

JIS

JAPANESE INDUSTRIAL STANDARD

**Machine tools — General
test code for performance
and accuracy**

JIS B 6201—1990

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In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

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Machine tools - General test code
for performance and accuracy

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1. Scope

This Japanese Industrial Standard specifies the common fundamental matters and essentials relating to test methods in the case where the tests of the running performances, rigidities, mechanical accuracies and machining accuracies of machine tools are carried out.

Remarks 1. The machine tools mentioned herein include also those which are numerically controlled.

2. The testing and inspecting methods on each machine tool shall be defined in other standards, selecting items concretely from respective essentials in this Standard according to the object and performance of the machine tool.

3. As regards the machine tool which is not specified in the standard of testing and inspecting methods for specific type of machine, the methods in accordance with this Standard apply, as appropriate.

4. The applicable standards to this Standard shall be given in Attached Table 1.

5. The equivalent International Standards to this Standard shall be as given in the following.

ISO 230-1 Acceptance code for machine tools - Part 1:
Geometric accuracy of machines operating under
no-load or finishing conditions

ISO 230-2 Acceptance code for machine tools - Part 2:
Determination of accuracy and repeatability
of positioning of numerically controlled machine
tools

6. The units and numerical values given in { } in this Standard are in accordance with the traditional system of units, and are appended for reference.

2. Fundamental matters

2.1 The test shall generally be carried out in the factory where the machine tool is manufactured.

2.2 The test shall be carried out after the installation and adjustment have been executed so that performances and accuracies required in the running of the machine tool are not influenced.

2.3 The test shall generally be carried out without disassembling the machine.

2.4 The test shall be carried out in the condition that the equipment necessary for running are mounted and lubricant, hydraulic oil, cutting oil and others have been filled appropriately.

2.5 The test shall generally be carried out after the machine tool has been run on respective parts, and the conditions such as temperature and lubrication have become nearly settled.

2.6 The mechanical accuracy shall generally be measured under such a condition that the workpiece is not mounted on the machine tool and the force accompanied with working or the force equivalent to it is not applied.

2.7 The measuring instruments to be used in testing and accuracies thereof shall be in accordance with the Appendix.

2.8 The test may also be carried out by using the measuring instruments or measuring methods which are recognized as equal to or superior to these in accuracies, other than the measuring instruments or measuring methods specified in this Standard.

2.9 The arrangements of items of testings and inspections in the standard of specific type of machine shall not be those specifying the order of executions of the testings and inspections.

2.10 In the standard of specific type of machine, when two or more methods are specified for the same test item, it shall be made by either one of the given methods.

2.11 When any abnormality has been found during testing, trace its source and adjust it and then test again, as a rule, from the beginning. However, the test may not be repeated on the items by which the adjustment is not influential to the test results carried out previously.

2.12 The rigidity test of the machine tool of the same design shall be represented by the test results carried out on a representative machine, and for the rest the test may be omitted.

2.13 In the case where it is difficult to apply the test method specified in JIS of a machine tool, on account of the construction of the machine tool, the test method shall be selected among the methods given in the essentials of this Standard.

2.14 In the inspection of the mechanical accuracy, if a measuring distance is smaller than the basic value on account of the construction of the machine tool, the numerical value of the specified permissible value shall be converted in proportion to the distance.

2.15 In the case where the results of the mechanical accuracy test are different from the results of the machining accuracy test having the same test object, the priority shall be placed on the results of the machining accuracy test.

2.16 As regards the mechanical accuracy and machining accuracy which are not specified in this Standard, JIS B 0621 shall apply.

3. Essentials relating to running test methods

3.1 Objects and items of running tests The running tests shall be intended to test the performances required to the running of the machine tool, and the test items consist of four items of the functional test, no-load running test, load running test and backlash test.

3.2 Functional test methods The functional tests shall be carried out on the function which is not based on the numerical control and on that which is based on the numerical control.

The functional test which is not based on the numerical control shall examine the smoothness of action and reliability of function by operating each part manually. The functional test which is based on the numerical control shall examine the reliability of function and the smoothness of action by allowing each part to operate by a numerical control tape and other numerically controlled command. The functional tests shall be carried out by the visual inspection or sense of feeling. The indicating method, test items and test methods shall be in accordance with the following:

- (1) Indicating method It shall be indicated by the quality of function.
- (2) Test items and test methods The test items and test methods shall be in accordance with Table 1.

