ASMPT enabling the digital world

Guideline for Verification of ASMPT drawings

Version 1.0 – March 2025

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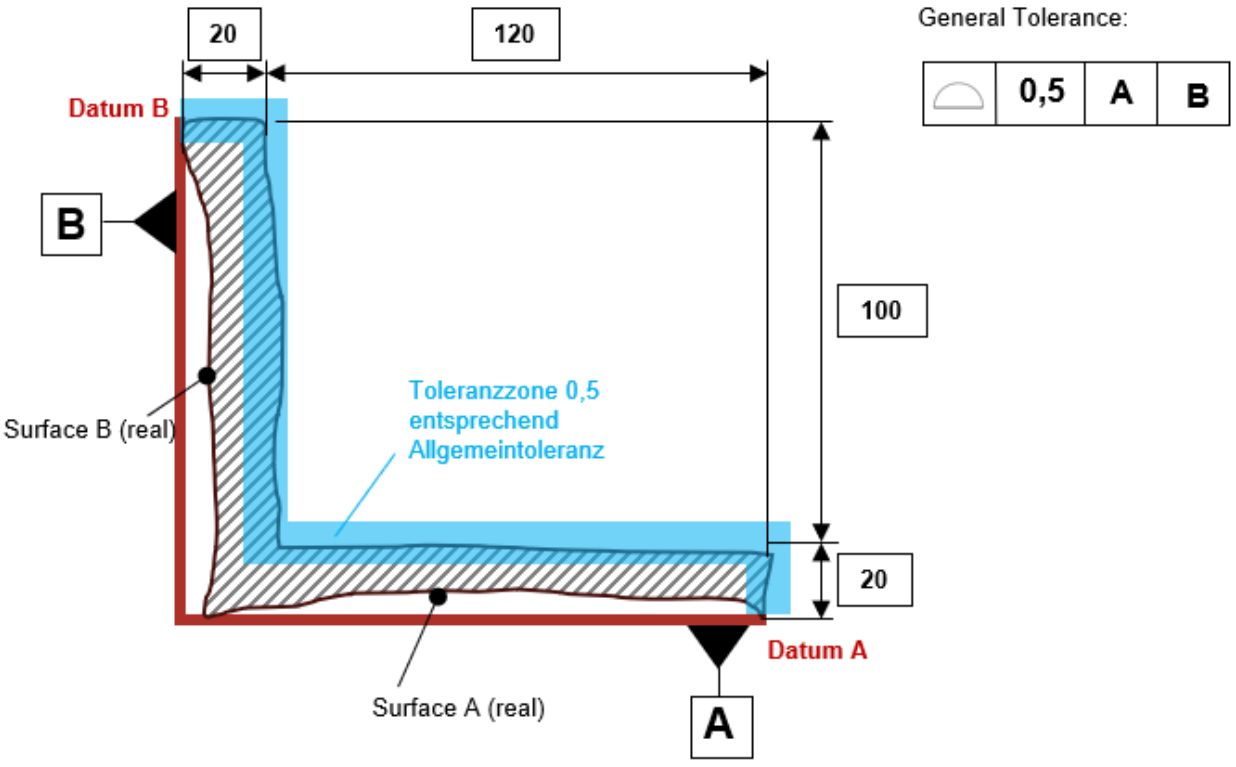
Contents

1. General

This verification guide is intended to help all users better understand the geometric product specifications (GPS) provided by ASMPT as well as assist in the correct implementation of manufacturing and verification. The guide is deliberately kept simple and practice-oriented and does not claim to be complete. The specification remains binding. The drawings created by ASMPT are based on ISO GPS 8015 and are therefore function-oriented geometry specifications and are explicitly not verification or manufacturing documents (principle of duality).

2. Clamping the workpiece

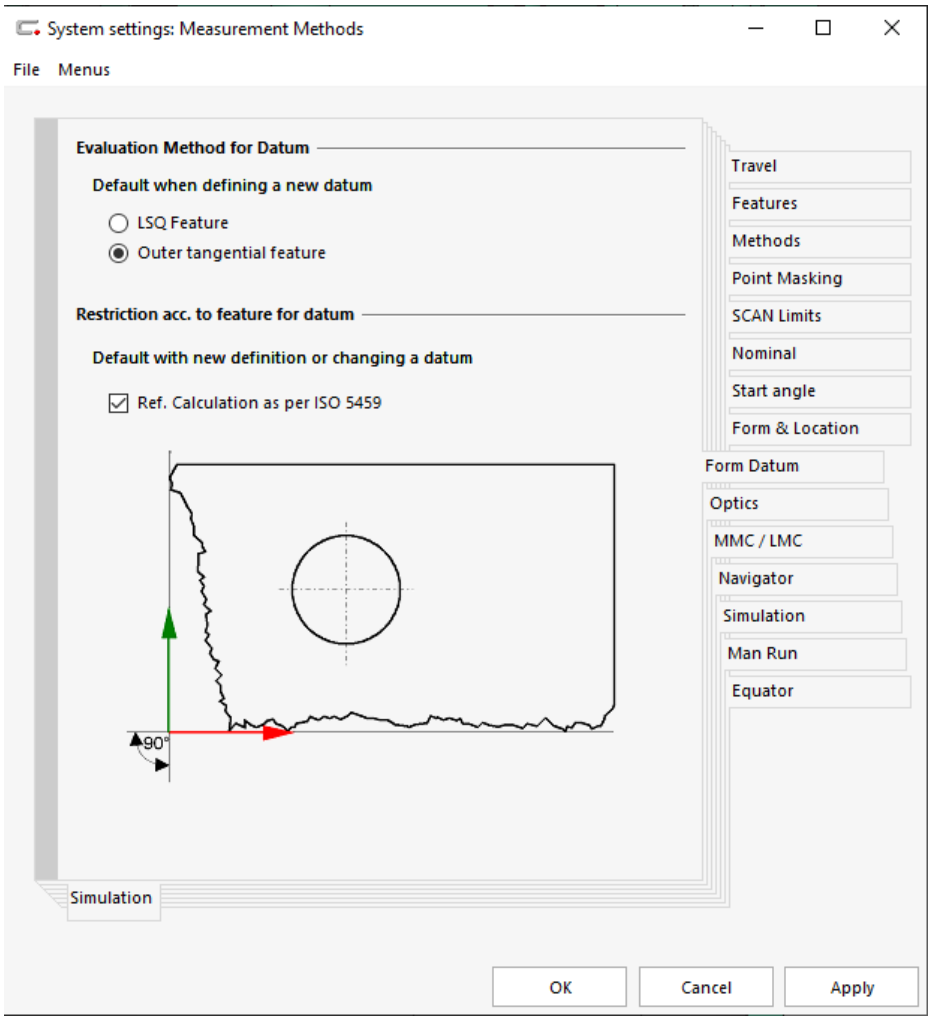
When clamping the workpiece, various influencing factors must be considered. In general, components must be measured in an unrestrained state. The chosen clamping device must not distort or deform the part. The clamping should be selected so that the reference elements can be captured as extensively as possible. For non-rigid parts, the clamping condition should be defined on the drawing, e.g., "clamped down on datum A". In principle, each drawing defines a datum (reference) system consisting of the primary datum (A), secondary datum (B), and tertiary datum (C). If the datums consist of multiple elements, this is also indicated (e.g., A-A). For rotationally symmetrical pieces, no tertiary alignment is required. Only a stable reference system enables reproducible and valid measurement results. Therefore, it is important to ensure that reference elements are manufactured with the smallest possible form error during production.



