Inspecting Geometric Tolerances Using a Roundness/ Cylindrical Geometry Measuring Instrument

JIS B 7451-1997: Roundness measuring instruments
JIS B 0621-1984: Definition and notation of geometric deviations
JIS B 0021-1998: Geometric property specifications (GPS) of products – Geometric tolerance notation method: Notation method of form, orientation, position, and runout

Compliments of
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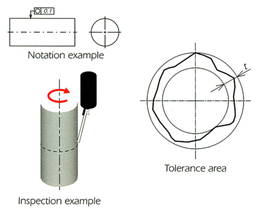
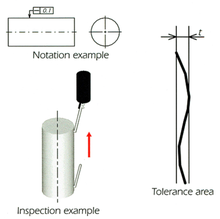
○ Roundness

Degree of deviation of a circular geometry from the geometrically true circle



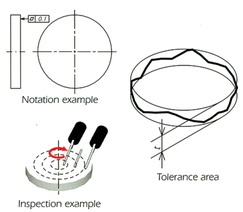
— Straightness

Degree of deviation of a linear geometry from the geometrically true straight line.



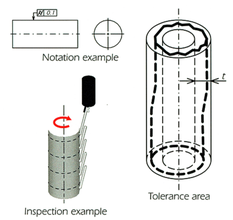
▱ Flatness

Degree of deviation of a planar geometry from the geometrically true flat surface



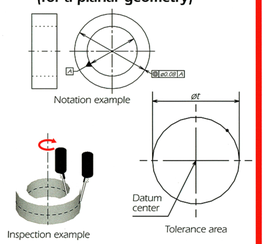
⌭ Cylindricity

Degree of deviation of a cylindrical geometry from the geometrically true cylinder



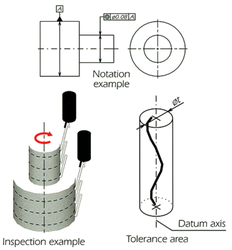
◎ Concentricity

Degree of deviation of the center position in a circular geometry from the datum circle center (for a planar geometry)



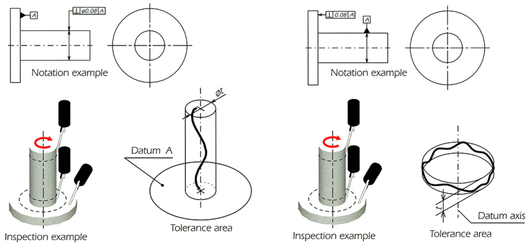
◎ Coaxiality

Degree of deviation of an axis from the datum axis, with which it is to be aligned



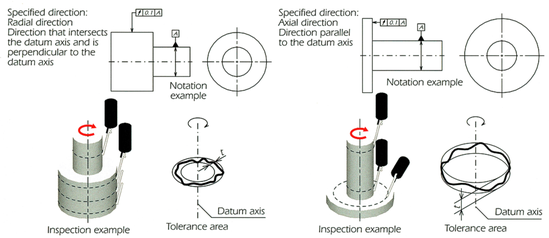
⊥ Squareness

Degree of deviation of a linear or planar geometry from the geometric line or plane perpendicular to the datum line or the datum plane



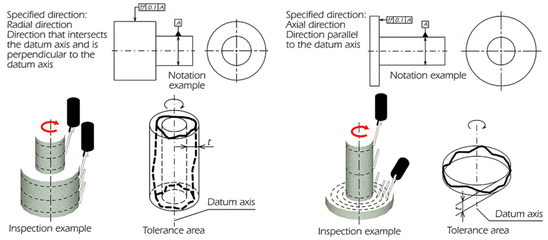
↗ Circular Runout

Degree of displacement of the object surface from the specified position or to the direction specified at a given position, if an object that should have a surface rotating on the datum axis or an object that should be a circular plane perpendicular to the datum axis is rotated on the datum axis



↗↗ Total Runout

Degree of displacement of the object surface to the specified direction, if an object that should have a cylindrical surface rotating on the datum axis or an object that should be a circular plane perpendicular to the datum axis is rotated on the datum axis



● Adjustment prior to Measurement

Centering

To prevent measurement errors due to eccentricity, centering must be performed so that the center of a geometric workpiece is sufficiently aligned with the rotation axis of the measuring instrument.

