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**Bridge type plano-milling machines —
Testing of the accuracy**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee, as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Machine Tool Builders' Association (JMTBA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently **JIS B 6228:1998** is replaced with this Standard.

This revision has been made based on **ISO 8636-1:2000 Machine tools — Test conditions for bridge type milling machines — Testing of the accuracy — Part 1: Fixed bridge (portal-type) machine** for the purposes of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

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In the event of any doubts arising as to the contents,
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Bridge type plano-milling machines — Testing of the accuracy

Introduction This Japanese Industrial Standard has been prepared based on the second edition of **ISO 8636-1** *Machines tools — Test conditions for bridge-type milling machines — Testing of the accuracy — Part 1: Fixed bridge (portal-type) machines* published in 2000 with some modifications of the technical contents.

Portions underlined with dots and annex 1 (informative) are the matters not stated in the original International Standard.

A list of modifications with the explanations is given in annex 2 (informative).

1 Scope This Japanese Industrial Standard specifies, with reference to **JIS B 6191** and **JIS B 6192**, testing methods and their applicable tolerances for static accuracy, machining accuracy and positioning accuracy by numerical control, of general purpose bridge type plano-milling machines for normal accuracy.

This Standard is applicable to fixed bridge (portal-type) machines with moving tables and does not apply to single-column (open sided) machines and those with fixed table and moving column.

This Standard deals only with the verification of the static accuracy of the machine, and shall not be applied to the testing of the machine operation (vibration, abnormal noise, stick-slip motion of components and so on), nor to machine characteristics (such as milling head speeds, feeds, and so on), which are generally be checked before testing accuracy. This Standard provides the terminology used for the principal components of machine and the designation of axes with reference to **JIS B 6310**.

NOTE : 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 8636-1 : 2000 *Machine tools — Test conditions for bridge-type milling machines — Testing of the accuracy — Part 1: Fixed bridge (portal-type) machines* (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 *Machines tools — Geometric accuracy tests and practical tests — Test methods*

NOTE : **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 6192 *Test code for machine tools — Determination of accuracy and repeatability of positioning numerically controlled axes*

NOTE : ISO 230-2:1997 *Test code for machine tools — Part 2: Determination of accuracy and repeatability of positioning of numerically controlled axes* is equivalent to the said standard.

JIS B 6310 *Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature*

3 Descriptions and definitions

3.1 Definitions of machining processes

3.1.1 milling operation machining operation consists of removing material by means of a rotary tool called a “milling cutter” of which there are several different types

NOTE : The typical milling operations mostly involve face milling or end milling. The tools are mounted either in the spindle taper bore or on the spindle front face.

3.1.2 boring operation operation consists of machining the diameters of cylindrical, conical, blind or through holes, to the required size

3.1.3 drilling and tapping operations drilling operation consists of drilling blind or through holes mainly with drill

Tapping operation consists of tapping internal threads with tap.

3.2 Definition and main classification of bridge type plano-milling machines

3.2.1 Definition

3.2.1.1 definition of bridge type plano-milling machines double-column machine with one or more vertical spindle heads mounted and move in the longitudinal traverse (Y-axis) along the cross rail above a table which moves on the table in the longitudinal direction (X-axis)

NOTE : Additional slewing type horizontal milling heads may be mounted on the column to move vertically (W-axis) and (or) to swivel (D-axis) the spindle center line.

3.2.2 Classification These machines are classified into two types depending upon their construction:

- bridge type plano-milling machines with a variable height cross-rail and a bridge or tie-plate between two columns;
- bridge type plano-milling machines with a fixed height cross-rail which may replace the bridge or tie-plate.

3.3 Descriptions of principal components Definitions of the principal components of these machines are described below. The number indicated in brackets is explained in 4.1.

3.3.1 Bed and table The bed (1) is the fixed base to support the machine which may be constructed of several parts. It supports the table (3) which moves parallel to the longitudinal axis of the bed.

3.3.2 Column, cross-rail and bridge or tie-piece The columns (4) and (5) provide the vertical frame of the machine and are fixed on either side of the bed.

The columns may be fitted with vertical sideways (6) to accommodate horizontal milling head(s) (9) with other horizontal or swivelling spindle axis.

The tie-piece (10) is a fixed horizontal piece connecting both columns at or near the top.

