TEXTBOOK NO. 7006④

Periodic Inspection

TEXTBOOK

Mitutoyo

CONTENTS

Appendix

1. PURPOSE AND IMPORTANCE OF PERIODIC INSPECTION

As the machine tool and other types of machines are becoming more accurate, the accuracies of the components used for them are required to be more accurately machined, and the accuracies of the measuring instruments must be well maintained. Therefore, the periodic inspection of the measuring instruments is very important to continue producing high-accuracy components. However, the actual situation is that priority is given to production jobs and enough attention is not paid to the periodic inspection of measuring instruments (which is one of the measurement control activities) although its importance seems to be well recognized. There are several purposes for periodic inspection and they must result in quality assurance and cost reduction. In other words, a quality control method which does not give rise to them cannot be a modern way of quality control. It may be true that data processing performed on the desk can be one of the measurement control activities; however, persuing an ideal may be fruitless. From this stand point, the execution of measurement control activities is most important for quality assurance and cost reduction. The method for execution will be later described. The value of products is determined by how accurate and how long the accuracies of the measuring instruments are preserved. This is why the periodic inspection of the instruments has a vital importance.

2. INTERNAL STANDARDS AND INTERVAL OF INSPECTION

2.1 Internal Standards

Generally, two types of internal standards are adopted by a company (manufacturer): one is for newly bought measuring instruments and the other is for periodic inspection. The former is performed in compliance with JIS (in some cases, not completely compliant). However, for periodic inspection of measuring instruments in use, more lenient specifications than those of JIS are applied; that is, tolerance is 1.5 to 2.0 times that of JIS. Usually, a company has its own standards according to its requirements on quality control. It may be better for a sub-contractor to consult with their customer when determining their standards. There are quite a few companies who perform periodic inspection of their measuring instruments in compliance with JIS. Depending on the locations, the standards are classified into grades A and B. In this case color-coding is used for them for discrimination against each other.

2.2 Interval of Inspection

The interval of inspection is determined by the following two factors.

1) Frequency of using of the measuring instrument in the company
2) Data of inspection previously performed

It is recommended to perform inspection as frequently as possible; generally once or twice in a year. In some factories, the measuring instruments which are frequently used are inspected every other month. Examples of inspection frequency for several types of measuring instruments are given below.

- Micrometer: 1 ~ 4 times/year
- Dial indicator: 2 ~ 4 times/year
- Vernier caliper and depth gage: 1 ~ 4 times/year
- Bore gage: 1 ~ 4 times/year
- Height gage: 1 ~ 4 times/year
- Dial gage tester: 1/year
- Gage block: 1 ~ 2 times/year
- Granite surface plate: 1/year

The above examples are given for reference. The most suitable interval must be determined for each company.

3. ACTUAL STATUS OF PERIODIC INSPECTION AND INSPECTION TOOLS

The measuring instruments must be inspected periodically. The first thing to do is to have the master (not necessary if relying the inspection on the maker of measuring instruments) and other inspection tools. These are listed in the table given later. The measuring instruments inspected must be classified into the following three categories.

1) Pass
2) To be repaired
3) To be discarded

For controlling the measuring instruments, these data should be used by color cording or by recording on their history card. Inspection of each measuring instrument is described as follows.

3.1 Outside Micrometer (JIS B 7502-1978)

It must be inspected in the following sequence.
(1) Spindle clearance
(2) Screw backlash
(3) Smoothness of spindle movement
(4) Appearance
(5) Flatness of measuring face
(6) Parallelism of measuring faces
(7) Instrumental error
(8) Determination

Fourteen items must be checked as shown in MITUTOYO's inspection sheet (Table 1).

Table 1. Internal inspection sheet

Type			Serial number				
Date			Room temperature				
Flatness	Anvil μm	Spindle μm	No.	Inspection item	Special	A	B
			1	Spindle clearance			
			2	Sleeve graduation			
Parallelism			3	Scratch on sleeve			
			4	Screw backlash			
		μm	5	Scratch and rust			
Instrumental error	Graduation (mm)	Error (μm)	6	Clamp			
	0		7	Fitting			
	2.5		8	Thimble graduation			
	5.1		9	Scratch on thimble			
	7.7		10	Sleeve hardness			
	10.3		11	Thimble position			
	12.9		12	Measuring force			
	15		13	Marking			
	17.6		14	Appearance			
	20.2		Determination		Special	A	B
	22.8						
	25				Inspector		

(1) Spindle clearance

This is the gap between the spindle and spindle guide hole. It must be less than 10μm as specified by JIS B 7502.

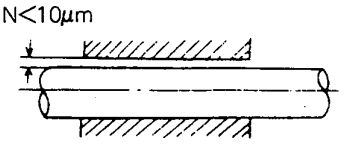


Fig. 1 Spindle clearance

If it is too large, the spindle is displaced in the radial direction and correct reading cannot be obtained. Particularly when measuirng a round workpiece, a large error is produced. There are several methods to measure the spindle clearance. The easiest way is to make a limit sample and compare the test instrument with it. A micrometer whose spindle clearance is too large cannot be repaired.

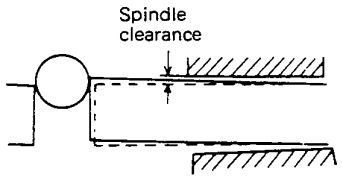


Fig. 2 Effect of excessive clearance

(2) Screw backlash

This is the gap between the male screw and female screw. It can be sensed when moving the spindle in the axial direction. It must be less than 20μm. Screw backlash can be adjusted by turning the tapered nut as shown in Fig. 3. Before this adjustment, apply a small amount of Microl (special oil) on the spindle screw threads.

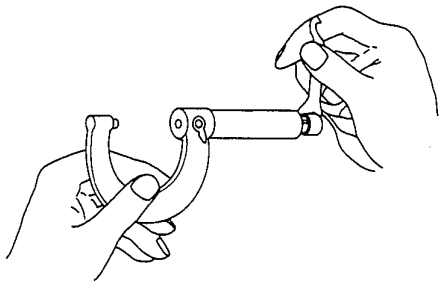


Fig. 3

(3) Smoothness of spindle movement

Turn the thimble by the ratchet stop and make sure that the spindle moves smoothly, without play, in the full range. If the movement is not smooth, check whether it is caused by the screw or guide hole. If it is caused by the screw, apply a microl oil and adjust it as shown in Fig. 3. If it is caused by the guide hole, consult with the manufacturer.

(4) Appearance

Inspect the graduation lines, scratches, clamping status, and reference line position on the sleeve. If a defect is found, isolate the defective one. If a replacement is necessary, replace the faulty part with a new one. If adjustment cannot be done properly after it is replaced, consult with the manufacturer.

(5) Flatness of measuring face

Use an optical flat or optical parallel to determine flatness with the number of red interference fringes by use of a white light source. See Table 2 below.

Table 2. Flatness of measuring face
(outside micrometer, JIS B 7502-1978)

Maximum measurement range (mm)	Number of interference fringes
300 or less	2
More than 300 and less than 500	3

There are several types of optical flat and they are used only for measuring flatness. An optical flat with external diameter of 45mm or 60mm is widely used for the inspection of the micrometer. Set the optical flat fitted on the measuring face of the anvil or spindle of the micrometer and observe the red interference fringes. One fringe is equivalent to 0.32μm (half wave length of red color).

