VOLKSWAGEN

AKTIENGESELLSCHAFT

Group standard **VW 01054**

Issue 2016-01

Class. No.: 02245

Descriptors: dimensioning, dimension line, extension line, dimension line limiting, reference line, dimension figure, parenthesized dimension, tube bend, hole spacing, radian measure, cone dimension, taper, inclination, equal spacing tolerance, dimension, envelope requirement, envelope principle, independency principle, tolerancing principle

Drawings

Dimensioning and Tolerancing; Envelope Requirement and Independency Principle

Preface

Effective starting with this issue, the envelope requirement for sizes that previously applied by default in all cases (the "tolerancing principle" as per Volkswagen standard VW 01054) is no longer the only option for new drawings (i.e., drawings drafted after this standard's date of publication), as this issue introduces the independency principle as an alternative. This means that, for every new drawing, it is necessary to choose either the envelope requirement or the independency principle and enter it into the title block. See section 3 and section 4 for details.

Previous issues

VW 01054: 1975-07, 1990-03, 1998-10, 2005-09, 2009-02, 2011-03, 2012-02

Changes

The following changes have been made to VW 01054: 2012-02:

- Standard title expanded
- Standard revised; new sections added and new outline defined
- Technical responsibility changed
- Preface added
- Section 1 "Scope" changed
- Section 2 "General dimensioning and tolerancing rules" added
- Section 3 "General applicability of envelope requirement and independency principle" added
- Section 4 ""Envelope requirement" and "independency principle" tolerancing types for Volkswagen Group drawings" added

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- Section 5 "Features of dimensioning" added (combines the old sections 3, 4, 5, and 6); reference to DIN 406-12 added
- Section 5.1 "Dimension lines, extension lines" revised, amended, and restructured; old figures 13, 17, 19 and corresponding texts deleted; old figure 18 deleted
- Section 5.2 "Dimension line limiting" revised, amended, and restructured; Figure 24, Figure 25, Figure 26, and Figure 27 added
- Section 5.3 "Dimension figures": Regulations with respect to entering deviations added; Figure 28 (old figure 23) changed;
- Section 5.3.1 "Dimension letters" added
- Section 5.3.2 "Position of graphic and letter symbols with dimension numbers" added
- Section 5.4 "Special dimensions – inside parentheses, brackets, or frames ": Old section 7, "Dimensions with labels," revised, amended, and restructured; Figure 36 added
- Section 5.4.1 "Auxiliary dimensions" rewritten
- Section 5.4.2 "Control dimensions": Second sentence amended
- Section 5.4.4 "Theoretically exact dimensions": Figure 42 updated
- Section 5.4.5 "Fixture dimensions for tool design": Figure 43 added
- Section 5.5 "Inspection marking for inspection features": Revised and amended; evaluation code "M" and corresponding text deleted; old figures 35 and 36 deleted; Figure 45, Figure 46, Table 1 added
- Section 5.5.1 "Inspection report" added
- Section 5.6 "Reference lines": Old figure 23 and text concerning datums deleted
- Section 6 "Entering dimensions" added; includes old sections 10 to 22
- Section 6.8 "Spacings" added; includes selected and revised contents from the old sections 16 and 17
- Section 6.9 "Parallel dimensioning, increasing dimensioning" added; includes selected and revised contents from the old sections 16 and 17
- Section 6.10 "Symmetrical parts": Reference to Figure 104 added
- Section 6.11 "Arc dimensions, effective lengths": Old figure 123 and corresponding text deleted
- Section 6.12 "Thread dimensions": Reference to standard VW 01179 added
- Section 6.13 "Equal spacing tolerance" amended; text concerning the explanation of the symbols for the equal spacing tolerance, Figure 135, and Table 2 added
- Section 6.15 "Bent tubes and rods (solid material)" revised and changed
- Old section 22.1.3, "Tube center tangent," deleted
- Old section 22.3, "Simplified representation with dimensions specified in table," deleted
- Section 7 "Collective information" added
- Section 7.1 "Note on undimensioned geometries in the data set" added
- Section 7.2 "General tolerances for linear and angular sizes" added
- Section 7.3 "Profile tolerances with respect to the data set and defined RPS reference system" (old section 9, "Surface shape tolerance and trim tolerance with respect to the data set") revised
- Section 8 "Applicable documents" updated
- Appendix A added

- Section 5 "Features of dimensioning" added (combines the old sections 3, 4, 5, and 6); reference to DIN 406-12 added
- Section 5.1 "Dimension lines, extension lines" revised, amended, and restructured; old figures 13, 17, 19 and corresponding texts deleted; old figure 18 deleted
- Section 5.2 "Dimension line limiting" revised, amended, and restructured; Figure 24, Figure 25, Figure 26, and Figure 27 added
- Section 5.3 "Dimension figures": Regulations with respect to entering deviations added; Figure 28 (old figure 23) changed;
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- Section 8 "Applicable documents" updated
- Appendix A added

- Appendix B added
- Appendix C "Definitions" added

Contents

1 Scope

This standard applies to the dimensioning and tolerancing used in engineering drawings, in the three-dimensional drawing-less process (3DZP), and in other documents involved in the development process.

This standard adheres to the international rules for engineering drawings to the greatest extent possible and has been expanded to meet the specific requirements of the Volkswagen Group.

Details that are not covered in this standard must be selected as necessary to meet the specific purpose at hand. Moreover, they must be unambiguous.

NOTE 1: The figures given in this standard are examples to illustrate the relevant rule. They are complete only to the extent that they show the situation described. The indicated dimensions and tolerances are intended only as example values.

2 General dimensioning and tolerancing rules

2.1 General information

In the design process, the components are designed with the help of CAD systems from geometrical features with nominal dimensions and ideal geometrical shapes. These designed nominal component models are referred to as 3-D models or data sets.

Due to the various factors involved in the manufacturing process, the components actually produced will have dimensional, shape, and positional deviations. These deviations must be limited with appropriate, function-related dimensional, location, orientation, runout, and form tolerances in order to ensure that the component will work properly.

2.2 General rules

The following general dimensioning and tolerancing rules must be observed:

- The type of tolerancing (envelope requirement for sizes (see section A.1.1) or independency principle) must be specified and entered into the drawing's title block.
- A datum system must be defined before dimensioning. The nominal dimensions must be entered based on the datum features. The datum features must be toleranced relative to each other. The tolerancing is carried out at the end in the following order: dimensional, location, orientation, and form tolerances. The function and assembly of individual parts play a defining role when it comes to the dimensioning and tolerancing.
- The dimensions in a drawing are finished dimensions and indicate the end condition of the part, including surface protection. Deviations from this, e.g., pre-turning dimensions, are marked as such with text.
- In order for the drawing to be easily understandable, dimensions must be entered outside the graphical representation whenever possible and only once for each geometrical feature (exception: repeat dimensions; see section 6.1).
- If dimensions cannot be made to fit in small graphical representations, the representations, or appropriate details, must be drawn using a larger scale (see VW 01050).
- In assembly (ASSY) drawings, only the dimensions that are necessary for assembly or for further machining are entered, e.g., parts that are drilled once assembled. Because of this, dimensions and tolerances used to manufacture parts must be specified in the part drawings.

  In the 3-D drawing-less process, parts without their own drawing (no drawing) cannot be processed; see VW 01058 supplement 1, "Requirements" section. Separate drawings must be drafted for these individual parts.
- The dimensioning and tolerancing must be complete. This means that all necessary geometric requirements needed in order for the parts to be manufactured and checked must be specified in the drawing or 3-D model. The dimensional, form, and positional deviations relevant to functional capability must be limited for all geometrical features by using individual and/or general tolerances.
- The dimensioning and tolerancing must be unequivocal, i.e., it must be impossible for there to be any ambiguities in downstream processes, e.g., production and/or quality assurance.
- The form and positional tolerances must be entered as per DIN EN ISO 1101.
- The datums and datum systems must be entered as per DIN EN ISO 5459.
- The reference point system (RPS) datum systems must be entered as per VW 01055.
- If dimensional, form, and positional tolerance specifications cannot describe all details, additional, clear text specifications must be prepared and entered in German and English using the "DoLittle" Volkswagen application, see VW 01058, section "Requirements."

3 General applicability of envelope requirement and independency principle

By defining the type of tolerancing in an engineering drawing, i.e., whether the independency principle is being used or the envelope requirement for sizes is generally applicable, a design engineer defines how the components will be checked afterwards. Because of this, it is absolutely necessary for every single drawing to indicate the specific type of tolerancing that is being used.

3.1 General applicability of envelope requirement for sizes

When **the envelope requirement for sizes** as per DIN EN ISO 14405-1 (tolerancing for inspection with gages; see section A.1) is generally applicable, the envelope requirement automatically applies to all geometrical features (referred to as "features-of-size"), of "cylindrical surface" type (cylinders – e.g., hole, shaft, pin) or "two parallel opposite planes" type (e.g., width – e.g., thickness, groove width, slot width, and key width), toleranced with dimensional tolerances (either "±" tolerances or ISO codes, e.g., H7) without a direct marking with symbol Ⓔ after the dimensional tolerance.

3.1.1 Envelope requirement

The **envelope requirement** as per DIN EN ISO 14405-1 defines a correlation between dimensional tolerance, form deviation, and parallelism deviation for sizes. It states that the dimensional deviation, the form deviation, and the parallelism deviation must not be greater than the dimensional tolerance of the toleranced geometrical feature. In other words, it states that for proper fit, a feature-of-size (see section A.1.1) of type "cylinder" or of type "two parallel opposite planes" must not penetrate a geometrically ideal envelope representing the maximum material size (go gage). At the same time, no actual local size must exceed (e.g., hole and groove width – internal dimensions) or fall below (e.g., shaft and key – external dimensions) the least material size (no go gage – two-point size; see section A.1.2).

In practice, the envelope requirement is checked as per the rules of the Taylor Principle; see section A.1.

The envelope requirement must only be used if the function requires a specific fit for two geometrical features (e.g., hole, shaft or groove, key) as per DIN EN ISO 286-1 and DIN EN ISO 286-2. The envelope requirement must be used preferentially and sensibly for geometrical features that are paired for a clearance fit. The geometrical features must be able to physically pass a go-gage check as per the Taylor Principle.

The envelope requirement cannot be used for:

- Features-of-size such as cones, wedges, spheres
- Non-features-of-size such as:
  – Complex geometrical features (for examples, see figure A.5) and
  – Distances that are dimensions other than linear sizes (for examples, see figure A.6 to figure A.8 and DIN EN ISO 14405-2).

3.2 Independency principle

The **independency principle** specifies that all dimensional, form, and positional tolerances in a drawing must be checked and adhered to independently of each other unless a special note (see section A.2) indicating otherwise has been entered.

This means that:

– There is no correlation between the dimensional tolerance, shape deviation, and parallelism deviation and all required form and parallelism tolerances for features-of-size must be specified

– By default, the sizes are local two-point sizes (see section A.1.2) as per DIN EN ISO 14405-1 i.e., they must be measured as the distance between two opposite points using what is referred to as the "two-point measuring method"

– If the envelope requirement needs to apply to individual sizes due to functional reasons, the requirement must be entered directly after the dimensional tolerance with the Ⓔ symbol; see section A.1.3 and section A.1.4

For more information on the independency principle, see section A.2.

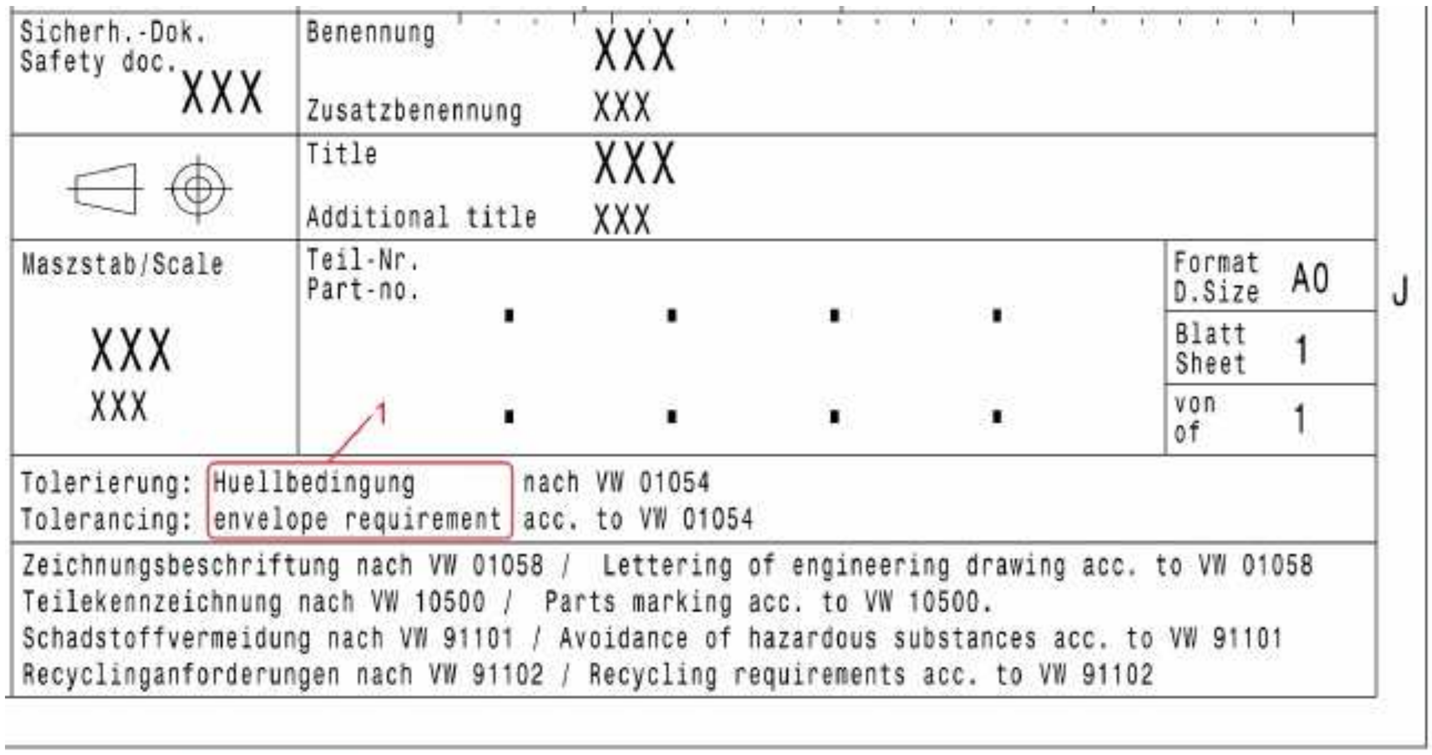
4 "Envelope requirement" and "independency principle" tolerancing types for Volkswagen Group drawings

4.1 "Envelope requirement" tolerancing for Volkswagen Group drawings

If the "envelope requirement" as per DIN EN ISO 14405-1 applies to all sizes in Volkswagen Group drawings, the draftsperson must use the current drawing frame for development (production drawing) as per VW 01014 with the integrated reference to VW 01054 in the "Unterlagen / References" section (see figure 1) and by the entry of the text macro NO-A11, "Huellbedingung / envelope requirement", from VW 01014 in order to ensure that the requirement is applied (see figure 2). The text can be entered automatically or manually depending on how the CAD systems being used are programmed. **The created note (see figure 2) has the same meaning as the drawing note as per DIN EN ISO 14405-1 shown in figure 3.**

Unterlagen References	Nr. No.	Feld Section	Datum Date	Geaendert Changed	Genehmigt Appr.	Beschreibung der Aenderung und Aenderungsterminschluessel Revision record and change date code
VW 01155						
VW 10500						
VW 91101						
VW 91102						
VW 01054						
VW 01058						

Figure 1 – "Unterlagen / References" field



Legend

1 Text macro NO-A11 from VW 01014

Figure 2 – Example for the drawing note for the general applicability of the envelope requirement to sizes on Volkswagen Group drawings

Figure 3 – Example for the drawing note for the general applicability of the envelope requirement to sizes as per DIN EN ISO 14405-1 (conformity is checked with a gage)

The drawing frame in the currently valid issue of VW 01014 **must always be used when drafting new drawings and making drawing changes.**

During the transition period, that is, until the drawing frame has been implemented in accordance with the currently valid issue of VW 01014 for the CAD systems in use in the Volkswagen Group, the drawing frame as per the previous issue of VW 01014[1) may be used.

After a drawing change, drawings that do not contain a note indicating the general applicability of the envelope requirement or the independency principle (for an example, see figure 4) must no longer be stored in the Engineering Data Management System (HyperKVS) with the old drawing frame.

1) For the use of the drawing frame as per VW 01014: 2012-09 (for an example, see figure 5), the note on the general applicability of the envelope requirement or the independency principle must be entered next to the title block.

4.1.1 Rule for drawings older than this issue of the standard

The envelope requirement is generally applicable to all Volkswagen Group drawings if:

1) They do not include a note indicating that the envelope requirement must be used and their initial release date is before VW 01054, issue 2010-05 was published. For an example, see figure 4.