Remarks 1. Functions not based on numerical control are as follows:

- (1) Function operated mechanically by direct manual handling.
- (2) Function of operation not based on the numerical control even though the input is made through the controlling system by manual handling.

2. Functions based on numerical control are as follows:

- (1) Function which is input by manual handling and operated by numerical control.
- (2) Function which is programmed in the numerical control tape and the like and operated by numerical control.
- (3) Function operating automatically within numerical controlling system.

Table 1. Test items and test methods in functional test

Test item		Reference No.	Testing methods	Example of application (Informative reference)
Main motion	Not based on N.C.	1-11	Choose one suitable speed and perform start and stop operations (including braking, reversing, inching and others) consecutively to ascertain smoothness and reliability of action.	Spindle of lathe, milling machine or drilling machine. Wheel spindle of grinding machine. Table of planing machine.
		1-12	Change the speed at each indicated range of speed and ascertain the smoothness of operation and the reliability of indication of control device.	Spindle of lathe, milling machine or drilling machine. Wheel spindle of grinding machine. Table of planing machine.
	Based on N.C.	1-21	Choose one suitable speed and repeat starting, stopping, braking, reversing and inching to ascertain smoothness and reliability of action.	Spindle of numerically controlled lathe and machining center. Spindle of numerically controlled boring machine and milling spindle. Feeding of electric discharge machine.
		1-22	Change the spindle speed to at least 3 speeds of the minimum, intermediate and maximum of marking to ascertain the reliability and smoothness of action.	Spindle of numerically controlled lathe and machining center. Spindle of numerically controlled boring machine and milling spindle.

Table 1 (Continued)

Test item		Reference No.	Testing methods	Example of application (Informative reference)
Feed motion	Not based on N.C.	1-31	Choose one suitable feed rate and perform start and stop operations (including braking, reversing, inching and others) to ascertain the smoothness and the reliability of action.	Carriage and cross slide of lathe. Work spindle and table of grinding machine. Table of milling machine and grinding machine. Tool post and tool slide of planing machine.
	Changing operation of feed speed	1-32	Change the feed rate to at least 3 feeds of the minimum, intermediate and maximum of marking to ascertain the smoothness of operation of operating device and the reliability of indication.	Carriage or cross slide of lathe. Work spindle speed of grinding machine. Table of milling machine.
	Changing operation of feed quantity	1-33	Change the feed quantity to at least 3 feeds of the minimum, intermediate and maximum of marking to ascertain the smoothness of operation of operating device and the reliability of indication.	Feed quantity of carriage or cross slide per revolution of spindle of lathe. Feed depth per stroke of table of planing machine.

Table 1 (Continued)

Test item		Reference No.	Testing methods	Example of application (Informative reference)
Feed motion	Not based on N.C.	1-34	Change the in-feed rate or in-feed quantity to at least 3 feeds of the minimum, intermediate and maximum of marking to ascertain the smoothness of operation of operating device and the reliability of indication.	Mechanical in-feed of wheel of grinding machine. Mechanical in-feed of wheel spindle stock, regulating wheel spindle and regulating wheel lower slide of centerless grinding machine.
		1-35	Ascertain the smoothness and the reliability of setting and action of automatic reversing position.	Feed of multiple spindle drilling machine. Feed of table of grinding machine.
		1-36	Ascertain the smoothness and the reliability of setting and action of automatic stopping position.	Automatic stopping device for table of milling machine and surface grinding machine. Automatic stopping device for hob saddle.
		1-37	Ascertain the smoothness and the uniformity of action of manual operation.	Hand wheel or micrometer collar for carriage or others of lathe. Ram of turret lathe.