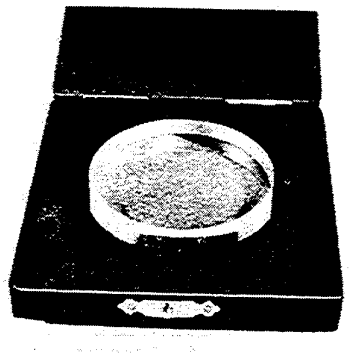


Photo 1

(6) Parallelism of measuring faces

Set the optical parallel fitted in between the two measuring faces and observe the red interference fringes. For a micrometer whose measuring range is 50mm or more, use a gauge block or standard bar together with the optical parallels.

Fig. 4 shows an example of parallelism measurement.

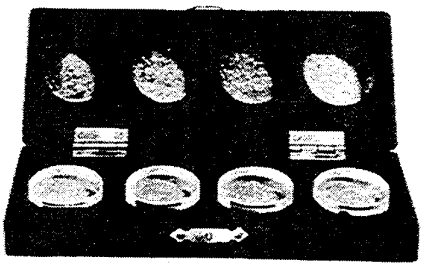


Photo 2. Optical parallels (4 pcs/set)

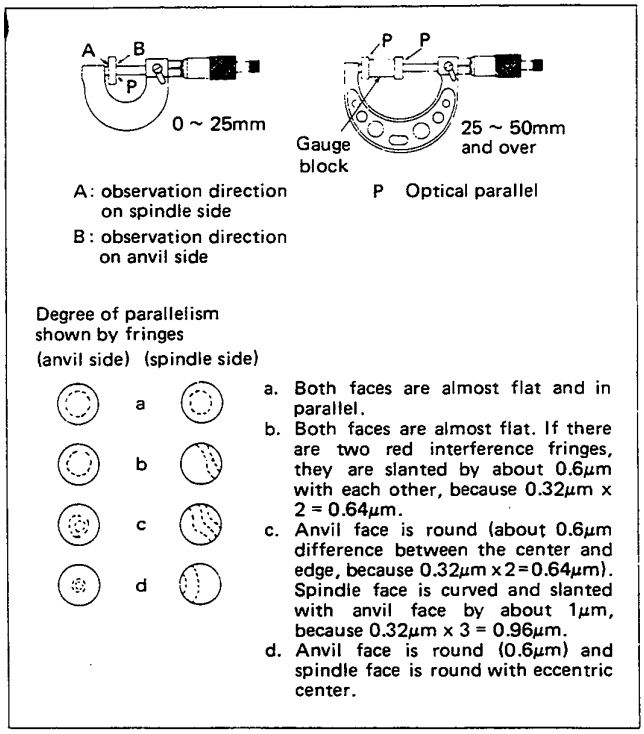


Fig. 4 Parallelism measurement

Table 3 lists the standards for parallelism set forth in JIS.

Table 3. Parallelism of measuring faces
(JIS B 7502-1978 for outside micrometer)

Maximum measurement range (mm) = L	Parallelism (μm)
$L \leqq 75$	2 (6 fringes)
$75 < L \leqq 175$	3 (9 fringes)
$175 < L \leqq 275$	4
$275 < L \leqq 375$	5
$375 < L \leqq 475$	6
$475 < L \leqq 500$	7

(7) Instrumental error

Mount the micrometer on the stand and measure the instrumental error with the gauge block. Enter the error for each graduation in the internal inspection sheet in Table 1. Compare the errors with the maximum allowable values listed in Table 4.

Photo 3. Gauge block for inspecting micrometer

Photo 4. Micrometer stand

Table 4. Instrumental error
(JIS B 7502-1978 for outside micrometer)

Maximum measurement range (mm) = L	Error (μm)
$L \leqq 75$	±2
$75 < L \leqq 150$	±3
$150 < L \leqq 225$	±4
$225 < L \leqq 300$	±5
$300 < L \leqq 375$	±6
$375 < L \leqq 450$	±7
$450 < L \leqq 500$	±8

(Spindle feed error must be 3μm or less.)

Table 5. Outside micrometer inspection standard in company A

Item	Maximum measurement range (mm) = L	Receiving inspection standard = R	Periodic inspection standard = P
Flatness of measuring face	$25 < L \leqq 250$	0.6μm(2 fringes) or less	1.0μm(3 fringes) or less
	$250 < L \leqq 300$	1.3μm(4 fringes) or less	1.6μm(5 fringes) or less
Parallelism of measuring faces	$25 < L \leqq 100$	2.0μm(6 fringes) or less	2.0μm or less
	$100 < L \leqq 175$	3.0μm(9 fringes) or less	3.0μm or less
	$175 < L \leqq 275$	4.0μm or less	4.0μm or less
	$275 < L \leqq 300$	5.0μm or less	5.0μm or less
Instrumental error	$25 < L \leqq 100$	±5μm or less	±5μm or less
	$100 < L \leqq 175$	±6μm or less	±7μm or less
	$175 < L \leqq 275$	±8μm or less	±9μm or less
	$275 < L \leqq 300$	±9μm or less	±10μm or less
Measuring force	300 or less	5~10N(510~1,020gf)	

(1) Instrumental error: A value obtained by subtracting the true value from the value indicated by the micrometer.

(2) Spindle feed error: Difference between the maximum instrumental error and minimum instrumental error in the range of spindle stroke.

(8) Determination

The micrometer inspected must be determined to be "pass" or "failed", or ranked.
Table 5 lists the standard for the micrometer in company A used for receiving inspection and periodic inspection.

Table 6. Requirement for micrometer accuracy (JIS B 7508)

Spindle stroke (mm)	Measurement range (mm)	Number of interference fringes (flatness of measuring face)	Parallelism of measuring faces (μm)	Instrument error (μm)	Spindle feed error (μm)	Measuring force N (gf)
25 or less	0~ 15	2	2 (6)	± 2	3	5~10 {510~1020}
	0~ 25					
	25~ 50					
	50~ 75					
	75~100		3 (9)	± 3		
	100~125					
	125~150					
	150~175			± 4		
	175~200		4			
	200~225					
	225~250			± 5		
	250~275					
	275~300		5	± 6		8~15 {816~1530}
	300~325	3				
	325~350					
	350~375		6	±7		
	375~400					
	400~425					
	425~450			± 8		
	450~475		7			
	475~500					
50 or less	0~ 50	2	2 (6)	± 4	5	5~10 {510~1020}
	50~100		3 (9)	± 5		
	100~150					
	150~200		4	± 6		
	200~250			± 7		
	250~300		5			
	300~350			± 8		
	350~400	3	6	± 9		8~15 {816~1530}
	400~450					
	450~500		7	±10		

3.2 Single Rod Type Inside Micrometer (JIS B7508)

(1) Visual inspection
(2) Smoothness of spindle movement
(3) Instrumental error

(1) Visual inspection

Check the wear of the measuring faces. Usually measuring faces are worn out during the interval of the periodic inspection unless they are carbide tipped. It is recommended to replace the measuring faces with the carbide tipped ones. Check also if the clamp is normally attached and graduation lines are clearly visible.

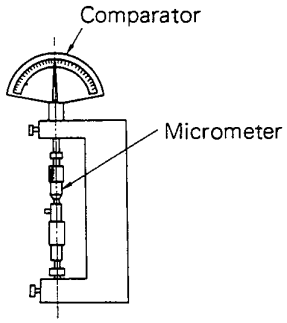
(2) Smoothness of spindle movement

Spindle movement is heavier than the outside micrometer. Check to see if the spindle moves smoothly and without play in the full range. The adjusting method is the same as for outside micrometer.

