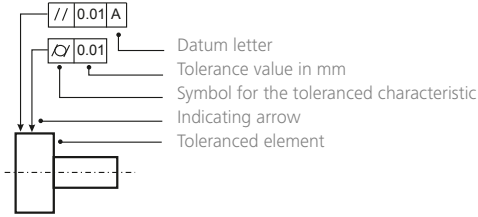




Form measurement systems
from Hommel-Etamic
Geometrical tolerancing in practice

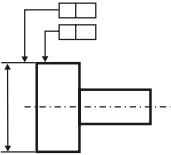


Tolerance frame

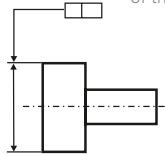


Toleranced elements

Indicating arrow to contour line or subsidiary line (offset from dimension line):
if the tolerance refers to the line or area.

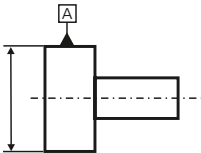


Indicating arrow as an extension of the dimension line:
if the tolerance applies for the axis or median plane or a point of the element.

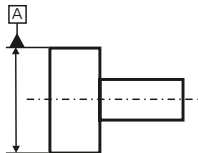


Datums

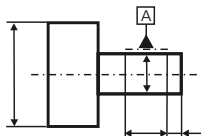
Datum triangle with datum letters on the contour line of the element or on the subsidiary line:
if the displayed datum is a line or area.



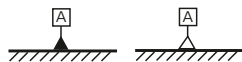
as an extension of the dimension line:
if the datum is the axis, the median plane or an appropriately dimensioned point.



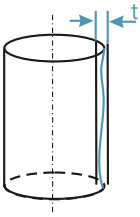
Restriction of the datum to an area of the element as a dot-dash line with dimensioning.



A filled in or empty datum triangle has the same meaning.



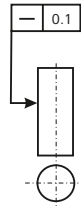
— Straightness



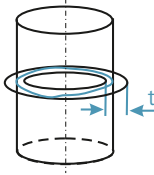
The tolerance zone is limited by two parallel lines at a distance t apart. Every envelope line of the tolerated cylinder must be between these two parallel lines.

Example

Every envelope line of the tolerated cylinder surface must be between two parallel lines at a distance apart of 0.1.



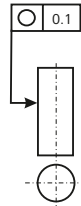
○ Roundness



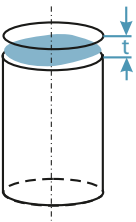
The tolerance zone is limited by two concentric circles at a distance t apart. The circumference line of the tolerated cylinder must be within a circle ring of the zone width t , in every radial section plane.

Example

The circumference line of the tolerated cylinder must be within a circle ring of the zone width 0.1 in every radial section plane.



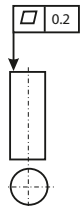
□ Flatness



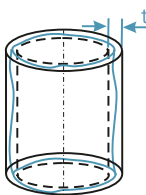
The tolerance zone is limited by two parallel planes at a distance t apart, the dimensions of which correspond to those of the tolerated area. The real workpiece area must be between the two parallel planes at distance t apart.

Example

The real workpiece area must be between two parallel planes at a distance apart of 0.2.



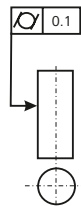
○ Flatness



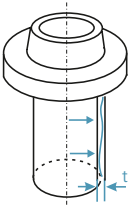
The tolerance zone for the cylinder envelope area limits the deviation of the roundness, the straightness of the envelope line and the parallelism of the envelope line to the cylinder axis. It is formed by two coaxial cylinders with the radial distance t .

Example

The tolerated cylindrical area must be between two coaxial cylinders with a radial distance of 0.1.

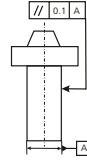


// Parallelism

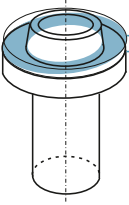


The tolerance zone within which the envelope lines of the tolerated cylinder must lie is limited by two parallel lines at a distance t apart which run parallel to the datum plane.

Example Every single envelope line of the tolerated area must be between two parallel lines that are at a distance of 0.1 apart, and are parallel to the center axis.

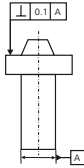


⊥ Perpendicularity

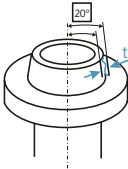


The tolerance zone is limited by two parallel planes at a distance t apart, which are perpendicular to the datum axis. The tolerated plane face must be between these two planes.

Example All points/circle lines of the tolerated area must be between two parallel planes that are at a distance of 0.1 apart, and are perpendicular to the datum plane.

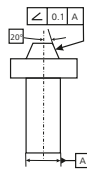


∠ Angularity

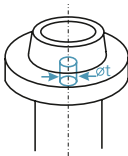


The tolerance zone is limited by two parallel planes at a distance t apart at the nominal angle to the datum axis.