Table 1 (Continued)

Test item		Reference No.	Testing methods	Example of application (Informative reference)
Feed motion	Based on N.C.	1-41	Change feeding rate at least to three feeds of lowest, medium and highest in the marking to ascertain the reliability and smoothness of action.	Feeding motion and revolving motion of each operational spindle of numerically controlled machine tools.
		1-42	Carry out inching to ascertain the reliability and smoothness of action.	Each operational spindle of numerically controlled machine tools.
Adjustment of position	Not based on N.C.	1-51	Ascertain the smoothness and reliability of setting of gearing position and action for power feed and rapid traverse.	Mechanical gearing for feed of lathe or drilling machine.
		1-52	Ascertain the reliability of setting of position to be commanded and action of automatic stopping device for positioning in the case of power feed.	Automatic stopping device for mechanical in-feed motion of wheel head of grinding machine. Automatic stopping device for spindle head of knee type vertical milling machine. Automatic stopping device for ram of turret lathe.

Table 1 (Continued)

Test item		Reference No.	Testing methods	Example of application (Informative reference)
Adjustment of position	Not based on N.C.	1-53	Ascertain the smoothness and the uniformity of action of motion by mechanical or manual operation.	Tailstock or tailstock spindle of lathe. Pivoting or vertical movement of arm of radial drilling machine. Indexing of square turret of lathe. Moving and pivoting of wheel head of grinding machine or work head.
	Operation of clamping	1-54	Clamp the element at an arbitrary position of its travel to ascertain the reliability.	Tailstock of lathe. Knee of milling machine.
	Changing operation of traveling speed or travel amount	1-55	Change the travel speed or travel amount ascertain the smoothness of action and reliability of function of operating device.	Feed rate of table or column of gear hobbing machine. Mechanical feed rate of table or wheel head of surface grinding machine.
	Manual operation of feed	1-56	Ascertain the smoothness and the uniformity of manual operation of feed.	Head of plano miller. Feed of wheel head of surface grinding machine.

Table 1 (Continued)

Test item		Reference No.	Testing methods	Example of application (Informative reference)
Adjustment of position	Based on N.C.	1-61	Ascertain the smoothness and the uniformity of action.	Indexing of tool post of numerically controlled lathe. Indexing of swiveling of numerically controlled horizontal boring machine and machining center. Positioning of table of numerically controlled grinding machine and setting of dimension of dimension setting device.
		1-62	Carry out returning operations to machine datum respectively from arbitrary plural positions from which returning is possible to ascertain the reliability of function and smoothness of action.	Returning to machine datum of numerically controlled machine tools.

Table 1 (Continued)

Test item		Reference No.	Testing methods	Example of application (Informative reference)
Not based on N.C.	Mounting and dismounting of cutting tool	1-71	Ascertain the smoothness and the reliability of mounting and dismounting of cutting tool.	Cutting tool of planing machine, horizontal boring machine and broaching machine. Wheel of grinding machine. Electrode of electric discharge machine.
		1-72	Ascertain the smoothness and the reliability of mounting and dismounting of workpiece.	Workpiece of vertical lathe and shaping electric discharge machine.
		1-73	Ascertain the smoothness of action and the reliability of indication of operating device.	Wire tension adjustment device of wire electric discharge machine and changing device of wire electrode travel speed.
		1-74	Ascertain the reliability of function.	Cum of single spindle automatic lathe and multi spindle automatic lathe.
Based on N.C.	Automatic change of cutting tool	1-81	Carry out automatic change of cutting tool and ascertain the reliability and smoothness of action.	Cutting tool of machining center.

Mounting and dismounting and adjustment

Table 1 (Continued)

Test item	Reference No.	Testing methods	Example of application (Informative reference)
Electrical equipment	1-91	Test the insulation of electrical equipment before and after the running test. This is not applied to the circuit using the semi-conductor and the like.	-
Safety device	1-92	Test the reliability of safety devices for operator and the protection of machine against damage [See JIS B 6014].	-
Lubrication arrangement	1-93	Test the reliability of functions such as oil tightness, correct distribution of oil, etc.	-
Hydraulic and pneumatic pressure arrangement	1-94	Test the reliability of functions such as oil tightness, pressure regulation, etc.	-
Position reading device	1-95	Test the reliability of function and the smoothness of action.	Position reading device of jig boring machine.
Auxiliary device of numerical control device	1-96	Test the reliability of functions and smoothness of actions of various kind of indicator light, tape reader, fan, etc.	-
Fittings	1-99	Test the reliability of function.	Device for cutting oil, adjustment device of liquid for electric discharge machining and disposal device for chip.