(3) Instrumental error

A method which is usually used to measure the instrumental error is a comparative measurement with the gauge block by means of the high accuracy comparator, In other methods, the Inside-Microchecker,

Height Master, and length measuring machine are used. The method in which the comparator is used is explained here.



Set the comparator on the stand and adjust to the size by a gauge block. Place the inside micrometer and read the maximum value on the comparator. The difference between the gauge block size and the micrometer is the instrumental error of the micrometer. Then to check the wear of measuring faces, turn the micrometer by 360°. If the measuring faces are not worn, the micrometer turns smoothly holded just by the measuring force of the comparator. If the inside micrometer comes off the contact point of the comparator (that is, the wear of the measuring faces are too much) it should be repaired. Inspection of the extension rod type inside micrometer is done in the almost same method.

Table 7. Instrumental error

Maximum measurement range (mm) = L	Error (μm)
100 or less	±4
100 < L ≦ 150	±5
150 < L ≦ 250	±6
250 < L ≦ 350	±7
350 < L ≦ 425	±8
425 < L ≦ 500	±9

1. Spindle feed error must be 3μm or less.
2. The values are obtained on the basis that the error is adjusted to zero for the minimum measurement size.

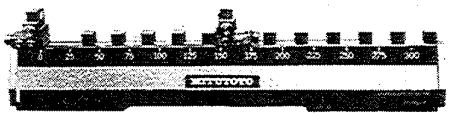


Photo 5. Checking by Inside-Micro Checker

3.3 Depth Micrometer (not specified in JIS)

There are two types: single rod type and interchangeable rod type. Different tolerances are specified for the two types.

3.3.1 Single rod type depth micrometer

(1) Smoothness of spindle movement
(2) Flatness of base face and rod face
(3) Instrumental error

(1) Smoothness of spindle movement

Turn the thimble by the ratchet stop and inspect whether the spindle moves smoothly or not without play in the full range. If the movement is not smooth, adjust it in the same procedure as for the outside micrometer.

(2) Flatness of base face and rod face

Set the optical flat fitted on the measuring faces of the base and rod and, observe the red interference fringes respectively.

Base length	Flatness
60mm	1.3μm
100mm	2.0μm

(3) Instrumental error

Zero set the depth micrometer on the Granite surface plate and then check it with the Depth-micro Checker or use two gauge blocks of the same size. The error must be within ±3.0μm.

3.3.2 Interchangeable rod type depth micrometer

Inspect it in the same procedure as for the single rod type depth micrometer. Check if the rods are curved. The method to check if the rod is curved is to roll it on the Granite surface plate. If the rod is curved, smooth movement cannot be obtained. If it is found to be curved greatly and does not roll smoothly on the plate, replace it with a new rod.
Table 8 lists the standard for the instrumental errors for new depth micrometers. The standard for periodic inspection is 1.5 times more lenient.

Table 8. Standard for periodic inspection in company A

Maximum measurement range (mm) = L	Error (μm)
100 or less	±5 or less
100< L≦200	±7 or less
200< L≦300	±9 or less
300< L≦400	±11 or less

Spindle feed error must be 3μm or less.

Table 9. MITUTOYO standard
Interchangeable rod type depth micrometer

Maximum measurement range (mm) = L	Datum point error (μm)	Error (μm)
25	±3	±3
50	±3	±6
75	±3	±6
100	±4	±7
125	±4	±7
150	±4	±7
175	±5	±8
200	±5	±8
225	±5	±8
250	±6	±9
275	±6	±9
300	±6	±9

Base size (mm)	Base flatness (μm)
60	1.3
100	2.0

The above values are specified at 20°C and are obtained on the basis that the error is adjusted to zero for the minimum measurement size.

3.4 Vernier Caliper (JIS B7507-1979)

The vernier caliper is classified into two types: M type and CM type. Inspect the following points.

a. The slider moves smoothly
b. Daylight between the jaws.
c. Wear of depth measuring face for the M type.
d. The clamp works properly.

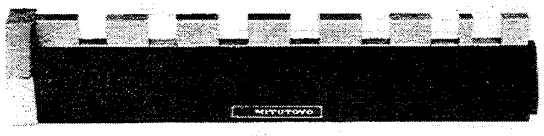
For the CM type, check the wear of the inside jaws with the outside micrometer at three points.

Measure the instrumental error with the Caliper Checker. Table 10 lists the allowable instrumental errors specified in JIS.

Table 10. Allowable instrumental errors

Measurement range (mm) = L \ Vernier reading	0.05mm	0.02mm
L≦100	±0.05	±0.02
100< L≦200	±0.05	±0.03
200< L≦300	±0.08	±0.04
300< L≦400	±0.08	±0.04
400< L≦500	±0.10	±0.05
500< L≦600	±0.10	±0.05
600< L≦700	±0.12	±0.06
700< L≦800	±0.12	±0.06
800< L≦900	±0.15	±0.07
900< L≦1000	±0.15	±0.07

Remarks: The above values are specified at 20°C.



Picture 6. Caliper Checker

Table 11 lists the standard in company A used for periodic inspection of vernier calipers.

Table 11. Periodic inspection standard in company A

Item	Maximum measurement range (mm) = L	Allowable limit at receiving inspection (mm)	Allowable limit at periodic inspection (mm)
Flatness of graduated face	300 max. 600 min.	0.05 max. 0.08 max.	0.08 max. 0.12 max.
Curvature of reference faces of main blade	Per 300	0.02 max.	0.03 max.
Protrusion of jaw tip		0.05 max.	0.10 max.
Width variation of caliper main blade		0.02 max.	0.04 max.
Thickness variation of main blade		0.03 max.	0.05 max.
Squareness between main blade reference face and measuring face.		±0.001 radian	±0.002 radian
Squareness between the graduated face of main blade and measuring face.		±0.0025 radian	±0.005 radian
Instrumental error (0.05mm vernier)	300 max. 300< L ≦ 400 400< L ≦ 600 600< L ≦ 800 800< L ≦ 1000	0.08 max. 0.08 max. 0.10 max. 0.12 max. 0.15 max.	0.10 max. 0.15 max. 0.15 max. 0.18 max. 0.20 max.
Instrumental error (0.02mm vernier)	100 max. 100< L ≦ 300 300< L ≦ 500 500< L ≦ 700 700< L ≦ 900	0.02 max. 0.04 max. 0.04 max. 0.05 max. 0.06 max.	0.04 max. 0.06 max. 0.08 max. 0.10 max. 0.12 max.

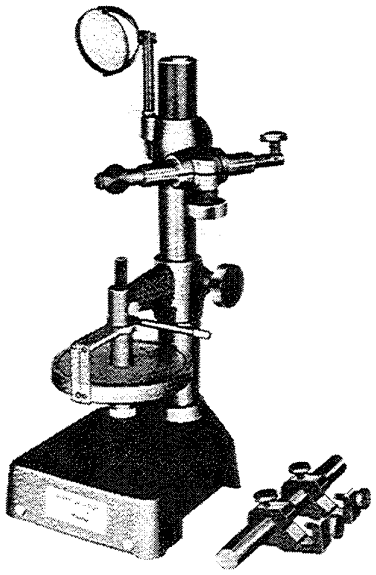


Photo 7

3.5 Dial Indicator

3.5.1 Dial indicator with 0.01mm Graduation (JIS B 7503-1974)

Perform visual inspection on the following.

