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**Machine tools—Test conditions for
bridge-type milling machines—
Testing of the accuracy—Part 2:
Travelling bridge (gantry-type)
machines**

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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 for establishment 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. Consequently, **JIS B 6230**:1998 has been withdrawn and replaced with this Standard.

This Standard is designated Part 2 of **JIS B 6228** to match the part numbers of the corresponding International Standard series.

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Machine tools—Test conditions for bridge-type milling machines—Testing of the accuracy—Part 2: Travelling bridge (gantry-type) machines

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **ISO 8636-2** published in 2007, with some modifications of the technical contents for the purpose of facilitating the understanding of the users of this Standard and corresponding to the actual situation regarding the products.

The portions with continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies, with reference to **JIS B 6190-2**, **JIS B 6190-7**, **JIS B 6191**, geometric tests, machining tests, and tests for checking accuracy and repeatability of positioning of numerically controlled axes for general-purpose normal accuracy bridge-type milling machines with a travelling bridge (gantry-type). This Standard also specifies the applicable tolerances corresponding to the above-mentioned tests.

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

This Standard deals with the verification of the accuracy of the machine. It does not apply to the testing of the machine operation (vibration, abnormal noise, stick-slip motion of components, etc.) nor to machine characteristics (such as speeds, feeds, etc.), which should generally be checked before testing the accuracy.

This Standard provides the terminology used for the principal components of the machines and the designation of the axes with reference to **JIS B 6310**.

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 8636-2:2007 *Machine tools—Test conditions for bridge-type milling machines—Testing of the accuracy—Part 2: Travelling bridge (gantry-type) machines* (MOD)

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 21-1**.

2 Normative references

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

JIS B 6190-2:2008 *Test code for machine tools—Part 2: Determination of accuracy and repeatability of positioning numerically controlled axes*

NOTE : Corresponding International Standard: ISO 230-2:2006 *Test code for machine tools—Part 2: Determination of accuracy and repeatability of positioning numerically controlled axes* (IDT)

JIS B 6190-7:2008 *Test code for machine tools—Part 7: Geometric accuracy of axes of rotation*

NOTE : Corresponding International Standard: ISO 230-7:2006 *Test code for machine tools—Part 7: Geometric accuracy of axes of rotation* (IDT)

JIS B 6191:1999 *Machine tools—Geometric accuracy tests and practical tests—Test methods*

NOTE : Corresponding International Standard: ISO 230-1:1996 *Test code for machine tools—Part 1: Geometric accuracy of machines operating under no-load or finishing conditions* (MOD)

JIS B 6310:2003 *Industrial automation systems and integration—Numerical control of machines—Coordinate system and motion nomenclature*

NOTE : Corresponding International Standard: ISO 841:2001 *Industrial automation systems and integration—Numerical control of machines—Coordinate system and motion nomenclature* (IDT)

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

3.1 milling operation

machining operation, which consists of removing material by means of a rotary tool (milling cutter), of which there are several different types

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

3.2 boring operation

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

3.3 drilling (tapping) operation

operation to produce blind or through-holes (or to make internal thread by means of a tap)

3.4 travelling bridge (gantry-type) milling machine

milling machine with one fixed workpiece-holding table, two slideways on either side of the table, and a travelling bridge (gantry) on which the milling head(s) are mounted

NOTE 1 The slideways may or may not be independent of the table.

NOTE 2 The gantry, composed of a left-hand column and a right-hand column supported by respective column slides and made integral with a fixed top bridge, is moved along the bed slideways. The gantry supports a

horizontal cross-rail, movable or fixed in the vertical plane, on which one or more milling heads are mounted with vertical or inclinable spindles.

4 Classification and description of travelling bridge (gantry-type) milling machines

4.1 Classification

These machines are classified into the following types depending upon construction:

- travelling bridge (gantry-type) milling machines with fixed cross-rail;
- travelling bridge (gantry-type) milling machines with movable cross-rail (see figure 1).

4.2 Descriptions of principal components

The principal components of these machines are described in figure 1.

NOTE : The numbers in the parentheses shown following respective component names correspond to the reference numbers as given in table 1.

4.2.1 Bed and table

The worktable (1) is located between two slideways (5 and 6) that form the bed (3 and 4). The worktable and the slideways can be constructed in one piece. Alternatively, the assembly may be made of several pieces rigidly connected through the foundation or directly to each other.

NOTE : The table can be replaced by a floorplate.