The cross-rail (7) has its major axis parallel to the table plane and is fitted with sideways on which one or more milling heads, with vertical (8) or swivelling spindles, can move lengthwise.

The variable height cross-rail may be moved up and down the vertical slideways (6) on the columns.

In the case of machines with a fixed height cross-rail, the latter is also fastened to the columns and may replace the tie-piece.

3.3.3 Milling head(s) These heads include the spindle and drive mechanism and the means for their mounting on the cross-rail or column. In some cases, the spindle may be mounted in a ram or quill (12) with a feed motion for drilling or boring operations.

3.3.4 Cutting motion Cutting motion is provided by the spindles and drive mechanisms of the milling heads.

3.3.5 Feed motion The following feed movements may be provided with a constant or variable feed rate:

- horizontal movement of the table;
- horizontal movement of the milling heads on the cross-rail or vertical movement of the side heads on the columns;
- vertical movement of spindle rams or quills (if any);
- vertical movement of the cross-rail (if any).

NOTE : In general, rapid traverse is available in addition to feed movement.

4 Terminology and designation of machine components and axes

4.1 Terminology of machine components Terminology of machine components shall be as figure 1 and table 1.

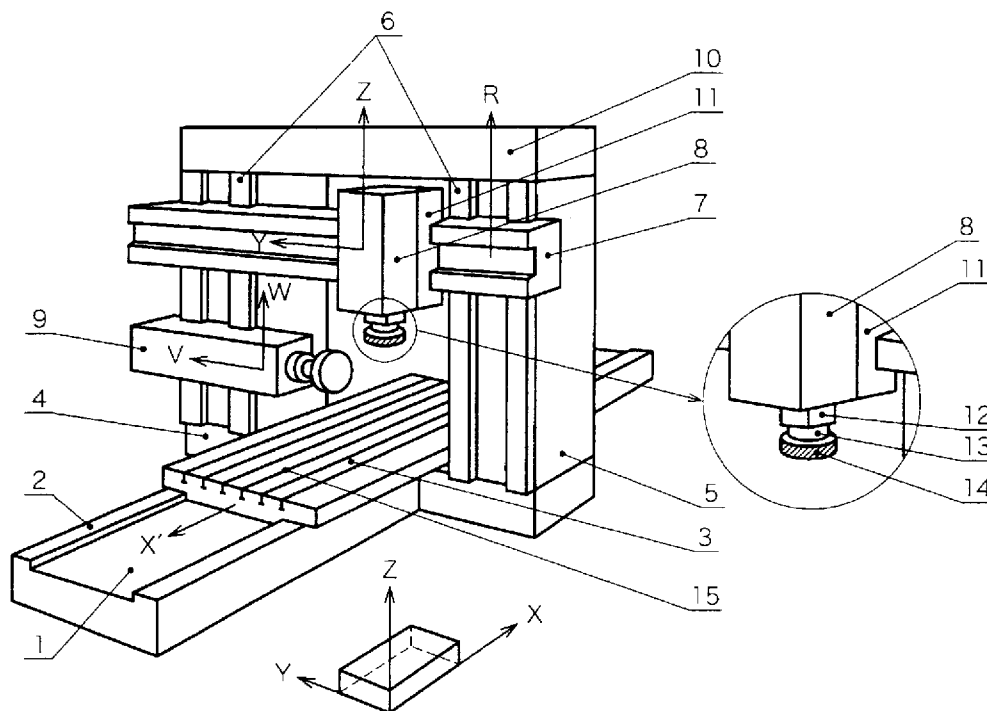


Figure 1 Bridge type plano-milling machine with variable height cross-rail

Table 1 Terminology of machine components

Ref.	Term		(Informative)	
	Japanese character	Reading	English	French
1	ベッド	BEDDO	Bed	Banc
2	ベッド案内面	BEDDO-ANNAI-MEN	Slideway, bed	Glissière du banc
3	テーブル (上面)	TÊBURU(ZYÔMEN)	Table (clamping surface)	Table (surface de bridage)
4	左コラム	HIDARI-KORAMU	Lef-hand column	Montant gauche
5	右コラム	MIGI-KORAMU	Right-hand column	Montant droit
6	右及び左コラム案内面	MIGI OYOBI HIDARI-KORAMU ANNAI-MEN	Slideway, right-hand and left-hand column	Glissière des montants droit et gauche
7	クロスレール (可動、固定)	KUROSU-RÊRU (KADÔ, KOTEI)	Cross-rail (movable, fixed)	Traverse (mobile, fixe)
8	縦フライスヘッド	TATE-HURAI-SU-HEDDO	Vertical milling head	Tête de fraisage verticale
9	横フライスヘッド	YOKO-HURAI-SU-HEDDO	Horizontal milling head	Tête de fraisage horizontale
10	ブリッジ	BURIZZI	Tie-piece	Entretoise
11	サドル	SADORU	Bottom slide (saddle)	Cuirasse
12	クイル (ラム)	KUIRU (RAMU)	Quill (ram)	Coulisseau (fourreau)
13	主軸	SYUZIKU	Milling head	Tete de fraisage
14	工具 (フライス)	KÔGU (HURAI-SU)	Tool (milling cutter)	Outil (fraise)
15	基準T溝	KIZYUN-T-KÔ	Reference T-slot	Rainure de référence