* Pointer position
* Wear of contact point
* Crystal (breakage)
* Dial

Then, inspect the dial indicator on the following items with UDT-2 type tester (calibration tester resolution is 0.001mm).

(1) Repeatability
(2) Wide range forward accuracy
(3) Narrow range forward accuracy
(4) Retrace error
(5) Narrow range adjacent error

Table 12. Tolerance of accuracy of dial indicator with 0.01mm graduation [specified in JIS (in μm)]

Wide range forward accuracy		Narrow range forward accuracy	Retrace error	Narrow range adjacent error	Repeatability
Measurement range					
For 5mm	For 10mm				
10	15	8	3	5	3

(1) Repeatability

Set the dial indicator vertically on the surface plate. Move the spindle several times abruptly and gradually at an arbitrary position in the stroke. After that let the contact point down on the surface plate and read the indicated value. Proceed this several times and obtain the difference between the maximum and minimum readings.

(2) Wide range forward accuracy

Set the dial indicator vertically on the calibration tester with the contact point in the downward position. Then depress the spindle by about 0.1mm to move the hand to the 12 o'clock position; this is the starting point of the measurement range. Looking at the readings of the dial indicator, move the spindle by 0.1mm steps within 1mm from the starting point and then in 0.2mm steps in the range over 1mm to the end point of measurement range. Subtract the reading of the inspection instrument from that of the dial indicator at each test point and obtain the maximum

and minimum values; and the difference between the maximum and minimum values is defined as the wide range forward accuracy.

(3) Narrow range forward accuracy

From the data obtained in the above (2) procedure, determine the difference between the max. and min. values of error in the range from the starting point to 1mm.

(4) Retrace error

When the wide range forward accuracy check is finished, move the spindle in reverse direction, taking the reading of difference between the indicator reading and tester reading at the same point of measurement for (2) above. Take difference between the readings in the forward direction and backward direction for each test point to determine the maximum value of difference, and the maximum value thus determined is defined as the retrace error.

Table 13. Periodic inspection standard in company A

Item	Maximum measurement range	Standard for receiving inspection	Standard for periodic inspection
Wide range forward accuracy	0.01 graduation Stroke 5mm 10mm 20mm	 10μm max. 15μm max. 20μm max.	 20μm max. 25μm max. 30μm max.
Adjacent error	0.01 graduation Stroke 5mm 10mm 20mm	 5μm max. 5μm max. 8μm max.	 8μm max. 8μm max. 10μm max.
Retrace error	0.01 graduation Stroke 5mm 10mm 20mm	 3μm max. 3μm max. 3μm max.	 3μm max. 3μm max. 4μm max.
Repeat-ability	0.01 graduation Stroke 5mm 10mm 20mm	1/3 graduation max.	1/3 graduation max.
Narrow range accuracy	0.01 graduation Stroke 5mm 10mm 20mm	8μm max.	
Measuring force	0.01 graduation Stroke 5mm 10mm 20mm	50–140gf	

3.5.2 Dial indicator with 0.001mm graduation (JIS B 7509-1974)

The items for visual inspection are the same as for the dial indicator with 0.01mm graduation explained above. However, the inspection instrument is UDT-105 type whose minimum reading is 0.0002mm. The following items are inspected.

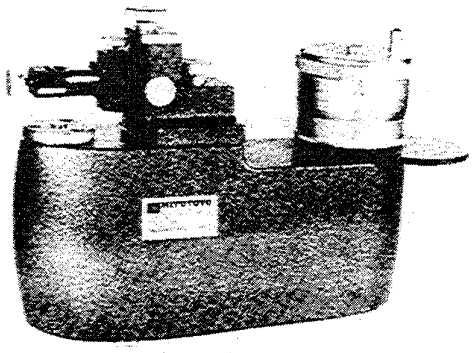
(1) Repeatability
(2) Wide range forward accuracy
(3) Retrace error
(4) Narrow range accuracy

Inspect the measuring force with the upper pan spring type weighing machine.

Table 14. Specifications for the accuracy for dial indicator with 0.01mm graduation (mm)

Unit: μm

Measurement range	Wide range forward accuracy	Narrow range accuracy	Backward error	Repeat-ability
1mm	3	2	–	–
2mm	5	–	2	0.3
3mm	8	–	–	–



The standard for the receiving inspection of the dial indicator with 0.001mm graduation conforms to the specifications of JIS. For periodic inspection, the specifications are 1.5 times more lenient than those of JIS. The above description is given assuming that only UDT is used. However, a Height Master can also be used to inspect the dial indicator.

3.6 Dial Test Indicator (JIS B 7533)

The name "dial test indicator" is used by MITUTOYO. Other companies use different names. In JIS, the name "lever type dial gage" is used. The items for visual inspection are the same as for the dial indicator. The graduation are specified for the measurement ranges in JIS as follows.

Graduation	Measurement range
0.01mm	0.5mm and 0.8mm
0.002mm	0.2mm and 0.28mm

The accuracy is also specified for the same measurement ranges as above.

Item	Tolerance
(1) Indication stability	Half graduation or less
(2) Wide range forward accuracy	Table 15.

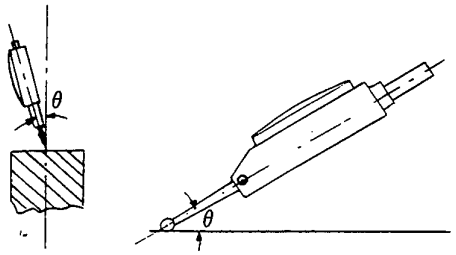
Table 15

0.01mm	0.5mm 5μm max.	0.8mm 8μm max.
0.002mm	0.2mm 3μm max.	0.28mm 3μm max.

(3) Retrace error 0.01mm: 3μm max.
0.002mm: 2μm max.

(4) Narrow range accuracy
0.01mm: 4μm max.

The inspection instrument is UDT-2 type or UDT-105 type. An error is produced by the angle between the contact point and measurement face of the workpiece. This can be said not only to the test indicator but also for the dial indicator.
Examples and compensation factors are given below.



The angle θ must be less than 10°.
True value = Measured value x Compensation factor

Table 16. Angle compensation

Angle	Compensation factor
10	0.98
20	0.94
30	0.87
40	0.77
50	0.64
60	0.50

When the reading of the test indicator is 0.005, the true values are given as follows.
$\theta = 10°$
0.005 x 0.98 = 0.0049
$\theta = 20°$
0.005 x 0.94 = 0.0047
$\theta = 30°$
0.005 x 0.87 = 0.0044

Table 17. Standard for lever type dial gage in company A

Item	Maximum measurement range	Standard for receiving inspection	Standard for periodi inspection
Wide range forward accuracy	0.01 graduation Stroke 0.5 mm 0.8 mm	5μm max. 8μm max.	15μm max.
	0.002 graduation Stroke 0.28mm	3μm max.	10μm max.
Retrace error	0.01 graduation Stroke 0.5 mm 0.8 mm	3μm max.	3μm max.
	0.002 graduation Stroke 0.28mm	2μm max.	3μm max.
Adjacent error	0.01 graduation Stroke 0.5 mm 0.8 mm	4μm max.	5μm max.
	0.002 graduation Stroke 0.28mm	3μm max.	4μm max.
Indication stability	0.01 graduation Stroke 0.5 mm 0.8 mm	Half graduation max.	
	0.002 graduation 0.28mm		

3.7 Bore Gage (JIS B 7515)

Table 18 lists the measurement ranges specified in JIS.