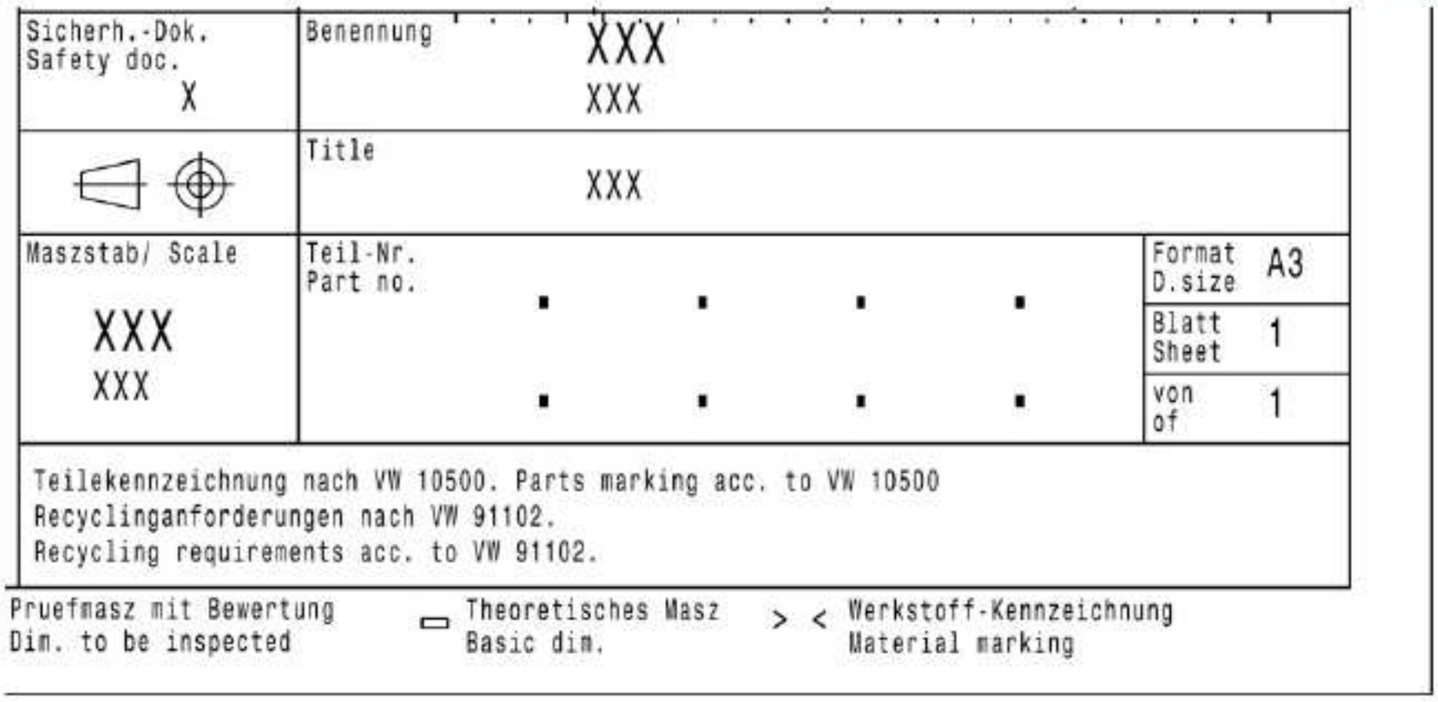


Figure 4 – Example showing the title block for a drawing without a note indicating the general applicability of the envelope requirement to Volkswagen Group drawings

2) They were drafted in accordance with specifications of VW 01054, issue 2011-03 and 2012-02, and contain the following text "Tolerierungsgrundsatz nach VW 01054. Tolerancing principle acc. to VW 01054." in the title block or in the "Bemerkungen / Notes" field. For an example, see figure 5.

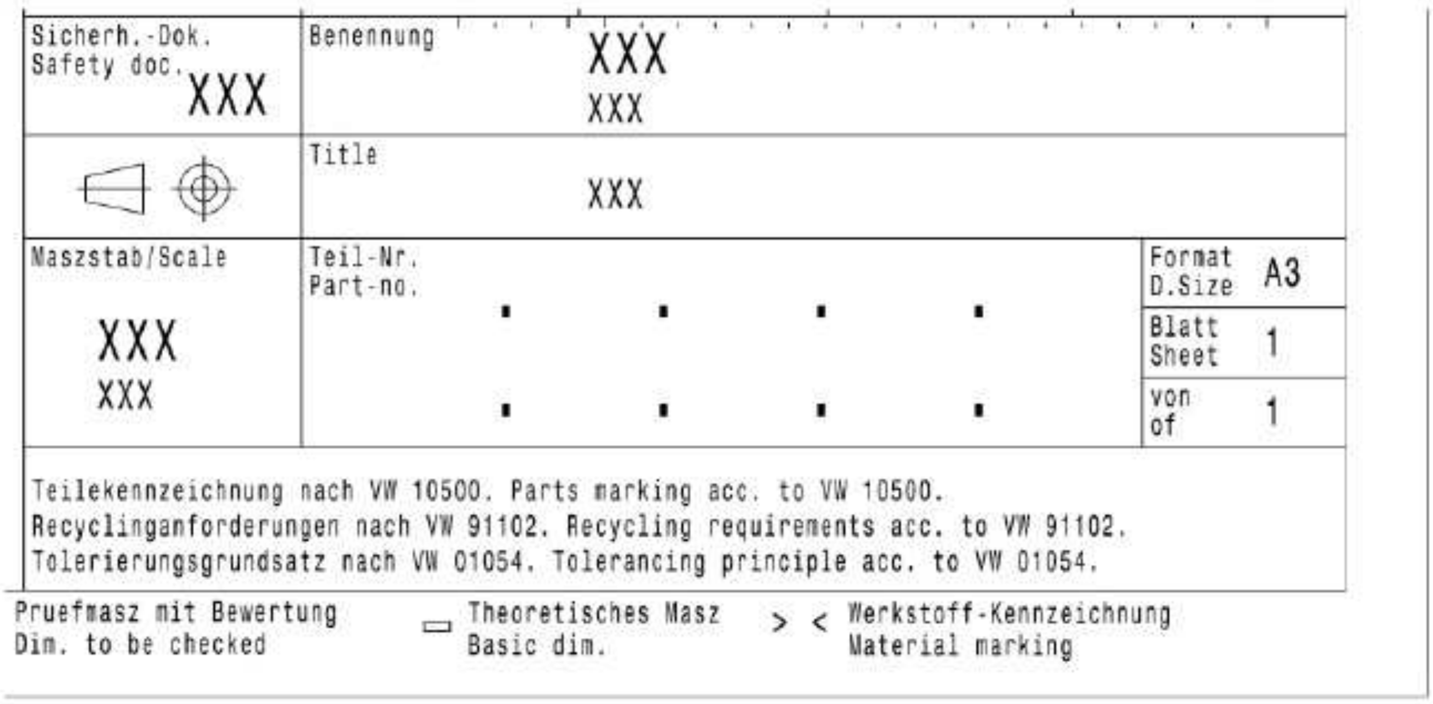
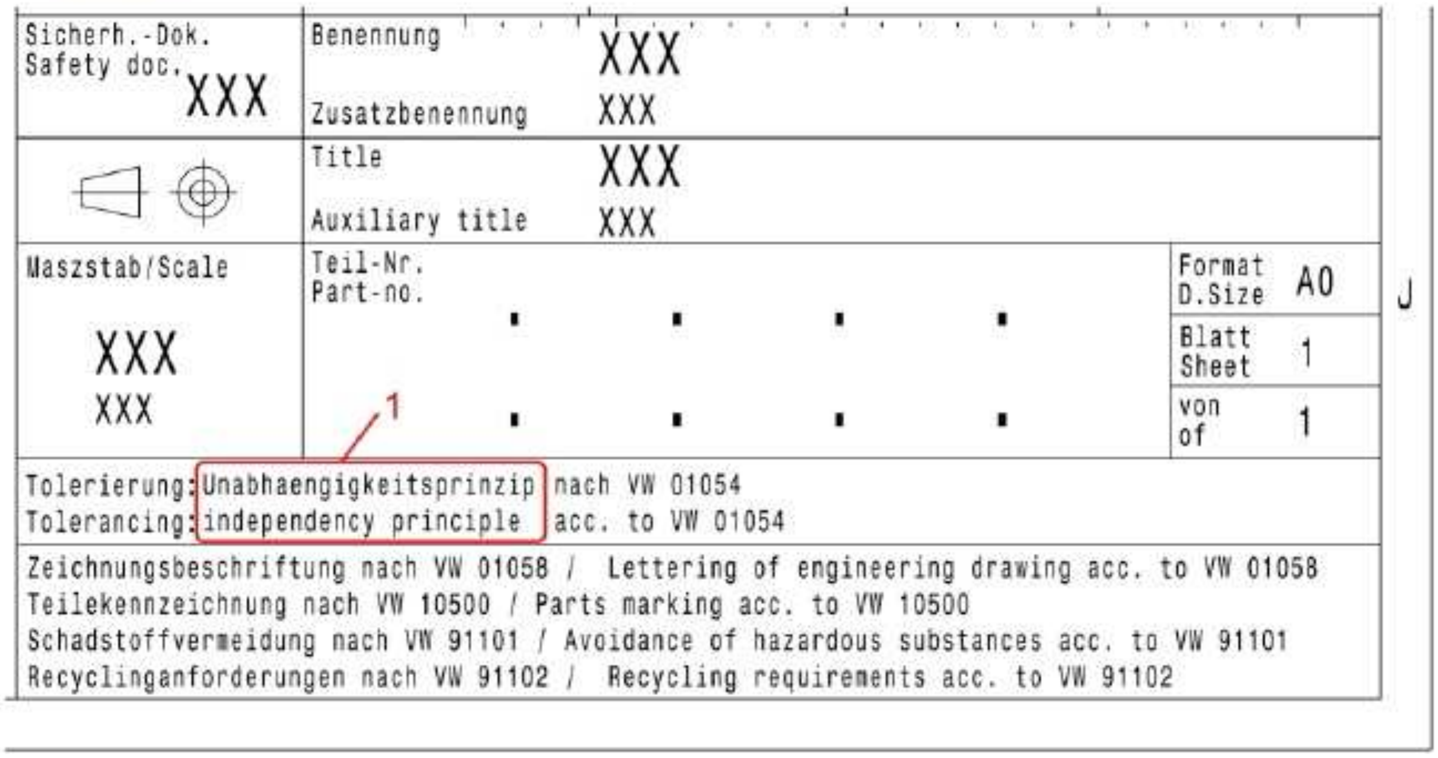


Figure 5 – Example showing the old drawing note for the general applicability of the envelope requirement to Volkswagen Group drawings

4.2 Applicability of the independency principle to Volkswagen Group drawings

If the independency principle as per DIN EN ISO 8015 applies to Volkswagen Group drawings, the draftsperson must use the current drawing frame for development (production drawing) as per VW 01014 with the integrated reference to VW 01054 in the "Unterlagen / References" field (see figure 1) and by the entry of text macro NO-A13, "Unabhaengigkeitsprinzip / independency principle", from VW 01014 in order to ensure that the principle is applied (see figure 6). The text can be entered automatically or manually depending on how the CAD systems being used are programmed.

The created note (see) has the same meaning as the drawing note as per DIN EN ISO 8015 shown in figure 7.



Legend

1 Text macro NO-A13 from VW 01014

Figure 6 – Example for the drawing note for the independency principle for Volkswagen Group drawings

Tolerierung ISO 8015
Tolerancing ISO 8015

Figure 7 – Example for the drawing note for the independency principle as per DIN EN ISO 8015.

4.3 Applicability of the envelope requirement or the independency principle to Volkswagen Group drawings with an external restriction on use

For Volkswagen Group drawings with an external restriction on use, the tolerancing type specified in the supplier drawing applies automatically.

When changing supplier drawings to Volkswagen Group drawings with an external restriction on use, the instructions in section 4.1 and section 4.2 must be followed as appropriate. Current text macros NO-A7 to NO-A10 from VW 01014 as per VW 01058, section "Changing supplier drawings to Volkswagen AG drawings with a restriction on use," must be used; see figure 8.

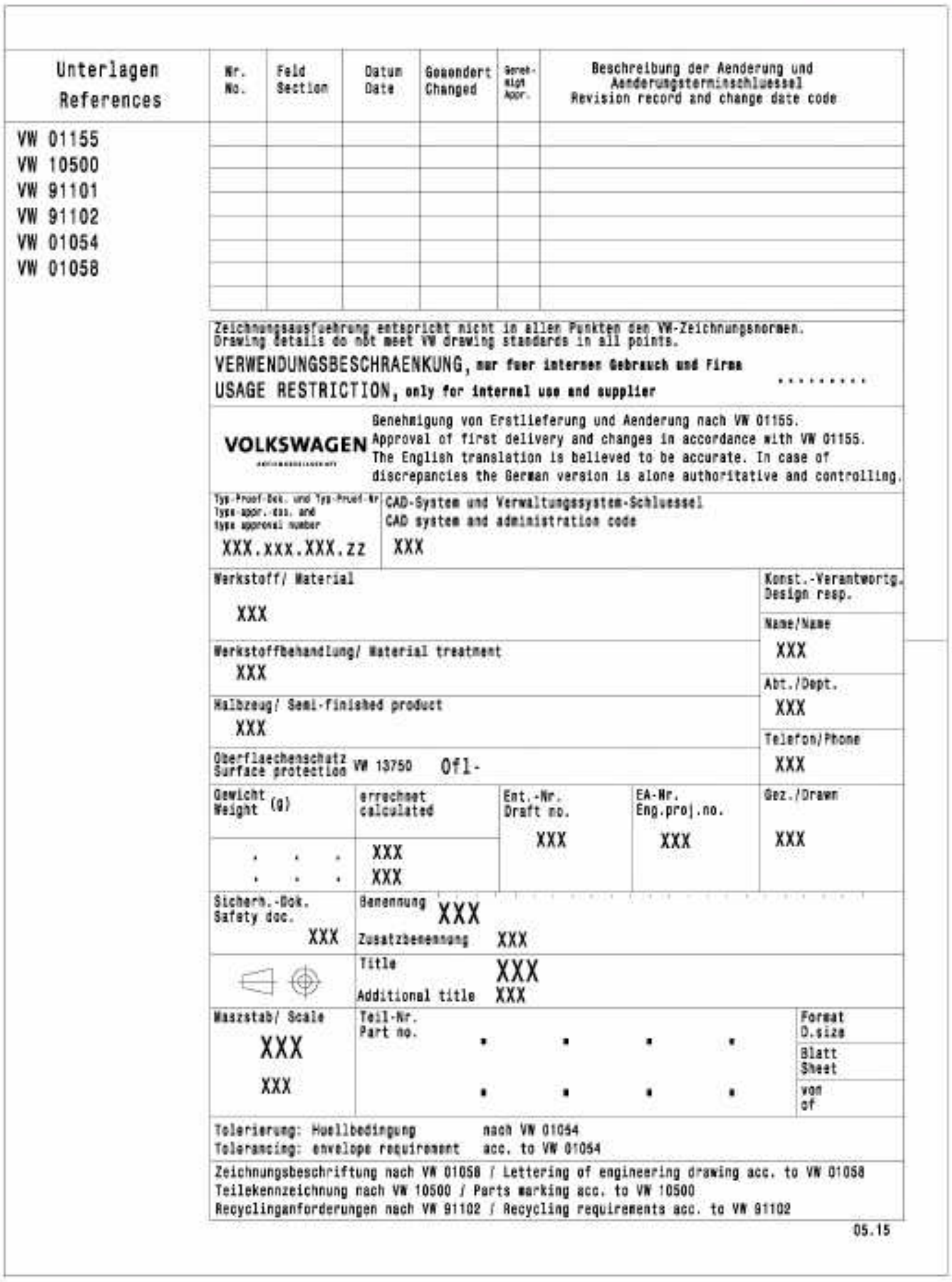


Figure 8 – Example for the drawing note for the general applicability of the envelope requirement to Volkswagen AG drawings with an external restriction on use

For more details on changing supplier drawings to Volkswagen Group drawings with an external restriction on use, see:

– "User Manual – Restrictions on Use for Data Providers and Data Recipients," available in HyperKVS. Path: "Extras Documentation/manuals" → "User documentation" → "Verwendungsbeschränkung" (restriction on use)
– "Criteria for Release-Compliant Drawings" (KfZ guideline). Available in HyperKVS, path "Extras Dokumentation / Handbücher" → "Anwenderdokumentation" → "Stückliste und Freigabe" (Extras documentation/manuals → User documentation → Bill of materials and release)

4.3.1 Supplier drawings without a note specifying the tolerancing type

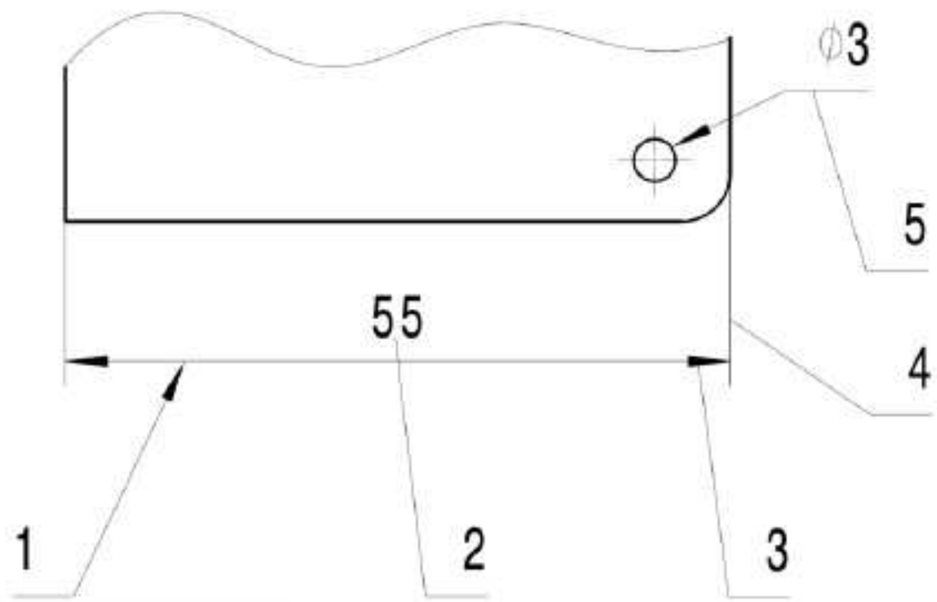
If a supplier drawing needs to be changed to a Volkswagen Group drawing with a restriction on use and does not contain a note indicating the general applicability of the envelope requirement or independency principle, the independency principle applies automatically to the drawing as per DIN EN ISO 8015.

In Germany, the envelope requirement applied to all features-of-size of type "cylinder" or type "two parallel opposite planes" until April 2011 as per DIN 7167 [2)]: 1987-01, provided the corresponding drawings were based on DIN standards. Because of this, it is strongly recommended to contact the supplier in order to clarify the requirements with regard to these drawings.

5 Features of dimensioning

Dimensioning is performed with the help of the features shown in figure 9.

Entering tolerances of length and angle dimensions, see DIN 406-12.



Legend

1	Dimension line
2	Dimension figure (dimension figure with symbol of tolerance class, dimension figure with deviations)
3	Dimension line limiting
4	Extension line
5	Reference lines for entering dimensions

Figure 9 – Features of dimensioning

2) DIN 7167: 1987-01 – Relationship between tolerances of size, form, and parallelism; envelope requirement without individual indication on the drawing

5.1 Dimension lines, extension lines

Dimension lines are generally drawn perpendicular to the corresponding part edges and parallel to the indicated dimension between extension lines.

The dimension lines must be placed approximately 10 mm away from the part edges, see figure 10. If otherwise impossible, they may also be entered between the shown part edges, see figure 11. If there are several parallel dimension lines, they must be evenly spaced, if possible, at intervals of approximately 7 mm. Center lines and part edges must not be used as dimension lines.

Dimension lines must be drawn in one continuous stroke with the dimension figure placed above the dimension line, see figure 10 and figure 11, or as per figure 12 in case of insufficient space.