4.2 Designation of axes Designation of axes is as figures 2 to 5.

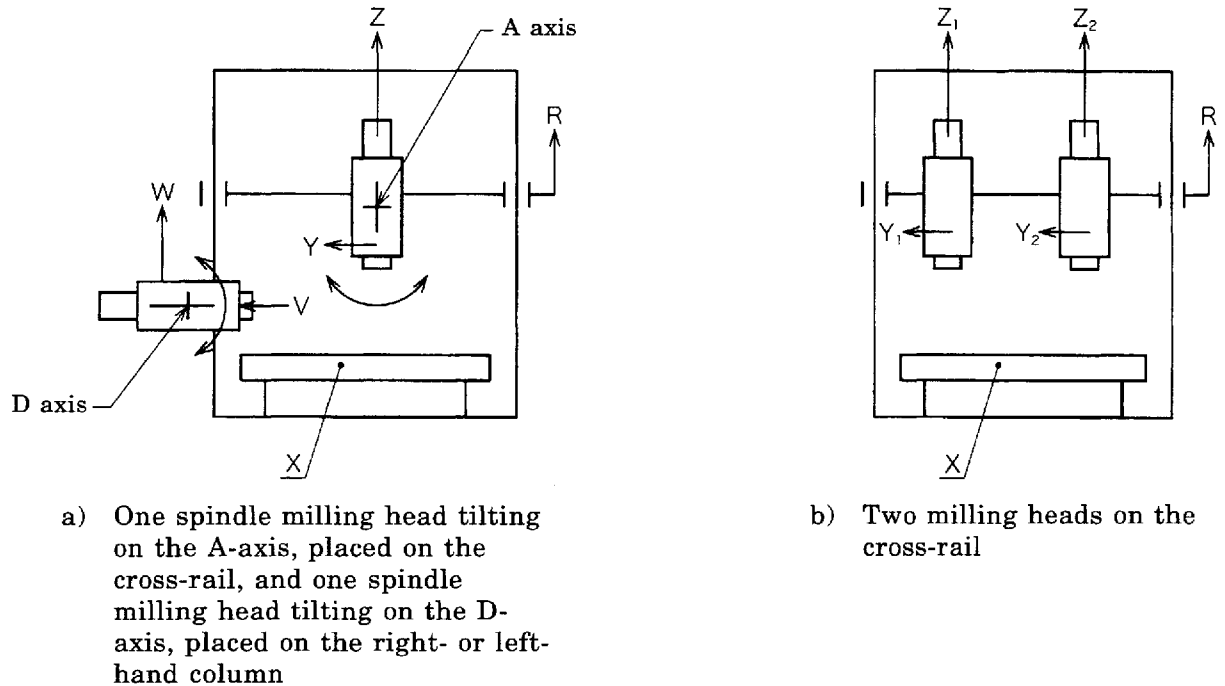


Figure 2 Type 1 : Machines with two milling heads

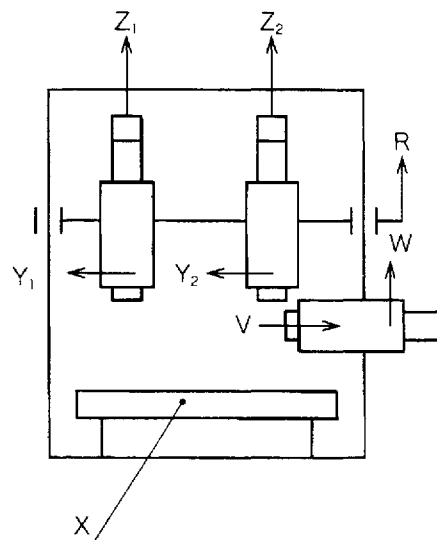


Figure 3 Type 2: Machine with three milling heads

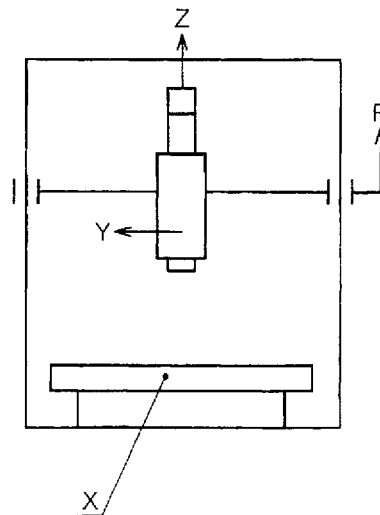


Figure 4 Type 3: Machine with one milling head on the cross-rail

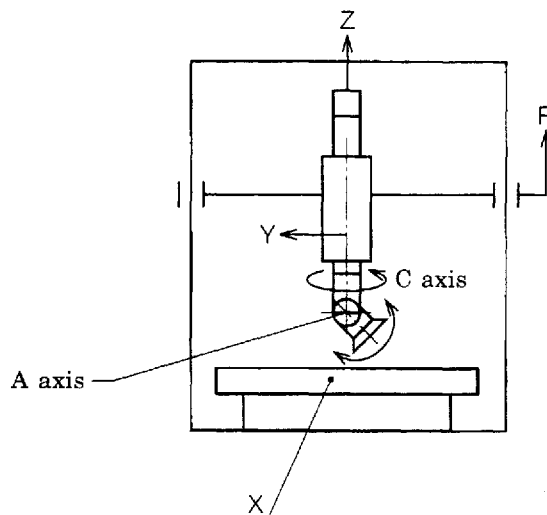


Figure 5 Type 4: Machine with one milling head on the cross-rail swivelling on axes C and A

5 Preliminary remarks

5.1 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 primarily expressed in ratios of length (e.g. 0.00x/1 000), but in some cases, microradians (μrad) or arcseconds (") may be used for clarification purposes. The equivalence of the following expressions should always be kept in mind:

$$0.010/1\,000 = 10 \times 10^{-6} = 10 \mu\text{rad} \approx 2''$$

5.2 Reference to 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.

In the "Observations" box of the tests described in the following clauses, the reference number and instructions are preceded to the corresponding clause in **JIS B 6191** and **JIS B 6192** in cases where the test concerned is in compliance with the specifications of **JIS B 6191** and **JIS B 6192**.

5.3 Temperature conditions The temperature conditions throughout the tests shall be specified by agreement between the manufacturer and user.

5.4 Testing sequence The Sequence in which the tests are presented in this Standard in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests may be performed in any order.

5.5 Tests to be performed When testing a machine, it is not always necessary 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 manufacturer, those tests relating to the components and/or the properties of the machine which are of interest. These tests are to be clearly stated when ordering a machine.

Mere reference to this 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 contracting party.

5.6 Measuring instruments The measuring instruments indicated in the tests described in the following clauses are examples only. Other instruments measuring the same quantities and having at least the same accuracy may be used.

5.7 Minimum tolerance When establishing the tolerance for a measuring range 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.

5.8 Machining tests Machining tests shall be made with finishing cuts only. Roughing cuts shall be avoided since they are liable to generate appreciable cutting forces.

5.9 Positioning accuracy tests Positioning accuracy tests shall refer to **JIS B 6192**. Items and tolerances in this Standard are given only for some parameters. The presentation of the test results shall be in compliance with **JIS B 6192**.

6 Static accuracy tests Tolerances are limited to the machines of table size up to 3 000 mm × 10 000 mm. When the machine is over this size in length or width, the tolerance shall be agreed upon between the manufacturer and user.