Table 18. Measurement ranges (mm)

Item number	Measurement range	Bore depth
1	18~35	50
2	35~60	100
3	50~100	150
4	100~160	150
5	160~250	250
6	250~400	400

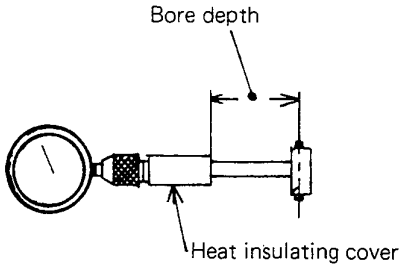


Fig. 5

Visually inspect the following.

* Movement of the contact point
* Wear of the contact point
* Wear of the interchangeable rod

The bore gage is a comparative measuring instrument, therefore, measuring accuracy depends on how zero-setting is made. A ring gage or UDT-2 with an optional CG stand is used for inspection. The specifications set forth in JIS are as follows.

	(Grade A)	(Grade B)
(1) Indication stability	2.0μm max.	3.0μm max.
(2) Effect of contact point rotation	2.0μm max.	4.0μm max.
(3) Wide range accuracy	5.0μm max.	10.0μm max.
(4) Adjacent accuracy	2.0μm max.	4.0μm max.
(5) Effect of guide	Item No. 1~4 · 5~6	Item No. 1~4 · 5~6
	1μm 2μm	2μm 3μm
(6) Supporting force of guide		
Item: 1~2	600gf(6N)	
Item: 3~4	1,000gf(10N)	
Item: 5~6	1,500gf(15N)	

Table 19. Standard for bore gage in company A

Item	Measurement range	Standard for receiving inspection	Standard for periodic inspection
Play of contact point	6 < L ≦ 10 10 < L ≦ 18 18 < L ≦ 35 35 < L ≦ 60 50 < L		B grade 4μm max. A grade 2μm max. " 4 max. " 2 max. " 4 max. " 2 max. " 6 max. " 3 max. " 6 max. " 3 max.
Wear of contact point and rod	6 < L ≦ 10 10 < L ≦ 18 18 < L ≦ 35 35 < L ≦ 60 50 < L		B grade 0.2mm max. A grade 0.2mm max. " 0.4 max. " 0.2 max. " 0.4 max. " 0.3 max. " 0.6 max. " 0.4 max. " 0.8 max. " 0.6 max.
Indication stability	B grade (0.01 graduation) A grade (0.001 graduation)	3μm max. 2μm max.	3μm max. 2μm max.
Wide range accuracy	B grade (0.01 graduation) A grade (0.001 graduation)	10μm max. 5μm max.	20μm max. 10μm max.
Adjacent accuracy	B grade (0.01 graduation) A grade (0.001 graduation)	4μm max. 2μm max.	4μm max. 3μm max.
Effect of guide plate	6 < L ≦ 10 10 < L ≦ 18 18 < L ≦ 35 35 < L ≦ 60 50 < L	B grade 2μm max. A grade 1μm max. " 2 " " 1 " " 2 " " 1 " " 3 " " 2 " " 3 " " 2 "	
Measuring force	6 < L ≦ 18 18 < L ≦ 60 50 < L	600gf (6N) 1000gf (10N) 1500gf (15N)	

B grade: Bore gage with 0.01mm dial indicator.
A grade: Bore gage with 0.001mm dial indicator.

If the contact point is worn out, send the bore gage to the maker. If the rod is worn out, replace it with a new rod. If the roundness of the contact point is to be inspected correctly, an optical measuring instrument (such as profile projector, toolmakers microscope, etc.) must be used. For a bore gage whose measurement range is 18mm or less which is not specified in JIS, MITUTOYO guarantees its performance as shown in Table 20 (only for grade A).

Range	0.95 ~ 7.3mm	7 ~ 10mm	10 ~ 18mm
Indication stability	2μm max.	2μm max.	2μm max.
Indication error	4μm max.	4μm max.	6μm max.
Measuring force	400gf max.	700gf max.	800gf max.

Table 20

3.8 Height Gage (JIS B 7517)

For periodic inspection, wipe the surface plate (granite surface plate is recommended) clean. Set the Caliper Checker vertically on it: and zero set the height gage with a scriber on the surface plate; then check the height gage reading with the scriber positioned on the specified gauge block of the Caliper Checker. Note that this method will not give a precise numerical value of height gage error. Therefore using the test indicator together is recommended. The error produced by the angle (described in section 3.6) must be taken into consideration.

Table 21. Total accuracy (mm)

L = Measured value \ Graduation	0.05	0.02
$L \leqq 100$	±0.05	±0.02
$100 < L \leqq 300$	±0.05	±0.03
$300 < L \leqq 500$	±0.06	±0.04
$500 < L \leqq 700$	±0.07	±0.05
$700 < L \leqq 900$	±0.08	±0.06
$900 < L \leqq 1000$	±0.09	±0.07

The parallelism between the bottom face of the base and scriber mount must be less than 10μm. Perform visual inspection first on the following.

* Slider movement
* Clamp screw
* Graduation lines

4. ACCURACY MAINTENANCE OF MEASURING INSTRUMENT

When measuring a size, the measured value must be correct enough all the time. If the measured value obtained is not correct, quality control cannot be performed properly and periodic inspection is insignificant. Therefore, the measuring instrument must be correct and accurate. To maintain the instrument in the best condition, following must be considered.

(1) The degree of error
(2) Contents of work
(3) Condition in which the instrument is used
(4) The way in which the instrument is used.
(5) Compensation of instrumental error
(6) Necessity of compensation for temperature coefficient

Thus, the accuracy of the instrument must be maintained. However, the effort of the person who is in charge of maintaining the instrument is fruitless, unless the other person who uses the instrument at his work site use it correctly. This necessitates the training of the inspection personnel. An appropriate curriculum is necessary to educate the new man to prevent him from learning measurement techniques in a wrong way such as only looking at the work of a man who is senior to him or getting knowledge by his own sense and self understanding. Moreover, the effort of the inspection personnel himself must be made on his daily job for controlling and stabilizing the quality of goods.

5. HANDLING OF INSTRUMENT TO BE REPAIRED OR DISCARDED

The criteria to repair the micrometer are listed below.

Item number	Item	Contents of failure	Can be repaired	Remarks
1	Smoothness of spindle movement	The spindle rotation is heavy and unsmooth.	Yes	Disassemble and clean it.
2	Ratchet stop	The ratchet stop rotation is heavy and unsmooth.	Yes	If the problem cannot be solved by cleaning the ratchet, replace it.
3	Clamp	The spindle cannot be clamped tight.	Yes	Send it back to maker.
4	Burr on measuring face edge	The edge of the measuring face is hit and is burred.	Yes	Remove the burr with Alkansas stone.
5	Flatness	The face becomes dull or flatness is 0.6μm or more.	Yes	Send it back to maker.
6	Parallelism	The parallelism of anvil and spindle is out of specifications.	Yes	Send it back to maker.
7	Accuracy	Pitch accuracy is worse than the specification by 2μm.	Yes	Send it back to maker.
8	The screw threads jammed.	A foreign material has entered in the screw and it does not turn.	No	Buy a new one.
9	The frame is bent.	It was bent while being set in the rathe in operation and measured and bit by the machine, or used in behalf of vise.	No	Buy a new one.
10	Spindle clearance	Excessive play in the spindle guide. The flatness of the measuring faces is satisfactory; however, there is abnormally big difference in parallelism inspection between the two cases (1) the gauge block is used and (2) the optical parallel is used.	No	Buy a new one.
11	Screw backlash (partial wear of screw thread)	Even if the tapered nut of the female screw is tightened, a portion has backlash and the other portion is heavy.	No	Buy a new one.
12	Graduation	The graduation is scratched and reading is impossible.	Yes	The thimble and sleeve can be replaced, consult with maker.
13	Others			Determine the way of solution, depending on the contents of failure.

