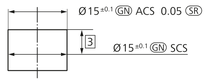
Sizes and modifiers

Sizes are dimensions of enclosed geometric features, e.g. diameter of cylinders and circles or distances of parallel surfaces. The type of metrology evaluation can be stipulated here by indicating specification modifiers.



LP	Local Point: analysis of the measurement points as a two-point dimension (based on the midpoint of a Gaussian circle)
GX	Global Maximum: evaluation of the measurement points as a maximum inscribed circle / maximum inscribed cylinder (MICI/MICY).
GN	Global Minimum: evaluation of the measurement points as a minimum circumscribed circle / cylinder (MCCI/MCCY).
GC	Global Chebyshev: evaluation of the measurement points as per the Chebyshev minimum zone method (MZCI/MZCY).
GG	Global Gauss: evaluation of the measurement points as a Gauss best fit (LSCI/LSCY).

So-called rank-order sizes can be indicated as a supplement to the modifiers:

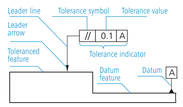
SX	Statistical Maximum: largest value of the measured values
SN	Statistical Minimum: smallest value of the measured values
SA	Statistical Average: mean value of the measured values
SM	Statistical Median: median of the measured values
SR	Statistical Range: range of the measured values
SD	Statistical Mid-Range: mean value of (SX) and (SN)

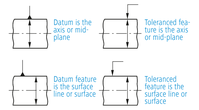
Additional information stipulates requirements for the measurement and evaluation:

ACS	Any Cross Section: inspection in any (possible) circular section.
SCS	Specific Cross Section: inspection only in the circular section (usually indicated by a theoretical dimension).
ALS	Any Longitudinal Section: inspection in each (possible) longitudinal section.
CZ	Common Zone: joint inspection of the characteristics in a common tolerance zone.
SZ	Seperate Zone: inspection of the characteristics independently of each other (in separate tolerance zones).
TED	Theoretically Exact Dimension: theoretical dimension without tolerance to indicate the ideal location, e.g. 25 or 60°.

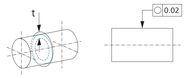
Form and location tolerances

Form tolerances limit the deviations of an individual 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.

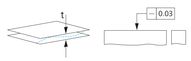




Roundness (form tolerance): the tolerance zone is limited in the measuring plane perpendicular to the measuring axis by two concentric circles a distance t apart.

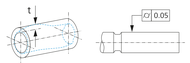


Straightness (form tolerance): the tolerance zone is limited by
- a cylinder of diameter t (⌀ of an axis or derived median line)
- two parallel planes a distance t apart (⌀ of an edge)
- two parallel lines a distance t apart (⌀ of a surface line).



Cylindricity (form tolerance): the tolerance zone is limited by two coaxial cylinders a distance t apart.

⌭ limits implicitly: ◎ and ⌀axis and ⌀surface and ▱surface



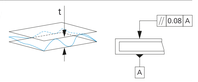
Flatness (form tolerance): the tolerance zone is limited by two parallel planes a distance t apart.

▱ limits implicitly: ⌀surface or ⌀derived median line

Unlike form tolerances, location tolerances almost always require one or multiple datums:

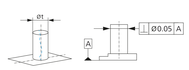
Parallelism (orientation tolerance): the tolerance zone is limited by two parallel lines or planes a distance t apart, which are parallel to the datum.

▱ limits implicitly: ⌭ ⌀surface or ⌀derived median line/axis



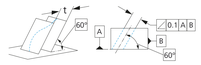
Perpendicularity (orientation tolerance): the tolerance zone is limited by two parallel planes a distance t apart (or a cylinder with Ø t) which are perpendicular to the datum.

⊥ limits implicitly: ⌭ ⌀surface or ⌀derived median line/axis



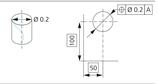
Angularity (orientation tolerance): the tolerance zone is limited by two parallel planes a distance t apart (or a cylinder with Ø t) which are at the defined angle to the primary datum.

∠ limits implicitly: ⌭ ⌀surface or ⌀derived median line/axis



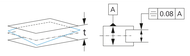
Position (location tolerance): the tolerance zone is limited by a cylinder of diameter t coaxial to the datum (position with Ø sign). For additional tolerancing, see ISO 5458.