6.1 Straightness and squareness of motion

Table 2 Static accuracy test

Unit: mm

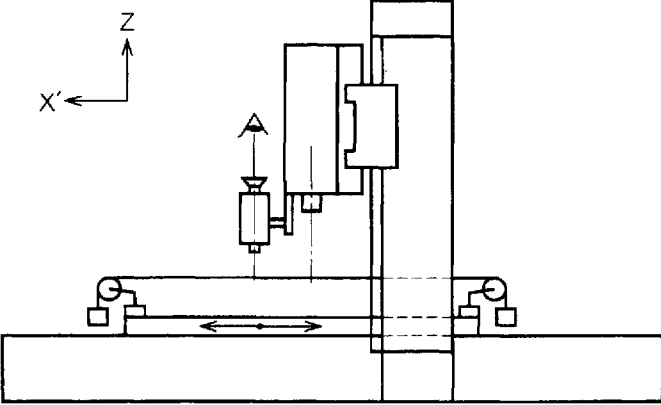
Object	G1
Checking of straightness of movement of the table (X-axis) in the horizontal XY-plane (EYX)	
Diagram of measuring method	
	
Tolerance	Measured value $X =$
0.02 for a measuring length up to 2 000 Add 0.01 to the preceding tolerance for each 1 000 increase in length over 2 000 Maximum tolerance: 0.10 Local tolerance: 0.01 for any measuring length of 1 000	
Measuring instruments	
Steel wire and micrometer microscope or other optical measuring instruments (e.g. autocollimator, laser interferometer)	
Notes and reference to JIS B 6191	
5.232.12, 5.232.13 and 5.232.14	
When using steel wire and micrometer microscope, the micrometer microscope shall be mounted on the vertical milling head, and the steel wire shall be fixed to each end of the table parallel ⁽¹⁾ to X-axis direction movement of the table.	
Traverse the table in the X-axis direction and record the readings.	
When using optical measuring instrument, the reflecting mirror shall be set on the spindle nose or on the vertical milling head near the spindle.	
The reticle of autocollimator is set on the table parallel to X-axis direction of the table and aligned with the reflecting mirror horizontally.	
Traverse the table in the X-axis direction and record the readings.	
⁽¹⁾ Parallel means: Readings of the telescope or reticle at both ends of the movement are the same. In this case, the maximum difference of readings gives the straightness deviation.	

Table 2 Static accuracy test (continued)

Unit: mm

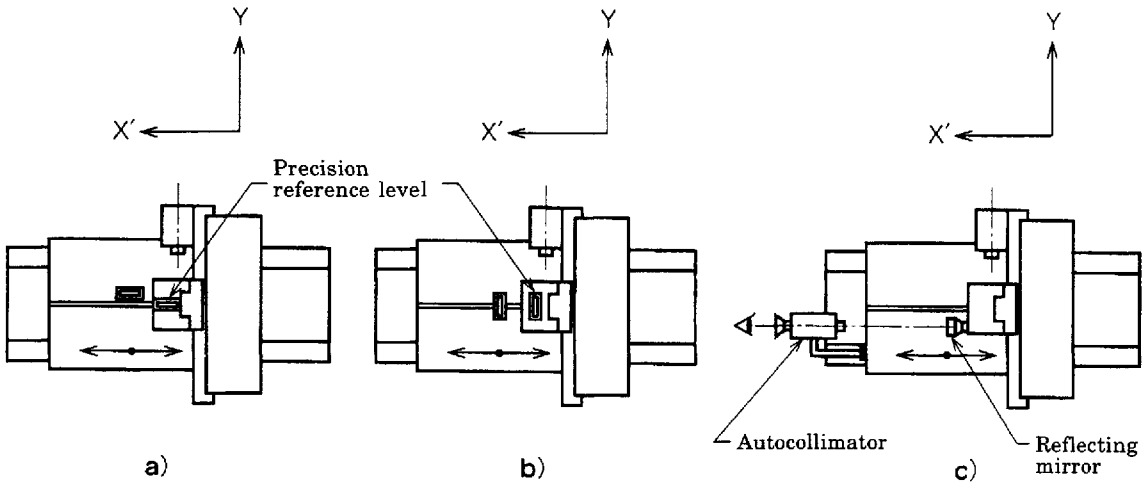
Object			G2
Checking of angular deviations of the movement of the table (X-axis): a) in the vertical ZX-plane (EBX: pitch); b) in the vertical YZ-plane (EAX: roll); c) in the horizontal XY-plane (ECX: yaw).			
Diagram of measuring method			
			