The repair parts can be handled by the sales agents. Refer to Table above to find the way to handle a faulty instrument. Any part from an instrument which is diagnosed to be discarded (such as ratchet stop, clamp lever, screw of caliper, clamp screw, etc.) must be stored for the next periodic inspection.

6. TOOLS USED FOR PERIODIC INSPECTION

The tools which are used for periodic inspection are tabulated here.

No.	Inspection tool	Model No.	Code No.	Remarks
1	Micrometer inspection block	MBI-10M	516-107	Ten pcs/set for outside micrometer (25mm)
2	Micrometer inspection block	BMI-10-1	516-979	Ten pcs/set for optical parallel, one unit for outside micrometer (25mm)
3	Optical parallel	OP-25	157-903	Four pcs/set for outside micrometer (25mm)
4	Optical parallel	OP-50	157-904	Four pcs/set for outside micrometer (50mm)
5	Gauge block 25mm 1 grade 50mm 1 grade 75mm 1 grade 100mm 1 grade			Auxiliary block for 50mm or more
6	Micrometer stand	MS-R	156-101	Outside micrometer (15 to 100mm)
7	Micrometer stand	MS-M	156-102	Outside micrometer (125 to 300mm)
8	Micrometer stand	MS-L	156-103	Outside micrometer (325 to 1000mm)
9	Micrometer stand	MS-T	156-201	Outside special micrometer (25 to 100mm) with table
10	Optical flat	OF-45A	158-118	Depth micrometer (60mm base)
11	Optical flat	OF-60A	158-120	Depth micrometer (100mm base)
12	Depth microchecker	CD-150	515-570	Depth micrometer (0 to 150mm)
13	Caliper checker	CC-300	515-550	Caliper and height gage (150, 200, and 300mm), inside/outside measurement (20 to 300mm)
14	Check master	HM-C1,000	515-724A	Caliper for 150 to 1000mm (50 to 1000mm)
15	Calibration tester	UDT-2	170-102	0.01mm test indicator, dial indicator and bore gage
16	Calibration tester	UDT-105	521-105	0.001mm test indicator, dial indicator
17	Height Master Accessory	HM-30	515-320 515-110	Height measuring instruments Bore gage
18	Height Master, U type	MM-U1,000	515-523	Height and Horizontal standards
19	Granite surface plate	517-103 600 x 600 517-105 750 x 500 517-107 1,000 x 750		Reference surface
20	Gauge block sets	BM1-103-1 BM1- 76-1 BM1- 56-1 BM1- 47-1	516-943 516-951 516-955 516-959	Reference
21	Gauge block accessories 60mm holder 100mm holder 160mm holder Inside-Micro Checker		619002 619003 619004	Block holders for inside micrometers

Appendix

PREFACE

This section explains the periodic inspection for the instruments (especially for large size) which are not specified in JIS.

1. OUTSIDE MICROMETER WITH MEASUREMENT RANGE MORE THAN 500mm (Including interchangeable anvil type)

1.1 Flatness of Measuring Faces

The method of inspection was described in the main text. The tolerances for several measurement ranges are given in Table 1.

Table 1. Flatness of measuring faces

Maximum measurement range (mm) = L	Number of interference fringes	Flatness
$300 < L \leqq 500$	3	1.0μm
$500 < L \leqq 1000$	4	1.3μm
$1000 < L$	5	1.6μm

1.2 Parallelism of Measuring Faces

In MITUTOYO, an optical parallel is used to measure the parallelism of the measuring faces. Usually, a standard bar is used together with a 1mm gauge block to take measurements at four points and the difference between the maximum and minimum values is defined as parallelism.
When using the 1mm gauge block, set it 2mm inside the periphery of the standard bar (see Fig. 1).

The parallelism of an outside micrometer of over 500mm in range is given by the following formula and the values instruments with several measurement ranges are listed in Table 2.

$$2 + \frac{\text{Maximum measurement range}}{100}\ \mu m$$

(the digit below the decimal point is rounded up)

The values given in Table 2 are those obtained by using the 1mm gauge block and standard bar.

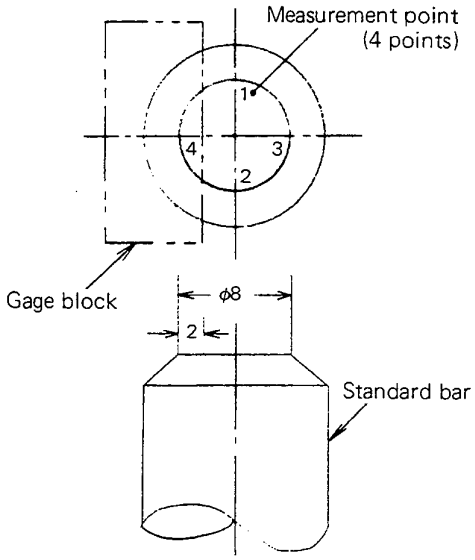


Fig. 1 Parallelism inspection

Table 2. Parallelism inspection

Maximum measurement range (mm) = L	Parallelism (μm)
$500 < L \leqq 600$	8
$600 < L \leqq 700$	9
$700 < L \leqq 800$	10
$800 < L \leqq 900$	11
$900 < L \leqq 1000$	12

1.3 Instrumental Error

The outside micrometer must be set in the specified micrometer stand (MS-L, Code No. 156-103) to measure the instrumental error with the gauge block and standard bar. A large outside micrometer is deformed, depending on the supporting posture and it must be set zero in the posture it is actually used See Table 3.

Table 3. Error due to the change of supporting posture (μm)

Unit: μm

Supporting point / Posture / Max. Measurement range (mm)	Center and bottom (Zero setting position)	Center	Center(horizontal position)	Facing down (held by hand)
325	0	− 5.5		− 4.5
425	0	− 2.5		− 10.5
525	0	− 5.5		− 10.0
625	0	− 11.0	0	− 5.5
725	0	− 9.5	− 9.5	− 19.0
825	0	− 18.0	− 5.0	− 35.0
925	0	− 22.5	− 14.0	− 27.0
1025	0	− 26.0	− 5.0	− 40.0

In MITUTOYO, the center and bottom are supported for inspection of micrometer.

Table 4. Instrumental error (μm)

Maximum measurement range (mm) = L	Standard outside micrometer	Interchangeable anvil type micrometer
$500 < L \leqq 600$	±10	±12
$600 < L \leqq 700$	±12	±13
$700 < L \leqq 800$	±13	±16
$800 < L \leqq 900$	±14	±20
$900 < L \leqq 1000$	±15	±22

The values in Table 4 are given by the following formulae.