⌖ limits implicitly: ⌀ ▱, if applicable also ⌭ ⊥ and ▱plane



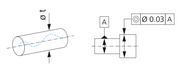
Symmetry (location tolerance): the tolerance zone is limited by two planes symmetrical to the datum axis or datum plane at a distance t apart.

⌯ limits implicitly: ⌀center plane ▱center plane if applicable ▱center plane



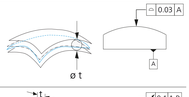
Coaxiality or concentricity (location tolerances): the tolerance zone is limited by a cylinder or circle of diameter t which is coaxial or concentric to the datum.

◎ Coaxiality limits implicitly: ⌀axis ▱axis ◎concentricity



Line profile (profile tolerance with and without datum): the tolerance zone is limited by two curves which envelop circles of diameter t whose mid-points are on a curve of geometrically ideal form. If applicable: a datum limits the position

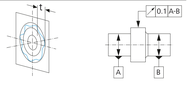
Surface profile (profile tolerance with and without datum): the tolerance zone is limited by two surfaces which envelop spheres of diameter t whose mid-points are on a curve of geometrically ideal form. If applicable: a datum limits the location.



Circular radial or axial run-out (run-out tolerances): the tolerance zone is limited by two concentric circles or parallel planes a distance t apart, which are located by datum A-B.

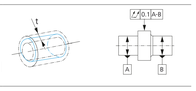
↗ Circular radial run-out limits: ◎ ◎

↗ Circular axial run-out limits: ⌭measuring line



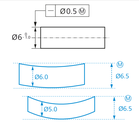
Total radial or axial run-out (run-out tolerances): the tolerance zone is limited by two coaxial cylinders or parallel planes a distance t apart, which are located by datum A-B.

↗ Total radial runout limits: ◎ ⌭ ▱ ◎ ▱. ↗ Total axial run-out limits: ▱ ⌭

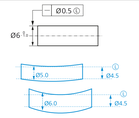


Additional drawing entries

(M) Maximum material requirement: Ⓜ permits the addition of unused dimension tolerance portions to the toleranced form or location error.
Example (simple case): cylinder diameter 6 mm and the axis straightness tolerance t = 0.5 mm (see image to the right). If the actual diameter is 5.0 mm, the straightness of the axis can deviate up to 1.5 mm.

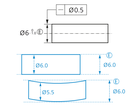


(L) Minimum material requirement: Ⓛ enables the addition of unused dimension tolerance portions (away from the material side) to the toleranced form or location error.
Example (simple case): cylinder diameter 6 mm and axis straightness tolerance t = 0.5 mm (see image to the right). If the actual diameter is 6.0 mm, the straightness of the axis can deviate up to 1.5 mm.

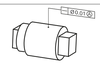


(R) Reciprocity requirement: the R-requirement enables the "reversal" of Ⓜ or Ⓛ, i.e. the addition of unused form and location tolerances to the dimension tolerance.

(E) Envelope requirement: as per ISO 8015, dimension tolerances and form and location tolerances must always be viewed independently of each other. By inputting Ⓔ on the dimension tolerance, the entire tolerance width, including form deviations, are limited to the dimensional tolerance. Thus, in the example to the right, the external envelope (dimension+form) may not exceed the diameter of 6.0 mm. If this is already utilized, e.g. by the dimensional tolerance, no more form deviations may occur.



(A) Axis as a toleranced feature: to illustrate that not the surface but rather the axis or center plane (center line) should be toleranced, a Ⓐ can be input in the drawing (in 3D drawings necessary).



(F) Free state: the inspection of the (elastic or plastic, non-rigid) workpiece must be performed in the unfixtured state (only formed by gravity) (as per ISO 10579).

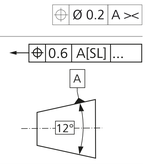
UZ Asymmetric tolerance zone (with profile form tolerances): the tolerance zone is shifted by the value t from the material center outwards (in the example to the right, the zone is entirely outside of the material).

OZ Asymmetric tolerance zone (with profile form tolerances): the tolerance zone is shifted by a non specified value away from the material center. So OZ (offset zone) only tolerances form, location and orientation, not size.

