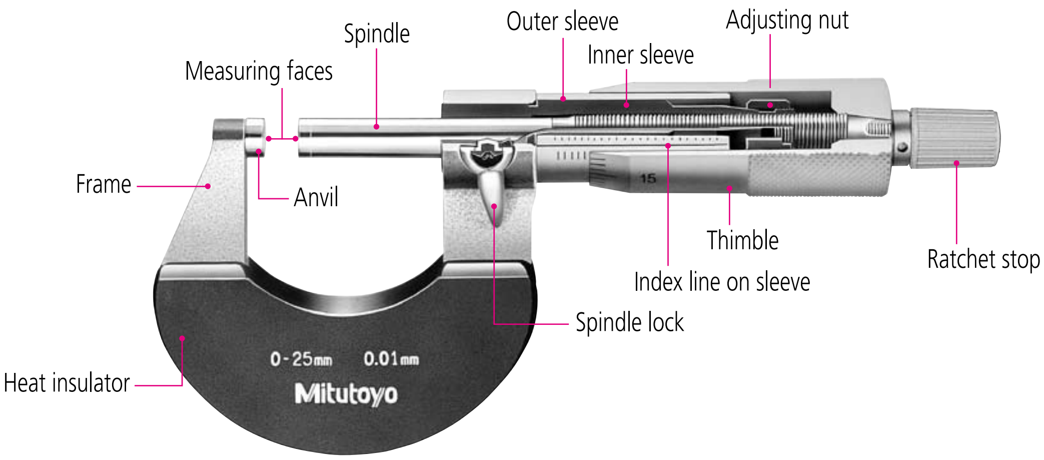
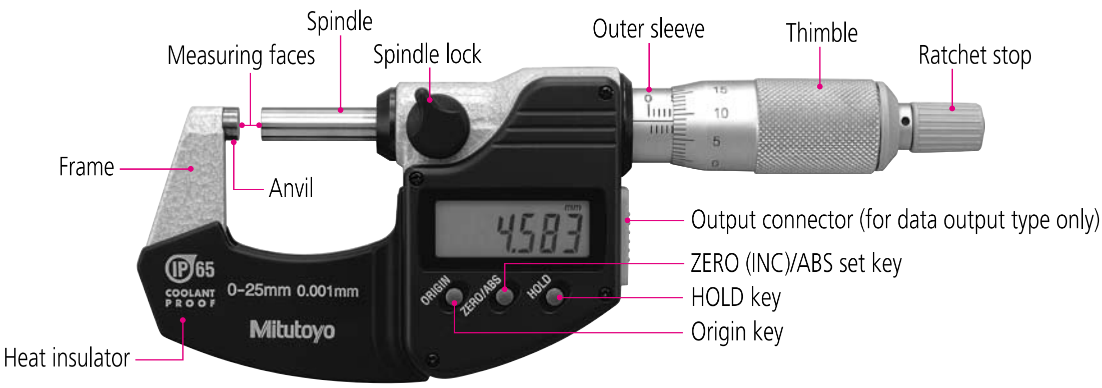
# Micrometers

## Nomenclature

### Standard Outside Micrometer

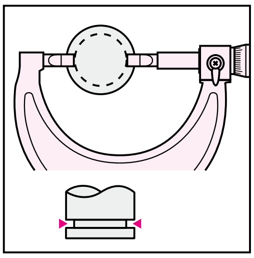



### Digimatic Outside Micrometer



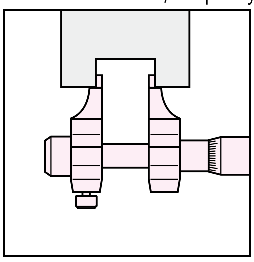

## Special Purpose Micrometer Applications

Blade micrometer



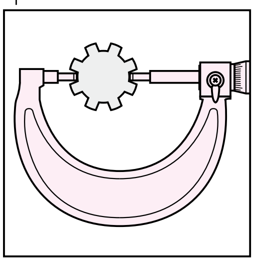
For diameter inside narrow groove measurement

Inside micrometer, caliper type



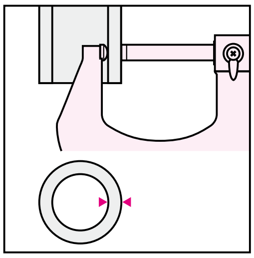
For small internal diameter, and groove width measurement