Standard outside micrometer $\pm (1 + \frac{\text{Max. measurement range}}{75})$ μm

(digit below the decimal point is rounded up)

Interchangeable anvil type micrometer $\pm (4 + \frac{\text{Max. measurement range}}{75})$ μm

(digit below the decimal point is rounded up)

The errors due to temperature variation and frame deformation are shown in Figs. 5 and 6.

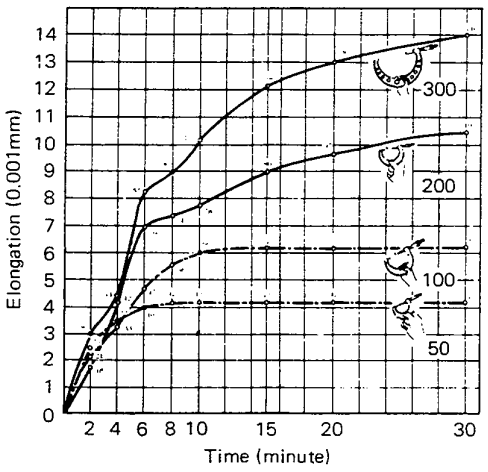
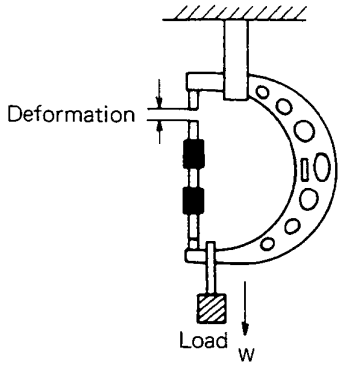


Fig. 5 Measurement error due to temperature variation



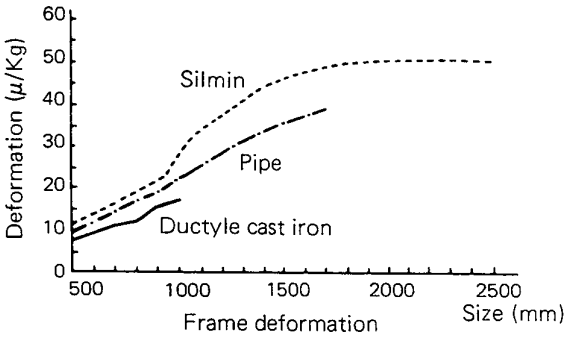


Fig. 6 Frame deformations of several materials

2. SLIDE ANVIL TYPE OUTSIDE MICROMETER

2.1 Parallelism and Flatness of Measuring Faces

The methods to measure the parallelism and flatness are the same as for the outside micrometer with measurement range more than 500mm.

2.2 Instrumental Error

The instrumental errors of OMS1 (25mm stroke) and OMS2 (50mm stroke) are given by the following formula and the values for several measurement ranges are listed in Table 7.

OMS1(25mm stroke)

$$\pm \left(4 + \frac{\text{Max. measurement range}}{75}\right) \mu m$$

OMS2(50mm stroke)

$$\pm \left(6 + \frac{\text{Max. measurement range}}{75}\right) \mu m$$

(The digit below the decimal point is rounded up.)

Table 7. Instrumental errors

Maximum measurement range (mm) = L (OMS1)	Error (μm)
$500 < L \leqq 600$	±13
$600 < L \leqq 700$	±15
$700 < L \leqq 800$	±16
$800 < L \leqq 900$	±18
$900 < L \leqq 1000$	±20
Maximum measurement range (mm) = L (OMS2)	**Error (μm)**
$1000 < L \leqq 1200$	±22
$1200 < L \leqq 1400$	±25
$1400 < L \leqq 1600$	±28
$1600 < L \leqq 1800$	±30
$1800 < L \leqq 2000$	±32

Note: The instrumental error for the slide anvil type micrometer with dial gage is the same as the above.

3. POINT MICROMETER

3.1 Visual Inspection

Except for the measuring faces, the procedure is the same as for the flat face micrometer on the items such as spindle clearance, screw backlash, smoothness in spindle movement, clamp, measuring force of ratchet, etc.

3.2 Instrumental Error and Eccentricity

Mount the point micrometer on the micrometer stand (MS-R) and inspect the instrumental error and eccentricity with the gauge blocks (10 pcs/set).
Perform eccentricity inspection in the following steps.

a. Zero set the instrument correctly
b. Set a 1mm gauge block between the measuring faces and read the minimum value
c. Turn the gauge block in the direction indicated by an arrow. If the gauge block can rotate by 360° around a point, the instrument under test is "pass".

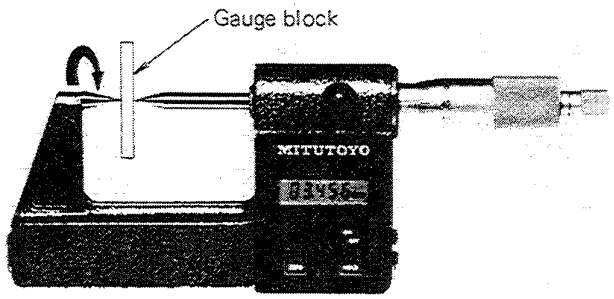


Fig. 3 Eccentricity inspection

If it comes off the micrometer, the micrometer under test is "fail". Send the micrometer to maker for repair. Then set a 1.25mm gauge block (equivalent to half rotation of the spindle) and turn it in the same way. The test criterion is the same as for the 1mm gauge block. The eccentricity inspection finishes at this point. The procedure for instrumental error inspection and tolerances are the same as for the flat face micrometer as listed in Table 8.

Table 8. Instrumental errors

Maximum measurement range (mm) = L	Error (μm)
25 or less	±3
25< L≦50	±3
50< L≦75	±4
75< L≦100	±4

Note: The method to inspect the tube micrometer of two round faces is the same as for the point micrometer.

Formula,

$$\pm\left(2+\frac{\text{Max. measurement range}}{75}\right)\mu m$$

(Digit below the decimal point is rounded up.)

NOTE

The same procedure and the tolerance of the instrumental error are applicable to the anvil and spindle spherical type of outside micrometer.

4. EXTENSION-ROD TYPE INSIDE MICROMETER

4.1 Visual Inspection

(1) Instrument proper

Inspect the wear of the adjustable anvil (see Fig. 4). If it is worn out, replace it with a new part or instrument itself. Check if the clamp works properly.

(2) Rod

Inspect the wear of the round face of the rod (see Fig. 5). If it is worn out greatly, ask the maker for repair or buy a new instrument.

ustable anvil

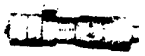


Fig. 4 IMZ proper

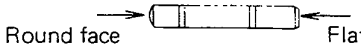


Fig. 5 Rod

4.2 Smoothness of Spindle Movement

The inspection procedure is the same as for the single rod type inside micrometer.

4.3 Instrumental Error

The instrumental error is calculated by the following formula (see Table 9).

Total error,

$$\left(3+N+\frac{\text{Max. measurement range}}{50}\right)\mu m$$

N: Number of rods

(The digit below the decimal point is rounded up.)

The high accuracy comparator is used in the comparative method with the gauge block. (In the other methods, the Inside-Micro Checker, length measuring machine, and Height Master are used.)

IMZ-proper is set to zero within ±1μm at 50mm, comparing to a 50mm gauge block. Then attach the rods to the instrument proper and compare with the gauge block, taking maximum reading on the indicator. Slightly turn the micrometer by 360° at that position. If the instrument does not come off the contact point of the comparator, it is "pass".