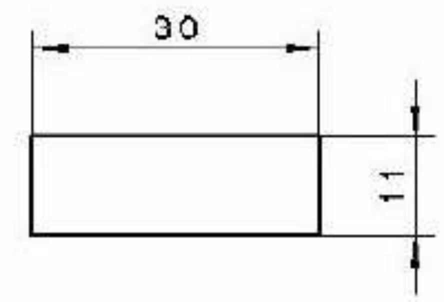


Figure 10

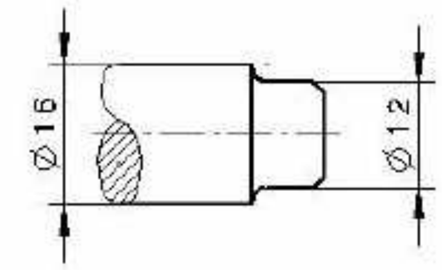


Figure 11

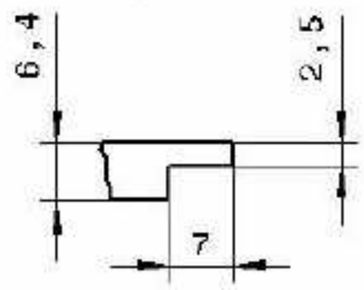


Figure 12

Dimension lines must not intersect with each other or with other lines. If it is unavoidable, they are drawn with no breaks, see figure 13. Center lines, extension lines, and hatching must be interrupted in areas around dimensions, see figure 14.

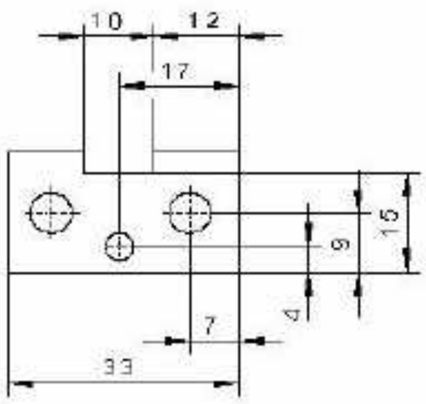


Figure 13

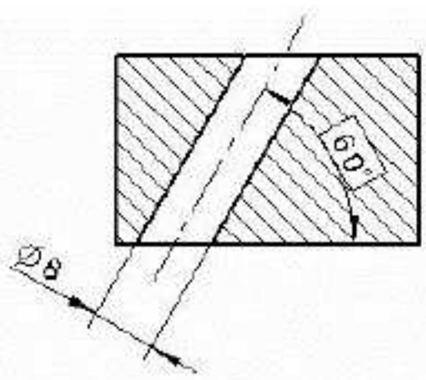


Figure 14

Extension lines (with the same width as the dimension lines) connect the dimension lines to the part edges. They are usually perpendicular to the dimension line. In individual cases, however, the extension lines are allowed to be drawn at an angled position (preferably under 60°) parallel to each other when necessary in order to make the drawing easier to understand; see figure 15. Center lines may be used as extension lines; in this case they are drawn as narrow solid lines outside of the part edges, see figure 16.

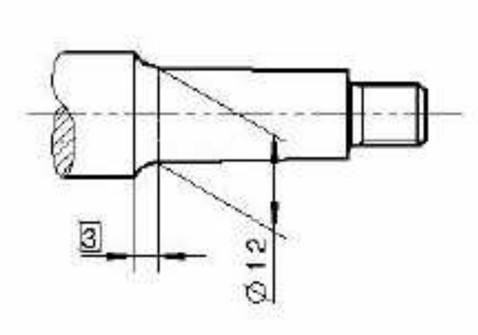


Figure 15

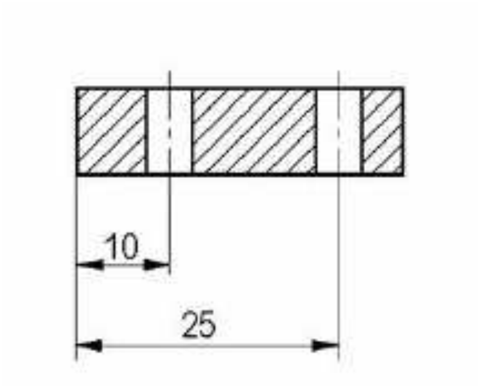


Figure 16

Extension lines may be interrupted, if it is clearly recognizable where they are continued, see figure 17.

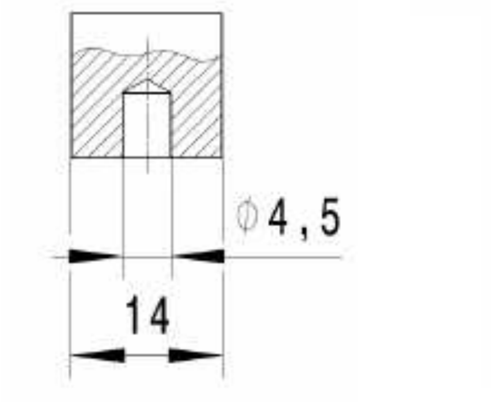


Figure 17

For **arc and angle dimensions**, the dimension line is a circular arc positioned concentric to the center of the circle or the vertex of the angle; see figure 18 and figure 19. For **chord dimensions**, it runs perpendicular to the median line; see figure 20.

For angle dimensions, the extension lines form an extension of the angle legs; for chord and arc dimensions up to 90°, they run parallel to the median line. For more details on arc dimensions, see section 6.11.

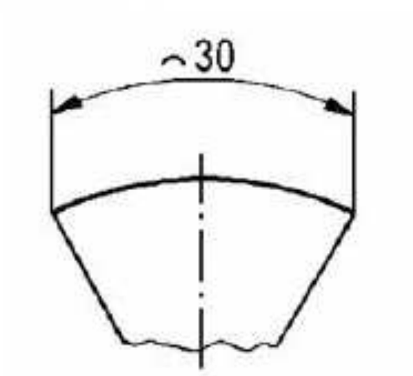


Figure 18

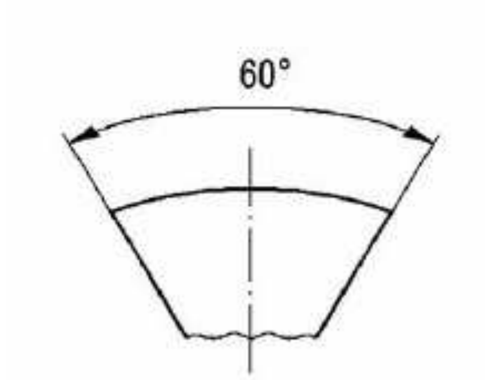


Figure 19

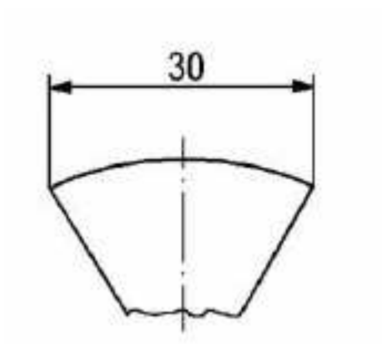


Figure 20

The dimension lines may be shortened in the case of views or sections that are only drawn up to the line of symmetry – see figure 21 – and in the case of half sections – see figure 22. In this case, the dimension lines have only one dimension line termination, but extend beyond the symmetry axis. Extension lines must not be drawn through from one view to another (full view/section) or drawn parallel to hatching lines.

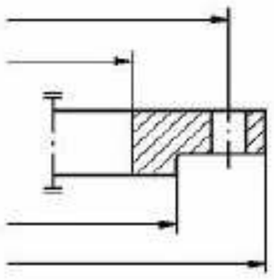


Figure 21

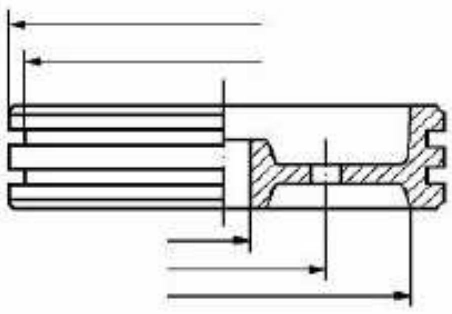


Figure 22

If there is a large number of individual distanc es, dimension lines with only one dimension line termination (dimensioning arrow) are permissible. In these cases, as per figure 28, the starting point must be clearly marked with a circle (see figure 26).

5.2 Dimension line limiting

Arrowhead

Dimension lines are preferably terminated with a solid arrowhead. This arrowhead must have the shape of an isosceles triangle with a vertex angle of 15° and a length equaling 10 times the width of the dimension line. In the case of dimensioning arrows that need to be drawn in places where there are black areas, recesses with an approx. width of 5 mm must be used; see figure 23.

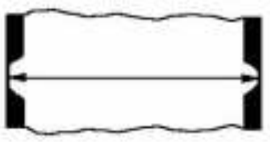


Figure 23

Dot

Dimension lines may also be terminated by dots in the event of insufficient space, see figure 24 and figure 33. The dot has a diameter of 5 times the width of the dimension line. The center of the dot is placed at the intersection point of the dimension line and extension line or part edge.

Slash

Dimension lines can be terminated by a slash that runs from the bottom left to the top right at 45° relative to the orientation for reading the drawing and has a length equaling 12 times the width of the dimension line. The center of the slash runs through the intersection point of the dimension line and the extension line, see figure 25 and figure 27.

Circle for indicating the origin

Dimension lines can be terminated by an unfilled circle for indicating the origin. The circle has a diameter of 8 times the width of the dimension line. The center of the circle is placed on the intersection point between the dimension line and the line of the datum feature at the location where the defined dimension begins; see figure 26. The symbol is used for increasing dimensions; see figure 28 and figure 29.

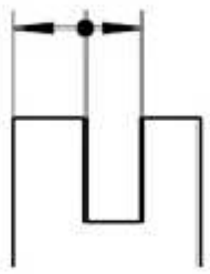


Figure 24

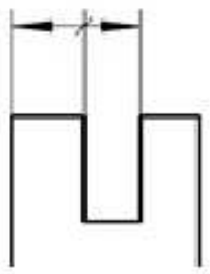


Figure 25

Figure 26

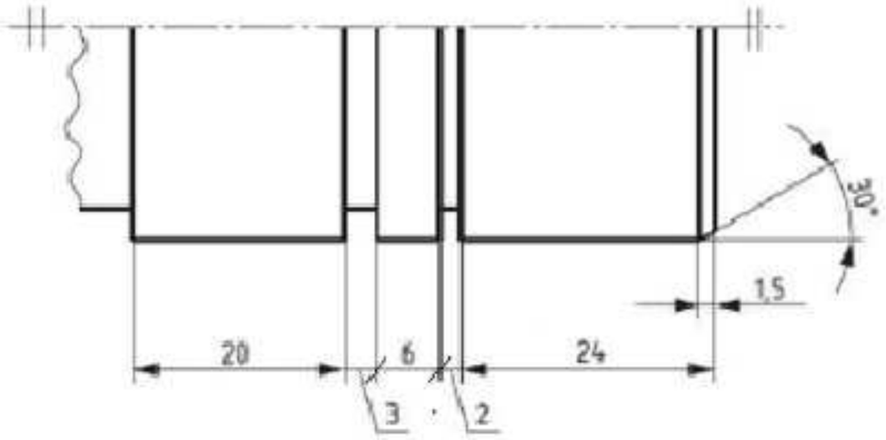


Figure 27

5.3 Dimension figures

In engineering drawings, the unit for the dimension figure is the millimeter. This unit is **not** indicated; however, other units, e.g., µm, kg, ° (degrees), must be indicated after the relevant figure. Deviations are indicated in the same units as the nominal dimensions.

For the dimensions, only the dimension figures are valid, never the graphical representation.

Dimension figures must be written in a font size of 3.5 mm (exceptions: 2.5 mm) type style B, vertical as per DIN EN ISO 3098-2. Their position is dependent on the direction of the dimension line, see figure 30 and figure 31. They are placed above the dimension line; if there is not enough space, the examples in figure 32 and figure 35 must be followed. In exceptional cases, if it does not impair clarity, datum lines may be used, see figure 33. The figures are still written in the direction of the dimension line. The figures must not be separated or crossed by lines. They must also not be positioned on edges or intersection points of lines. All dimension numbers must be readable from the bottom or from the right side as appropriate for their orientation. In the case of increasing dimension figures, the figures must be entered close to the dimension line termination, in parallel with or tangential to and significantly above the dimension line, see figure 28 and figure 29.

The font size for the deviations must be the same as the size for the nominal dimensions.

The two deviations must always be indicated, even if one of the two deviations is zero. For examples, see figure 40, figure 41, and DIN 406-12.

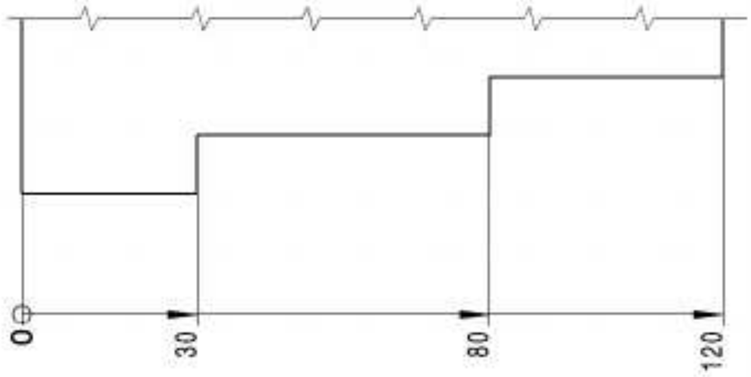


Figure 28

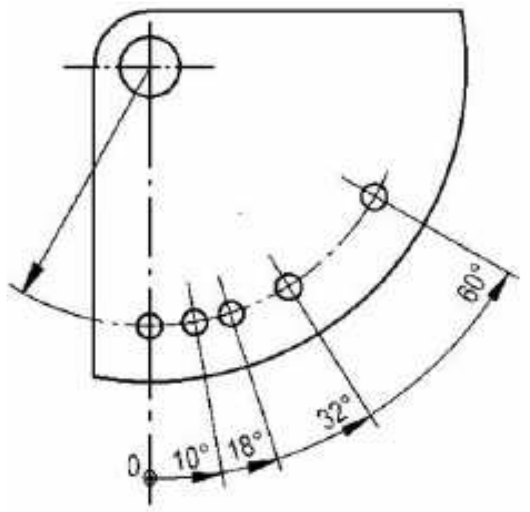


Figure 29

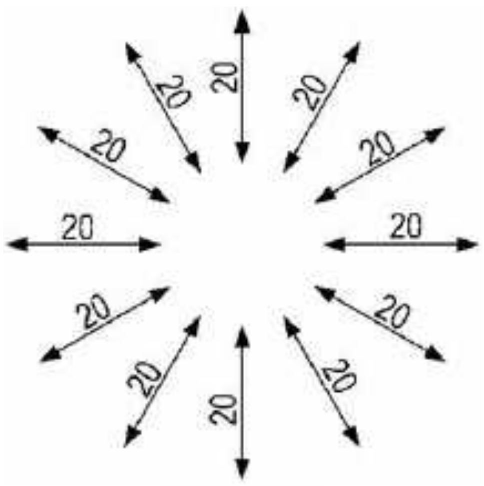


Figure 30

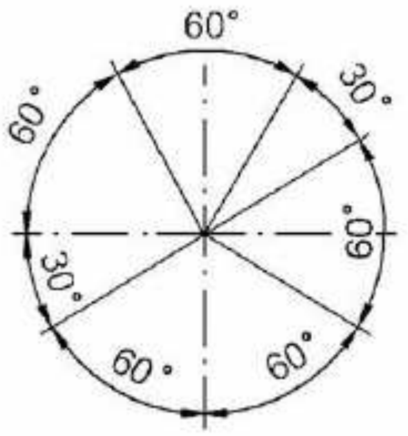


Figure 31

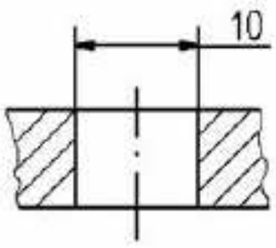


Figure 32

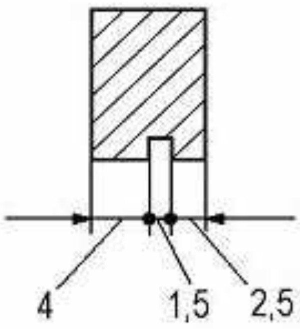


Figure 33

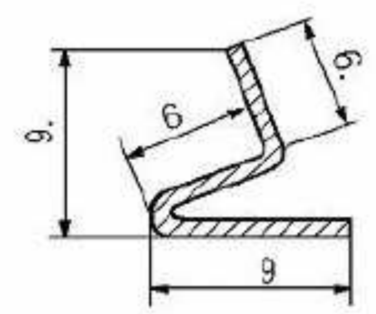


Figure 34

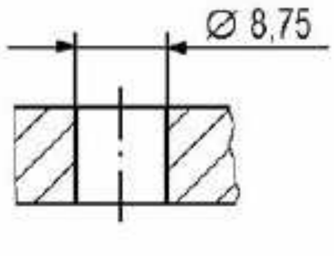


Figure 35

The numbers 6 and 9, as well as their combinations and combinations with the number 8, e.g., 68 or 89, must be followed by a dot, if there is a risk of confusion, see figure 34.

Dimensions with decimals generally contain a comma (it may be necessary to use a point instead of a comma, depending on the settings in the CAD system).

5.3.1 Dimension letters

Instead of dimension numbers, dimension letters (lowercase letters) may be used in table drawings, e.g., length = l, distance = d, diameter = dia, height = h, thickness = t, width = w. If there are several diameters, lengths, etc., in one drawing, indices must be used with the dimension letters in order to differentiate between them, e.g., d_1, d_2. The font size for the dimension letters is the same as for dimension numbers. The numeric values for the letters are compiled in a table.

5.3.2 Position of graphic and letter symbols with dimension numbers

The following symbols (referred to as "prefixes") must be placed directly before the dimension number without a space in between; see section 6.2, section 6.3, and section 6.5.

ø	Diameter
R	Radius
□	Square
Sø	Diameter of a spherical feature
SR	Radius of a spherical feature
⌒	Arc length
t=	Thickness of a workpiece (e.g., sheet)

5.4 Special dimensions – inside parentheses, brackets, or frames

Special dimensions (inside parentheses, brackets, or frames) are not used for the production of a part and must be marked accordingly. Their meaning is preprinted on the bottom edge of the drawing (see figure 36). The meaning of other special dimensions must be explained in the drawing in the "Bemerkungen / Notes" field.

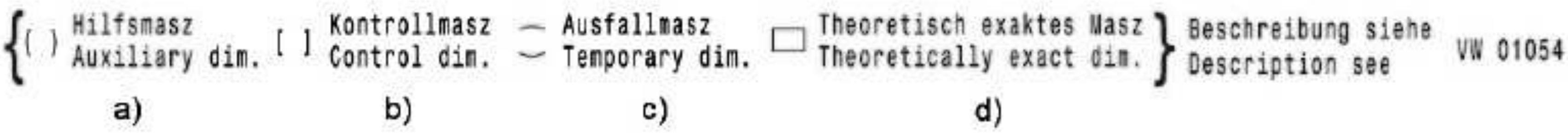


Figure 36

Curly brackets { } are used to put multiple specifications together.