Function of auxiliary equipment

Table 1 (Continued)

Test item	Reference No.	Testing methods	Example of application (Informative reference)
Not based on N.C.	1-01	Test the reliability of function and smoothness of action.	Program control device of single spindle automatic lathe.
Based on N.C.	1-02	Test the reliability of function and smoothness of action.	Single block feed, feedrate override, sequence number indication and search, and feed hold.
Other functions			

3.3 No-load running test methods

3.3.1 No-load running test In the no-load running test, the machine tool shall be run under the specified no-load condition to examine the running conditions⁽¹⁾, temperature change and required electric power. The indicating method of test results, test items and measuring methods shall be in accordance with the following:

Note ⁽¹⁾ The running conditions shall be the speed, number of strokes and length and the differences between these and the markings, and such conditions as vibration, noise, lubrication, oil-tightness and air-tightness.

- (1) Indicating method It shall be indicated by the running conditions of respective parts, temperature, required electric power and others.
- (2) Test items and measuring methods The test items and measuring methods shall be in accordance with Table 2.

Table 2. Test items and measuring methods in no-load running test

Test item		Refer- ence No.	Measuring instruments	Testing method	Examples of application (Informative reference)
Spindle speed		2-11	Tachometer (Resister and stop- watch) Stroboscope	Measure spindle speeds at respective steps ⁽²⁾ of speed.	—
Feed		2-21	Scale and stopwatch (Test indi- cator and stopwatch)	Measure feed rates (feed quantities) at respective steps ⁽²⁾ of feed.	—
Temperature	Temperature of bearing	2-31	Etched-stem thermometer Thermo- electric thermometer Resistance thermometer	Starting from the minimum speed of spindle, run at re- spective steps, continue running at the maximum speed succeedingly, and measure the tempera- tures of bearing parts.	Main spindles of lathe, milling machine or drilling machine. Arbor support of milling machine. Hob bearing and master worm spindle of gear hobbing machine. Wheel spindle of grinding machine.

Table 2 (Continued)

Test item		Reference No.	Measuring instruments	Testing method	Examples of application (Informative reference)
Temperature	Temperature of hydraulic oil	2-23		Measure the temperature of hydraulic oil in the same condition as above operation.	Hydraulic oil of grinding machine.
	Temperatures of spindle head, gear box, etc.	2-33		Measure the temperatures of spindle head, gear, box, etc. in the same condition as above operation.	Spindle head and gear box of horizontal boring machine
	Temperature of room	2-34		Measure the room temperature around machine in the same condition as above operation.	—
Consumed electric power		2-41	Wattmeter (Voltmeter, ammeter and power-factor meter)	Measure the consumed power (volt, ampere and power factor) under given running conditions. In addition at the end of running, measure the consumed power at full running.	—
Vibration		2-51	Measure by means of sensory test or in accordance with JIS B 6003.		—
Noise		2-61	Measure by means of sensory test or in accordance with JIS B 6004.		—

Note (2) In the case where spindle speed and feeding speed are of variable speeds, the test shall be performed in every speed range for the lowest speed, medium speed and the highest speed.

3.3.2 Continuous no-load running test In the continuous no-load running test, a machine tool shall be run continuously under the prescribed no-load condition to examine for the presence of abnormality. The indicating method of test results, test items and measuring methods shall be in accordance with the following:

- (1) Indicating method It shall be indicated by the presence or absence of abnormality during continuous running.
- (2) Test items and measuring methods Carry out about 2 h of continuous running (including 2 cycles or over) of the machine tool generally by the numerically control commands including each type control function or other controlling method to examine for the presence or absence of abnormality.

3.4 Load running test methods In the load running test, a machine tool shall be run under the loaded conditions to examine the running conditions⁽¹⁾ and working capacities. The indicating method of test results, test items and measuring methods shall be in accordance with the following:

- (1) Indicating method
 - (a) It shall be indicated by the working conditions of respective steps until the prescribed electric power, torque or cutting principal component is reached and electric power and torque or principal cutting component of force corresponding to the load.
 - (b) It shall be indicated by the behavior (chattering or the like) under a specified load.
- (2) Test items and measuring methods The test items and measuring methods shall be in accordance with Table 3.