Example All points of the tolerated area must be between two parallel planes that are at a distance apart of 0.1, and are angled at 20° to the datum axis.

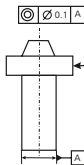


◎ Coaxiality

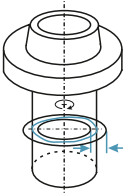


The tolerance zone is limited by a cylinder of diameter t , the axis of which matches the datum axis. The actual axis of the tolerated element must be within the tolerance zone.

Example The axis of the tolerated cylinder must be within a cylinder that has a diameter of 0.1 and is coaxial to the datum axis A.

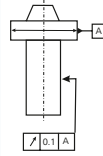


Radial run-out



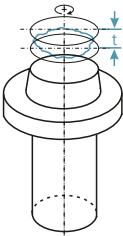
In every radial section plane perpendicular to the surface, the tolerance zone is limited by two concentric circles at a distance t apart, the common center point of which is on the datum axis. The radial run-out tolerance applies generally for a full revolution of the tolerated element around the datum axis.

Example



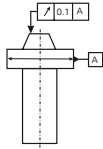
The circumference line of every radial section plane of the tolerated cylindrical area must be between two concentric circles at a distance apart of 0.1 with their common center point on the datum axis A.

Axial run-out



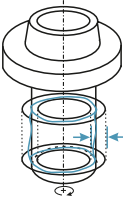
The tolerance zone is limited in every radial distance of two circles at a distance t apart. The circles are in a cylinder, the axis of which matches the datum axis. The diameter of the cylinder can adopt any value of the diameter of the plane face.

Example



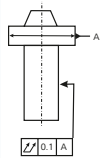
Every circle line of the tolerated area must be between two parallel circle planes at a distance apart of 0.1 with their common center point on the datum axis A.

Total radial run-out



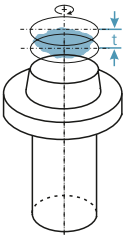
The tolerance zone is limited by two coaxial cylinders at a distance t apart, the axes of which match the datum axis. After several rotations around the datum axis and axial shift of the transducer all points of the tolerated element must be within the tolerance zone.

Example



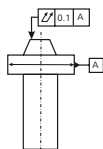
The tolerated cylindrical area must be between two coaxial cylinders with a radial distance apart of 0.1 with their common axis on the datum axis A.

Total axial run-out



The tolerance zone is limited by two parallel planes at a distance t apart, which are perpendicular to the datum (rotational) axis. After several rotations around the datum axis and radial shift of the transducer, all points of the surface of the tolerance plane face must be within the tolerance zone.

Example



The tolerated area must be between two parallel circle planes at a distance apart of 0.1 with their common center point on the datum axis A.

Our global presence.



Our service range

Metrology

Tactile metrology
Pneumatic metrology
Optical metrology

Product range

Roughness measurement
Contour measurement
Form measurement
Optical shaft measurement
Dimensional measurement
Optical surface inspection

Inspection process

In-process
Post-process
PLC
Final inspection
Measuring room

Service

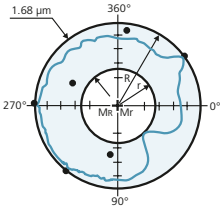
System solutions
DKD calibration service
Consulting, training and service



www.hommel-etamic.com

Evaluation method

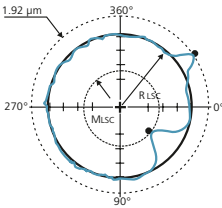
Effect and function of different evaluation methods on the roundness evaluation



MZCI Minimum Zone Circle

Concentric inner and outer perimeter circles with a minimum radial distance, and which enclose the roundness profile.

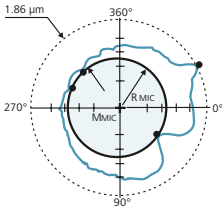
Individual profile peaks influence the center point **considerably**.
Gives the least possible form error.



LSCI Least Square Circle

Circle through the roundness profile with minimum sum of profile deviation squares.

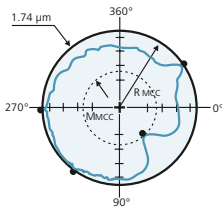
Individual profile peaks influence the center point **only a little**.
Very suitable for stable datum formation.



MICI Maximum Inscribed Circle

Maximum circle inscribed in the roundness profile for inside areas.

The method is used for form measurement of the inside diameter.



MCCI Minimum Circumscribed Circle

Minimum circle circumscribing the roundness profile for outside areas.

The method is used for form measurement of the outside diameter.

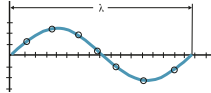
Filtering method

Definition according to ISO 11562 for roughness and form measurement.