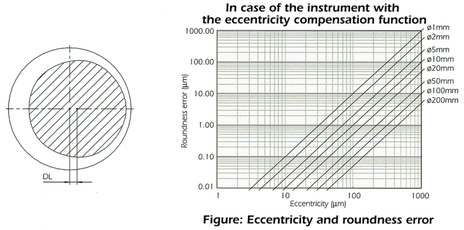


Figure: Eccentricity and roundness error

Leveling

The inclination of a geometric workpiece axis with respect to the rotation axis may cause an elliptic error. Leveling must be performed so that the workpiece axis is sufficiently parallel to the rotation axis.

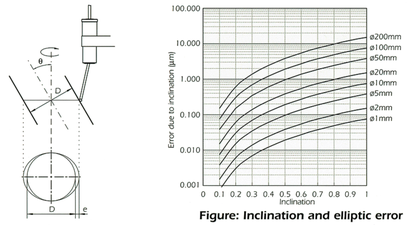


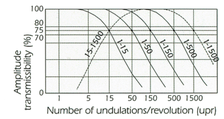
Figure: Inclination and elliptic error

● Filter Cutoff Value and Combination

Filter type	Cutoff value and its combination (number of undulations/revolution, upr)
Low-pass filter	15 50 150 500 (1500)
High-pass filter	(15) (50) (150)
Band-pass filter (combination of low-pass and high-pass filters)	(15-150) (15-500) (50-500) (15-1500) (50-1500) (150-1500)

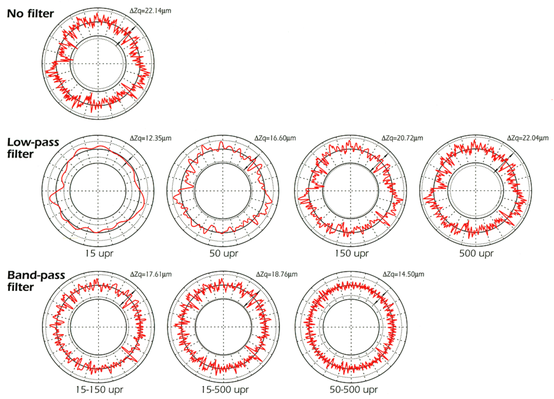
The cutoff value and its combination in parentheses may not always be selected.

● Relationship between the Amplitude Transmissibility and Number of Undulations of a Filter



● Roundness Difference due to Variations of Filter Cutoff Value

Roundness is greatly affected by a variation of filter cutoff value. It is necessary to set up the filter appropriate for evaluation purpose.

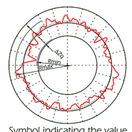


● Evaluation Method of Roundness

To evaluate the roundness of a circular object using the radius method, it is necessary to define its center clearly. There are four kinds of evaluation methods of roundness as follows:

Least Square Circle (LSC) Method

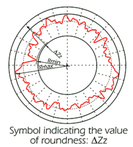
Define such a reference circle that the sum of the squares of the deviation from a circular geometry is a minimum. Assuming the center coordinate of this circle as the center of the circular geometry, roundness is defined as the radial difference between two circles which are inscribed and circumscribed with the circular geometry and concentric to it.



Symbol indicating the value of roundness: ΔZq

Minimum Zone Circles (MZC) Method

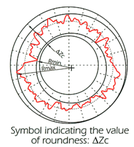
Define the center coordinate of two concentric circles between which a circular geometry is positioned, so that the radial difference between the two circles is a minimum. Assuming the center coordinate of the circles as the center of the circular geometry, roundness is defined as the radial difference between the two circles.



Symbol indicating the value of roundness: ΔZz

Minimum Circumscribed Circle (MCC) Method

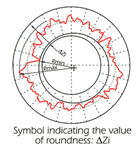
Determine the circumscribed circle on a circular geometry. Assuming the center of this circle as that of the circular geometry, draw a circle which is concentric to the circular geometry and inscribed with it. Roundness is defined as the radial difference between the two circles.