Tolerance	a) and c)	b)	Measured value X =
$X \leq 4\,000$	0.04/1 000	0.02/1 000	a)
$X > 4\,000$	0.06/1 000	0.02/1 000	b)
Local tolerance: 0.02 for any measuring length of 1 000			c)
X = Table travel quantity			
Measuring instruments			
a) Precision level or optical angular deviation measuring instruments (e.g. autocollimator, laser interferometer)			
b) Precision level			
c) Optical angular deviation measuring instruments (e.g. autocollimator, laser interferometer)			
Notes and reference to JIS B 6191			
5.231.3 and 5.232.2			
The precision level or reflecting mirror shall be placed on the movable component.			
a) (EBX: pitch) in the X-axis direction, set vertically;			
b) (EAX: roll) in the Y-axis direction, set vertically;			
c) (ECX: yaw) in the X-axis direction, set the autocollimator horizontally.			
When X-axis direction motion causes angular deviation of both the spindle head and work-holding table, set the precision reference level on the spindle head in the measuring direction, and differential measurements between this precision level and that on the table shall be taken.			
The maximum reading shall not exceed the tolerance.			
The spindle head shall be in the middle of its travel range.			
Measuring shall be carried out at least of five positions equally spaced along the travel, in both directions of movement.			
For tests a) and b), the measuring instrument shall be placed at the two ends and possibly in the middle of the table. The measuring instrument located at one end of the table explores the characteristics of half of the bed.			
The measuring instrument located in the middle of the table reveals different deviations from the ones located at both ends of the table.			

Table 2 Static accuracy test (continued)

Unit: mm

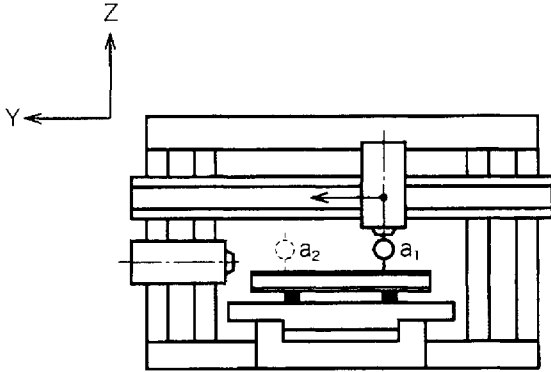
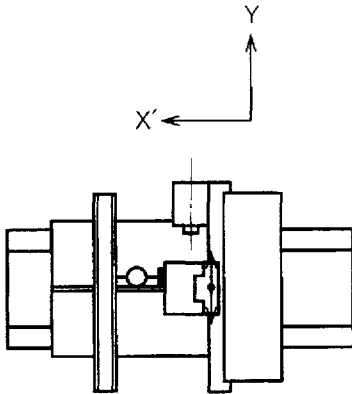
Object Checking of straightness of horizontal movement of the vertical milling head (Y-axis): a) in the horizontal XY-plane (EXY); b) in the vertical YZ-plane (EZY).		G3
Diagram of measuring method  a) b)		
Tolerance For a) and b) 0.02 for a measuring length up to 1 000 Add 0.01 to the preceding tolerance for each 1 000 increase in length over 1 000 Maximum tolerance: 0.04 Local tolerance: 0.01 for any measuring length of 500		Measured value a) b)
Measuring instruments Straightedge, dial gauge and gauge blocks or optical measuring apparatus or micrometer microscope and steel wire (for measurement in horizontal plane)		
Notes and reference to JIS B 6191 5.232.11, 5.232.12 and 5.232.13 Fix the cross-rail in the mid-height and move the table in mid-travel. Place a straightedge on the table, parallel ⁽¹⁾ to the Y-axis direction movement of the vertical milling head; for a) horizontally and for b) vertically. Attach a dial gauge to the vertical milling head. The dial gauge stylus shall be normal to the reference face of the straightedge. Traverse the vertical milling head in the Y-axis direction through the measuring length ⁽²⁾ and record the readings.		
⁽¹⁾ Parallel means: Readings of the dial gauge touching the straightedge at both ends of the movement are the same value and, in this case, the maximum difference of the readings gives the straightness deviation. ⁽²⁾ The measuring length is normally the length between two columns (not the full length of cross-rail). In other cases, this shall be agreed upon between the manufacturer and user.		