(P) Projected tolerance zone: the tolerance zone has been moved by t entirely outside of the workpiece in order to inspect the locations relevant for later assembly.

Datum and tolerance direction limitations

><	Datum feature only acts as an orientation feature. The position coordinates are not considered.
[PL]	Plane: datum feature only functions as a plane. Other parameters of the datum feature (e.g. origin coordinates) are not considered.
[SL]	Straight Line: datum feature functions only as a straight line. Other parameters of the datum feature (e.g. origin coordinates) are not considered.
[PT]	Point: datum feature functions only as a point. Other parameters of the datum feature (e.g. orientation information) are not considered.
//|B	Orientation Plane: the tolerance should only be inspected in direction B. In the example to the right, the parallelism must only be inspected parallel to the datum B.
⟂|B	Intersection plane indicator: the tolerance should only be inspected in the intersection plane B. In the example, straightness must be inspected perpendicular to B.
K↔L	Tolerance zone limitation: the tolerance must be inspected only in the area between K and L.
t/...	Tolerance zone limitation: the tolerance must contain the value 0.5 in every section of the length 100 (in the example to the right).
K↔L	Variable tolerance zone: the tolerance width changes from 0.3 mm (with K) linear up to 0.5 mm (with L).
	All Around: the profile tolerance applies to all line and surface features surrounding the entire workpiece in the viewing plane.
○|B	Collection Plane: the collection plane defines, in connection with the „All around" symbol, a set of individual geometry elements that are to be checked together.
	All Over: the profile tolerance applies to all (marked) line and surface features surrounding the entire workpiece.



Tolerance indications for associations and filters

In addition, indications can be made in the tolerance box for the association (calculated best fit) of the features and for filtering, e.g. // 0.1 X G50–A or ○ 0.1 N S150–50 or ○ 0.1 F3. The following applies:

X	Inscribed feature: the toleranced and measured feature must be evaluated as an inscribed circle / inscribed cylinder (MICI/MICY).
N	Circumscribed feature: the toleranced and measured feature must be evaluated as a circumscribed circle / circumscribed cylinder (MCCI/MCCY).
G	Gaussian feature: the toleranced and measured feature must be evaluated as a Gaussian best fit (LPCI/LPCY).
C	Minimum feature: the toleranced and measured feature must be evaluated in accordance with the Chebyshev minimum method (MZCI/MZCY).
T	Tangential feature: the toleranced and measured feature must be evaluated as an external tangential feature (as per the Chebyshev minimum method) (OTPL).
G	Gaussian filtering: the standard Gaussian filter must be used as a digital filter. The indication "G15–" means a low-pass filter with 15 waves per revolution. "G150–50" would be a band-pass
S	Spline filtering: the spline filter must be used as a digital filter. The indication "S50–" means a low-pass filter, "S150–50" means a band-pass filter with 50-150 waves per revolution.
F	Fourier analysis: the evaluation is performed using Fourier analysis. Here "F3" limits the analysis to the third harmonic vibration (orbiform curve form).

Important ISO standards for the GPS

ISO 1101	GPS – tolerances of form, orientation, location and run-out
ISO 1160	GPS – Profile tolerancing
ISO 2692	Form and position tolerancing, maximum material requirement
ISO 5458	GPS – Position tolerancing
ISO 5459	GPS – Datum and datum systems
ISO 8015	GPS – Geometric tolerancing – Fundamentals – Concepts, principles, rules
ISO 10579	GPS – Dimensioning and tolerancing – non-rigid parts
ISO 12180	GPS – Cylindricity
ISO 12181	GPS – Roundness
ISO 12780	GPS – Straightness
ISO 12781	GPS – Flatness
ISO 14405-1	GPS – Dimensional tolerancing – part 1: linear dimensions
ISO 14405-2	GPS – Dimensional tolerancing – part 2: dimensions other than linear sizes

(AD) Altered Default: If a different standard or work standard becomes applicable for a technical drawing in addition to the GPS standards (or if these are replaced), this can be performed in the tolerance box by adding the "(AD) Name of the particular standard."

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GPS – Geometric Product Specifications

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There is additional information on geometric product specifications (and the differences to the ASME standardization) in the seminars and books of the ZEISS Metrology Academy. Books can be ordered here: shop.metrology.zeiss.com