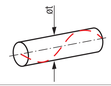
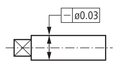
Form tolerances

Straightness

Tolerance zone

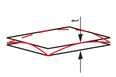


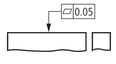
Drawing notation



The extracted median line of the cylindrical part of the bolt shall be contained within a cylindrical zone of diameter 0.03 mm.

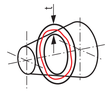
Flatness

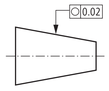




The toleranced surface shall be contained between two parallel planes 0.05 mm apart.

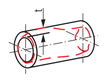
Roundness

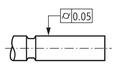




The extracted circumferential line of any cross section shall be between two concentric circles with a difference in radii of 0.02 mm.

Cylindricity



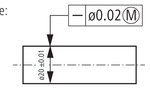


The extracted cylindrical surface shall be between two coaxial cylinders that have a radial distance of 0.05 mm.

Drawing notations

Ⓔ Symbol for envelope requirement
Ⓜ Symbol for maximum material requirement
Ⓟ Symbol for projected tolerance zone
Ⓛ Symbol for minimum material requirement

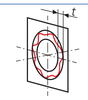
Example:

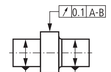


Maximum material condition (simple case):
the maximum material requirement (MMR) permits utilization of unused dimension tolerances portions through the toleranced form or location error.
Example: cylinder diameter dimension tolerance 20 ±0.01 and the axis straightness tolerance t= 0.02. If the actual diameter is 19.99 mm, the straightness of the axis can deviate up to 0.04 mm.

Run-out tolerances

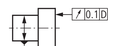
Radial run-out





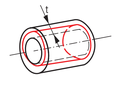
The extracted circumferential line in any cross-section plane perpendicular to the common datum axis A-B shall be between two coplanar and to A-B concentric circles with a difference in radii of 0.1 mm.

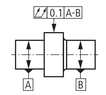
Axial run-out



The extracted line in any cylindrical section, the axis of which coincides with datum axis D, shall be between two parallel planes perpendicular to datum axis D with a distance of 0.1 mm.

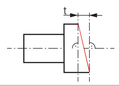
Total radial run-out

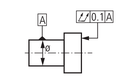




The extracted surface shall be within two cylinders lying coaxially to the common datum straight line A-B whose radial distance is 0.1 mm.

Total axial run-out





The extracted surface shall be between two parallel planes perpendicular to datum axis A with a distance of 0.1 mm.

Orientation tolerances

Parallelism of a line

Tolerance zone

Drawing notation

The extracted median line shall be within a cylinder lying parallel to datum axis A with a diameter of 0.1 mm.

Parallelism of a surface

The extracted surface shall be between two planes parallel to datum plane A with a distance of 0.01 mm apart.

Perpendicularity

The extracted median line shall be within a cylinder of diameter 0.05 mm lying perpendicular to datum plane A.

Angularity

The extracted median line shall be between two parallel planes 0.1 mm apart that are inclined at a theoretically exact angle of 60° to datum plane A.

Location tolerances

Position

The extracted median line shall be within a cylinder of diameter 0.05 mm whose axis is located at the theoretically exact position with respect to datum planes B and C and perpendicular to datum plane A.

Symmetry

The extracted median surface shall be between two parallel planes 0.08 mm apart and symmetrical to the median datum plane A.

Coaxiality (for axes) Concentricity

Coaxiality: The extracted median line of the toleranced cylinder shall be in a cylinder of diameter 0.03mm, the axis of which is datum axis A.
Concentricity: The extracted center point of the toleranced circle shall be within a 0.03 mm diameter circle whose center point is concentric to datum point A in the same cross section.

Profile tolerances

Profil tolerance of a line not related to a datum

The extracted profile line of any section shall be between two enveloping lines whose distance is determined by circles with a diameter of 0.08 mm. The midpoints are located on the theoretically exact geometrical form.

Profil tolerance of a surface not related to a datum

The extracted surface shall be between two enveloping surfaces whose distance is determined by spheres with a diameter of 0.03 mm.
The centres of the spheres are located on the surface having the theoretically exact geometrical form.

Created in cooperation with Prof. Dr. habil. Eberhard Heidt, Chemnitz

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Form and position toleration – ISO 1101 brief information

1. General

Form tolerances limit the error of a single feature from its geometrically ideal form.

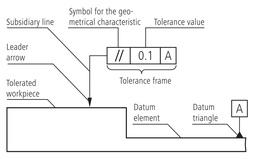
Orientation, location and runout tolerances limit the errors of the mutual location of two or more features. One or more features can be specified as datum features. A datum feature should be sufficiently form accurate for its intended use. Therefore, it may be necessary to specify form tolerances for the datum features.