Symbol indicating the value of roundness: ΔZc

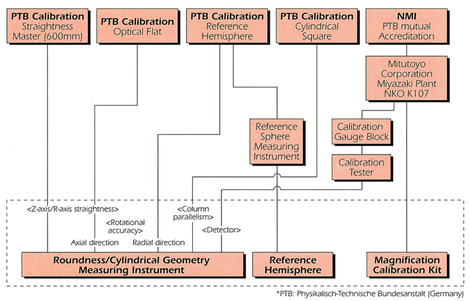
Maximum inscribed Circle (MIC) Method

Determine the inscribed circle on a circular geometry. Assuming the center of this circle as that of the circular geometry, draw a circle which is concentric to the circular geometry and circumscribed with it. Roundness is defined as the radial difference between the two circles.



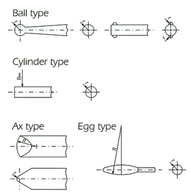
Symbol indicating the value of roundness: ΔZi

● Traceability System to Roundness/ Cylindrical Geometry Measuring Instruments (Traceability System to PTB*)



*PTB: Physikalisch-Technische Bundesanstalt (Germany)

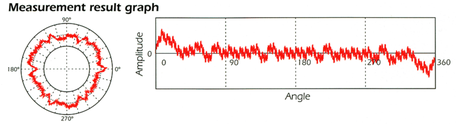
● Stylus Tip



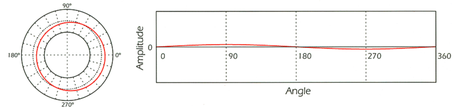
Tip shape: Ball, ax, cylinder, and egg
Tip radius : 0.25mm, 0.8mm, 2.5mm, 8mm, 25mm (tolerance: ±30% of the nominal value)
Measuring force: 250mN or less

● Undulation Components Included in a Measurement Result Graph

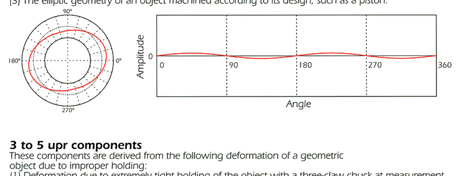
Measurement result graph



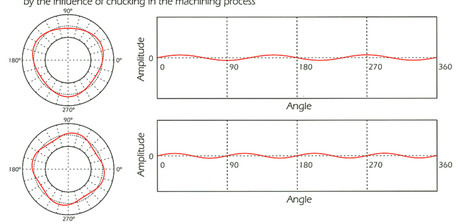
1 upr component
This component is derived from the eccentricity of a geometric object from the rotation center of the measuring instrument.
The amplitude of 1 upr component varies depending on the leveling adjustment even on the same geometric object.
The amplitude of the first harmonic component varies depending on the leveling adjustment even on the same geometric object.



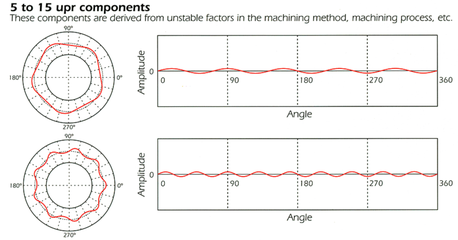
2 upr component
This component is derived from:
(1) Insufficient leveling adjustment at the setup of a geometric object on the measuring instrument.
(2) Circular runout due to incorrect mounting of a geometric object on the rotation axis of the machine tool in the machining process.
(3) The elliptic geometry of an object machined according to its design, such as a piston.



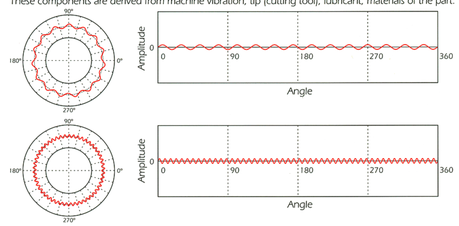
3 to 5 upr components
These components are derived from the following deformation of a geometric object due to improper holding:
(1) Deformation due to extremely tight holding of the object with a three-claw chuck at measurement (Care should be exercised for measurement of soft materials, thin parts, etc.)
(2) Deformation at the time of releasing a part from chucking due to stress accumulated in the part by the influence of chucking in the machining process



5 to 15 upr components
These components are derived from unstable factors in the machining method, machining process, etc.



15 or more upr components
These components are derived from machine vibration, tip (cutting tool), lubricant, materials of the part.



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