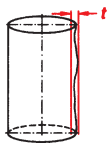
General notes on form and location tolerances

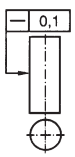
A **form and location tolerance** of a feature (surface, axis, point or median plane) defines the zone within which every point of this feature is to be contained.
According to the feature to be toleranced and the manner in which it is dimensioned, **the tolerance** zone is one of the following:

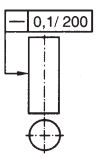
- the area within a circle
- the area between two concentric circles
- the area between two parallel, straight lines
- the area between two equidistant lines
- the space between two parallel planes
- the space between two equidistant surfaces
- the space within a cylinder
- the space between two coaxial cylinders
- the space within a parallelepiped

For **location tolerances**, it is necessary to define a **datum** indicating the exact location if the tolerance zone. A datum is a theoretically exact, geometrical feature (e.g. axis, plane, straight line, etc.); datums can be based on one or several **datum features**.
The **toleranced feature** may be on any form, location or orientation within the tolerance zone, unless a more restrictive indication is given.
The **tolerance value** *t* is indicated in the same unit used for linear measurements. If not otherwise specified, the tolerance applies to the whole lenght or surface of the toleranced feature.

Straightness, ISO 1101







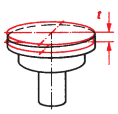
Definition
The tolerance zone is limited in the measuring plane by two parallel straight lines a distance *t* apart.

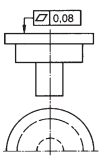
Examples
Any generating line of the toleranced cylindrical surface shall be contained between two parallel, straight lines 0.1 apart.

Any portion of length 200 of any generating line of the toleranced cylindrical surface shall be contained between two parallel, straight lines 0.1 apart.

Note
For further straightness tolerances, see ISO 1101.

Flatness, ISO 1101

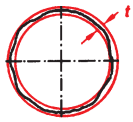




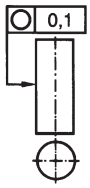
Definition
The tolerance zone is limited by two parallel planes a distance *t* apart.

Example
The toleranced surface shall be contained between two parallel planes 0.08 apart.

Roundness, ISO 1101

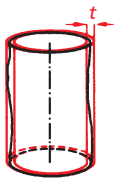


Definition
The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance *t* apart.

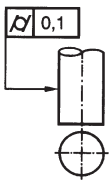


Example
The circumference of any cross-section of the toleranced cylindrical surface shall be contained between two concentric circles 0.1 apart.

Cylindricity, ISO 1101

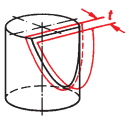


Definition
The tolerance zone is limited by two coaxial cylinders a distance *t* apart.

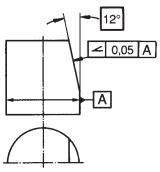


Example
The toleranced cylindrical surface shall be contained between two coaxial cylinders 0.1 apart.

Angularity, ISO 1101

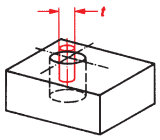


Definition
The tolerance zone is limited by two parallel planes a distance *t* apart and inclined at the specified angle to the surface.

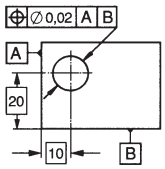


Example
The tolerance surface shall be contained between two parallel planes 0.05 apart which are inclined at 12° to the datum axis **A**.

Position, ISO 1101



Definition
If the tolerance value is preceded by the sign ∅, the tolerance zone is limited by a cylinder of diameter *t*, the axis of which is in the theoretically exact position of the toleranced line.

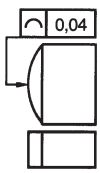


Example
This axis of the toleranced bore shall be contained within a cylinder of diameter 0.02, the axis of which is in the theoretically exact position with respect to the surfaces **A** and **B**.

Note
For the positional tolerance of a point or a plane, see ISO 1101.

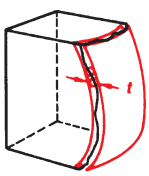
Profile any line, ISO 1101

Definition
The tolerance zone is limited by two lines enveloping circles of diameter *t*, the centres of which are situated on a line having the true geometrical form.

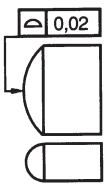


Example
In each section parallel to the plane of projection, the toleranced profile shall be contained between two lines enveloping circles of diameter 0.04, the centres of which are situated on a line having a true geometrical form.