When capturing the reference system using a coordinate measuring machine, the following evaluation methods should be used for the different geometric elements (reference calculation according to ISO 5459-2011):

Surfaces:	outer tangential element (minimum method of Chebyshev)
Outer diameter (shaft):	outer tangential element (minimum method of Chebyshev)
Inner diameter (bore):	inner tangential element (minimum method of Chebyshev)

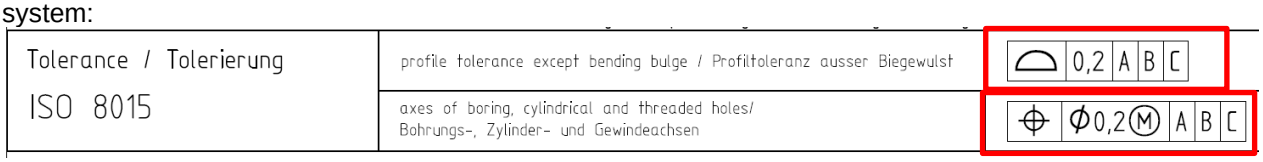
Example settings in Zeiss Calypso:



3. General tolerances

All geometric elements that are specified only by theoretically exact dimensions (dimensions in a rectangle, also "TEDs") - must be evaluated according to the general tolerance indicated at the edge of the drawing. The same applies to geometric elements that are not fully toleranced, i.e., still have unconstrained degrees of freedom. Reference elements themselves are excluded. For drawings created before the year 2025, general tolerance always consists of profile tolerance and position tolerance to create a defined reference

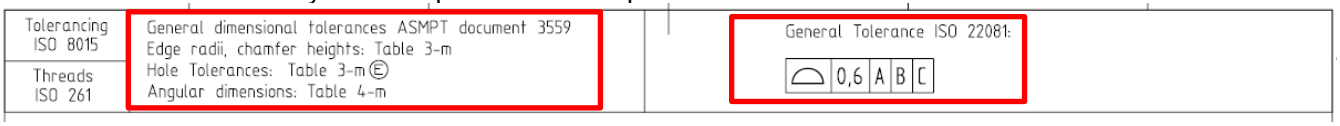
system:



4. Surfaces

Profile tolerance is to be applied to all surfaces of the component, while the positional tolerance is to be applied to the derived geometric elements (bore, cylinder, and thread axes). If the maximum material condition (Ⓜ) is specified for the general positional tolerance, it must also be applied. A more detailed explanation of this is followed in chapter 8.

After the change to the drawing frame in 2025, positional tolerance is no longer required, and general tolerance now consists only of the requirement to the profile tolerance:



Positional tolerances for bore axes, etc., are explicitly specified on the respective geometric element in this version. For non-toleranced two-point dimensions the specified table can be found on page 11 of the “ISO GPS – supplier information” on the ASMPT homepage in the “Suppliers” section.
In general, the number of measurement points should be chosen so that a meaningful measurement result can be obtained over the entire surface. For surfaces with a very tight tolerance, the number of probing points should be increased accordingly, or scanning paths should be used. The distance of the outer probing points from the edge of the surface should be 10% of the longest dimension of the surface.

5. Bores and fits

Holes and fits are often marked with the envelope condition Ⓔ, therefore the envelope element and the two-point dimension must be specified in the result documentation. A detailed explanation is provided in the corresponding **Chapter 10**. If Ⓔ is not specified, the geometric element is evaluated with Gauss evaluation In general, enough measurement points must be used to ensure a valid measurement result. Here too, the number of measurement points should be increased for tight tolerances, or scanning paths should be used.