Table 2 Static accuracy test (continued)

Unit: mm

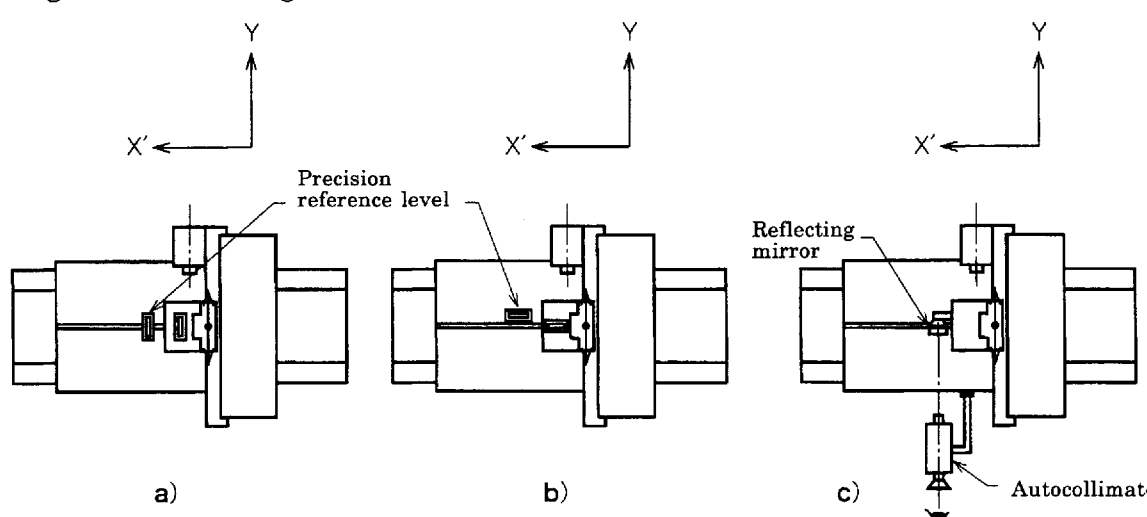
Object		G4
Checking of angular deviations of the horizontal movement of the vertical milling head (Y-axis): a) in the vertical YZ-plane (EAY: pitch); b) in the vertical ZX-plane (EBY: roll); c) in the horizontal XY-plane (ECY: yaw).		
Diagram of measuring method		
		
Tolerance		Measured value
For a), b) and c) 0.04/1 000 Local tolerance: 0.02/1 000 for any measuring length of 300		a) b) c)
Measuring instruments		
a) Precision level or optical angular deviation measuring instruments (e.g. autocollimator, laser interferometer) b) Precision level c) Optical angular deviation measuring instruments (e.g. autocollimator, laser interferometer)		
Notes and reference to JIS B 6191		
5.231.3 and 5.232.2		
The precision level or reflecting mirror shall be placed on the movable component. a) (EAY: pitch) in the Y-axis direction, set vertically; b) (EBY: roll) in the X-axis direction, set vertically; c) (ECY: yaw) in the Y-axis direction, set the autocollimator horizontally.		
When Y-axis direction motion causes angular deviation of both the spindle head and workholding table, differential measurements between the reading of precision level on the spindle head and that of this precision level shall be taken.		
The table shall be in the middle of its travel range.		
Measuring shall be carried out at least of five positions equally spaced along the travel, in both directions of movement.		
The maximum reading shall not exceed the tolerance.		

