measurements of the two angular movements shall be made and this shall be stated. In this case, when using precision levels for measurement, the reference level shall allow for the difference between the angular positions of the tool-holding and workholding components to be measured. Measurements shall be taken at least at five positions equally spaced along the travel in both directions of movement at every position. The difference between the maximum and the minimum readings shall not exceed the tolerance.	

Object Checking of angular deviations of the Y-axis motion: a) in the vertical YZ plane parallel to the axis movement (pitch, EAY); b) in the horizontal XY plane (yaw, ECY); c) in the vertical ZX plane perpendicular to the axis movement (roll, EBY).	G5
Diagram 	
Tolerance For a), b) and c) 0.060/1 000 (or 60 μrad or 12'')	Measured deviation - a) - b) - c)
Measuring instruments a) (pitch, EAY) Precision level or optical angular deviation measuring instruments b) (yaw, ECY) Optical angular deviation measuring instruments c) (roll, EBY) Precision level	
Observations and references to JIS B 6191 5.231.3, 5.232.2 and 5.233.2 The measuring instrument shall be placed on the moving component (spindle head or workholding table): a) (pitch, EAY) longitudinally b) (yaw, ECY) horizontally c) (roll, EBY) transversely When Y-axis motion causes an angular movement of both the spindle head and the workholding table, differential measurements of the two angular movements shall be made and this shall be stated. In this case, when using precision levels for measurement, the reference level shall allow for the difference between the angular positions of the tool-holding and workholding components to be measured. Measurements shall be taken at least at five positions equally spaced along the travel in both directions of movement at every position. The difference between the maximum and the minimum readings shall not exceed the tolerance.	

Object Checking of angular deviations of the Z-axis motion: a) in the vertical YZ plane (EAZ); b) in the vertical ZX plane (EBZ); c) in the horizontal XY plane (roll, ECZ).	G6
Diagram  a)  b)  c)	
Tolerance For a), b) and c) 0.060/1 000 (or 60 μrad or 12")	Measured deviation - a) - b) - c)
Measuring instruments a) and b): Precision level or optical angular deviation measuring instruments c) Straightedge, cylindrical square and dial gauge	
Observations and references to JIS B 6191 5.231.3, 5.232.2 and 5.233.2 Measurements shall be taken at least at five positions equally spaced along the travel, in both directions of movement at every position. The difference between the maximum and the minimum readings shall not exceed the tolerance. The instrument shall be placed on the moving component (spindle head or workholding table): a) in the Y' direction for angular deviation (EAZ); b) in the X' direction for angular deviation (EBZ). When the Z-axis motion causes an angular movement of both the spindle head and workholding table, differential measurements of the two angular movements shall be made and this shall be stated. In this case, when using precision levels for measurement, the reference level shall allow for the difference between the angular positions of the tool-holding and work-holding components to be measured. c) (roll ECZ), place a cylindrical square on the straightedge on the table, approximately parallel to the Z-axis, and set the stylus of a dial gauge mounted on a special arm against the square. Note the readings and mark the corresponding heights on the square. Move the table along the X-axis and move the dial gauge to the other side of the spindle head so that the stylus can touch the square again along the same line. The possible roll deviation of the X-axis motion shall be measured and taken into account. The dial gauge shall be zeroed again and the new measurements shall be taken at the same heights as the previous ones, and noted. For each measurement height, calculate the difference of the two readings. The maximum and the minimum of these differences shall be selected and the result of $\frac{\text{Maximum difference} - \text{minimum difference}}{d}$ shall not exceed the tolerance, "d" being the distance between the two positions of the dial gauge.	

4.3 Squareness between linear motions

Object Checking of squareness between Z-axis motion and the X-axis motion.	G7
Diagram  Step 1)  Step 2)	
Tolerance 0.02 for a measuring length of 500	Measured deviation
Measuring instruments Straightedge or surface plate, square and dial gauge	
Observations and references to JIS B 6191 5.522.4 In step 1), the straightedge or the surface plate shall be set parallel to the X-axis. In step 2), the Z-axis shall then be checked by means of a square standing on the straight-edge or on the surface plate. If the spindle can be locked, the dial gauge may be mounted on it; if the spindle cannot be locked, the dial gauge shall be placed on the spindle head of the machine. The value of angle α, being less than, equal to or greater than 90°, should be noted for information and possible correction.	