6. Threads

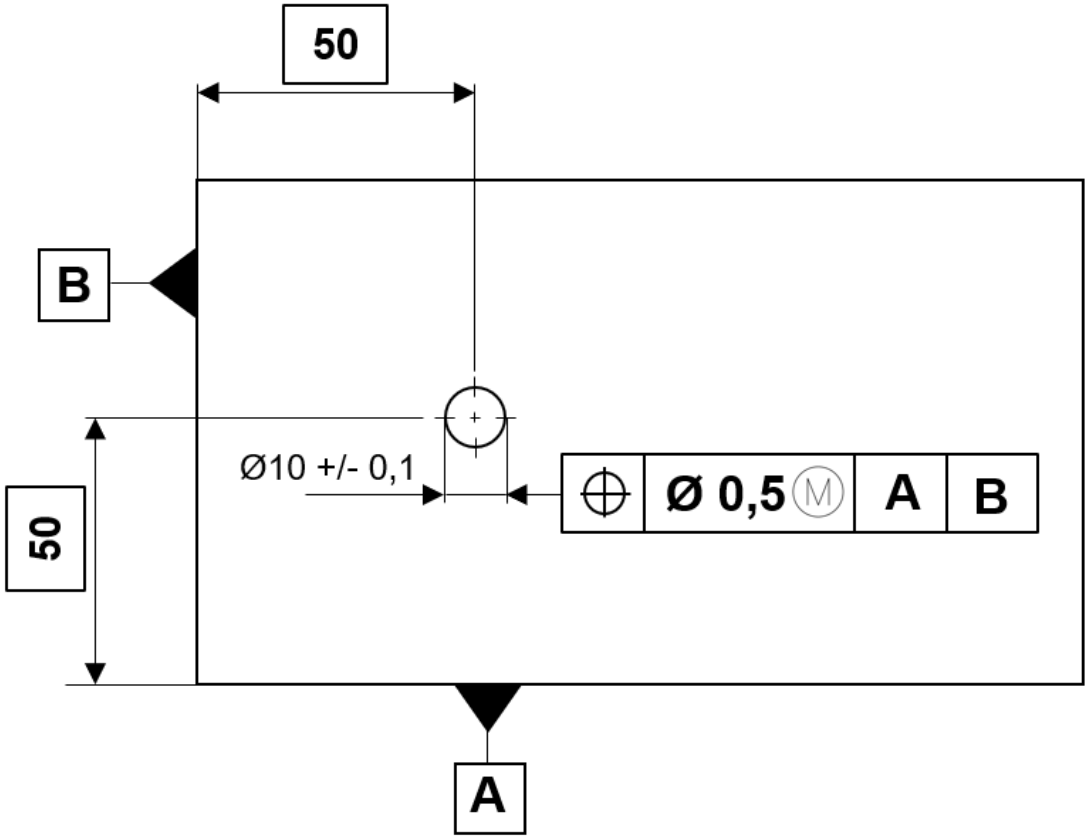
Threads are captured with at least two helical paths. The thread core hole and the thread pitch can be most reliably validated using a thread plug gauge or a thread ring gauge. The thread depth can, if possible, be checked with a mating counterpart or an equivalent sample, such as a screw.

7. Maximum material condition

The maximum material condition allows for a tolerance compensation between form and positional tolerances and is indicated by the operator Ⓜ. This means that the specified positional tolerance only

applies when "maximum material" is present, i.e., for holes at the lower tolerance limit and for shafts at the upper tolerance limit. If this is not the case, the difference to this tolerance limit can be added to the positional tolerance. This ensures that functional and mating parts do not have to be discarded. The maximum material condition thus corresponds to a virtual gauge. Example for a bore:

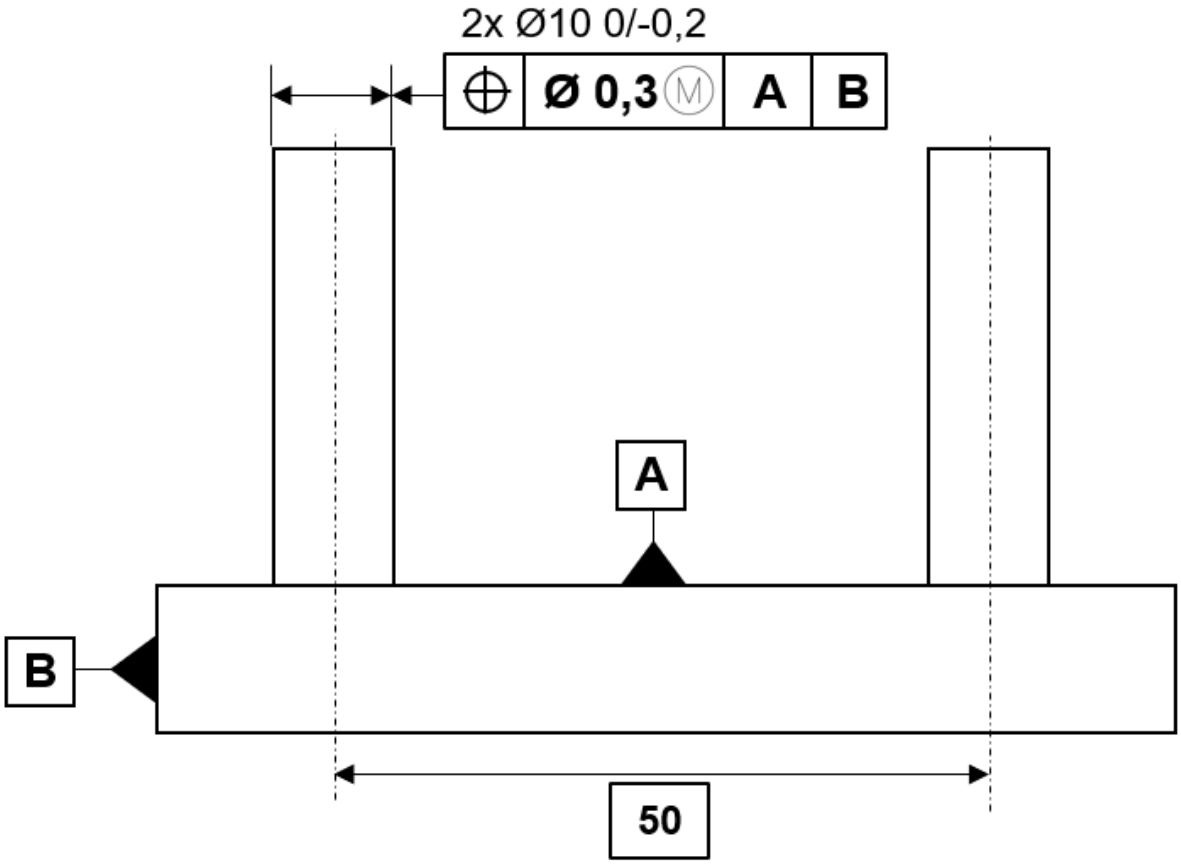
Bore example:



We consider the positional requirement for the bore in the above example. Initially, a positional tolerance of Ø0.5 applies. Due to the operator of the maximum material condition, this tolerance increases depending on the actual value of the hole of diameter Ø10. The resulting positional tolerance is listed in the table below, depending on the actual diameter:

Actual value	Resulting positional tolerance
d = 9,9	Ø 0,5
d = 9,95	Ø 0,55
d = 10,1	Ø 0,7