4.2.2 Columns, top bridge and cross-rail

The columns (9 and 10) are rigid part with vertical slideways, which either slide on the bed or are fixed rigidly to column slides (7 and 8) which slide horizontally on the bed.

The top bridge (11) is a fixed part connecting the two columns near their top ends.

The cross-rail (14) is a part whose horizontal slideways are parallel to the plane of the table. In the case of machines with fixed cross-rails, the cross-rail is made integral with the columns and may be used as a top bridge. In the case of machines with movable cross-rails, the cross-rail slides vertically on the slideways of the columns (12 and 13). One or more milling heads with vertical, horizontal or inclinable spindles are mounted on the cross-rail slideways.

4.2.3 Milling head(s)

Milling heads (16 and 20) are mounted on head saddles (15 and 21) which move on the cross-rail or column slideways.

The portion in direct contact with the cross-rail or column slideways is called the vertical or horizontal head saddle (15 or 21).

The milling head may be mounted so that it slides on the vertical head saddle in the direction of the spindle axis; it is then called a ram. The spindle may be mounted in a quill (17) sliding in the milling head in the direction of the spindle axis. Some parts of the head may be inclinable.

4.2.4 Cutting motion

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

4.2.5 Feed motion

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

- horizontal movement of the movable bridge (gantry);
- vertical movement of the movable cross-rail;
- horizontal and vertical movement of the milling heads;
- vertical movement of rams, if any;
- vertical movement of quill, if any;
- rotational movement (tilt movements of milling heads), if any.

NOTE 1 In general, rapid traverse is available in addition to feed movement.

NOTE 2 The vertical movement of the movable cross-rail can be either a feed movement (in which case the cross-rail is said to be movable when working) or a movement between fixed working positions (the cross-rail is then said to be movable when being positioned).

5 Terminology and designation of axes

5.1 Terminology

See figure 1 and table 1.

5.2 Designation of axes

See figures 1 to 4.

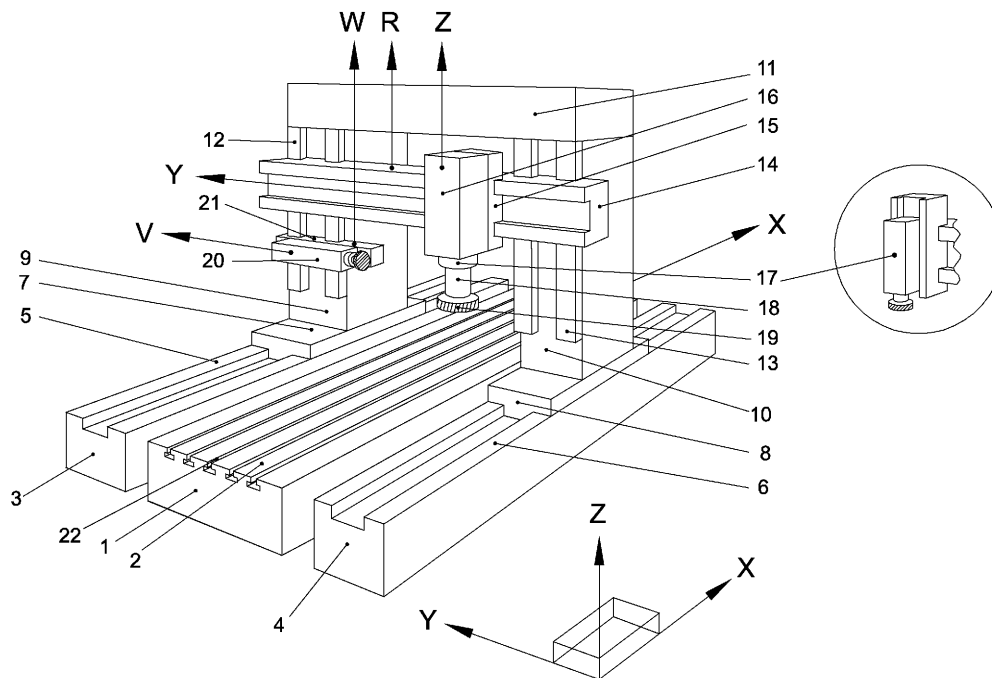


Figure 1 Travelling bridge (gantry-type) machine with movable cross-rail (see table 1)

Table 1 Terminology

Ref.	Designation
1	table (or floorplate)
2	clamping surface
3	left-hand part of the bed
4	right-hand part of the bed
5	left-hand bed slideways
6	right-hand bed slideways
7	left-hand column slide
8	right-hand column slide
9	left-hand column
10	right-hand column
11	top bridge
12	left-hand column slideways
13	right-hand column slideways
14	cross-rail (movable or fixed)
15	vertical head saddle
16	vertical milling head
17	quill (ram)
18	milling spindle
19	tool (milling cutter)
20	horizontal milling head
21	horizontal head saddle
22	reference T-slot