Table 3. Test items and measuring methods in load running test

Test item		Refer- ence No.	Measuring instrument	Measuring method	Examples of application (Informative reference)
Machining capacity of machine	Power	3-11	Wattmeter (Voltmeter, ammeter and power-factor meter)	Apply the load until the speci- fied power is reached ⁽³⁾ by changing the feed and depth of cut or any one of these, and measure the power at each step.	Outside turning on lathe. Drilling on drilling machine. Face milling on knee type vertical milling machine.

Table 3 (Continued)

Test item		Refer- ence No.	Measuring instrument	Measuring method	Examples of application (Informative reference)
Machining capacity of machine	Torque	3-12	Cutting dynamometer Wattmeter (Voltmeter, ammeter and power-factor meter)	Apply the load until the speci- fied torque is reached ⁽⁴⁾ , by changing the feed and depth of cut or any one of these, and measure the torque ⁽⁵⁾ at each step.	Cylindrical grinding on external cylindrical grinding machine.
	Principal cutting component of force	3-13	Cutting dynamometer Wattmeter (Voltmeter, ammeter and power-factor meter)	Apply a load until the speci- fied principal cutting com- ponent of force is reached ⁽⁶⁾ , changing the feed and depth of cut or any one of these, and measure the principal cutting com- ponent of force ⁽⁷⁾ at each step.	

Table 3 (Continued)

Test item		Refer- ence No.	Measuring instrument	Measuring method	Examples of application (Informative reference)
Machining capacity of machine	Under specific requirement	3-14	—	Observe the behavior under specific loading con- dition.	Surfacing on lathe. Infeed cutting on turret lathe. Surfacing with surface plate on horizontal boring machine. Gear cutting on gear hobbing machine. Working performance test on shaping electric discharge machine.
	Vibration	3-21	Measure by means of sensory test or in accordance with JIS B 6003.		—
	Noise	3-31	Measure by means of sensory test or in accordance with JIS B 6004.		—
	Condition of machined surface	3-41	Observe by sensory test.		—

Notes (³) In a special case, the test is finished before reaching the specified power.

(⁴) In a special case, the test is finished before reaching the specified torque.

(⁵) The torque is given by the following formula:

In the case of measurement by means of cutting dynamometer;

$$T = P \cdot r$$

In the case of measurement by means of dynamometer;

$$T = \frac{955(W - W_0)}{n} (\text{daN} \cdot \text{m}) \left\{ T = \frac{974(W - W_0)}{n} (\text{kgf} \cdot \text{m}) \right\}$$

where

- T : torque (daN·m) {kgf·m}
- P : principal cutting component of force (daN) {kgf}
measured with cutting dynamometer
- r : cutting radius (m)
- W : load input (kW)
- W_0 : no load input (kW)
- n : spindle speed (min^{-1}) {rpm}

- (⁶) In a special case, the test is finished before reaching to specified principal cutting component of force.
- (⁷) The principal cutting component of force shall be given by cutting dynamometer or be calculated from the following formula:

$$P = \frac{6000(W - W_0)}{V_c} \text{ (daN)} \left\{ P = \frac{6120(W - W_0)}{V_c} \text{ (kgf)} \right\}$$

where

- P : principal cutting component of force (daN) {kgf}
- W : load input (kW)
- W_0 : no load input (kW)
- V_c : cutting speed (m/min)

3.5 Backlash test method In the backlash test, these items having remarkable influence on operations or machining accuracies shall be tested. The indicating method of test results, test items and measuring methods shall be in accordance with the following:

- (1) Indicating method It shall be indicated as the rotational angle or calculated dimension corresponding to the mechanism of the system.
- (2) Test items and measuring methods The test items and measuring methods shall be in accordance with Table 4.

Table 4. Test items and measuring methods in backlash tests

Test item	Reference No.	Measuring instrument	Measuring method	Examples of application (Informative reference)
Backlash of system of main motion	4-11	Test indicator, angle gauge and lever	Set the spindle speed change gear to the highest and the lowest speed, and for each case, measure, as a rule, the total backlash of the driving system in its specified region indicated by the angle of the spindle rotation at several positions through one complete rotation of the spindle.	Total backlash of driving system for spindle of lathe.
	4-12	Test indicator and angle gauge	Measure the rotational angle of base shaft of driving system for table from the position where the table starts moving following the rotation of the base shaft in one direction to the position where the table starts moving in reverse direction following the reverse rotation of the base shaft. Backlash is expressed with the values converted into travelled quantity.	Total backlash of driving system for table of planing machine.