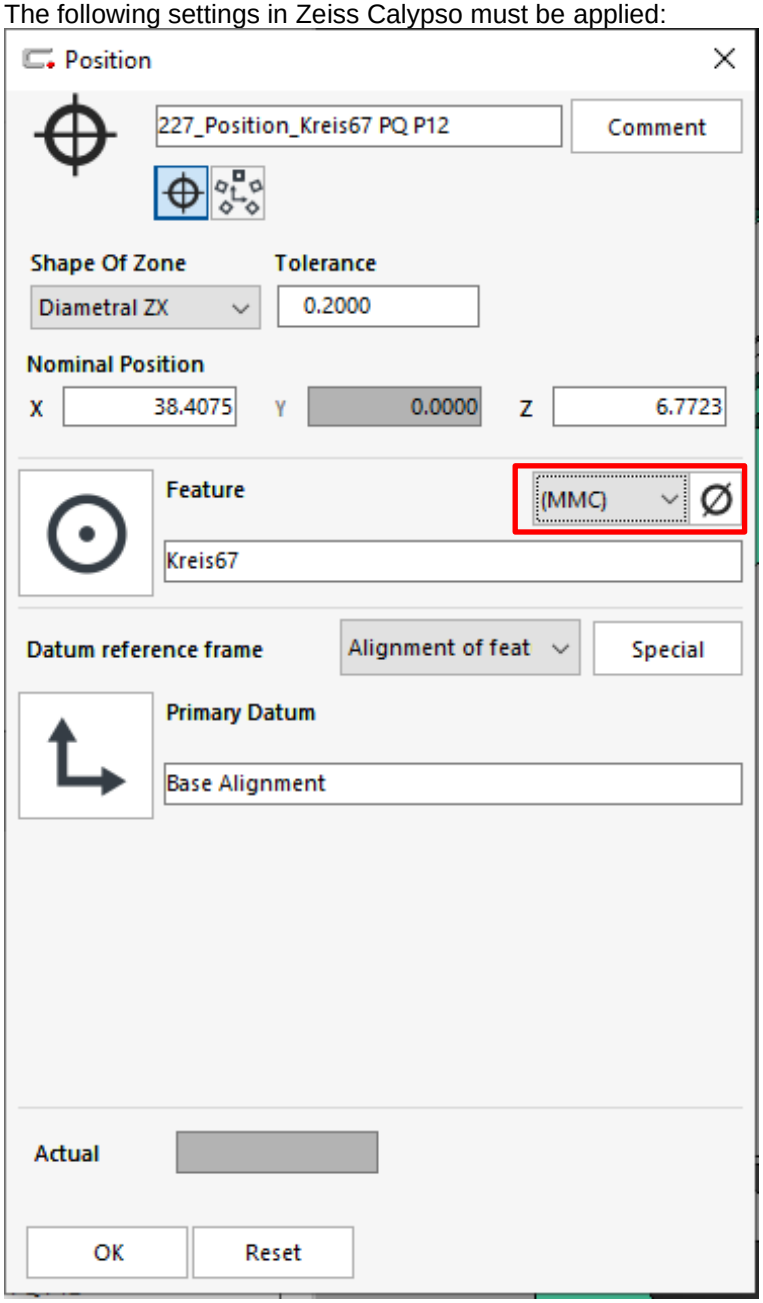
Pin example:



We consider the positional requirement for the pin in the above example. Initially, a positional tolerance of Ø0.3 applies. Due to the operator of the maximum material condition, this tolerance increases depending on the actual value of the pin diameter Ø10. The resulting positional tolerance is listed in the table below, depending on the actual pin diameter:

Actual pin diameter	Resulting positional tolerance
d = 10.0	Ø 0.3
d = 9.9	Ø 0.4
d = 9.8	Ø 0.5

The following settings in Zeiss Calypso must be applied:

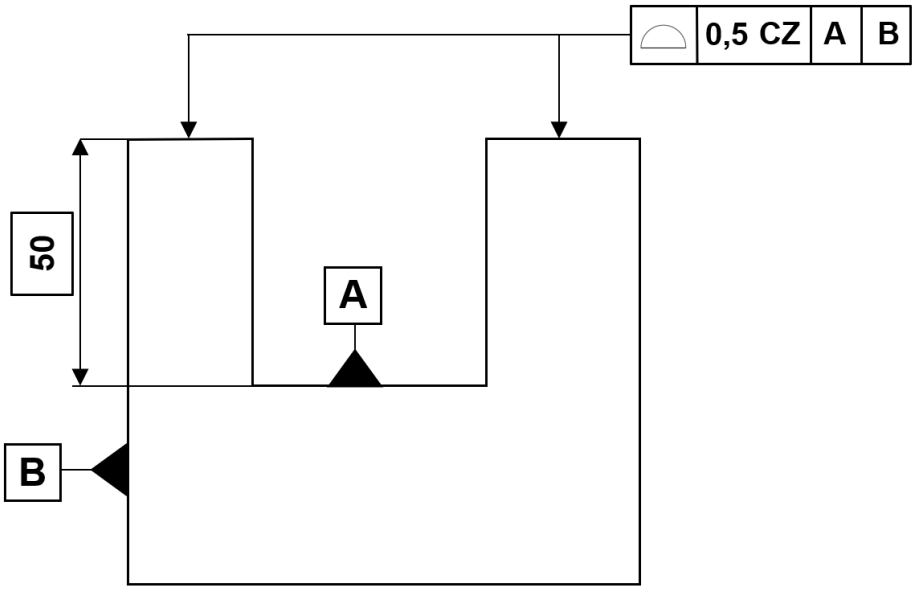


8. Combined Zone (CZ)

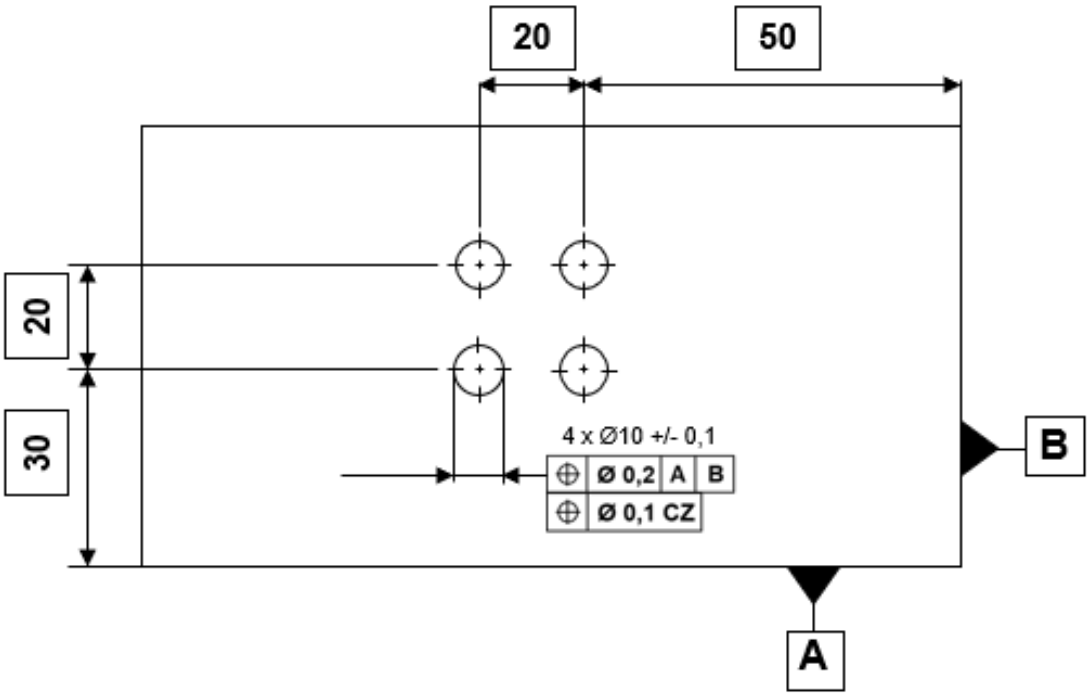
By specifying CZ in the geometrical specification frame for combined zone or "common tolerance zone," a continuous tolerance zone applies to all marked geometric elements. This is mainly used for surfaces lying in one plane and coaxial bores, but also for bore patterns.

Example surfaces:

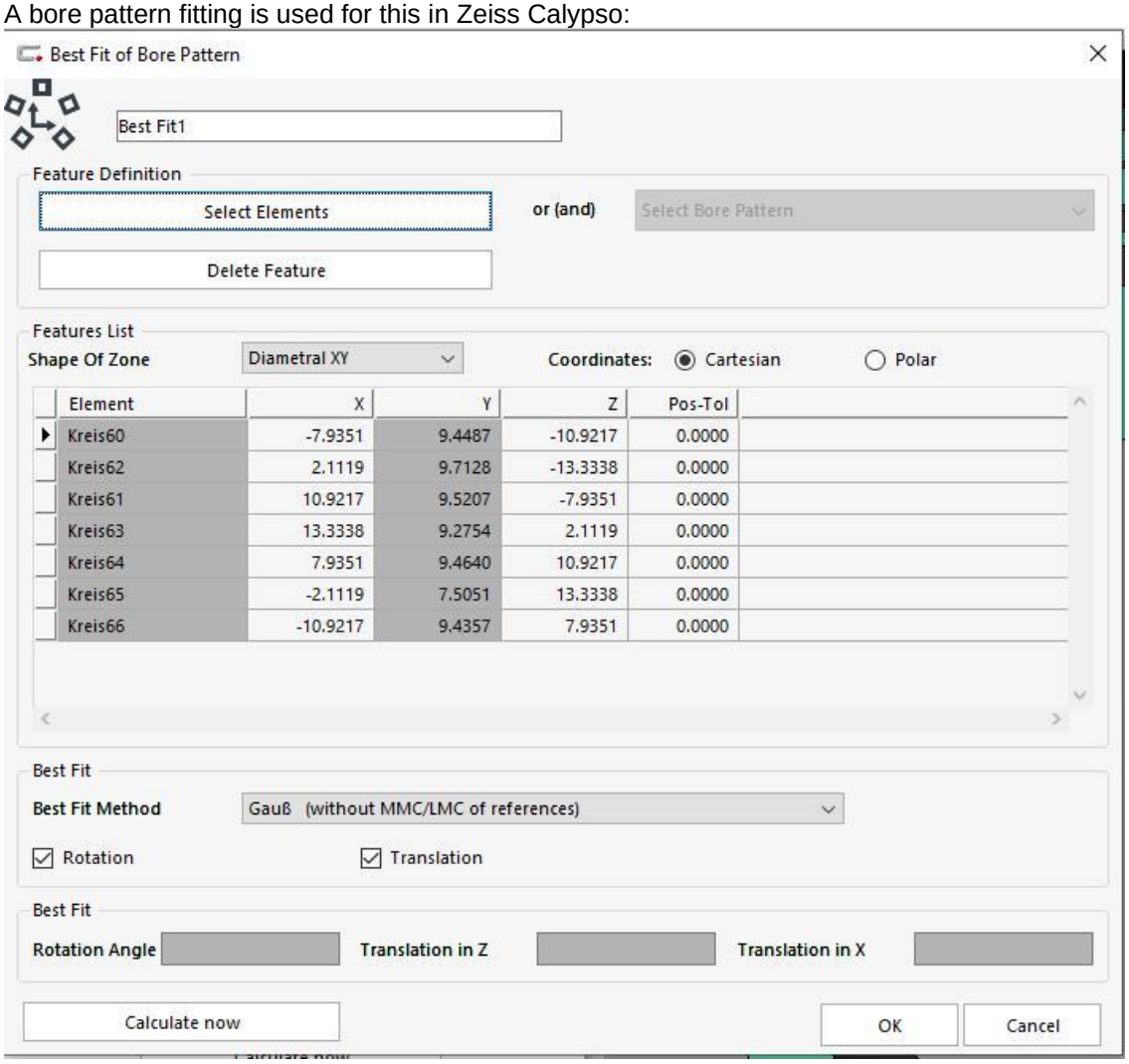
In the image below, two surfaces are shown that are toleranced with a profile form of 0.5 CZ. As a result, the individual surfaces are evaluated as a continuous surface and must not exceed a profile form tolerance of 0.5 collectively.