Unless otherwise specified, the tolerance for the overall expansion of the toleranced feature applies. If a limited area is indicated, e.g. 0.02/50 it means that a tolerance of 0.02 mm applies for a length of 50 mm at any location along the toleranced element. When tolerances are specified, the following procedure is recommended:

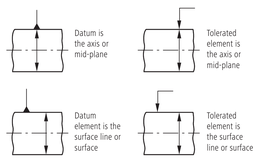
1. Are the general tolerances for form and location errors (ISO 2768-2) sufficient depending on the production procedure?
   If no:
2. Specify the toleranced feature
3. Specify the datum (if required)
4. Specify the type of tolerance
5. Form tolerance for datum required?
6. Form tolerance of the toleranced feature required?

2. Symbols

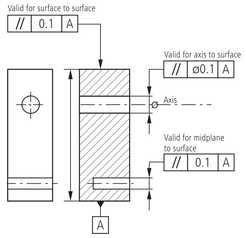
2.1 Identification of the toleranced feature and the datum.



The following possibilities of drawing notations have been defined depending on the requirement for datums, datum elements and toleranced features:



Example of parallelism:



A

A single datum is identified with a capital letter.

A-B

A joint datum created by two datums is identified by two datum letters combined by a horizontal line.

A B C

If the order of two or more datums is important, these datum letters must be placed in different boxes where the order from left to right identifies the hierarchy and must be adhered to during the measurement. (See ISO 5459 "Technical drawings; geometrical tolerancing; datums and datum-systems for geometrical tolerances")

// 0.01/100 B

If the tolerance value applies to a limited length at any location of the toleranced feature, the value of this length is given after the tolerance value and separated from it through a slash.

// Ø 0.01 B

If the Ø symbol precedes the tolerance value, it means that the tolerance zone is a cylinder. Without the Ø symbol, the tolerance only applies in the direction of the leader arrow.

50

Theoretical dimensions are tolerance-less dimensions that are required for specifying the geometrically ideal (theoretically exact) location and form of the dimensioned element. They are identified through a squared frame.

General tolerances for form and location in accordance with ISO 2768-2

ISO 2768-2 is used to simplify drawings **and defines general tolerances in three tolerance classes for form and location.**

The selection of a specific tolerance class will take into consideration the respective accuracy common in the workshop.

If narrower tolerances are required for form and location or larger tolerances are more economical, these tolerances must be entered directly in accordance with ISO 1101.

General tolerances for form and location **apply for form elements in which the form and location tolerances are not entered individually.** They can be applied for all properties of form elements with the exception of the cylinder form, profile of a line or surface, inclination, concentricity, position and total runout.

Tolerance classes	General tolerances for straightness and flatness in mm					
	Nominal size range in mm					
	up to 10	More than 10-30	More than 30-100	More than 100-300	More than 300-1000	More than 1000-3000
H	0.02	0.05	0.1	0.2	0.3	0.4
K	0.05	0.1	0.2	0.4	0.6	0.8
L	0.1	0.2	0.4	0.8	1.2	1.6

Tolerance classes	General tolerances for perpendicularity			
	Nominal size range in mm			
	up to 100	More than 100-300	More than 300-1000	More than 1000-3000
H	0.2	0.3	0.4	0.5
K	0.4	0.6	0.8	1.0
L	0.6	1.0	1.5	2.0

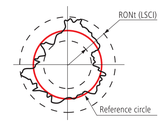
Tolerance classes	General tolerances for symmetry			
	Nominal size range in mm			
	up to 100	More than 100-300	More than 300-1000	More than 1000-3000
H	0.5	0.5	0.5	0.5
K	0.6	0.6	0.8	1.0
L	0.6	1.0	1.5	2.0

Regardless of the size of the nominal size ranges, the following values are valid for the radial runout and axial runout tolerances: H (0.1 mm), K (0.2 mm) and L (0.5 mm).

Reference circle ISO 12181-1, 2

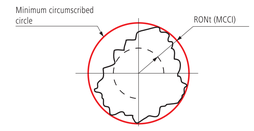
Gaussian compensating circle (LSCI)

Compensating circle calculated through the roundness profile. Circle in which the sum of squares of the local roundness errors is at a minimum. Compared to other circles, the center of this circle has the advantage of having the most stable position.



Minimum circumscribed circle (MCCI)

Calculated circle with smallest possible diameter, which includes the roundness profile from outside.



Minimal radial distance (MZCI)

Two calculated concentric circles that encompass the roundness profile with the least possible radial distance.

Maximum inscribed circle (MICI)

Calculated, largest encompassed circle that includes the roundness profile from inside.

Form and position tolerances
ISO 1101

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