Table 4 (Continued)

Test item	Reference No.	Measuring instrument	Measuring method	Examples of application (Informative reference)
Backlash of feed system of feed motion	4-21	Test indicator	Measure the rotational angle of driving shaft from the position where the tool or work rest begins to move when it is operated to feed, to the position where the tool or work rest begins to move in reverse direction when the feed is reversed.	Lead screw of tool rest. Driving system of the ram of turret lathe. Master worm and master worm wheel of gear hobbing machine.
	4-22	Test indicator and lever	(1) Measure the difference of readings of the test indicator, when the table has been moved in positive and negative directions by a lever attached to the rotary table. (2) Taking the reading of the test indicator when the tool or work rest is allowed to feed to move slightly as the reference, measure the difference of readings of the test indicator when the tool or work rest has been moved further in the same direction from the above condition without using a feed device.	Master worm and master worm wheel of gear hobbing machine. Feed screw of hob saddle.

Table 4 (Continued)

Test item	Reference No.	Measuring instrument	Measuring method	Examples of application (Informative reference)
Backlash of system of feed motion	4-23	Test indicator and angle gauge	Measure the rotational angle of base shaft of driving system for table from the position where the table starts moving following the rotation of the base shaft in one direction to the position where the table starts moving in the reverse direction following the reverse rotation of the base shaft. Backlash is expressed by the value converted into travelled quantity.	Total backlash of driving system for table of plano miller.

4. Essentials relating to rigidity test methods

4.1 Object of rigidity tests The object of rigidity tests shall be to examine the deformed conditions by applying a load to the portion which exerts a remarkable influence on the machining accuracy.

4.2 Indicating method of test results, test items and measuring methods of rigidity tests

- (1) Indicating method It shall be indicated by the displacement, in respect to a load, being presented by the sum of elastic deformation and clearance of mechanism.
- (2) Test items and measuring methods The test items and measuring methods shall be in accordance with Table 5.

Table 5. Test items and measuring methods in rigidity test

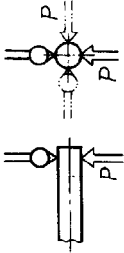
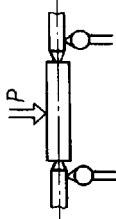
Test item	Refer- ence No.	Measuring instrument	Measuring method	Drawing of measuring method	Examples of application (Informative reference)
Rigidity of spindle against bending	5-11	Test indicator and load cell	Measure the displacement in loading direction when the load (P) of vertical direction to spindle has been applied to the spindle. This measurement shall generally be carried out in two directions vertical to each other.		Spindle and tailstock spindle of lathe. Wheel spindle and work spindle of internal cylindrical grinding machine.
	5-12		Support a work between the spindle (work spindle) and the tailstock spindle, and measure the displacements in loading direction of the spindle and tailstock spindle when the load (P) has been applied to the center of work in vertical direction to the spindle. This measurement shall generally be carried out in two directions vertical to each other.		Work spindle and tailstock spindle of cylindrical grinding machine.

Table 5 (Continued)

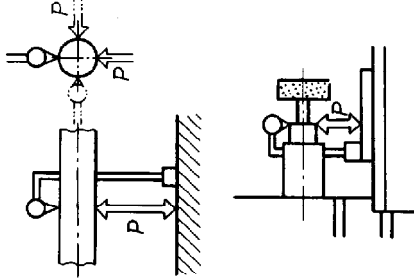
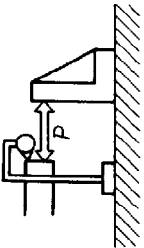
Test item	Reference No.	Measuring instrument	Measuring method	Drawing of measuring method	Examples of application (Informative reference)
Resultant rigidity of spindle and table	5-21	Test indicator and load cell	Measure the relative displacement between the spindle and the table when the load (P) has been applied through the table in vertical direction of spindle to the spindle. This measurement shall generally be carried out in two directions vertical to each other.		Arbor support of knee type horizontal milling machine. Wheel head of horizontal spindle reciprocating table surface grinding machine.
	5-22		Measure the relative displacement between the spindle and the table when the load (P) has been applied through the table in vertical direction of spindle to the spindle.		Spindle and table of horizontal boring machine.