Example bore pattern :
In the image below, four bores are shown with two different positional requirements. The first requirement is a positional tolerance of all four bore axes of Ø0.2 to the reference system, each considered separately. Below that, there is a positional tolerance of Ø0.1 CZ, without specifying a reference. This means that the four holes must not exceed this positional tolerance relative to each other. Since the resulting tolerance zone can no longer be easily represented, the corresponding function in the measurement software should be used.

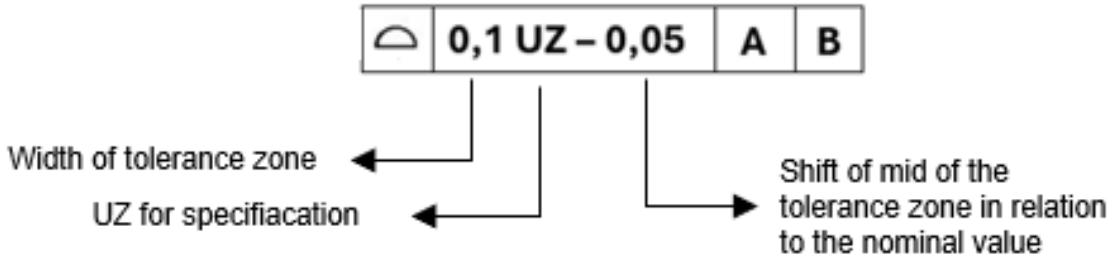


A bore pattern fitting is used for this in Zeiss Calypso:

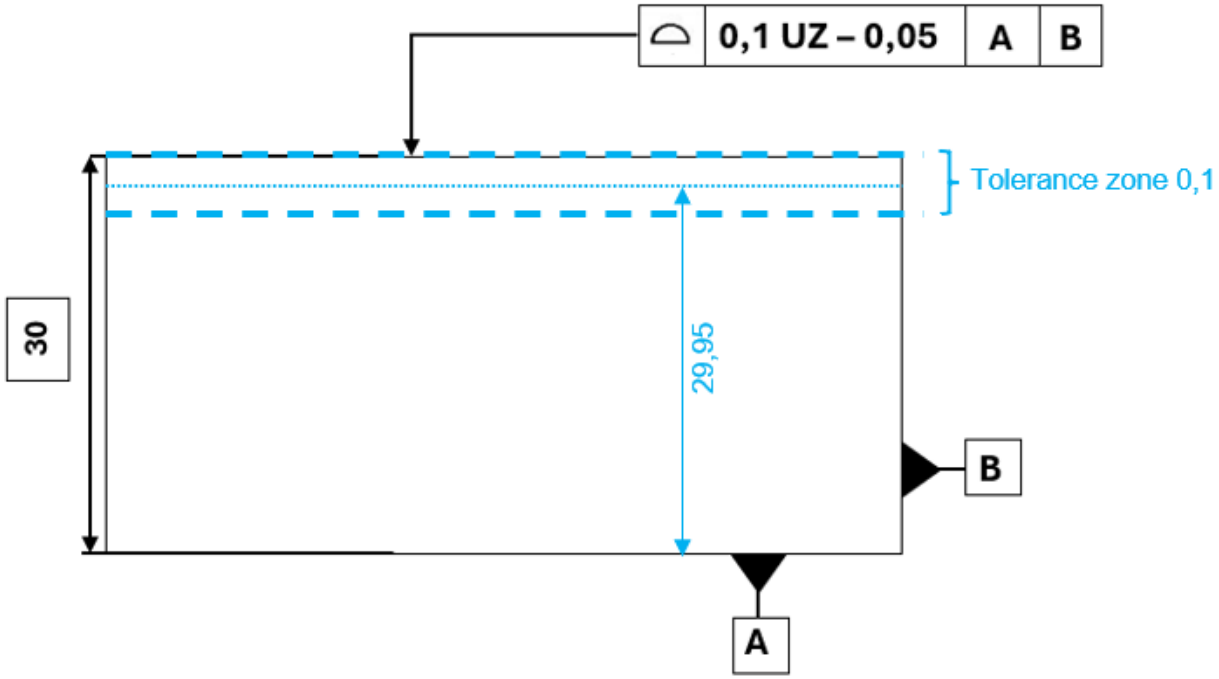


9. Unequal zone (UZ)

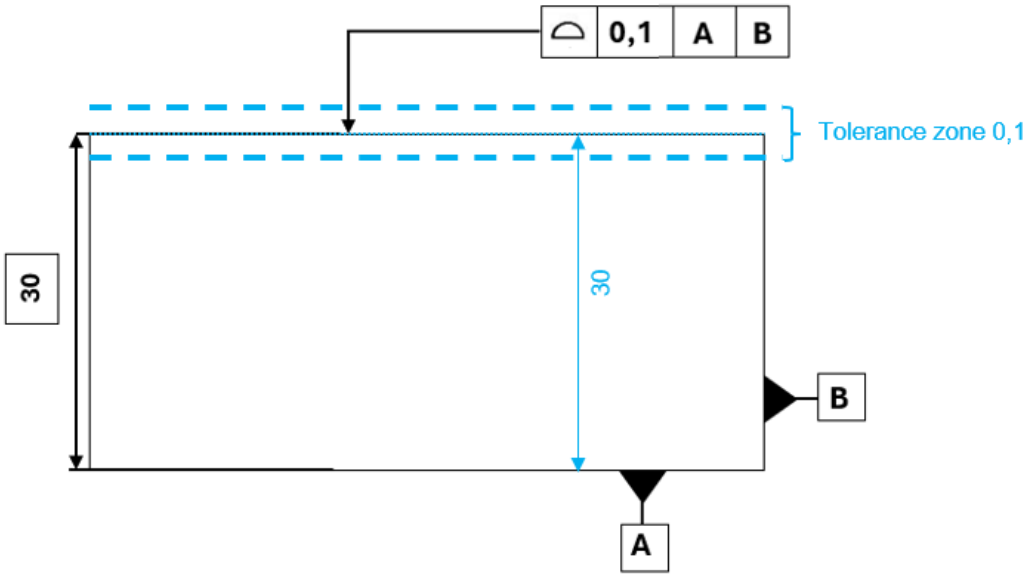
The UZ modifier causes the tolerance zone to shift by the numerical value specified in the tolerance frame. If the numerical value is negative, the tolerance zone shifts inward (into the material); if the value is positive, it shifts outward (out of the material).