Spline micrometer



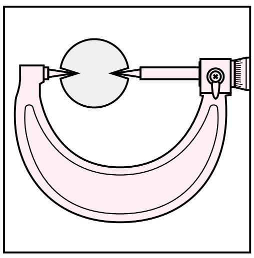
For splined shaft diameter measurement

Tube micrometer



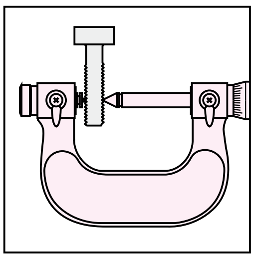
For pipe thickness measurement

Point micrometer



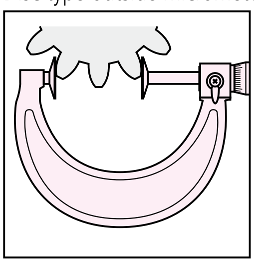
For root diameter measurement

Screw thread micrometer



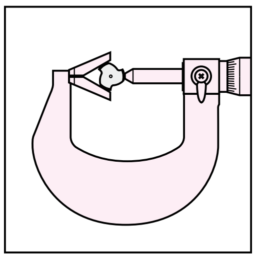
For effective thread diameter measurement

Disc type outside micrometer



For root tangent measurement on spur gears and helical gears

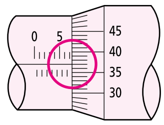
V-anvil micrometer



For measurement of 3- or 5-flute cutting tools

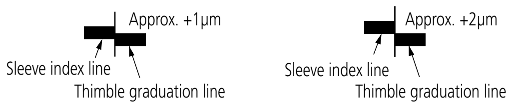
## How to Read the Scale

### Micrometer with standard scale (graduation: 0.01mm)



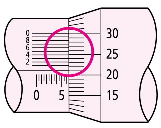

| | |
|---|---|
| Sleeve reading | 7. mm |
| Thimble reading | + .37mm |
| Micrometer reading | 7.37mm |

The scale can be read directly to 0.01mm, as shown above, but may also be estimated to 0.001mm when the lines are nearly coincident because the line thickness is 1/5 of the spacing between them.



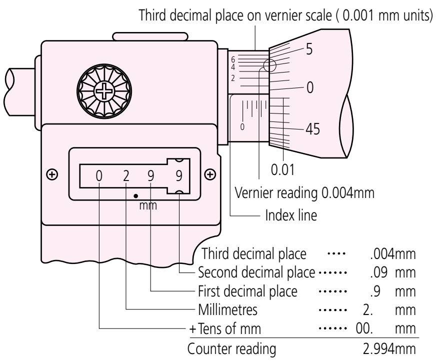

### Micrometer with vernier scale (graduation: 0.001mm)

The vernier scale provided above the sleeve index line enables direct readings to be made to within 0.001mm.




| | |
|---|---|
| Sleeve reading | 6. mm |
| Thimble reading | .21mm |
| Reading from the vernier scale marking and thimble graduation line | .003mm |
| Micrometer reading | 6.213mm |

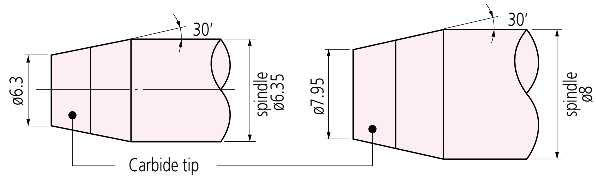
### Micrometer with digital display (resolution: 0.001mm)




## Constant-force Devices

| | Audible in operation | One-handed operation | Remarks |
|---|---|---|---|
| Ratchet stop | Yes | Unsuitable | Audible clicking operation causes micro-shocks |
| Friction thimble (F type) | No | Suitable | Smooth operation without shock or sound |
| Ratchet thimble (T type) | Yes | Suitable | Audible operation provides confirmation of constant measuring force |
| Ratchet thimble | Yes | Suitable | Audible operation provides confirmation of constant measuring force |