Filter characteristic: Gaussian amplitude transmission function

Amplitude damping at cut-off λc : 50 %

Number of points per wave



At least 7 points per wave must be selected.

Roundness measurement: Specification of cut-off in w/r (waves/revolution). The specification is independent of the workpiece diameter.

Recommended cut-off numbers: 15, 50, 150, 500 w/r

Conversion of w/r to wavelength: $\lambda c = D \times 3.14 / \text{number of cut-offs}$

Straightness measurement: Specification of cut-off in mm

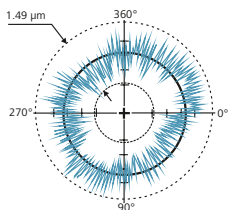
Recommended cut-offs: 0.25; 0.8; 2.5; 8.0 mm

Recommended filter settings for roundness measurement

	Workpiece \varnothing (mm)	Number of cut-offs (s/r)	Measuring points per circumference
Form only	... 8	15	> 105
	> 8 ... 25	50	> 350
	> 25 ... 250	150	> 1050
	> 250	500	> 3500
Form and waviness	...8	50	> 350
	> 8 ... 25	150	> 1050
	> 25 ... 250	500	> 3500
	> 250	1500	> 10500
Waviness only	...8	50-150	> 1050
	> 8 ... 25	50-500	> 3500
	> 25 ... 250	50-500	> 3500
	> 250	150-1500	> 10500

Filter stages

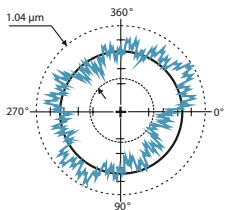
Filter effect of different cut-off numbers on the roundness result.
Gauss filter 50 %



No filter

☐ 1.49 μm

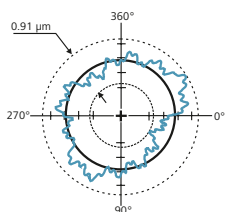
RONt (MZCI) = 1.49 μm



Filter 150 W/R

☐ 1.04 μm

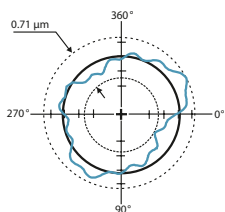
RONt (MZCI) = 1.04 μm



Filter 50 W/R

☐ 0.91 μm

RONt (MZCI) = 0.91 μm



Filter 15 W/R

☐ 0.71 μm

RONt (MZCI) = 0.71 μm

Tolerances of form, orientation, location and run-out according to ISO 1101

Using the standardized tolerance specifications, tolerance zones are determined within which the tolerated elements (line, area, point, axis, median plane) of the workpiece must lie.

Form tolerance refers to the tolerance zone that limits the deviation of a form element from its ideal geometry (straightness, flatness, roundness, cylindricity) and is orientated exclusively to the tolerated element. Only the tolerances for profile any line and profile any surface require theoretically exact dimension specifications and datums.

An orientation tolerance refers to a tolerance zone with which the deviation from the general direction (parallelism, perpendicularity, angularity) between the tolerated element and the datum and form deviation of the tolerated element is limited.

Location tolerance refers to the tolerance zone which limits the deviation of the tolerated element (position, coaxiality, concentricity, symmetry) from its ideal geometrical location, which must be defined clearly by a datum or a system of datums.

A run-out tolerance refers to a tolerance zone which limits the form and position deviations of envelope areas or plane faces in relation to the rotational axis.

General tolerances according to ISO 2768

For workpieces produced by cutting

All dimensions in mm

Tolerance class H

Nominal dimension range	...10	> 10 ...30	> 30 ...100	> 100 ...300	> 300 ...1000	> 1000 ...3000
	0.02	0.05	0.1	0.2	0.3	0.4
	0.2			0.3	0.4	0.5
				0.5		
				0.1		

Tolerance class K

Nominal dimension range	...10	> 10 ...30	> 30 ...100	> 100 ...300	> 300 ...1000	> 1000 ...3000
	0.05	0.1	0.2	0.4	0.6	0.8
	0.4			0.6	0.8	1.0
	0.6				0.8	1.0
				0.2		

Tolerance class L

Nominal dimension range	...10	> 10 ...30	> 30 ...100	> 100 ...300	> 300 ...1000	> 1000 ...3000
	0.1	0.2	0.4	0.8	1.2	1.6
	0.6			1.0	1.5	2.0
	0.6			1.0	1.5	2.0
				0.5		

Tolerance value corresponds to the diameter tolerance or maximum general tolerance for the radial run-out.

Tolerance value corresponds to the maximum value in comparison of the dimension tolerance of the distance dimension with the general tolerance for the straightness or the flatness of the form elements being inspected.