Table 5 (Continued)

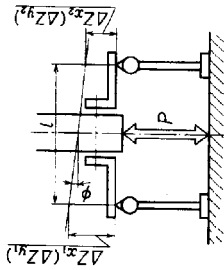
Test item	Refer- ence No.	Measuring instrument	Measuring method	Drawing of measuring method	Examples of application (Informative reference)
Resultant rigidity of spindle and table	5-23	Test indicator and load cell	Measure the relative displacement between the spindle and the table or base when the load (P) has been applied through the table or base in axial direction to the spindle. Measure the displacement as the change of distance between the point at the position of the diameter (ϕ) on the arm which has been attached to the spindle radially and the table or base. Besides, the quantity of the maximum inclination and direction may also be obtained from the change of inclination of the arm in vertical two directions. The quantity of the maximum inclination and direction shall be calculated by the following method.		Spindle and table of drilling machine, milling machine and machining center.
Rigidity in spindle direction					

Table 5 (Continued)

Test item	Refer- ence No.	Measuring instrument	Measuring method	Drawing of measuring method	Examples of application (Informative reference)
	5-23		$\tan \phi = \frac{\Delta Z}{l}$ $\tan \theta = \frac{\Delta Z_x}{\Delta Z_y}$ ϕ = angle of maximum inclination θ = direction of maximum inclination (angle made with X-axis) where $\Delta Z = \sqrt{\Delta Z_x^2 + \Delta Z_y^2}$ $\Delta Z_x = \Delta Z_{x1} - \Delta Z_{x2}$ $\Delta Z_y = \Delta Z_{y1} - \Delta Z_{y2}$		
Rigidity in vertical direction to axis	5-24		Measure the relative displacement between the spindle and the table or base when the load (P) has been applied through the table or base in vertical to axial direction to the spindle. Besides, the quantity of inclination may also be obtained from the change of the distance between the point at the position of the diameter (ϕ) on the arm which has been attached		

Table 5 (Continued)

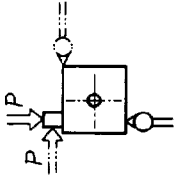
Test item	Refer- ence No.	Measuring instrument	Measuring method	Drawing of measuring method	Examples of application (Informative reference)
	5-24		to the spindle radially and the table or base. The quantity of inclination shall be calculated by the following method. $\tan \phi_x = \frac{\Delta Z_{x1} - \Delta Z_{x2}}{2}$ $\tan \phi_y = \frac{\Delta Z_{y1} - \Delta Z_{y2}}{2}$ ϕ_x, ϕ_y = angle of inclination This measurement shall be carried out on the load of two directions vertical to the axis.		
Rigidity of tool rest	5-31	Test indicator and load cell	Measure the displacement when the load (P) has been applied to the tip end of the tool in the direction of backward component of force. Carry out this measurement also in the direction of the feed component.		Tool rest of lathe.

Table 5 (Continued)

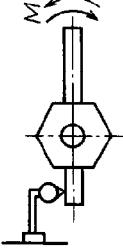
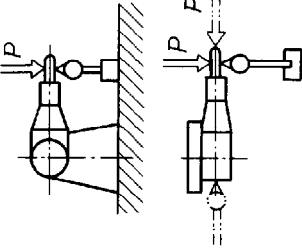
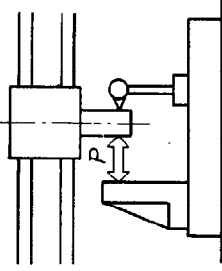
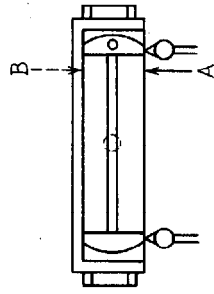
Test item	Refer- ence No.	Measuring instrument	Measuring method	Drawing of measuring method	Examples of application (Informative reference)
	5-32		Attach a lever to the turret head, and measure the displacement in the loading direction when the moment (M) has been applied to the lever.		Turret head of turret lathe.
	5-33		Measure the displacement in loading direction when the load (P) of loading has been applied on the position of a diamond dresser at the wheel truing device.		Wheel truing device of internal grinder.
	5-41	Test indicator and load cell	Measure the relative displacement of loading direction when the load (P) of the principal component of force and feed component of force direction has been applied between the tool holder and the table.		Rail head and table of vertical lathe