Table 2 Static accuracy test (continued)

Unit: mm

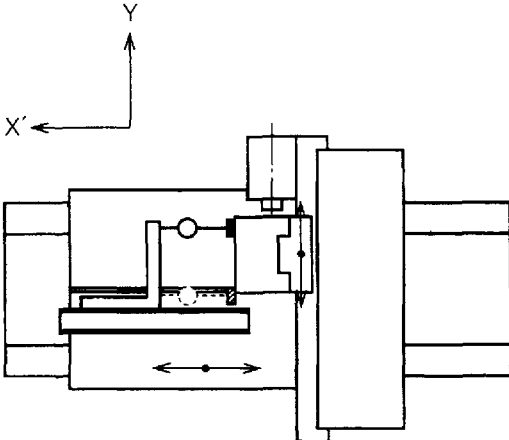
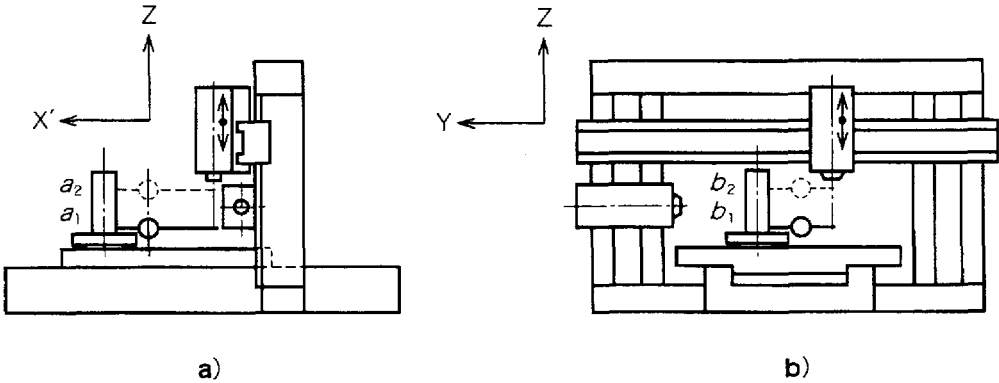
Object	G5
Checking of squareness between the movement of the table (X-axis) and the horizontal movement of the vertical milling head (Y-axis).	
Diagram of measuring method	
	
Tolerance	Measured value
0.03 for a measuring length of 1 000 up to a table width of 3 000 NOTE : In the case of a table width over 3 000, the tolerance is subject to agreement between the manufacturer and user.	
Measuring instruments	
Straightedge, square and dial gauge	
Notes and reference to JIS B 6191	
5.552.4	
Lock the cross-rail in the mid-travel.	
Attach a dial gauge to the vertical milling head. Align a straightedge parallel ⁽¹⁾ to the table movement (X-axis) in the horizontal plane.	
Press one edge of the square against the straightedge and set the dial gauge against the other edge of the square. Move the vertical milling head by the measuring length ⁽²⁾ and read indications at least of five equally spaced positions, Record the maximum difference of the readings.	
For more precise measurement, rotate the square by 180° and repeat the checking in the same order.	
Calculate the average value at each measuring position, and record the maximum difference.	
If the table width exceeds 2 000, tests shall be repeated at different positions across the table width.	
⁽¹⁾ Parallel means: Readings of the dial gauge touching the straightedge at both ends of the movement of vertical milling head are the same value and, in this case, the maximum difference of the readings gives the straightness deviation.	
⁽²⁾ The measuring length is normally the length between two columns (not the full length of cross-rail). In other cases, this shall be agreed upon between the manufacturer and user.	

Table 2 Static accuracy test (continued)

Unit: mm

Object Object Checking of squareness between the vertical movement of the milling head (Z-axis) and a) the movement of the table (X-axis); b) the horizontal movement of the vertical milling head (Y-axis). NOTE : This test is also applicable to additional vertical milling heads on the cross-rail.		G6
Diagram of measuring method 		
Tolerance For a) and b) 0.02 for a measuring length of 300		Measured value a) b)
Measuring instruments Cylindrical square, surface plate, adjustable blocks and gauge		
Notes and reference to JIS B 6191 5.522.4 Place a surface plate on the table and adjust its top surface parallel to both X- and Y-axes movements. Position the cylindrical square on the surface plate. Attach a dial gauge to the milling spindle when the spindle can be locked, otherwise to the milling head near the spindle and lock the vertical milling head saddle (Y-axis) to the cross-rail. Apply the stylus of the dial gauge to the cylindrical square in the X-axis direction and move the head through the measuring length a_1 a_2 and record the maximum difference of dial gauge readings as squareness deviation. For more precise measurement, rotate the cylindrical square by 180° and repeat the checking in the same order. Calculate the average value at each measuring position and record the maximum difference. Check subsequently in the Y-axis direction over the measuring length b_1 b_2. For a large machine, the check may be made in the mid-position and in two extreme positions of the cross-rail.		