In the example below, the upper surface is specified with a theoretically exact dimension of 30mm. Due to the UZ modifier and the shift of the tolerance zone by -0.05, the resulting permissible dimension is 29.95 +/- 0.05.



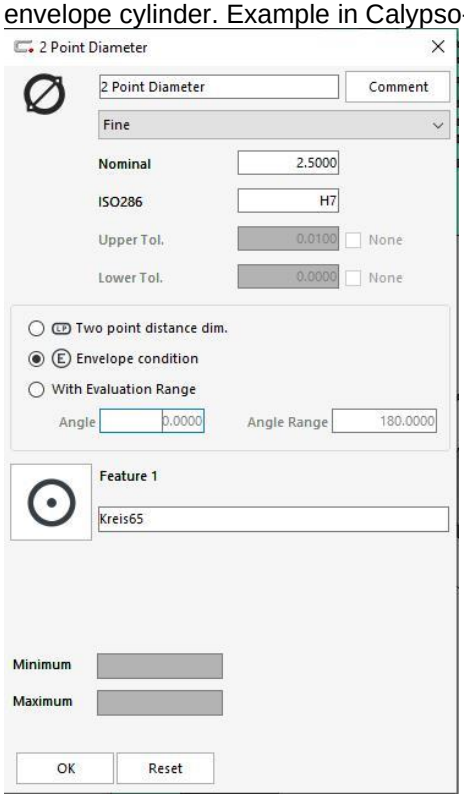
or clarification, the same part is shown below with a profile tolerance without the UZ modifier. Here, the resulting dimension is 30 +/- 0.05:



10. Envelope condition (E)

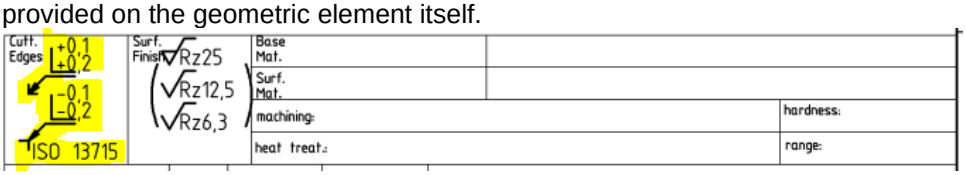
The envelope condition is indicated by the symbol Ⓔ and complements two-point dimensions (LP), such as hole diameters or distances. For internal diameters, the circumscribed cylinder (GX) is applied, and for external diameters, the envelope cylinder (GN) is used. The envelope condition is mainly used when it comes to the mating of parts (e.g., bore and shaft). In the evaluation, the largest two-point dimension (LP)

must also be specified for the circumscribed cylinder, and the smallest two-point dimension (LP) for the envelope cylinder. Example in Calypso-Protocol:



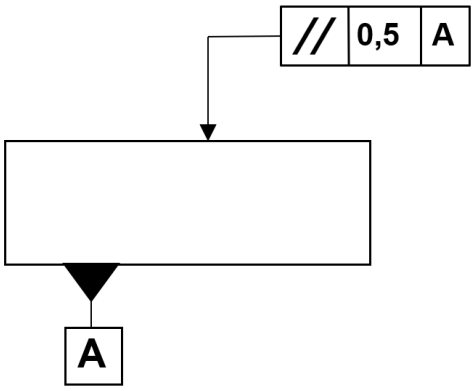
11. Radii, chamfers and edges

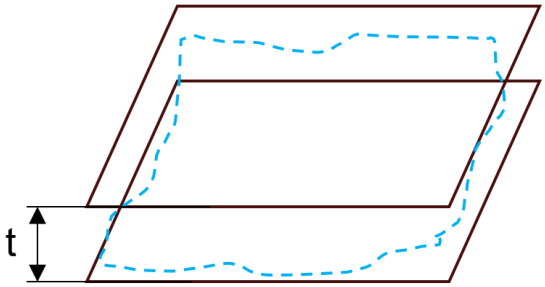
In general, ISO 13715 applies here (see the image below marked in yellow), unless explicit specifications are provided on the geometric element itself.



12. Parallelism

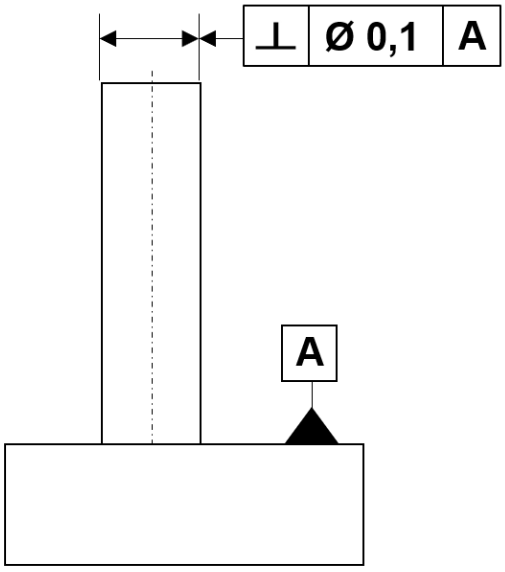
Parallelism (direction tolerance): The tolerance zone is limited by two planes at a distance t, which are parallel to the reference. Parallelism implicitly restricts the flatness and straightness of the surface or the centerline/axis.

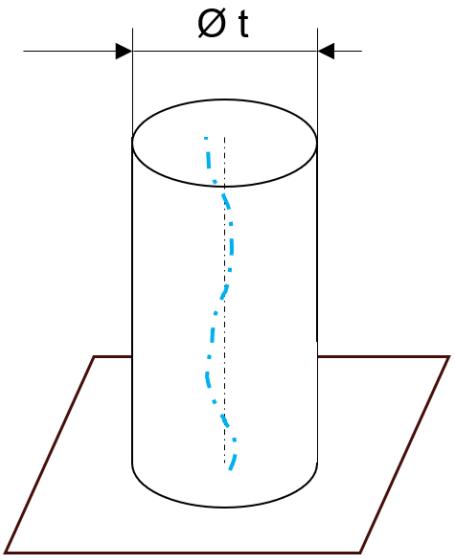




13. Perpendicularity

Perpendicularity (direction tolerance): The tolerance zone is limited by two parallel planes at a distance t (or a cylinder with a diameter øt), which are perpendicular to the reference. Perpendicularity implicitly restricts the flatness and straightness of the surface or the centerline/axis.