5.4.1 Auxiliary dimensions

Auxiliary dimensions (informational dimensions) are not required for the geometrical definition of a part. They supply additional information and are used only for understanding. They indicate, for example:

– The sum of length or angle dimensions (for examples, see figure 106 and figure 107) or
– the dimensional relationship to other parts or to ruled lines (for an example, see figure 37).

So that they do not lead to overdetermination, they are placed inside parentheses and thus declared as auxiliary dimensions. Auxiliary dimensions are not allocated a tolerance and not considered part of the contract.

5.4.2 Control dimensions

Control dimensions are placed between square brackets [ ], see figure 36 b. They are used to indicate dimensions on parts that must be kept as finished dimensions in a next higher processing stage, e.g.:

– In ASSY drawings for dimensions that have already been dimensioned in a part drawing but that must not change, or that may only change up to a specific value, during assembly, e.g., welding; for an example, see figure 38.
– In part drawings as an inspection dimension in addition to the manufacturing dimensions, e.g., to ensure a proper fit after heat treatments.

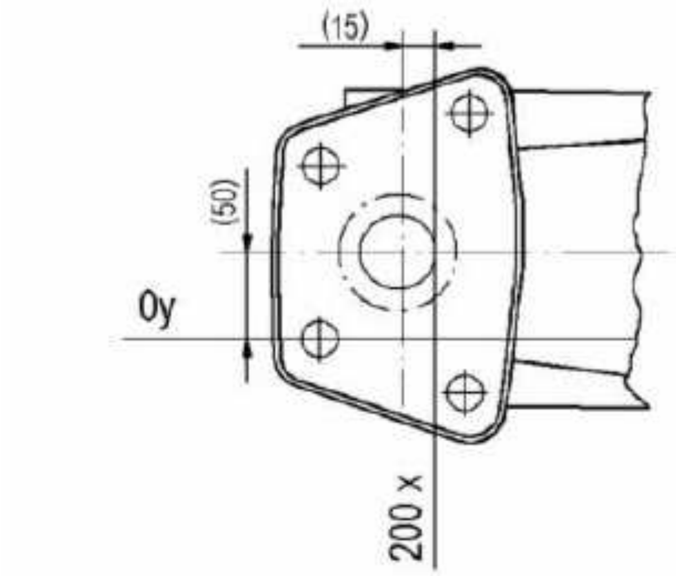


Figure 37

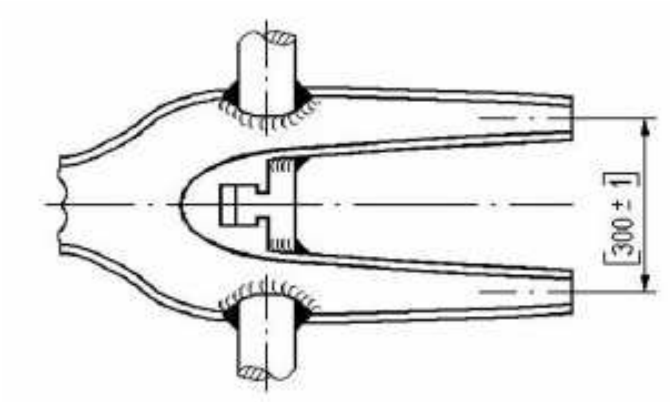


Figure 38

5.4.3 Final dimensions for parts manufactured using non-machining operations

Final dimensions are identified with flattened arcs above and below the dimension number ; see figure 36 c) and figure 39. They are entered on the **original drawing** if, during acceptance, Quality Assurance determines that a tolerance has been exceeded but that this will not affect the vehicle's operation.

The marking must be used only on parts produced without cutting and only if the Development, Inspection, and Planning departments approve this on the inspection report. Final dimensions are therefore not corrected in the drawing and are not checked during production; their marking is not entered in the drawing change block either. When new tools are produced based on this drawing, the dimension entered in the drawing represents the ideal.

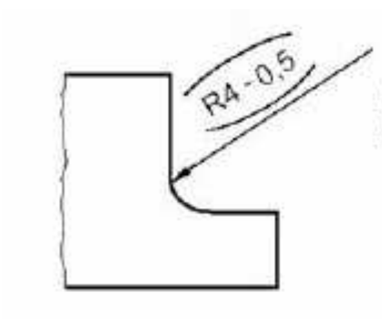


Figure 39

5.4.4 Theoretically exact dimensions

Theoretically exact dimensions are enclosed in a rectangle ; see figure 36 d. They do not have tolerances, are theoretically exact, and are specified for purely theoretical values (not functional dimensions), e.g., for distances between a datum plane or part edge to a measuring plane used as a basis for dimensioning; see figure 40 and figure 41.

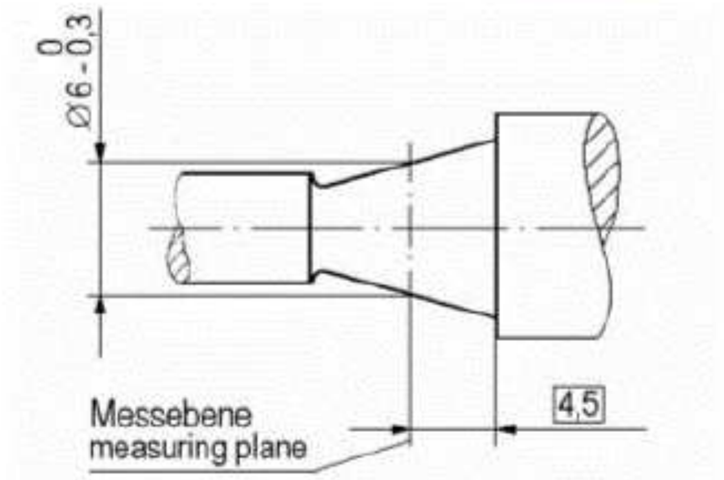


Figure 40

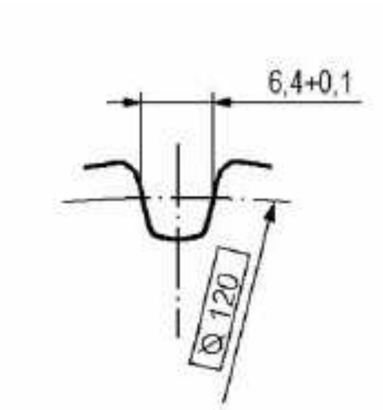


Figure 41

In connection with shape and positional deviations, **theoretically exact dimensions** are used to define the ideal geometric shape and position of the tolerance zones (form and positional tolerancing as per DIN EN ISO 1101). For an example, see figure 42.

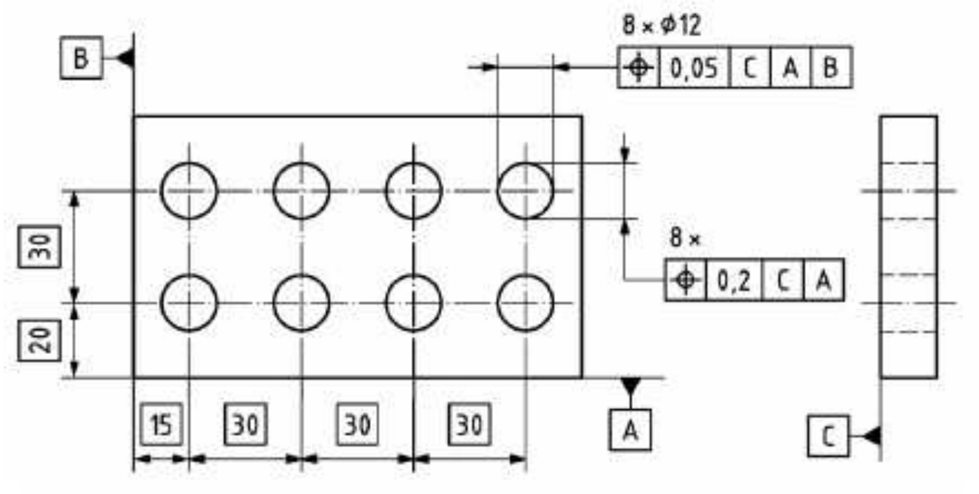


Figure 42

5.4.5 Fixture dimensions for tool design

Fixture dimensions are placed between angle brackets < >; see figure 43a. They are of importance for tool design purposes only and are generally entered only if specifically requested by the Planning department; see figure 44.

Figure 43

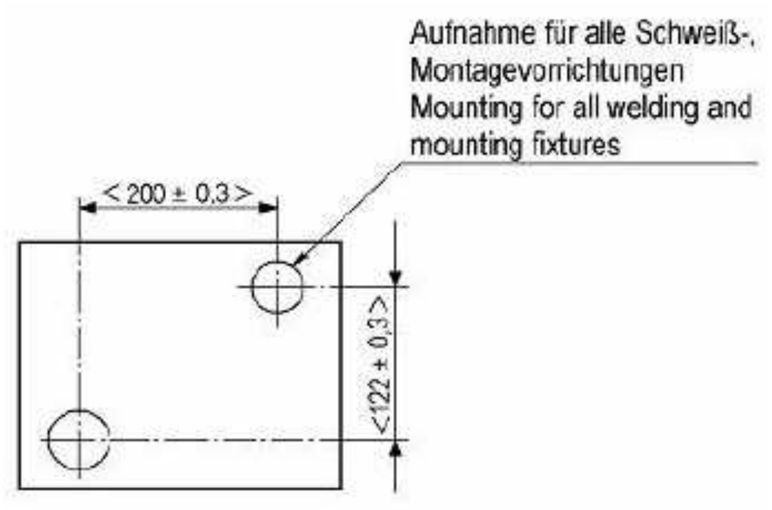


Figure 44

5.5 Inspection marking for inspection features

Inspection features are important geometrical properties such as dimension, form, position, and surfaces of components and system ASSYs, whose non-compliance can have a large influence on function, safety, installation capability, reliability, and further processing and therefore must be adhered to in particular.

Inspection features are defined jointly by Design Engineering, Production Planning, and Quality Assurance (purchaser) and are marked with an inspection marking. Inspection features must be checked and documented in particular for the part inspection (contractor, e.g., production testing, checking of outgoing goods by the supplier, or checking of incoming goods (purchase parts) by the part purchaser).

The "inspection marking" graphic symbol (see figure 45 and table 1) consists of a frame as per DIN 406-10 that can be divided into sections using vertical lines. Some valid examples are shown in figure 46.

Figure 45 – Basic graphical symbol "Test marking"

Figure 46 – Basic graphical symbol "Test marking" divided into fields – Designs

If the random sample size, frequency of testing, and report contents are not specified by the purchaser, they must be agreed upon explicitly with the purchaser.

The divided fields can contain notes with respect to the percentage that must be tested, as well as letter and/or number codes that are explained outside of the graphical representation in assembled form.

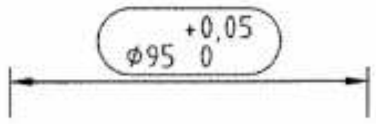
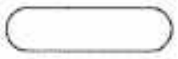
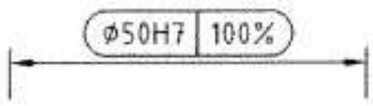
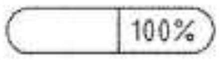
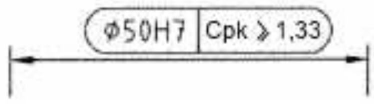
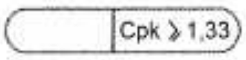
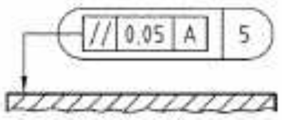
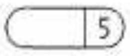
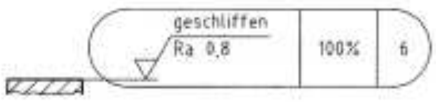
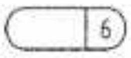
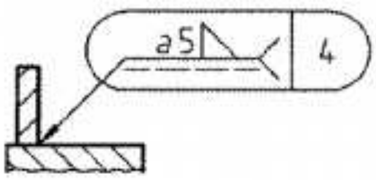
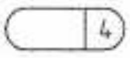
Additional definitions must be specified in the drawing/test specification:

- The testing scope (random sample size – how many parts)
- The frequency of testing (how often tests are performed)
- How the measurement results must be recorded

For examples of the marking of inspection features and their explanation, see table 1.

It is hereby explicitly noted that inspection features are not a replacement for the usual production tests and quality checks. Within the scope of its production responsibility, the internal or external supplier is responsible for adhering to all the dimensional, form, and positional tolerances specified in the drawing and to check them accordingly.

Table 1 – Examples of markings and explanation of the inspection features

No.	Symbols in the graphical representation	Explanation of the meanings in the drawing in the "Bemerkungen/Notes" field
1		 = functionally relevant feature (text for test setup or reference to corresponding docu-ments)
2		 = for acceptance 100% inspection
3		 = adhere to Cpk value
4		 = part must be checked in vertical position
5		 = (text for test setup)
6		 = ultrasonic testing on weld
		If the test requirements are clear, the explanatory notes are omitted.

5.5.1 Inspection report

The inspection report is used to record the results of the inspection feature checks in writing during the component inspection, e.g., with the following scope:

- Designation of the component or system tested
- Designation of the current test requirements, e.g., production drawings or test specifications, including change suffix
- Test location/date
- Test equipment used
- Designation or reference system for each test datum point
- Desired values with tolerances
- Measured actual values; minimum, maximum, and average values; standard deviation

The contractor performs the production inspections and outgoing goods inspections as per its scope of responsibilities and any existing special agreements.

The inspection reports must be submitted to the purchaser as proof of adherence to the inspection features required in the drawing.

5.6 Reference lines

Reference lines are narrow solid lines that extend out from the graphical representation at an angle, such that they cannot be confused with part edges or other lines, see figure 47. They end with a **dot** when indicating shown surfaces (see figure 47, figure 67, figure 83, figure 96, figure 97), with an **arrowhead** when indicating part edges (see figure 44 and figure 48), and without a terminating symbol for all other lines, e.g., dimension lines, center lines (see figure 27 and figure 33). Where there is insufficient space, reference lines may also be used as datum lines for dimensions; see figure 33.

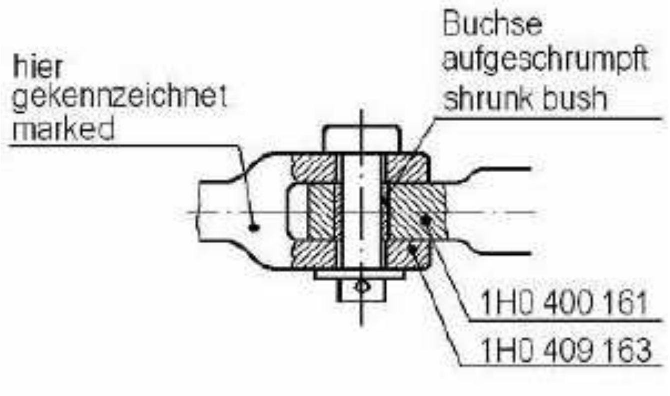


Figure 47

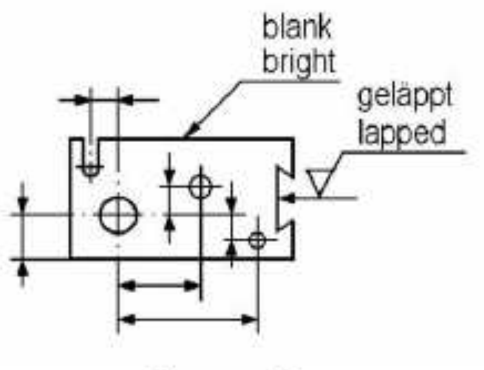


Figure 48

6 Entering dimensions

6.1 Repeat dimensions

As a rule, in a drawing, one dimension must have only one dimension figure. If, in exceptional cases, a dimension needs to be repeated in the same drawing, the dimension number must still appear only once. Both dimensions are marked with dimension letters, which are explained under "Bemerkungen / Notes" in the lower left-hand corner of the drawing, see figure 49.

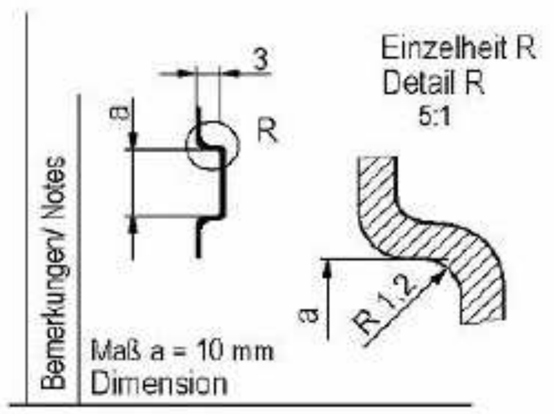


Figure 49

6.2 Radii

Radii are always marked by the capital letter R, which must be placed before the dimension figure. The dimensioning arrowhead is drawn, wherever possible, from the inside pointing outwards, see figure 50 to figure 52; if there is insufficient space, it may be drawn from the outside touching the circular arc, see figure 53 to figure 55. In this case, the radius is drawn to the center point and marked by a center line cross, if its position is required for operation, production, or acceptance.

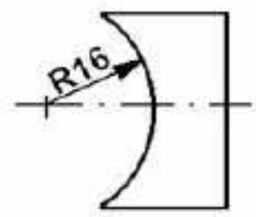


Figure 50

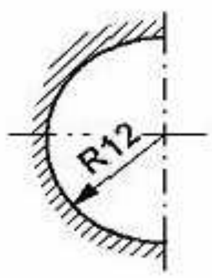


Figure 51

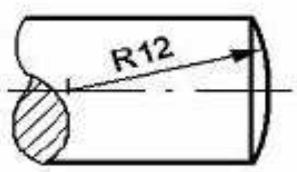


Figure 52

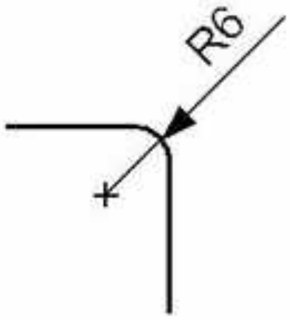


Figure 53

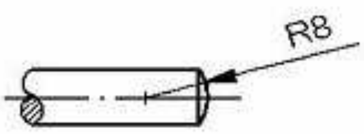


Figure 54

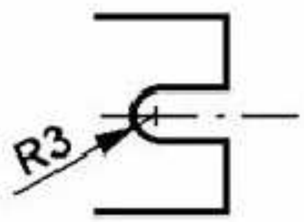


Figure 55

If the center point cannot be indicated for small radii, see figure 56 and figure 57, or is outside the drawing surface for large radii, the marking may be omitted, if the case is clear and unambiguous. If, in exceptional cases, the view must include a dimension where the radius does not appear as a circular arc – see figure 59 –, the radius starting point must always be indicated.