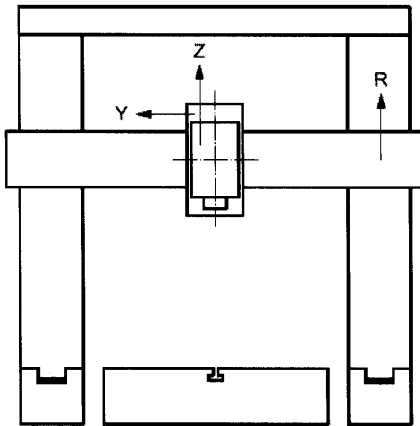


Figure 2 Machine with one milling head

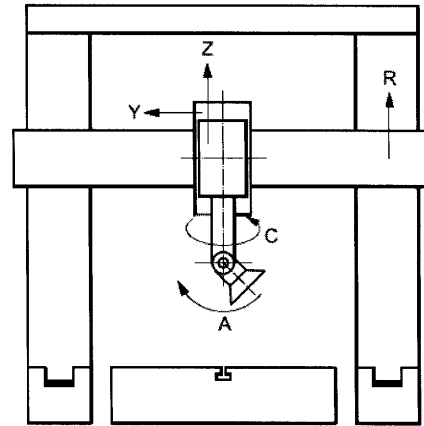
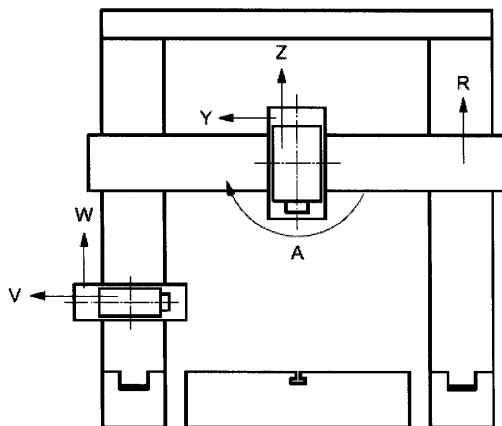
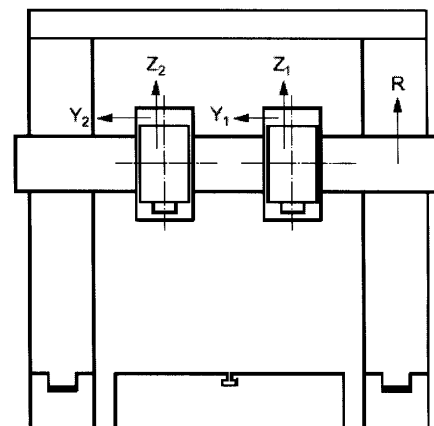


Figure 3 Machine with one milling head swivelling on axes C and A



a) One swivelling (A-axis) milling head mounted on the cross-rail and one horizontal milling head mounted on the right- or left-hand column



b) Two vertical milling heads mounted on the cross-rail

Figure 4 Machine with two milling heads (two examples)

6 Preliminary remarks

6.1 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 (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:

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

6.2 Reference to JIS B 6190-2, JIS B 6190-7 and 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 clauses **7** to **10**, the instructions are preceded by a reference to the corresponding clause in **JIS B 6190-2**, **JIS B 6190-7** and **JIS B 6191** in cases where the test concerned is in compliance with the specifications of one of those standards.

6.3 Temperature conditions

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

6.4 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 facilitate the mounting of instruments or gauging, tests may be performed in any order.

6.5 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. If the tests are required for acceptance purposes, it is the responsibility of the user to choose, in agreement with the supplier/manufacture, 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. 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.

6.6 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 no larger measurement uncertainty may be used.

6.7 Minimum tolerance

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

6.8 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.

6.9 Positioning tests

Positioning tests for numerically controlled machines shall refer to **JIS B 6190-2**. This Standard specifies parameters, measuring procedures and tolerances. The presentation of the test results shall be in compliance with **JIS B 6190-2**.