Table 5 (Continued)

Test item	Refer- ence No.	Measuring instrument	Measuring method	Drawing of measuring method	Examples of application (Informative reference)
Rigidity relating to swivel of table	5-51	Test indicator	Apply fixed test indicators to both ends of the front face of the table, move the one end of the table which the swivel screw (arrow mark A), take the position when another end of the table begins to move as the reference, next, move the table in the opposite direction (arrow mark B), and measure the travelled distance of the driving side until the other end begins to move.		Table of cylindrical grinder.

5. Essentials relating to mechanical accuracy test methods

5.1 Object and items of mechanical accuracy tests The object of the mechanical accuracy tests shall be to examine the accuracies relating to shapes and motions of important parts constituting the machine tools, and it shall consist of the three items of the static accuracy test, positioning accuracy test and accuracy tests for auxiliary equipments⁽⁸⁾.

Note ⁽⁸⁾ These are carried out as required.

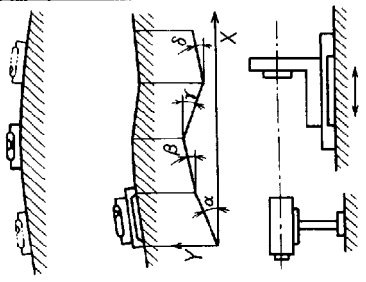
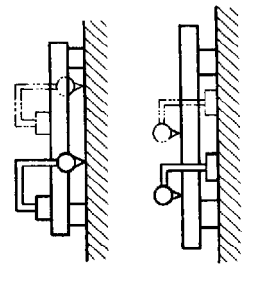
5.2 Static accuracy test methods

5.2.1 Object and items of static accuracy test The object of the static accuracy test shall be to examine on those which exert influences on machining accuracy, among the geometrical accuracies of shapes and motions of important parts constituting the machine tools and the assembling accuracies of units or each part, and these shall consist of 10 items of the straightness, parallelism, flatness, perpendicularity, runout of rotating shaft, axial runout during rotation, coaxiality, equidistant degree, indexing accuracy and intersection of axes.

5.2.2 Straightness The definition, indicating methods, test items and measuring methods shall be in accordance with the following:

- (1) Definition The magnitude of deviation from geometrical straight line of a machine part which is to be a straight line, the magnitude of deviation from geometrical straight line of a motion which is to be a straight line, or the magnitude of deviation of the posture of a machine part during movement (accuracy of posture).
- (2) Indicating method The indicating method of the straightness shall be in accordance with the following (a), (b) or (c).
 - (a) Taking a straight line connecting both ends of a broken line or curved line described by measured values as the reference line, it shall be expressed by the interval of two lines when the broken line or curved line has been interposed between two straight lines in parallel to that line so that the interval becomes minimum.
 - (b) It shall be expressed by the maximum difference of the angles made with the reference line or tangents thereof of a broken line or curved line described by the measured values.
 - (c) The accuracy of posture shall be expressed by the maximum value of the angles of the change in posture or tangents thereof during movement.
- (3) Test items and measuring methods The test items and measuring methods shall be in accordance with Table 6.

Table 6. Test items and measuring methods relating to straightnesses in static accuracy tests

Test item	Refer- ence No.	Measuring instruments	Method to obtain measuring value	Drawing of measuring method	Examples of application (Informative reference)
Straightness of form of machine component	6-11	Precision level or auto-collimator	Take the horizontal line as reference. The maximum differ- ence of readings taken at several positions. When required to find the precise form of surface, it may be measured by chain method as shown in drawing.		Slideways of bed of lathe, planing machine, grinding machine, boring machine and gear hobbing machine.
	6-12	Straightedge and test indicator	Take a straightedge as the reference line. The maximum difference of readings taken at several positions. The readings at both ends of the straightedge shall be allowed to coincide.		Top surface of table of horizontal boring machine.