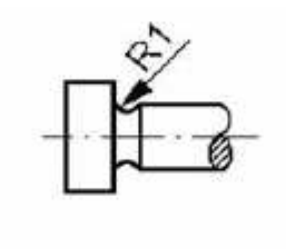


Figure 56

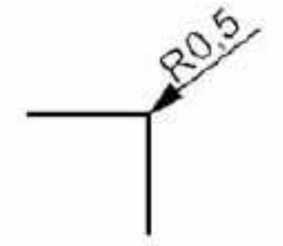


Figure 57

If there might be confusion in terms of the position of the center point, e.g., short circular arcs with large radii, see figure 58, the radius must always be indicated from the inside, i.e., from the center point.

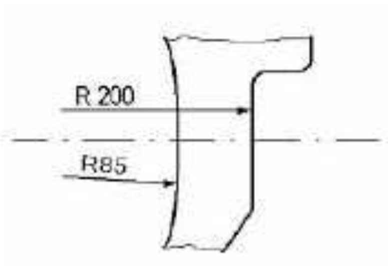


Figure 58

Figure 59

If the radius is indicated by the width, e.g., figure 60, the circular form is expressed by a single R. If the center point for large radii must be dimensioned, the extension of the dimension line that runs to the circular arc must be directed to the actual center point; the bend must be a right angle, see figure 61. Straight lines (no bend) must be used for drawings created using CAD technology.

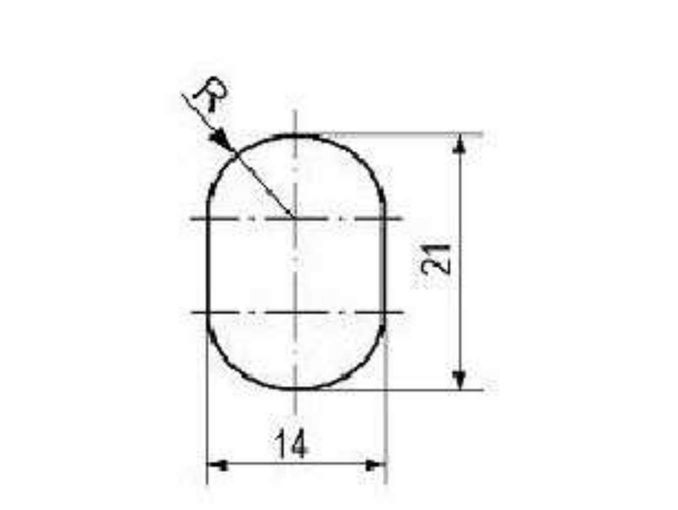


Figure 60

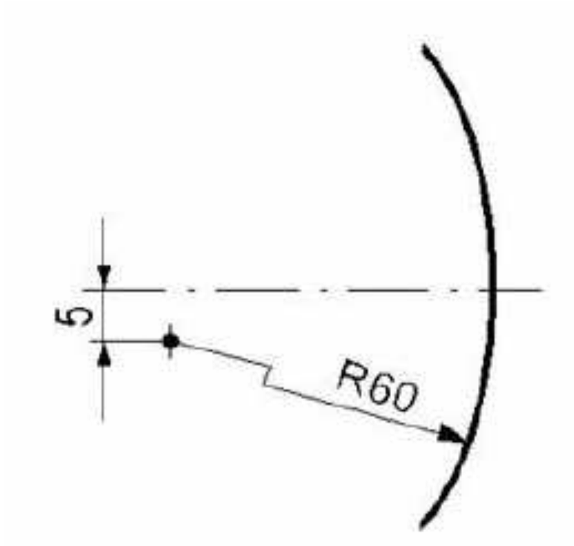


Figure 61

Several radii with a common center point are drawn to an auxiliary circular arc only or end with a shortened dimension line; see figure 62.

If required for clarity, auxiliary circles as per figure 63 are permissible.

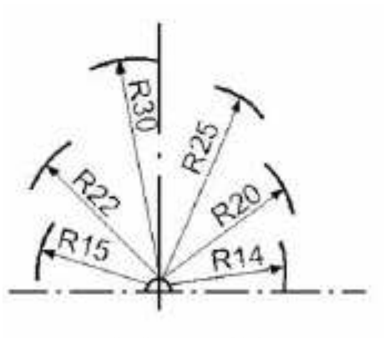


Figure 62

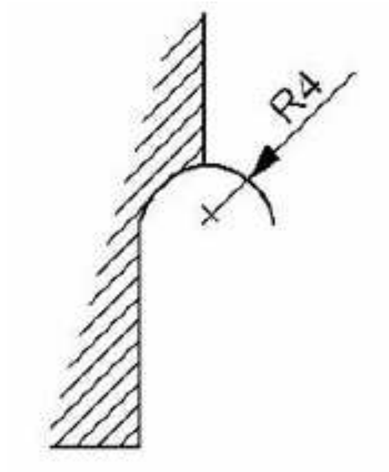


Figure 63

The dimension lines for several radii of the same size may be combined; see figure 64. Radii on bent and drawn parts are dimensioned on the inside, as the outside is generally flattened; see figure 65.

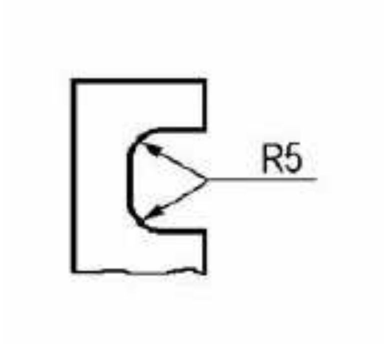


Figure 64

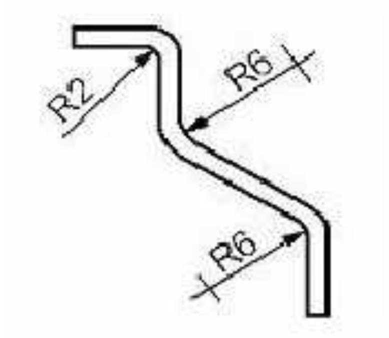


Figure 65

Instead of using sections to represent rounded shapes, the radius center point line, as a tangent line, may be drawn and dimensioned for both constant and changing radii; see figure 66 (RE = tangent line).

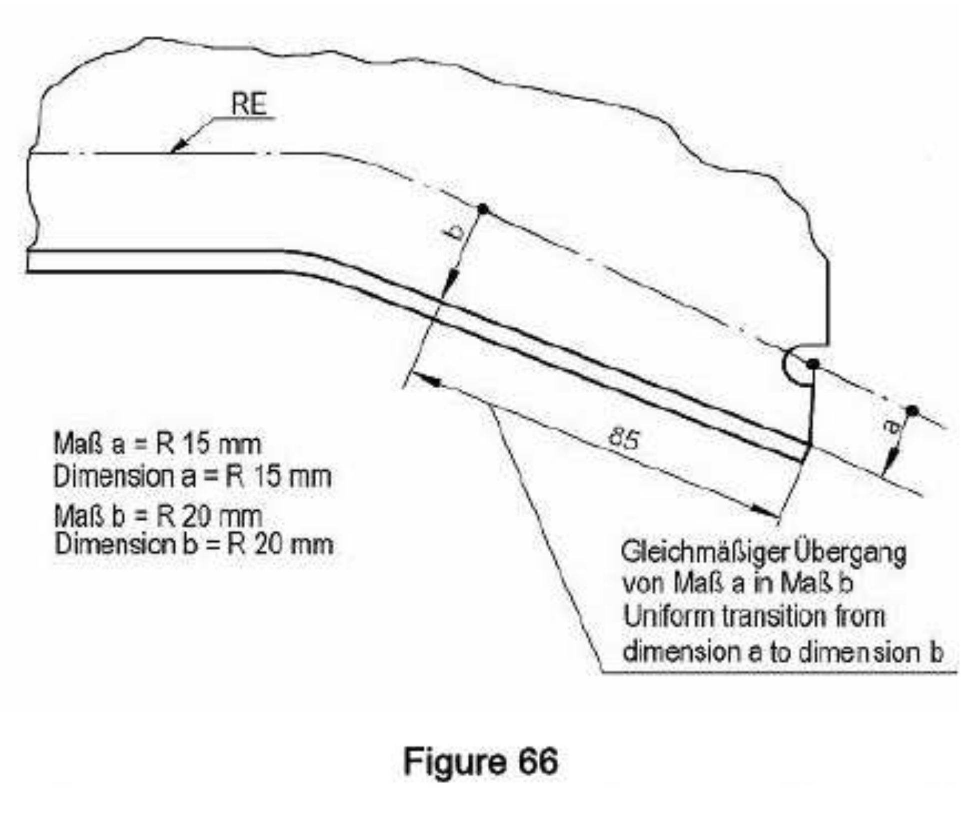


Figure 66

If there are several views in the drawing, the evenly changing profile may be entered as per figure 67.

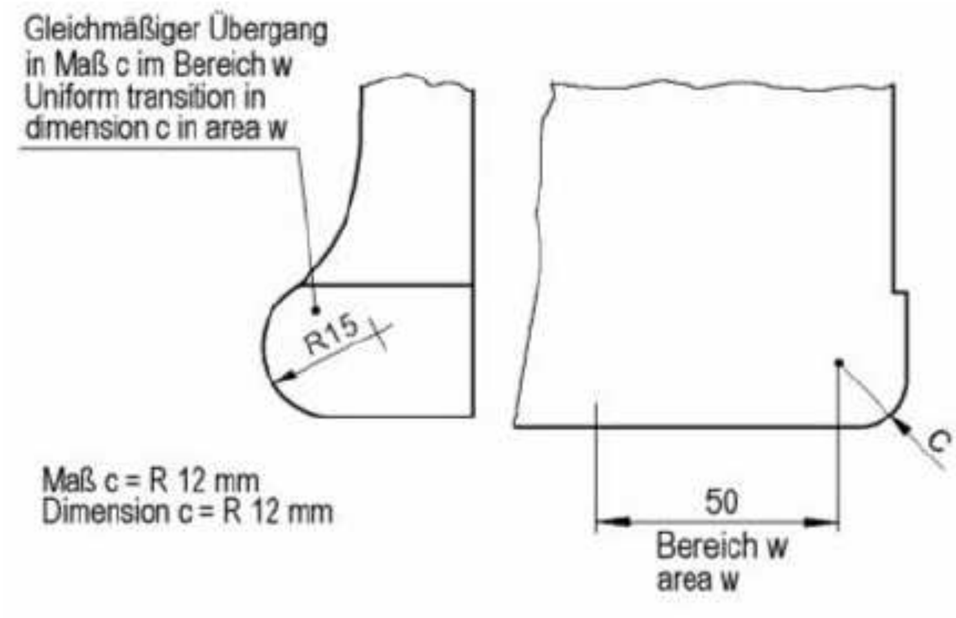


Figure 67

Constant radii used all around on parts that do not have a circular shape are specified only once and identified with "all around"; see figure 68 If a radius is constant, but is not used all around, it is identified with "constant" instead; see figure 69.

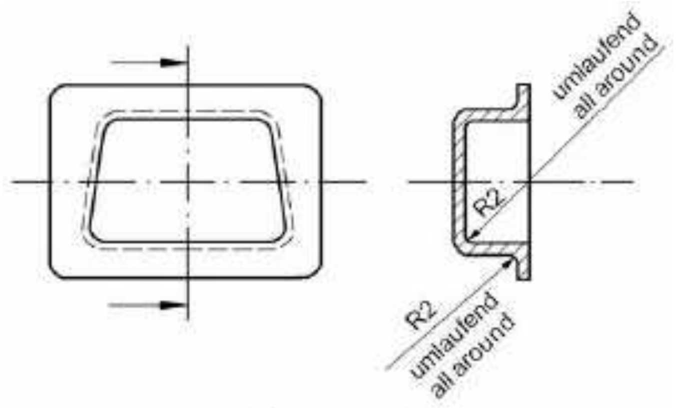


Figure 68

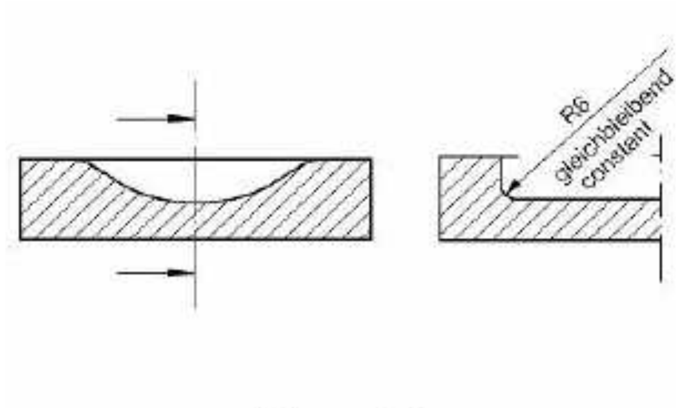


Figure 69

Radii for bent tubes are entered on the tubes' axis; see figure 70. In the case of steel sections, they are entered on the inner edges instead; see figure 71.

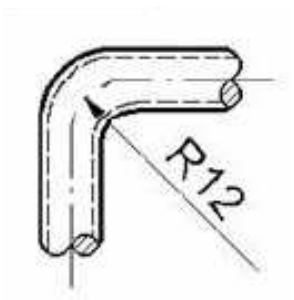


Figure 70

Figure 71

6.3 Diameter symbol

Diameter symbol Ø is used to identify circular forms and is always placed before the dimension number; see figure 72, figure 73, and figure 74. The symbol, a circle with a slash running through it at an angle of 75°, is placed before the nominal dimension and is centered with respect to the dimension figure.

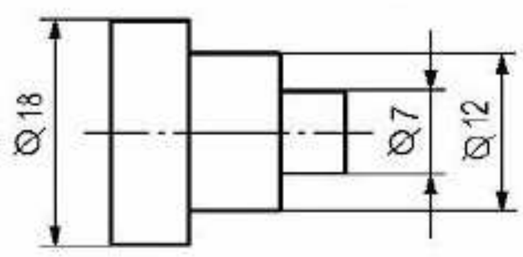


Figure 72

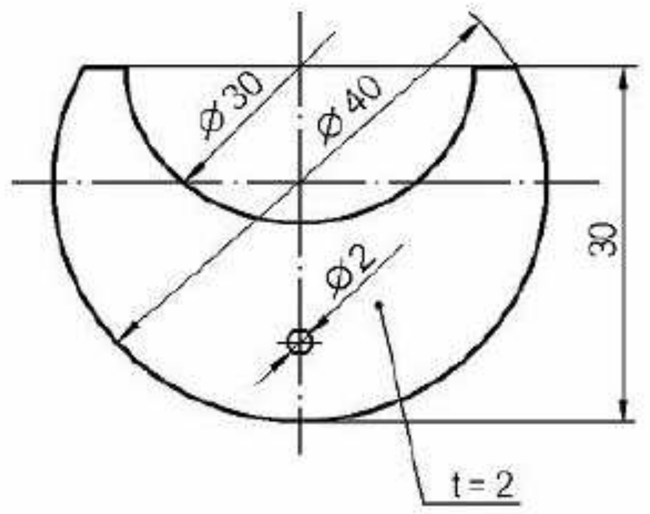


Figure 73

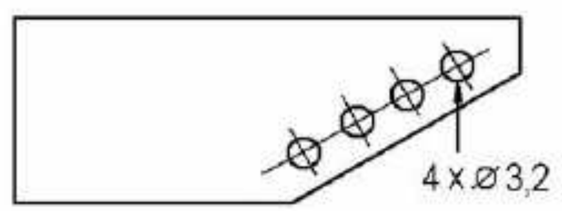


Figure 74

Several diameter dimensions in one view are confusing and must therefore be drawn out from the graphical representation, see figure 75.

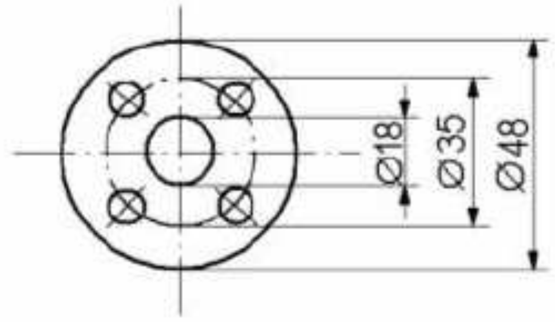


Figure 75

6.4 Sphere

The capital letter "S" (for "sphere") is always inserted in front of the diameter or radius specification of a sphere, see figure 76 and figure 77. For oval points, e.g., bolt or rod ends, the additional letter "S" is omitted, see figure 78.

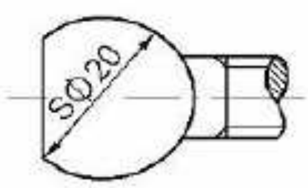


Figure 76

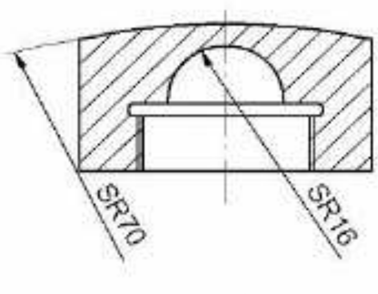


Figure 77

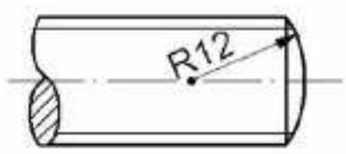


Figure 78

6.5 Square symbol, diagonal cross, widths across flats

The graphical symbol □ is always positioned before the dimension figure. The length of only one side of the square is given, see figure 79 and figure 80. Square shapes must preferably be dimensioned in the view in which the shape is recognizable, see figure 80.

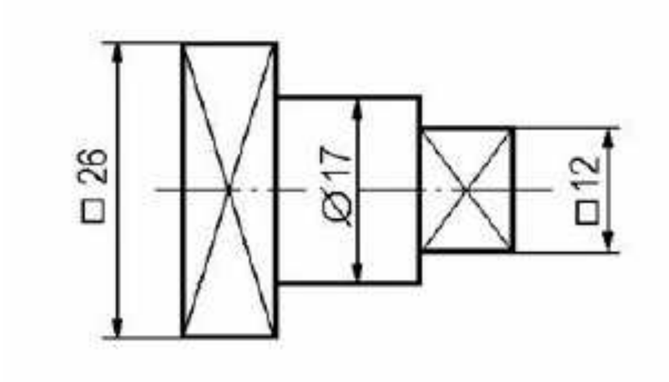


Figure 79

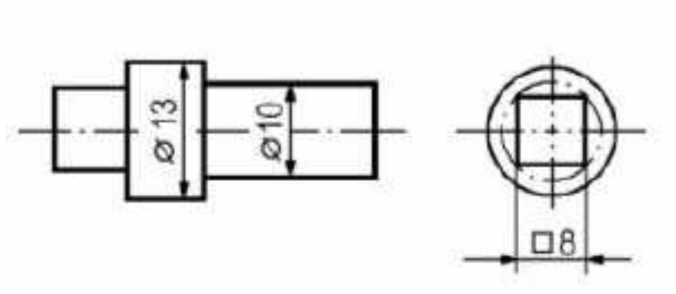


Figure 80

If only one view is available, planar four-sided surfaces are marked by a diagonal cross (line width same as for dimension lines), see figure 79. Surfaces that are not planar do not have a diagonal cross, see figure 81.