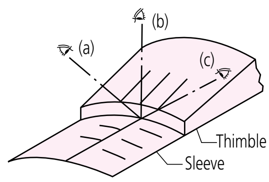
## Detailed Shape of Measuring Faces



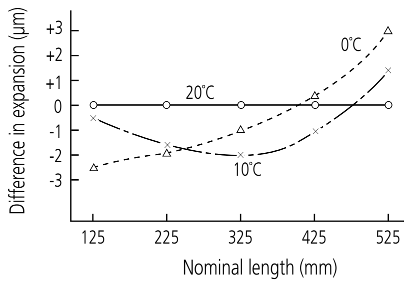

These drawings above are used for explaration and they are not to scale

## Potential Reading Error Due to Parallax

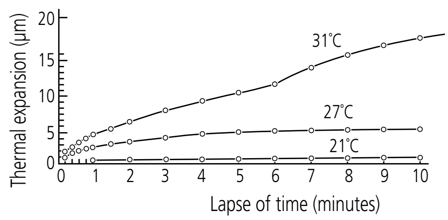
When a scale and its index line do not lie in the same plane it is possible to make a reading error due to parallax, as shown below. The viewing directions (a) and (c) will produce this error, whereas the correct reading is that seen from direction (b).




## Difference in Thermal Expansion between Micrometer and Standard Bar




## Standard Bar Expansion with Change of Temperature (for 200mm bar initially at 20˚C)

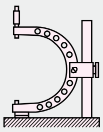
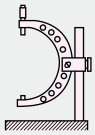


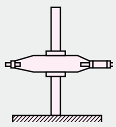
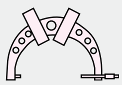

The graphs above show the change in size of a standard length bar when held in the hand at palm temperatures of 21˚C, 27˚C and 31˚C.

# Micrometers

## Measurement Error Depending on Attitude and Supporting Point (Unit: μm)

Since the measurement value is changed by the supporting point and maximum measuring length, it is recommended to use the instrument by performing zero-setting with the same orientation as it will be used in practice.

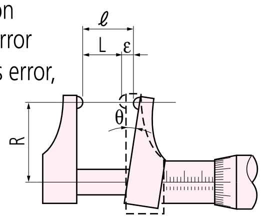
| Supporting point | Supported at the bottom and center | Supported only at the center |
|---|---|---|
| Attitude / Maximum measuring length (mm) |  |  |
| 325 | 0 | −5.5 |
| 425 | 0 | −2.5 |
| 525 | 0 | −5.5 |
| 625 | 0 | −11.0 |
| 725 | 0 | −9.5 |
| 825 | 0 | −18.0 |
| 925 | 0 | −22.5 |
| 1025 | 0 | −26.0 |

| Supporting point | Supported at the center in a lateral orientation. | Supported by hand downward. |
|---|---|---|
| Attitude / Maximum measuring length (mm) |  |  |
| 325 | +1.5 | −4.5 |
| 425 | +2.0 | −10.5 |
| 525 | −4.5 | −10.0 |
| 625 | 0 | −5.5 |
| 725 | −9.5 | −19.0 |
| 825 | −5.0 | −35.0 |
| 925 | −14.0 | −27.0 |
| 1025 | −5.0 | −40.0 |

## Abbe's Principle

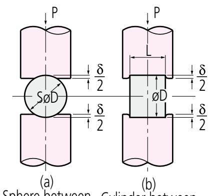
Abbe's principle states that "maximum accuracy is obtained when the scale and the measurement axes are common".

This is because any variation in the relative angle (q) of the moving measuring jaw on an instrument, such as a caliper jaw micrometer causes displacement that is not measured on the instrument's scale and this is an Abbe error ($\varepsilon = \ell - L$ in the diagram). Spindle straightness error, play in the spindle guide or variation of measuring force can all cause q to vary and the error increases with R.




## Hertz's Formulae

Hertz's formulae give the apparent reduction in diameter of spheres and cylinders due to elastic compression when measured between plane surfaces. These formulae are useful for determining the deformation of a workpiece caused by the measuring force in point and line contact situations.