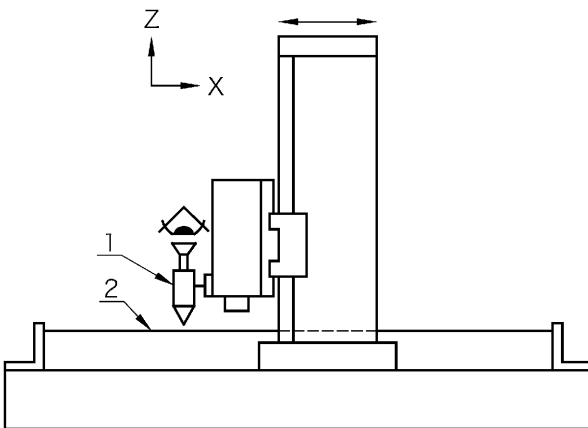
7 Geometric tests

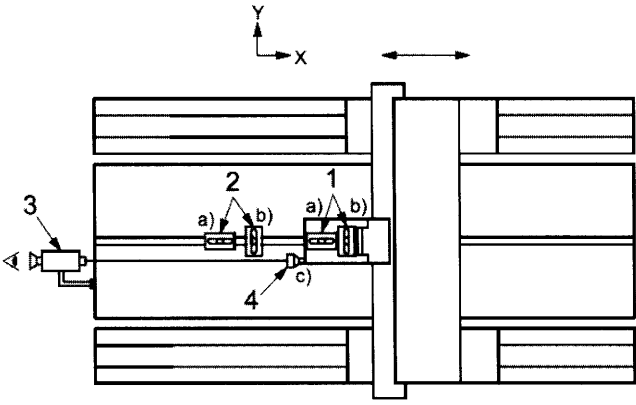
Tolerances are limited to the machines of table size up to 3 000 mm × 10 000 mm. For machines greater than this length or width, the tolerance shall be agreed upon between the supplier/manufacturer and user.

Place the gantry at mid-stroke, with milling head at mid-position on cross-rail (or in symmetrical positions if several heads are available).

7.1 Axes of motion

Unit: mm

Object Checking of straightness of movement of the column (X-axis) in the horizontal X-Y plane (EYX)		G1
Diagram  Key 1 microscope 2 taut wire		
Tolerance 0.02 for measuring length up to 2 000 Add 0.01 to the preceding tolerance for each 1 000 increase in length beyond 2 000. Maximum tolerance: 0.10 Local tolerance: 0.01 for any measuring length of 1 000		Measured deviation
Measuring instruments Microscope/CCD camera and taut wire or other methods		
Observations and references to JIS B 6191, 5.232.12, 5.232.13 and 5.232.14 When using microscope/CCD camera and taut wire, the microscope/CCD camera shall be mounted on the head, and the taut wire shall be fixed to each end of the table parallel to X axis movement of the column (readings of the microscope/CCD camera at both ends of the movement should be the same. In this case, the maximum difference of the readings gives the straightness deviation). Traverse the column in the X-direction and record the readings.		

Object		G2						
Checking of angular deviations of the movement of the column (X-axis): a) in the vertical Z-X plane (EBX:pitch); b) in the vertical Y-Z plane (EAX:roll); c) in the horizontal X-Y plane (ECX:yaw).								
Diagram 								
Key 1 measuring level 2 reference level 3 autocollimator 4 mirror								
Tolerance	<table> <tr> <th></th><th>a) and c)</th><th>b)</th></tr> <tr> <td>$X \leq 4\,000$</td><td>0.04/1 000</td><td>0.02/1 000</td></tr> </table> a) and c) Add 0.01/1 000 to the preceding tolerance for each 1 000 increase in length larger than 4 000 b) Add 0.005/1 000 to the preceding tolerance for each 1 000 increase in length larger than 4 000		a) and c)	b)	$X \leq 4\,000$	0.04/1 000	0.02/1 000	Measured deviation a) b) c)
	a) and c)	b)						
$X \leq 4\,000$	0.04/1 000	0.02/1 000						
Measuring instruments a) Precision level or optical angular deviation measuring instruments b) Precision level c) Autocollimator or other optical angular deviation measuring instruments								
Observations and references to JIS B 6191, 5.231.3 and 5.232.2 The level or instrument shall be placed on the movable component: a) in the X-axis direction (autocollimator shall be set vertically); b) in the Y-axis direction, set vertically; c) in the X-axis direction, set the autocollimator horizontally. If X-axis motion causes angular deviation of both the spindle head and work-holding table, differential measurements of the two angular movements shall be taken. When the differential measurement is applied, the reference level shall be placed on the work-holding table, and milling head shall be placed at mid-position on cross-rail. Measurements shall be carried out at a minimum of five positions equally spaced along the travel, in both directions of movement.								