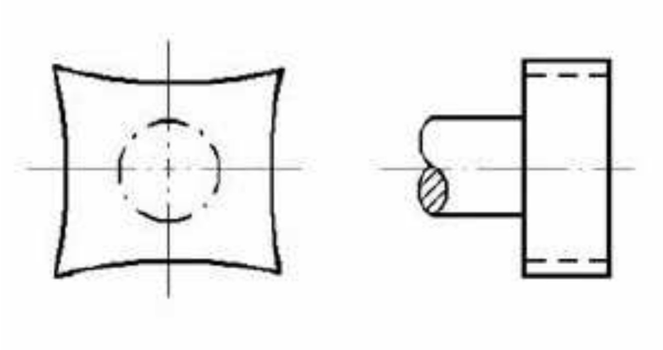


Figure 81

Widths across flats are indicated as per figure 82. If the distance between wrench bearing surfaces cannot be dimensioned in the graphical representation, the capital letters "SW" (width across flats) must be placed before the dimension number; see figure 83.

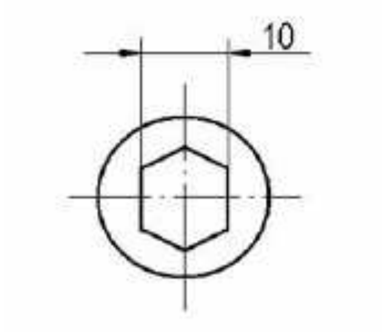


Figure 82

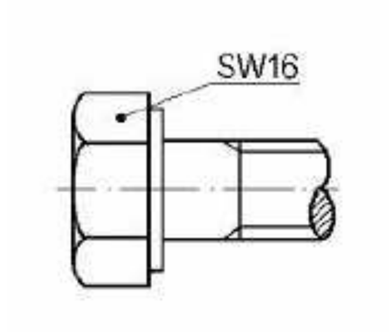


Figure 83

NOTE:

- Threaded joints, design and installation specifications as per VW 01110-1
- Width across flats selection as per DIN 475-1
- Tolerance of width across flats as per DIN ISO 272

6.6 Cone, taper, incline

The cone taper C is the ratio of the difference between two cone diameters and the distance between them. It is computed using the following formula, see figure 84.

$$C = \frac{D - d}{L} = 2\tan\left(\frac{\alpha}{2}\right)$$

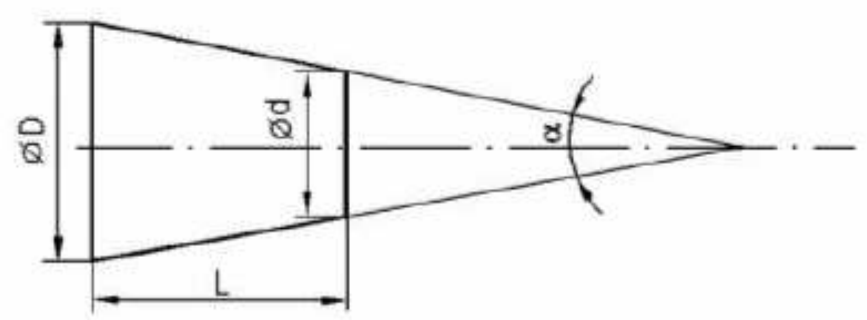


Figure 84

Graphic symbol ▷ is always placed before the dimension number for the taper (as a ratio or percentage) on a bent reference line. The direction of the graphical symbol must correspond to the direction of the taper, see figure 85 and figure 86. For standard cones, see DIN 254.

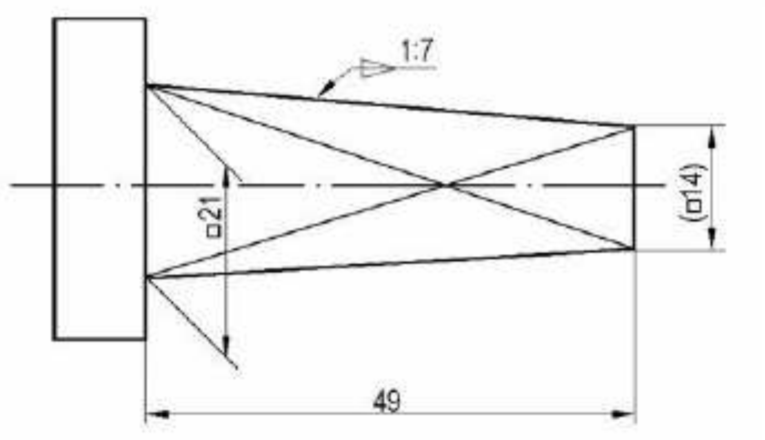


Figure 85

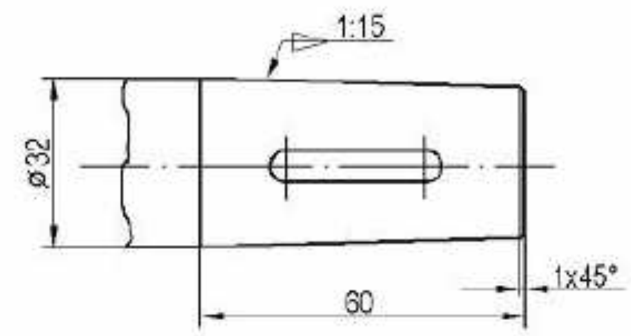


Figure 86

Graphic symbol ▷, which is used for the "cone" and "taper" geometrical features (height of triangle: 16 times the fonts' line width; base-to-height ratio of 1:2) is entered near the cone. The datum line must be connected to the contour of the cone by a reference line, see figure 87. The datum line is drawn parallel to the center line of the cone.

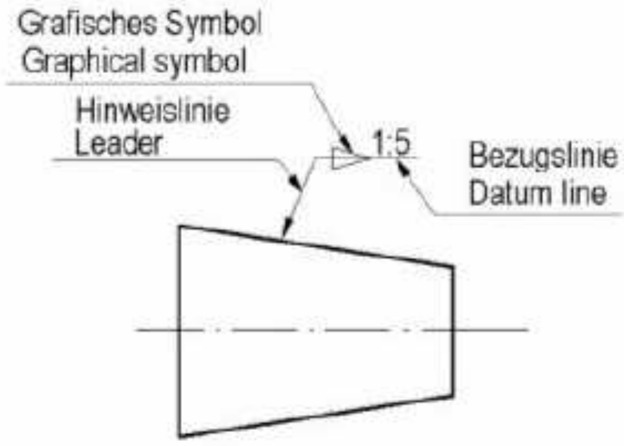


Figure 87

The graphical symbol for inclines is always indicated before the dimension figure of the incline (as a ratio or in percentage). This specification must preferably be entered on a bent reference line, see figure 88. However, it may also be entered on the line of the inclined surface – see figure 89 – or horizontally – see figure 90 – in exceptional cases.

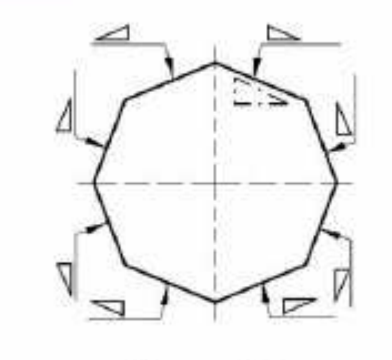


Figure 88

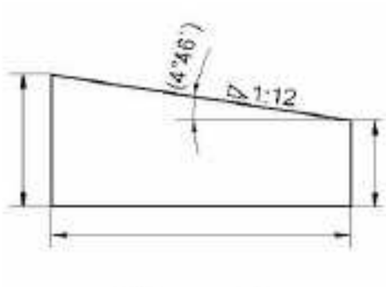


Figure 89

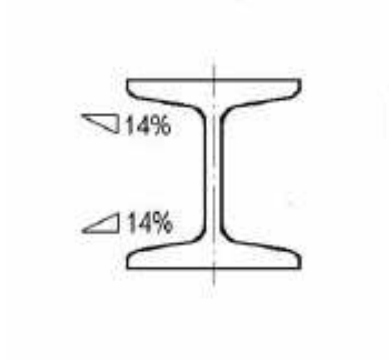


Figure 90

Graphic symbol symbolizes the shape of the part at the point of the incline; see figure 88. The angle of incline may also be indicated, for manufacturing reasons, as a reference or auxiliary dimension, see figure 89.

6.7 Grooves

Grooves are dimensioned as per figure 91 to figure 105. For grooves that are open (on at least one side), the groove depth is dimensioned from the opposite side; see figure 91. For all other grooves, the groove depth is dimensioned from the groove side; see figure 92 to figure 95. The depth of the groove is the greatest distance between the outer diameter of the part body and the groove base.

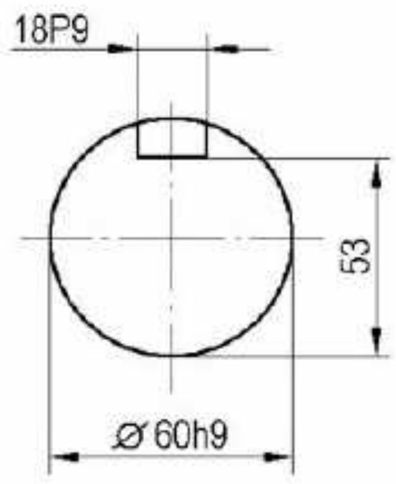


Figure 91

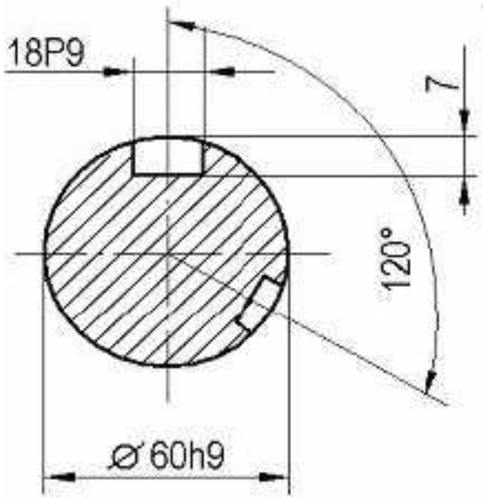


Figure 92

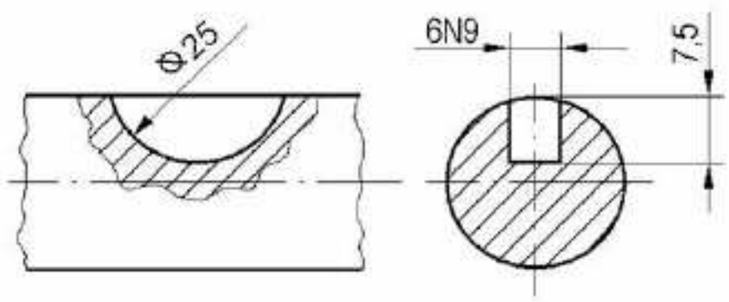


Figure 93

For an example showing how to dimension the groove depth when the base of the groove runs parallel to the envelope line of a cone, see figure 94. For an example showing how to dimension the groove depth when the base of the groove runs parallel to the cone axis, in which case the depth is dimensioned starting from the larger cylinder's envelope line, see figure 95.

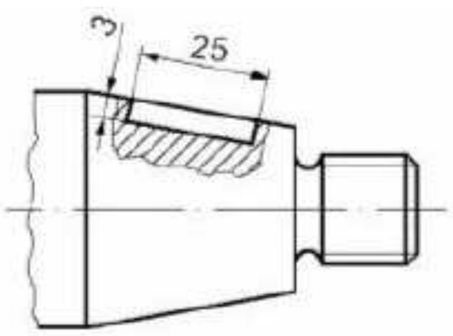


Figure 94

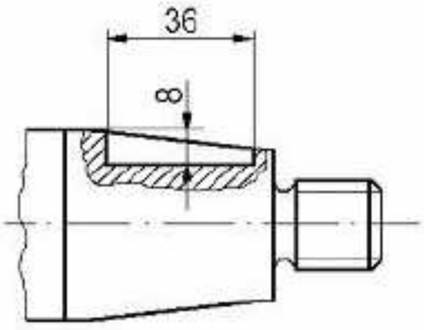


Figure 95

Simplified dimensioning of the depth of grooves in the top view using the letter h, see figure 96, or combined with the groove width, see figure 97.

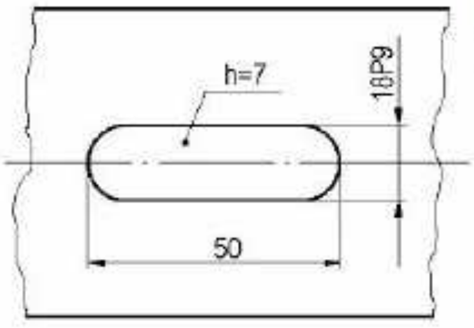


Figure 96

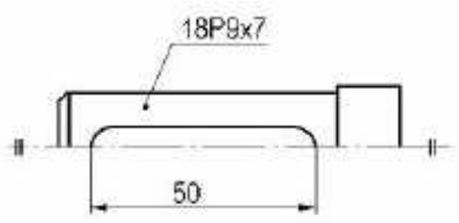


Figure 97

Dimensioning of grooves for keys in cylindrical holes, see figure 98.

NOTE 2: For the adequate dimensioning of key grooves, it may also be necessary, where corresponding accuracy requirements exist, to include the shape and positional tolerances as per DIN EN ISO 1101, e.g., for parallelism or symmetry.

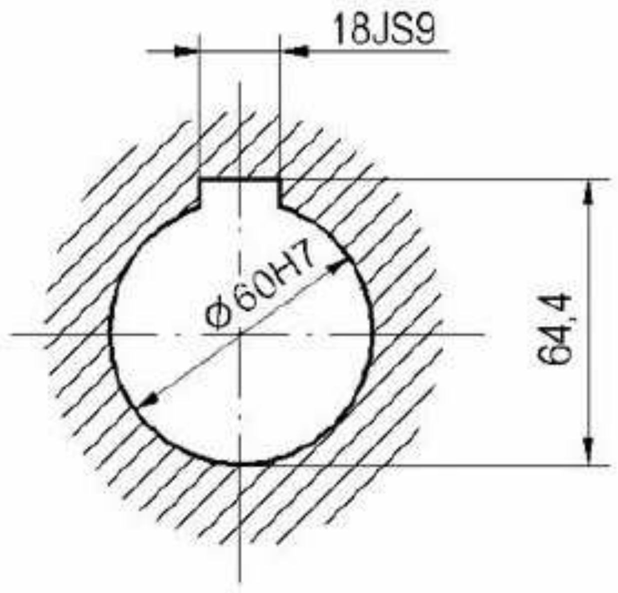


Figure 98

For an example showing how to dimension grooves for keys in conical hub holes (base of groove running parallel to the cone envelope line), see figure 99. For an example showing how to dimension grooves for keys in conical hub holes (base of groove running parallel to the cone axis), see figure 100.

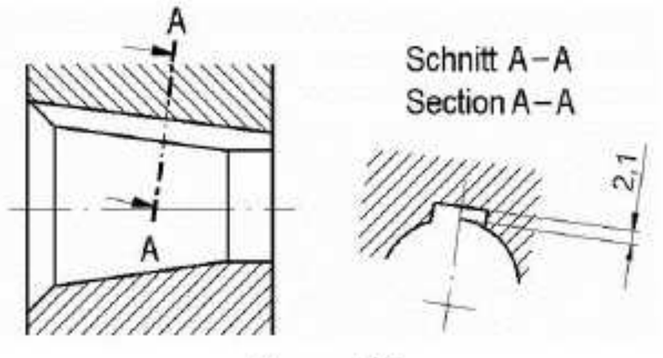


Figure 99

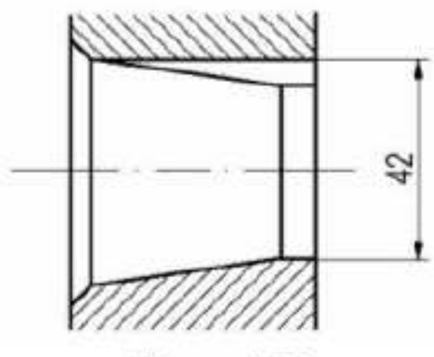


Figure 100

For hubs with wedge-shaped grooves, the direction of the incline must be indicated by the graphical symbol for "incline"; see figure 101.

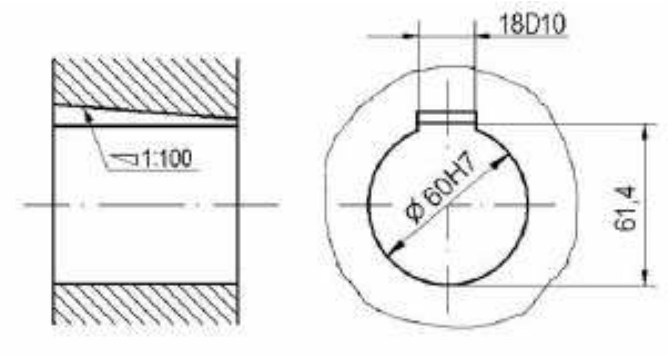


Figure 101

Complete dimensioning of grooves (recesses), e.g., for retaining rings, see figure 102 and figure 103. Simplified dimensioning of grooves (recesses), e.g., for retaining rings, see figure 104 and figure 105.