Profile any surface, ISO 1101

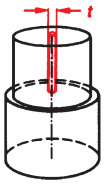


Definition
The tolerance zone is limited by two surfaces enveloping spheres of diameter *t*, the centres of which are situated on a surface having the true geometrical form.

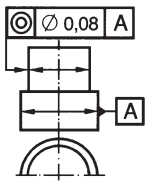


Example
The considered surface shall be contained between two surfaces enveloping spheres of diameter 0.02 the centres of which are situated on a surface having the true geometrical form.

Concentricity / Coaxiality, ISO 1101



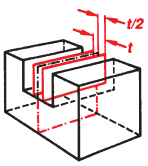
Definition (coaxiality)
The tolerance zone is limited by a cylinder of diameter *t*, the axis of which coincides with the datum axis.



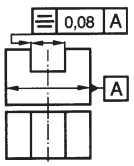
Example (coaxiality)
The axis of the toleranced cylinder shall be contained within a cylinder of diameter 0.08 coaxial with the datum axis **A**.

Note
For concentricity tolerance, see ISO 1101

Symmetry, ISO 1101



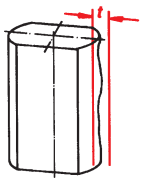
Definition
The tolerance zone is limited by two parallel planes a distance *t* apart and symmetrically disposed to the median plane with respect to the datum axis or datum plane.



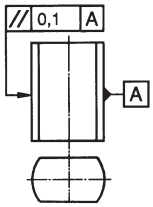
Example
The median plane of a slot shall be contained between two parallel planes which are 0.08 apart and symmetrically disposed to the median plane with respect to the datum feature **A**.

Note
For symmetry tolerance of a line or an axis, see ISO 1101.

Parallelism, ISO 1101



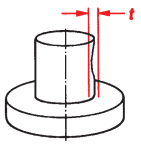
Definition
The tolerance zone is limited in the measuring plane by two straight lines a distance *t* apart and parallel to the datum.



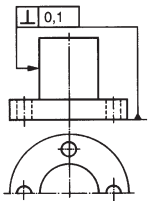
Example
Any generating line of the toleranced surface shall be contained between two straight lines 0.1 apart and parallel to the datum surface **A**.

Note
For further parallelism tolerances, see ISO 1101.

Perpendicularity, ISO 1101



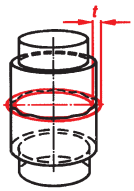
Definition
The tolerance zone is limited in the measuring plane by two parallel, straight lines a distance *t* apart and perpendicular to the datum.



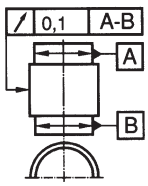
Example
Any generating line of the toleranced cylindrical surface shall be contained between two straight lines 0.1 apart and perpendicular to the datum surface.

Note
For further perpendicular tolerances, see ISO 1101.

Radial run-out, ISO 1101



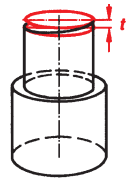
Definition
The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance *t* apart, the common centre of which lies on the datum axis.



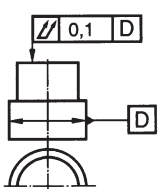
Example
The circumference of any cross-section of the toleranced cylindrical surface shall be contained between concentric circles 0.1 apart, the common centre of which lies on the datum axis formed by **A** and **B**.

Note
When taking the measurement, the workpiece has to be turned about the datum axis. For axial run-out and run-out tolerances in any or a specified direction, see ISO 1101.

Total run-out, ISO 1101



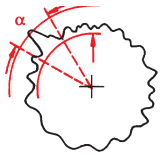
Definition (total axial run-out)
The tolerance zone is limited by two parallel planes a distance *t* apart and perpendicular to the datum axis.



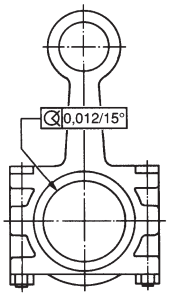
Example (total axial run-out)
The toleranced surface shall be contained between two parallel planes 0.1 apart and perpendicular to the datum axis **D**.

Notes
When taking the measurement, the workpiece has to be turned around the datum axis several times. Workpiece and measuring instrument have to move radially to each other. For total radial run-out, see ISO 1101.

Angular sector roundness, not yet described by standards.



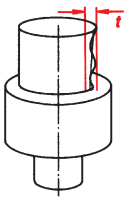
Definition
The tolerance zone is limited in the measuring plane perpendicular to the axis by two concentric circles a distance apart. The measured circumfence shall be contained in any angular sector *t* starting from the profile centre within the tolerance zone.