Otherwise, the measuring face (adjustable anvil or round face of rod) is worn out. Send it to maker for repair. However, if the rod is bent and eccentric, it cannot be repaired.

Table 9. Instrumental errors

Maximum measurement size (mm) = L	Error (μm)
$50 < L \leqq 150$	± 9
$50 < L \leqq 300$	±14
$50 < L \leqq 500$	±18
$50 < L \leqq 1000$	±21
$50 < L \leqq 1500$	±44

1. Spindle feed error must be less than 3μm.
2. The values in Table 9 are obtained by adjusting the error to zero at the minimum measurement value.

5. EXTENSION-PIPE TYPE INSIDE MICROMETER

5.1 Visual Inspection

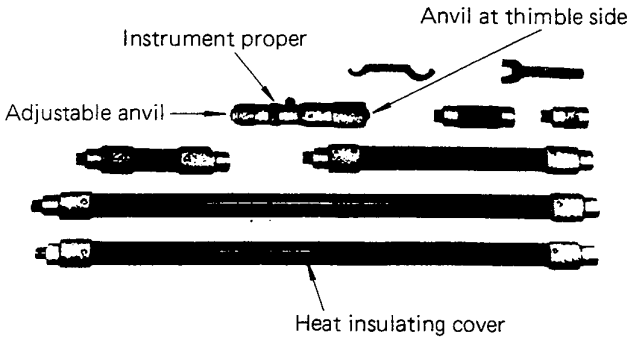


Fig. 6 IMJ proper and pipes

There are two types of extension pipe type inside micrometer: one with 25mm head stroke, the other with 50mm head stroke. Check the wear of the adjustable anvil and thimble-side anvil. See Fig. 6. If the face is worn out, replace it with a new part, or send the instrument to maker for repair.

The instrument proper and pipes can be purchased. Then check the clamp. The pipes cannot be repaired and so new parts must be purchased.

5.2 Screw Backlash

Use the same procedure as for the single rod type micrometer.

5.3 Instrumental Error

The instrumental error for the measurement range 100 to 2100mm is given by the following formula and tolerances are listed in Table 10.

$$\pm \left(3 + N + \frac{\text{Max. measurement range}}{50}\right) \mu m$$

(digit below the decimal point is rounded up.)

If the measurement range is 1000 to 5000mm, the following formula is used.

$$\pm \left(7 + N + \frac{\text{Max. measurement range}}{50}\right) \mu m$$

(digit below the decimal point is rounded up.)

where N represents the number of pipes.

An instrument with the measurement range 100 to 2100mm must be inspected in the same way as for IMZ (extension-rod type). However, for an instrument whose measurement range is 1000 to 5000mm, only the length measuring machine can be used. The instrumental errors are listed in Table 10.

Table 10. Instrumental errors

Maximum measurement range (mm) = L	Error (μm)
$100 < L \leqq 500$	± 17
$100 < L \leqq 900$	± 26
$100 < L \leqq 1300$	± 35
$100 < L \leqq 1700$	± 44
$100 < L \leqq 2100$	± 53
$1000 < L \leqq 3000$	± 73
$1000 < L \leqq 4000$	±112
$1000 < L \leqq 5000$	±155

1. Spindle feed error must be 3μm max. for 25mm stroke and 5μm max. for 50mm stroke.
2. The values in Table 10 are obtained by adjusting the error to zero at the minimum measurement value.

The instrument is very sensitive to temperature variation. Fig. 11 shows how it is affected by human body temperature (the pipes are gripped by hands).

IM: Single rod type inside micrometer
IMSL: Interchangeable rod type inside micrometer
IMJ: Extension-pipe type inside micrometer
IMZ: Extension-rod type inside micrometer

As shown by data, caution must be taken when there is not a heat insulating cover and the rod is touched by hand.

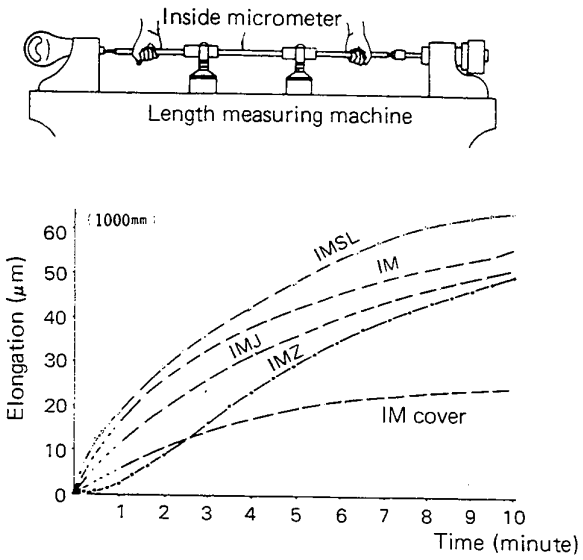


Fig. 11 Elongation by body heat

6. SNAP METER

6.1 Visual Inspection

Inspect the following (see Fig. 7).

a. Lead nut
b. Clamp
c. Indication when pressing the button
d. Movement in the whole range (if it is heavy, send the instrument back to maker for repair).

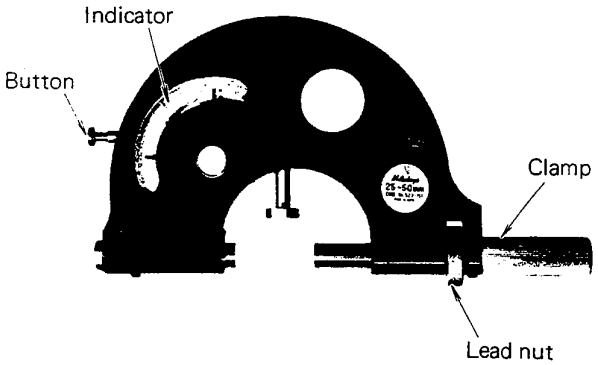


Fig. 7 Snap meter

6.2 Parallelism and Flatness of Measuring Faces

The flatness must be 0.6μm max. for all the measurement ranges.

The parallelism must be checked by the optical parallel and gauge block. Table 12 lists the tolerances.

Table 12. Parallelism

Maximum measurement range (mm) = L	Error (μm)
25 or less	1.0
25< L ≦50	1.0
50< L ≦75	1.3
75< L ≦100	1.3
100< L ≦125	2.0
125< L ≦150	2.0

If only the gauge block is used, set it 2mm inside the periphery of the measuring face. The parallelism is determined by the difference between the maximum and minimum values. Refer to the parallelism measurement of a large size otuside micrometer with the gauge block and standard bar.

6.3 Correctness of Indicator

Inspect the accuracy of the indicator with the following gauge block.

25.00mm

Plus side	25.02mm	25.04	25.06	25.08
Minus side	24.98mm	24.96	24.94	24.92

Zero set the instrument on 25mm gauge block and take reading of indicator on each gauge block above, at the plus and minus sides.
Table 13 lists the allowable ranges of errors for several measurement range.

Table 13. Indication errors (μm)

Maximum measurement range (mm) = L	Tenth graduation from zero point	Whole range
25 or less	±1	±2
25< L ≦50	"	"
50< L ≦75	"	"
75< L ≦100	"	"
100< L ≦125	±2.5	±5
125< L ≦150	"	"

Note: The tenth graduation from the zero point is equivalent to 10μm.

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