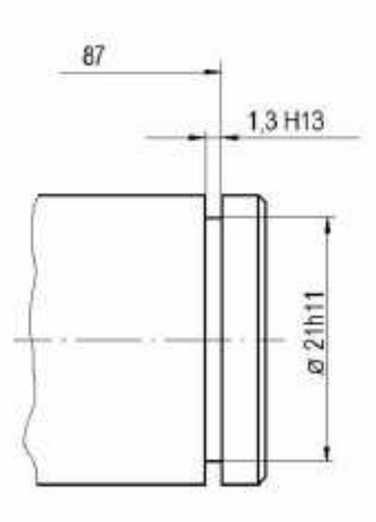


Figure 102

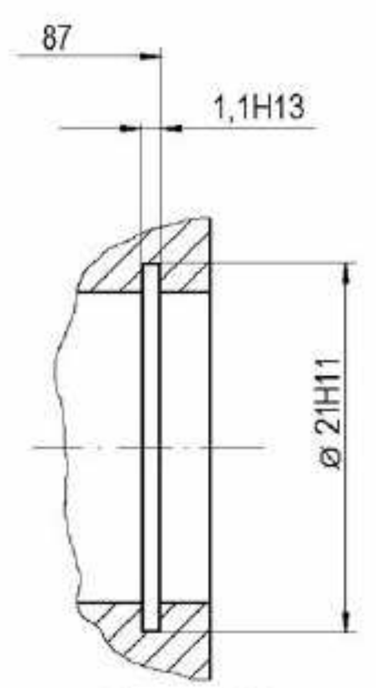


Figure 103

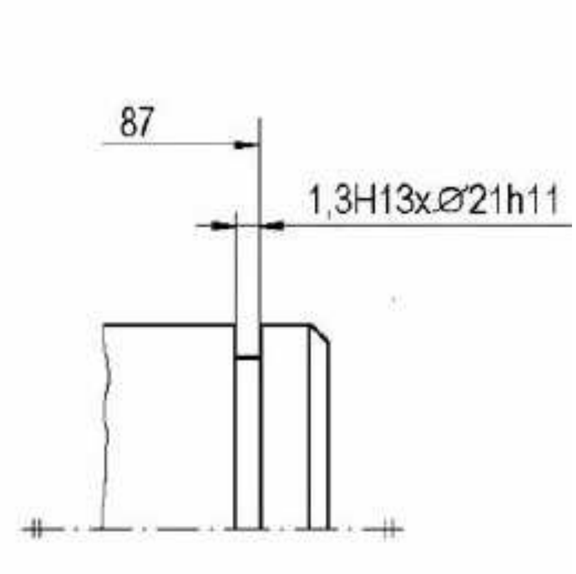


Figure 104

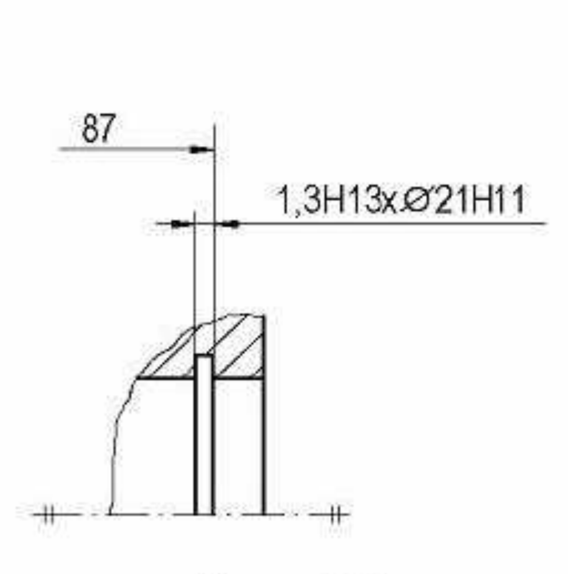


Figure 105

6.8 Spacings

Spacings with equal distances for equal geometrical features are indicated as per figure 106 and figure 107. The linear distance or angular distance is indicated only once. The number of distances is indicated in front of the symbol "×". The total size (sum of distances) is indicated as an auxiliary dimension after the symbol "=" in parentheses. Spacings for rectangular holes are dimensioned from the hole edges, see figure 108.

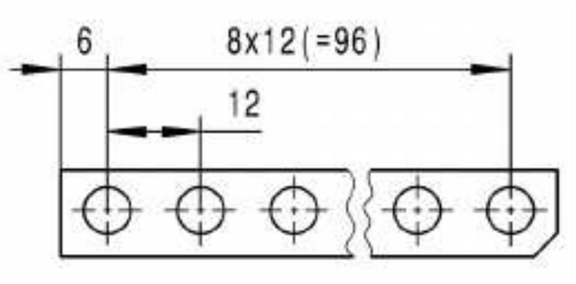


Figure 106

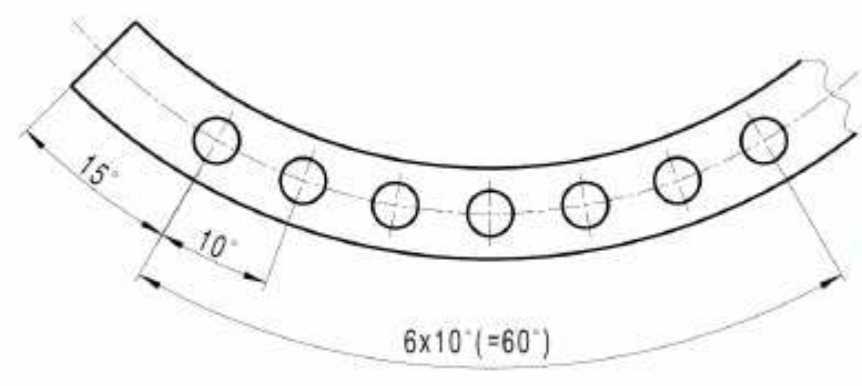


Figure 107

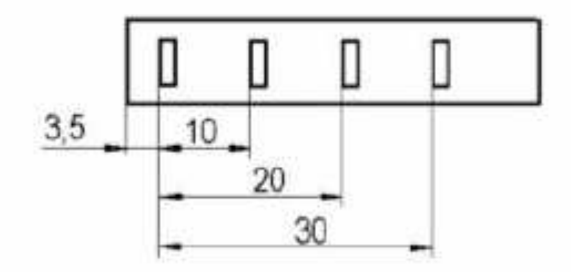


Figure 108

Angles are specified in degrees, minutes, and seconds (e.g., 30°33'18") or in a decimal notation (e.g., 50.5°). The use of different notations in a drawing must be avoided. The tolerance must be the same, respectively (e.g., 30°33'18" ±0°30' or 50.5° ±0.5°).

For the tolerancing of distances, it is recommended to use positional tolerances, see section A.1.1, DIN EN ISO 14405-2, and DIN EN ISO 1101.

6.9 Parallel dimensioning, increasing dimensioning

For parallel dimensioning, the dimension lines are entered parallel in a direction of a common datum feature; for an example, see figure 109.

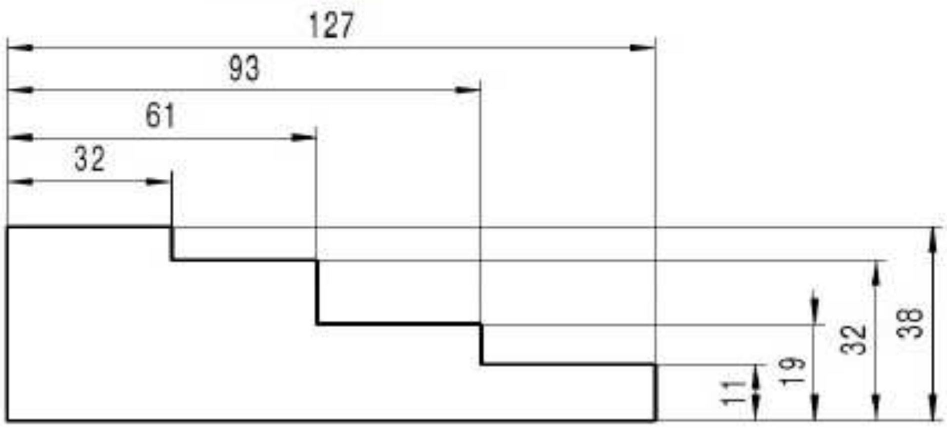


Figure 109

For increasing dimensioning, starting from a datum feature for a dimensioning direction, only one dimension line is entered, see figure 110 and figure 111. For each component edge to be dimensioned, an extension line is drawn. The first extension line represents the origin that is marked by a circle symbol (see figure 26). Each dimension represents the distance from this datum feature/origin.

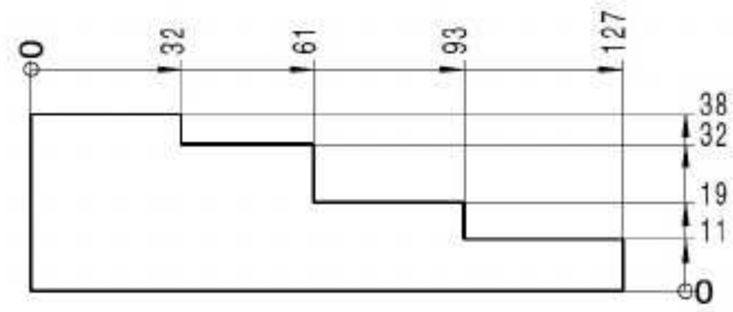


Figure 110

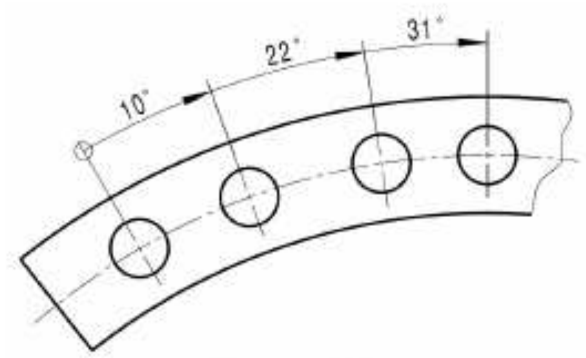


Figure 111

For the tolerancing of distances, it is recommended to use positional tolerances, see section A.1.1, DIN EN ISO 14405-2, and DIN EN ISO 1101.

6.10 Symmetrical parts

In the case of symmetrical geometrical features, the symmetrical dimensions are dimensioned only once (exception: square; see figure 112) and the symmetry is emphasized by the symmetry axis running perpendicular to the dimension lines regardless of whether dimensioning is from the inside or outside; see figure 113 and figure 114. Symmetry symbols (╪-·—; see figure 27 and figure 104) are not required in either arrangement. The symmetry must be adhered to with the usual workshop accuracy. If greater accuracy is required, the permissible coaxiality or symmetry must be prescribed; for more details see also DIN EN ISO 1101. Broken parts must be shown such that the break lines on both halves have the same distances, so as not to affect the symmetry, see figure 115.

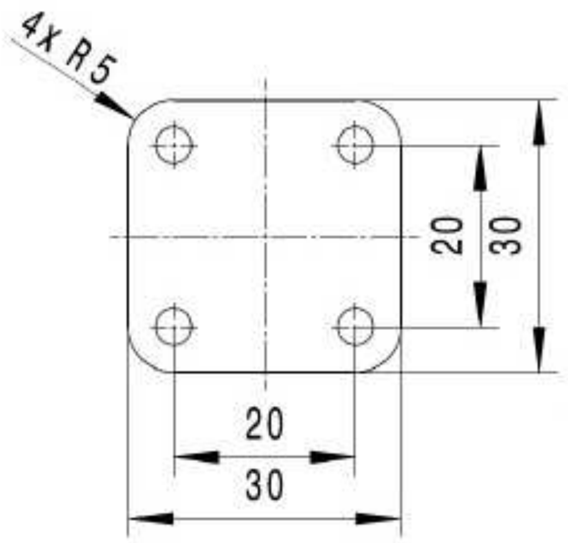


Figure 112

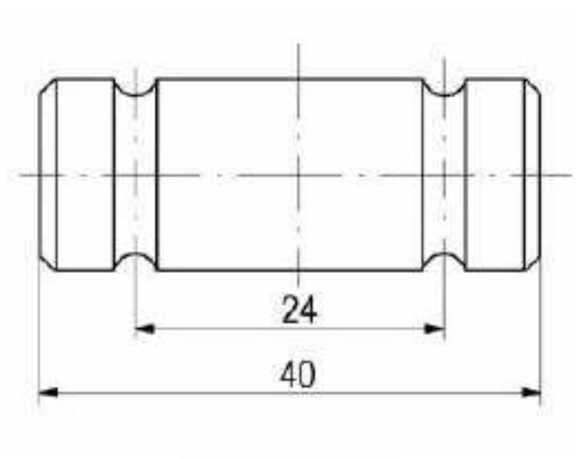


Figure 113

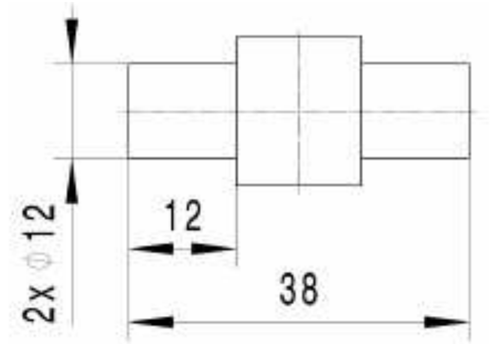


Figure 114

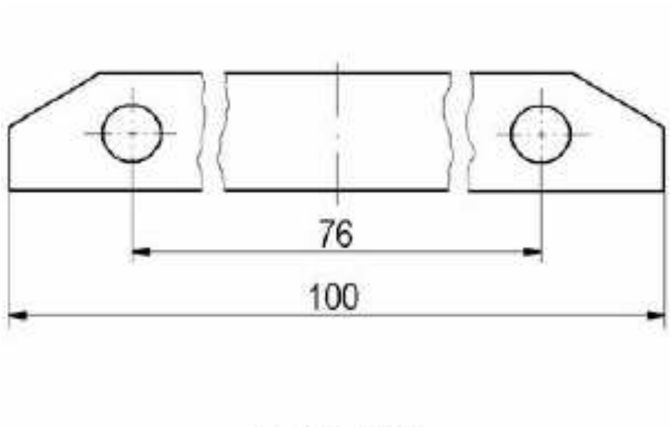


Figure 115

6.11 Arc dimensions, effective lengths

Graphic symbol ⌒ (diameter: 14 times the font's line width) is placed before the dimension number; see figure 116.

For central angles up to 90°, the extension lines are drawn parallel to the median line of the angle. Each arc dimension is entered with its own extension line. Consecutive arc dimensions and length or angle dimensions that border on arc dimensions must not be entered on the same extension line, see figure 117.

For arc dimensions see also section 3.

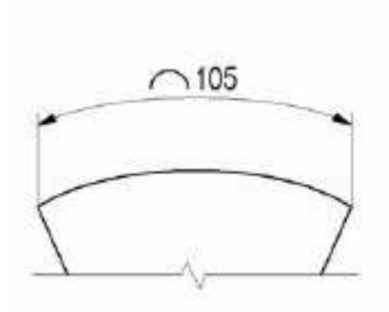


Figure 116

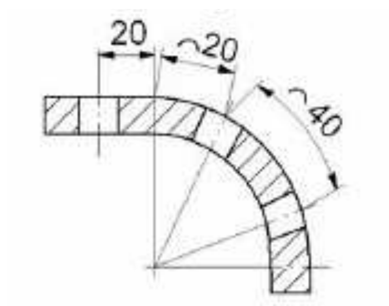


Figure 117

For central angles greater than 90°, the extension lines are drawn in the direction of the center of the arc. Where the reference is not clear, the connection between the arc length and the dimension figure must be marked by a line with an arrowhead and dot or circle on the dimension line, see figure 118.

Consecutive arc dimensions or length or angle dimensions that border on arc dimensions are entered on an extension line, see figure 118.

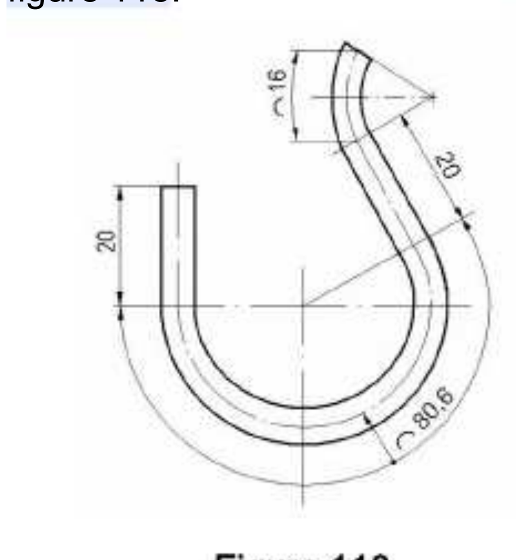


Figure 118

If an effective length is specified, graphic symbol ⟴ must be used instead of the words "effective length". The symbol must always be placed before the dimension number for the effective length; see figure 119. The graphic symbol is a circle with a tangential, horizontal arrow at the bottom. The circle has a diameter that is 10 times the font's line width. The length of the line with an arrowhead corresponds to 1.5 times the diameter of the circle (arrowhead: vertex angle 15°, length 10 times the font's line width). The dimensioning of the developed view as an auxiliary dimension is shown as in figure 120. The developed view is drawn using the line type G as per VW 01050.

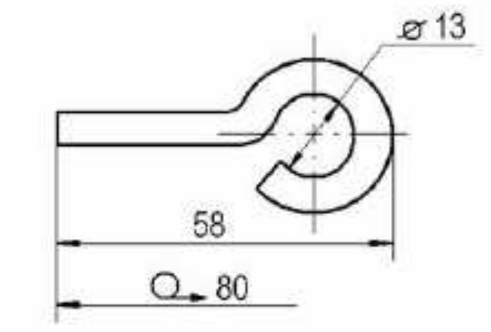


Figure 119

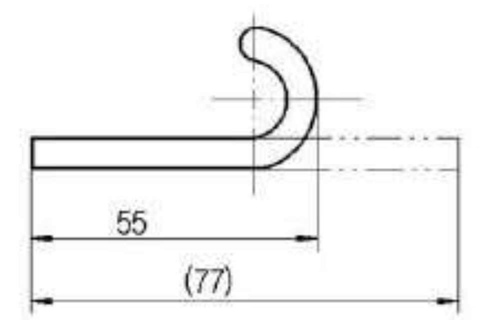


Figure 120

6.12 Thread dimensions

Standard threads are indicated with abbreviated names, see figure 121 and figure 122 (for a complete overview see VW 01031). The thread diameter is written without the diameter symbol and is also deemed to include surface protection; see section 3.

Left-hand threads must bear the additional text "LH" or "left." Where right and left-hand threads of equal size are present on the same part, the right-hand thread is also marked "RH" or "right," see figure 123.

The tolerance class "medium" is the default and is not indicated; however, the tolerance classes "fine" and "coarse" must be indicated after the thread designation, see figure 124 and figure 125. For further detail on the thread system, see VW 01041.

Formed (rolled) threads must be dimensioned as per figure 131 by specifying VW 01178 or VW 01179 next to the thread diameter.