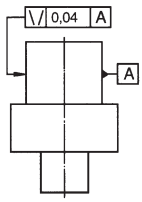
Example
The "local" roundness deviation shall be smaller than 0.012 in any angular sector starting from the profile centre and featuring a width of 15°.

Note
The roundness deviation as per ISO 1101 may be greater, if necessary, it can be toleranced separately.

Conicity, Not yet described by standards.



Definition
The tolerance zone is limited in the measuring plane by two straight lines a distance *t* apart and parallel to the datum. Not the measured profile, but that section of the reference straight line calculated according to **LSS** which is restricted to the measuring lenght shall be contained within the tolerance zone.



Example
Each section of a reference straight line calculated according to **LSS** which is measured in the toleranced, cylindrical surface shall be contained between two straight lines 0.04 apart and parallel to the opposite generating line.

Note
The parallelism deviation may be greater, if necessary, it can be toleranced separately.

General tolerances [mm] for machined workpieces, ISO 2766

Tolerance class H

Range of nom, lenght	... 10	> 10 ... 30	> 30 ... 100	> 100 ... 300	> 300 ... 1,000	> 1,000 ... 3,000
⏤ ▱	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 L

Range of nom, lenght	... 10	> 10 ... 30	> 30 ... 100	> 100 ... 300	> 300 ... 1,000	> 1,000 ... 3,000
⏤ ▱	0,1	0,2	0,4	0,8	1,2	1,6
⊥		0,6		1	1,5	2
⌯		0,6		1	1,5	2
⌭			0,5			

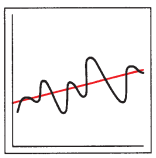
Tolerance class K

Range of nom, lenght	... 10	> 10 ... 30	> 30 ... 100	> 100 ... 300	> 300 ... 1,000	> 1,000 ... 3,000
⏤ ▱	0,05	0,1	0,2	0,4	0,6	0,8
⊥		0,4		0,6	0,8	1
⌯			0,6		0,8	1
⌭			0,2			

Roundness
The general tolerance on roundness is the **minimum** formed by the diameter tolerance and the general tolerance on run-out.

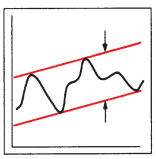
Parallelism
The general tolerance on parallelism is the **maximum** formed by the dimensional tolerance and the general tolerance on straightness/flattness.

Formtester – Evaluation methods e.G. ISO 2766



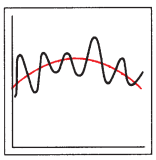
Regression straight line (Gaussian straight line)
Mean line laid throught the measured profile such that the sum of the squares of all profile deviations is a minimum.

(**LSS** = **L**east **S**quare **S**traight line)



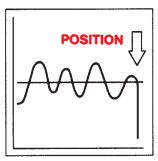
Enveloping parallel lines
Parallel, straight lines enclosing the profile and having the least separation.

(**MZS** = **M**inimum **Z**one **S**traight lines)



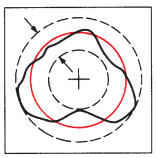
Regression parabola
Mean parabola (2nd order) laid through the profile such that the sum of the squares of all profile deviations is a minimum.

(**LSP** = **L**east **S**quare **P**arabola)



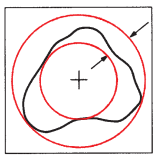
Edge identifikation
The position of a profile interruption (edge) is determindes. The profile is evaluated up to the edge according to LSS.

(**EID** = **E**dge**ID**entification)



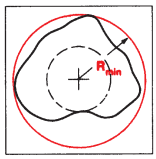
Regression circle (Gaussian straight circle)
Circle laid into the measured circular profile such that the sum of the squares of all profile deviations is a minimum.

(**LSC** = **L**east **S**quare **C**ircle)



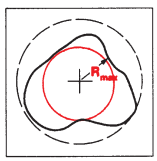
Circular zone with minimum radial separation
Concentric circles enclosing the circular profile and having the least radial separation.

(**MZC** = **M**inimum **Z**one **C**ircles)



Minimum circumscribed circle
Smallest possible circle which can be fitted around the circular profile.

(**MCC** = **M**inimum **C**ircumscribed **C**ircle)



Maximum inscribed circle
Largest possible circle which can be fitted within the circular profile.

(**MIC** = **M**aximum **I**nscribed **C**ircle)