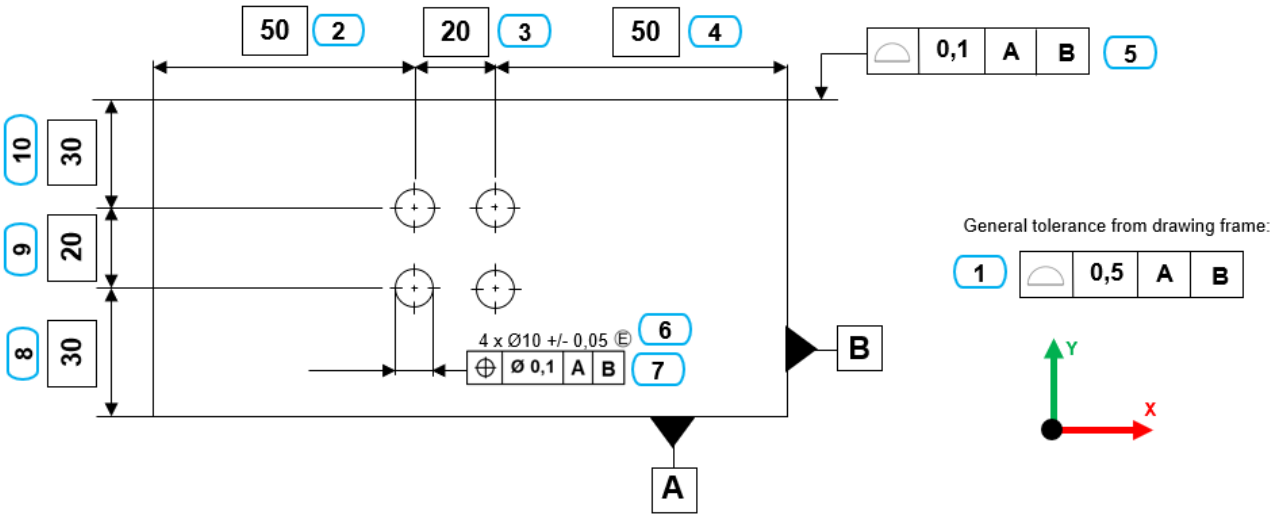


14. Flatness

The flatness tolerance is used to define the permissible form error of surfaces. The flatness value is determined by the minimum distance between two parallel Chebyshev planes.

15. Examplary evaluation and documentation

To provide a better understanding of how the evaluation and documentation of measurement results, e.g., in the first article inspection report, should be carried out, we will explain this using a simple example. The image below shows a component with 4 holes. For simplicity, we limit ourselves to the two-dimensional space, which in this case requires only a primary datum (A) and a secondary datum (B). Each specification in the drawing has been assigned a stamp number, which serves to allocate the measurement results in the report. It has proven useful to start the numbering of the stamping with the general tolerance:



Datums (A) and (B) are each placed on one of the outer surfaces and would, in practice, be provided with flatness and perpendicularity requirements. The four holes have a diameter of Ø10 and a tolerance of +/- 0.05, additionally defined with the envelope Ⓔ condition. The position of the holes is each tolerated with Ø 0.1 to the datum system |A|B|. The form and position of the surface parallel to datum (A) are tolerated with a profile tolerance of 0.1 to the datum system |A|B|. The surface parallel to datum (B) has no explicit tolerancing, so the general tolerance, in this case, the profile tolerance of 0.5 to |A|B|, applies. We assume that the fictitious component has now been measured on a coordinate measuring machine. The results are then documented in the first article inspection report as follows:

Characteristics/ Drawing Grid	Bubble No	Me				
		Material certificate				
		RoHS certificate				
		Surface treatment				
		Nominal	Upper Tolerance	Lower Tolerance	#01	
					Supplier	ASM
Profile tolerance 0,1 A B	5	0,000	0,10	0,00	0,040	
Y-Value		80,0	-	-	80,020	
Ø10 +/- 0,05 (GX/LP)	6.1	10,0	0,05	-0,05	10,01 / 10,012	
Ø10 +/- 0,05 (GX/LP)	6.2	10,0	0,05	-0,05	9,98 / 10,02	
Ø10 +/- 0,05 (GX/LP)	6.3	10,0	0,05	-0,05	9,99 / 10,0	
Ø10 +/- 0,05 (GX/LP)	6.4	10,0	0,05	-0,05	10,02 / 10,04	
Pos. 0,1 A B	7.1	0,0	0,100	0	0,014	
X-Value		-70,0			-70,010	
Y-Value		50,0			49,990	
Pos. 0,1 A B	7.2	0,0	0,100	0	0,020	
X-Value		-50,0			-49,98	
Y-Value		50,0			50,000	
Pos. 0,1 A B	7.3	0,0	0,100	0	0,011	
X-Value		-70,0			-70,005	
Y-Value		30,0			30,010	
Pos. 0,1 A B	7.4	0,0	0,100	0	0,015	
X-Value		-50,0			-49,985	
Y-Value		30,0			30,002	
Profiltoleranz 0,5 A B	1+2+3+4	0,0	0,5	0	0,400	
X-Value		-120,0			-119,8	

Notes:

- Theoretically exact dimensions have no tolerance but serve only to define the position of geometric elements, which is why they are not listed in the inspection report.
- For profile and position tolerances, the position of the geometric element in X/Y is also listed in the rows below to indicate the direction of the deviation.
- If a requirement on the drawing applies to multiple geometric elements, these must be listed individually and traceably (as in the example with diameters and position tolerance #6 and #7).
- If a diameter is specified by the envelope condition, two measurement results must always be provided for completeness: GX/LP for holes and LP/GN for shafts (as in the example with the results for diameter #6).
- If a geometric element is specified only by the general tolerance, all stamp numbers of the features that specify the position of the geometric element must be listed in the inspection report for clear assignment (as in the example #1+#2+#3+#4).