(a) Sphere between two planes (b) Cylinder between two planes

Assuming that the material is steel and units are as follows:
Modulus of elasticity: E=196 GPa
Amount of deformation: δ (μm)
Diameter of sphere or cylinder: D (mm)
Length of cylinder: L (mm)
Measuring force: P (N)

a) Apparent reduction in diameter of sphere

$$\delta 1 = 0.82 \sqrt[3]{P^2/D}$$

b) Apparent reduction in diameter of cylinder

$$\delta 2 = 0.094 \cdot P/L \sqrt[3]{1/D}$$

## Effective Diameter of Thread Measurement

● Three-wire Method of Thread Measurement. The effective diameter of a thread can be measured by using three wires contacting the thread as shown in figure below. Effective diameter E can be calculated by using formula (1) or (2).

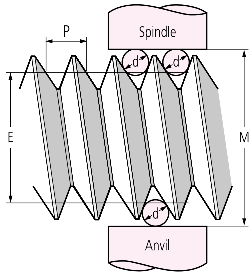
For metric or unified screw threads (60° thread angle)

$$E = M - 3d + 0.866025P \quad .......(1)$$

For Whitworth screw threads (55° thread angle)

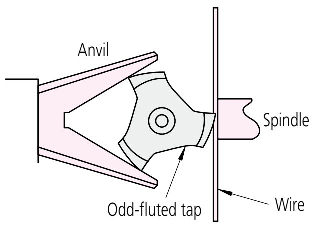
$$E = M - 3.16568d + 0.960491P \quad .......(2)$$

Where, P: Screw thread pitch (A pitch in inches is converted to its metric equivalent for unified screw threads.)
d: Mean diameter of the three wires
E: Effective diameter of the thread
M: Measurement over the three wires




| Screw thread type | Best wire size |
|---|---|
| Metric screw thread (60°) | 0.577P |
| Whitworth screw thread (55°) | 0.564P |

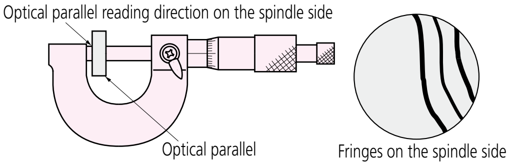
Single-wire Method of Thread Measurement. An Odd-fluted tap can be measured using a V-anvil micrometer and a single wire in contact with the thread flanks as shown. This method uses two measurements and a calculation to obtain an equivalent value for M as was obtained by direct measurement in the 'three-wire' method.
Where, M1: Maximum micrometer reading over the single wire (at cutting edge)
D: Maximum diameter of tap (at cutting edge)
For a three-flute tap: $M = 3M_1 - 2D$
Or for a five-flute tap: $M = 2.2360M_1 - 1.23606D$
Then, the effective diameter E can be calculated by substituting this M in formula (1) or (2)



## Hooke's Law

Hooke's law states that strain in an elastic material is proportional to the stress causing that strain, providing the strain remains within the elastic limit for that material.

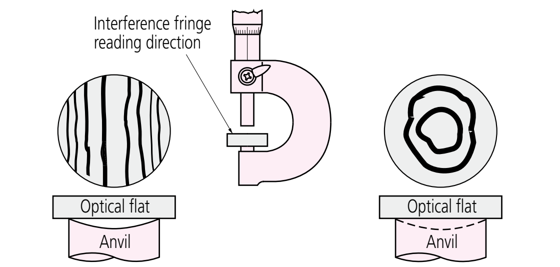
## Testing Parallelism of Micrometer Measuring Faces




Parallelism can be estimated using an optical parallel held between the faces. Firstly, wring the parallel to the anvil measuring face. Then close the spindle on the parallel using normal measuring force and count the number of red interference fringes seen on the measuring face of the spindle in white light. Each fringe represents a half wavelength difference in height (0.32µm for red fringes).
In the above figure a parallelism of approximately 1µm is obtained from 0.32µm x 3=0.96µm.

## Testing Flatness of Micrometer Measuring Faces

Flatness can be estimated using an optical flat (or parallel) held against a face. Count the number of red interference fringes seen on the measuring face in white light. Each fringe represents a half wavelength difference in height (0.32µm for red).




Measuring face is curved by approximately 1.3µm. (0.32µm x 4 paired red fringes.)

Measuring face is concave (or convex) approximately 0.6µm deep. (0.32µm x 2 continuous fringes)