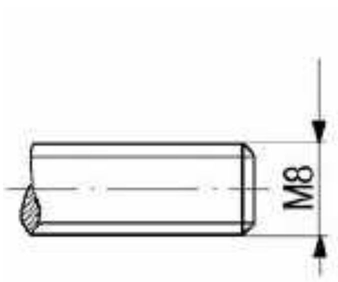


Figure 121

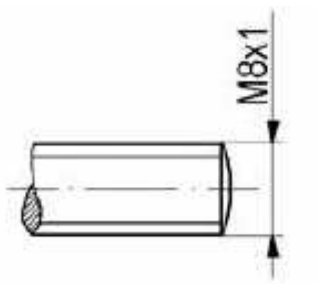


Figure 122

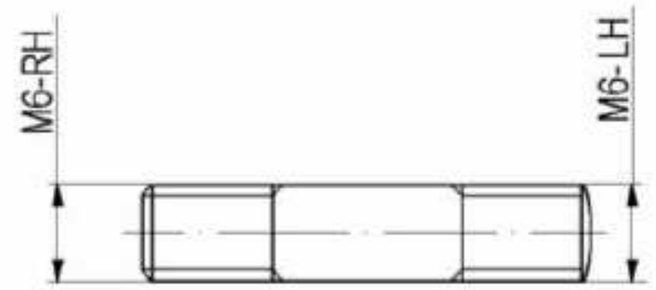


Figure 123

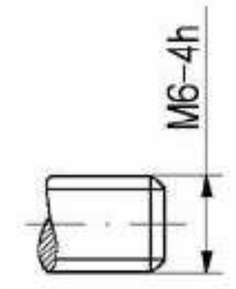


Figure 124

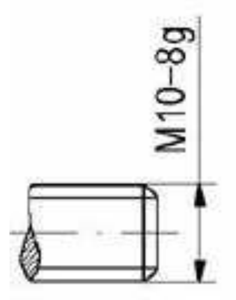


Figure 125

For special threads, the profile must be drawn and all the dimensions necessary for manufacture must be entered.

Thread ends are dimensioned like the ends of standard bolts. The spherical end is positioned inside the thread length and its height is usually 1.5 times the thread pitch, see figure 126 and figure 127.

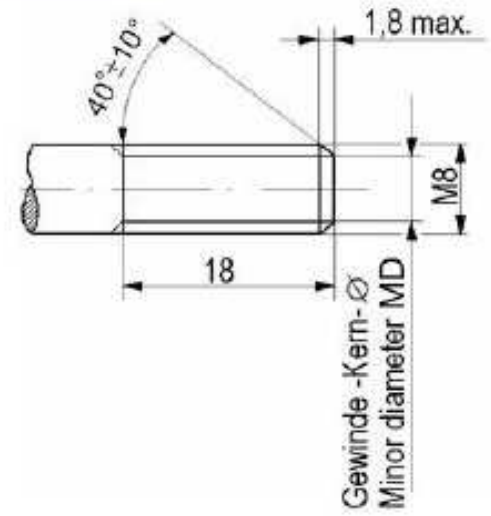


Figure 126

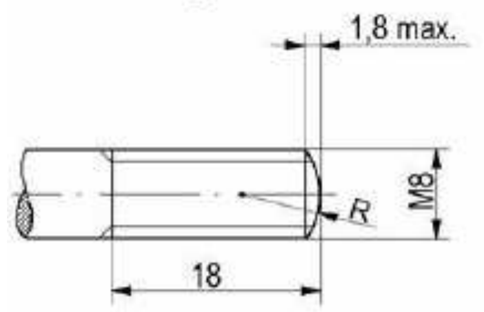


Figure 127

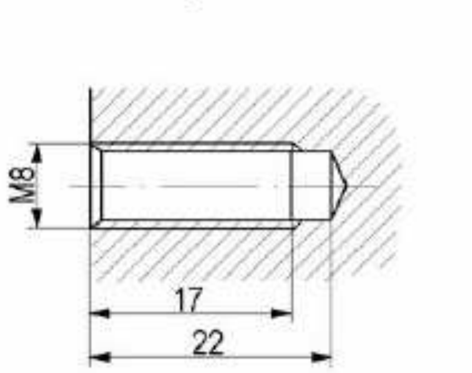


Figure 128

Thread lengths, thread runouts: The useful thread is the thread length (without runout), see figure 126, figure 127, and figure 128. The runout, see DIN 76-1, is usually not dimensioned. For minimum lengths of engagement, see VW 01110-1.

Thread grooves for external threads are dimensioned as per figure 129 and for internal threads as per figure 130; see DIN 76-1.

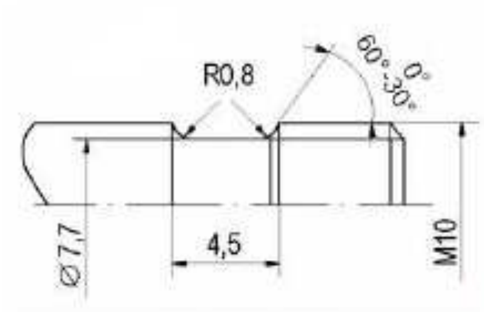


Figure 129

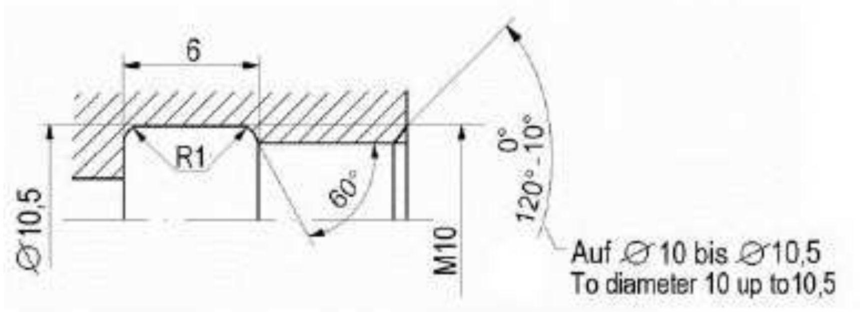


Figure 130

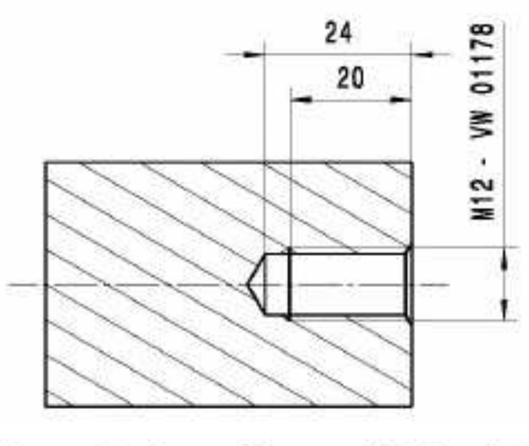


Figure 131 – Dimensioning of formed (ridged) internal threads

Blind tapped holes are dimensioned as per figure 128. Apart from the thread diameter, the minor-diameter hole depth and the usable thread length are indicated. For minimum lengths of engagement, see VW 01110-1; for wire thread inserts, see DIN 8140-1.

Sheet eyelets with thread must be drawn and dimensioned as per VW 01045.

The countersink on the thread is drawn and dimensioned. The usual countersink is 120° -10° and is between d = external thread diameter and 1.05 x d, see figure 132 and figure 133. Larger countersinks are indicated as per figure 134.

If there are several internal threads on the housing or other parts, the countersink may also be indicated in the drawing field in the "Notes" field. It would then read, e.g., "Countersink on both sides of the internal thread 120° −10° from d to 1.05d." If the countersink is on one side only, then 120° must be indicated in the graphical representation and the following is entered in the "Notes" field: "Thread countersinks from d to 1.05d" (for d = external thread diameter, the relevant values must be entered).

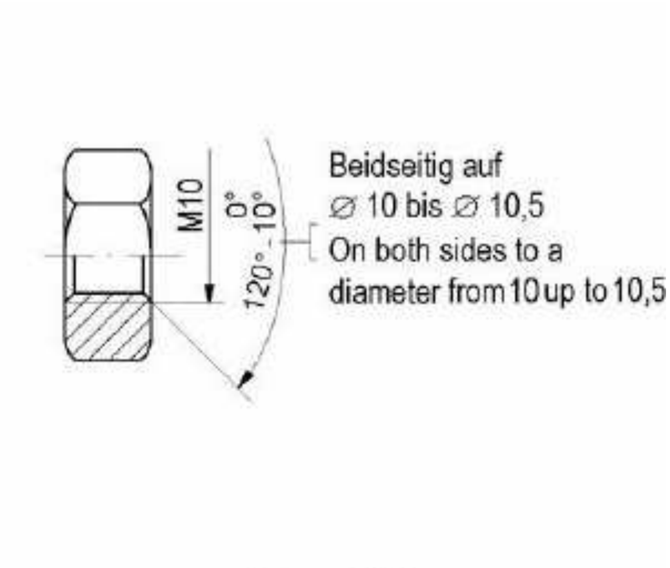


Figure 132

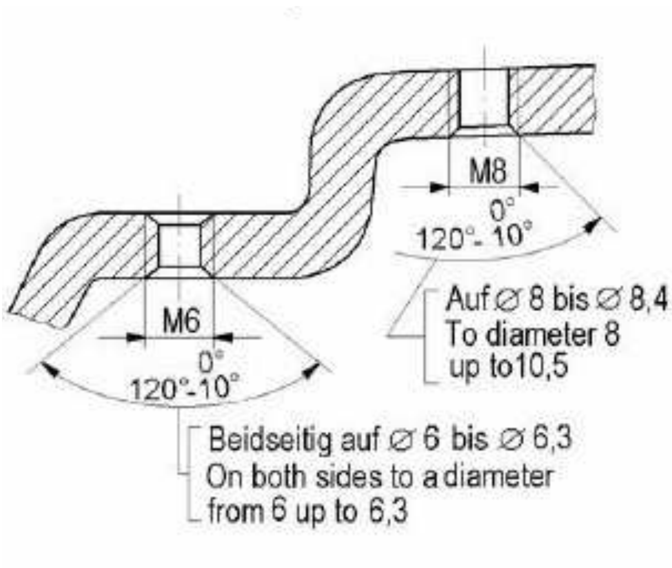


Figure 133

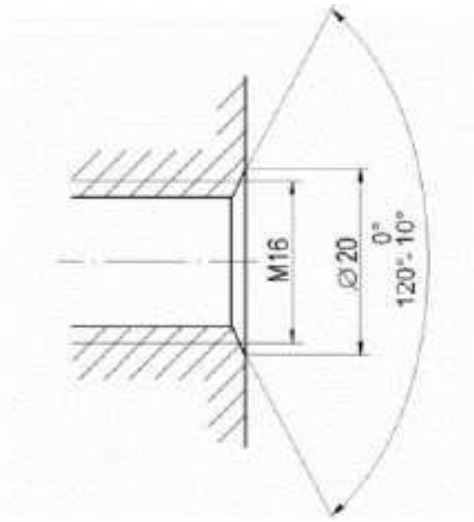


Figure 134

6.13 Equal spacing tolerance

The equal spacing tolerance (graphical symbol ⧺) is the permissible difference between the largest and the smallest actual dimension (two-point measurement) on an individual geometrical feature, for examples, see figure 136 and figure 137.

The equal spacing tolerance must be indicated if only a limited range of the dimension tolerance must be used on an individual geometrical feature.

The equal spacing tolerance must be entered on the right next to the nominal dimension (with or without indication of the dimensional tolerance) with the symbol ⧺ and the equal spacing tolerance value (absolute value without sign), e.g., 3 ±0.3⧺0.15 or 80⧺0.2. For examples, see figure 136 and figure 137.

The meaning of the symbol must be explained on the drawing in the "Bemerkungen / Notes" field; for an example for a drawing note, see figure 135.

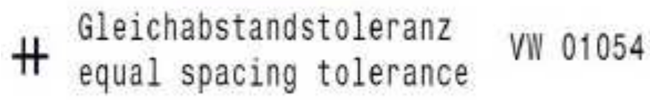


Figure 135

If the nominal dimension is entered without a dimensional tolerance, the general tolerances specified in the drawing apply.

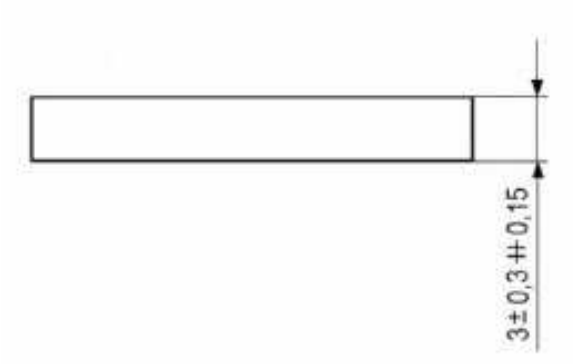


Figure 136

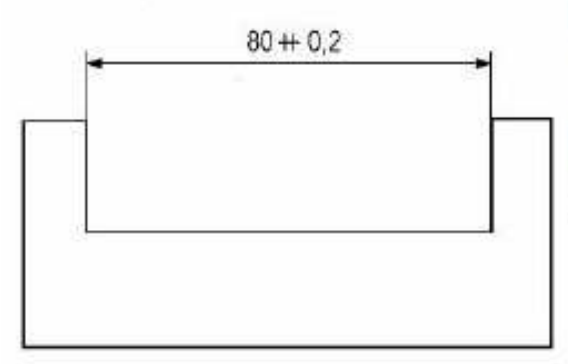


Figure 137

NOTE on figure 136: All thickness dimensions between 2.7 mm and 3.3 mm are permissible. However, the difference in actual dimensions present on an individual part must not exceed 0.15 mm. For examples, see table 2.

Table 2 – Examples for measurement results and conformity inspection

Example 1	Example 2
Largest actual dimension 3.07 mm Smallest actual dimension 2.92 mm Difference = 0.15 mm Thickness dimension tolerance and equal spacing tolerance requirement met	Largest actual dimension 2.88 mm Smallest actual dimension 2.71 mm Difference = 0.17 mm Thickness dimension tolerance tolerance requirement met Equal spacing tolerance requirement not met

6.14 Workpiece edges

As a result of the relevant production process and depending on the workpiece strength, burrs which are caused by cutting or grinding processes might occur on the edges of workpieces manufactured either by metal-cutting or non-machining operations. If such burr formations must be removed or minimized due to the risk of injury or functional impairments, symbols as per VW 01088 must be entered in the drawings.

The following are defined in the standard:

- Permissible burr
- Sharp-edged
- Permissible removal

If for functional reasons, certain shapes are required for the workpiece edges, such as

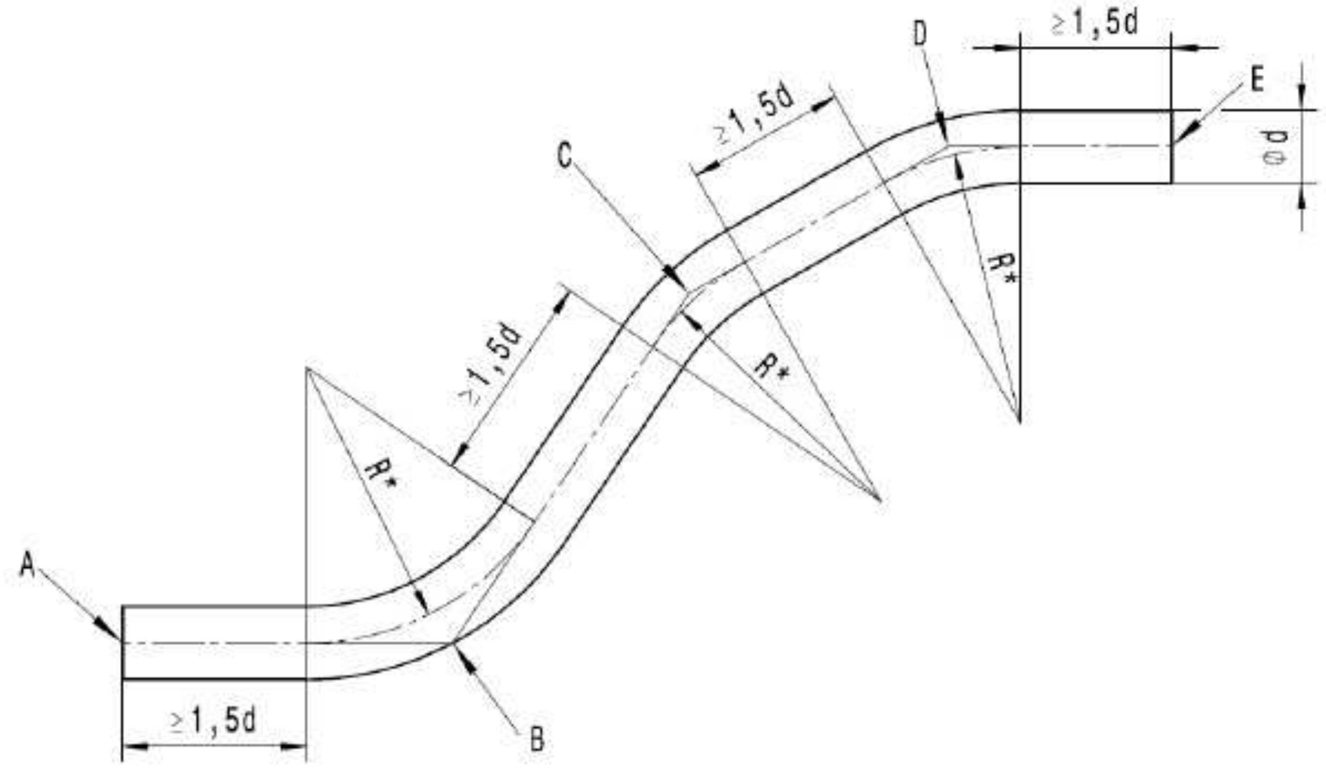
- Chamfers,
- Bevels,
- Undercuts, etc.,

these must be dimensioned and toleranced accordingly in the drawing.

6.15 Bent tubes and rods (solid material)

The use of computer-controlled bending machines and measuring devices requires, for the bending of tubes and bars, production-related dimensioning and tolerancing of parts. All arcs of a tube or a rod must have an equally large bend radius. The largest possible bend radii must be preferred. A straight section of length ≥ 1.5 x d (diameter of the tube/rod) must be positioned at the start, at the end, and between two arcs, see figure 138. Deviations from this requirement must be agreed upon with the Production department.

The dimensioning on the part is used for explanation purposes only.



Legend

R* For rods (solid material), the bend radius is specified at the inside edge.

Figure 138

6.15.1 Dimensioning in coordinate system and tolerancing

When using computerized entry, it is better to enter the theoretical coordinate dimensions and the positional tolerances in a table rather than doing dimensioning directly on the part. In this case, it is essential that the direction of coordinate dimensions be clearly defined using minus "−" and plus "+" signs; see figure 139.

The general bend radius and the roundness tolerance in the bend area must also be specified in the table; see numbers 1 and 2 in figure 139. When required, additional specifications must be provided in the graphical representation.

6.15.1.1 Center axis of tubes[3)] (tube center)

The X-axis, Y-axis, and Z-axis coordinates for the start and end points of the individual axis stretches must be specified, relative to the coordinate system origin "A," as theoretical coordinates (coordinate dimensioning) in a table as per VW 01014 , code no.: NO-G10 (see figure 139).

The permissible positional deviations for the axis stretches are defined by entering "cylindrical positional tolerances"; see DIN EN ISO 1101 and figure 140. The positional tolerances limit the axis stretches' positional, orientation, and straightness deviations. The positional tolerances in the table in figure 139 are equivalent to the dimensioning in figure 140.

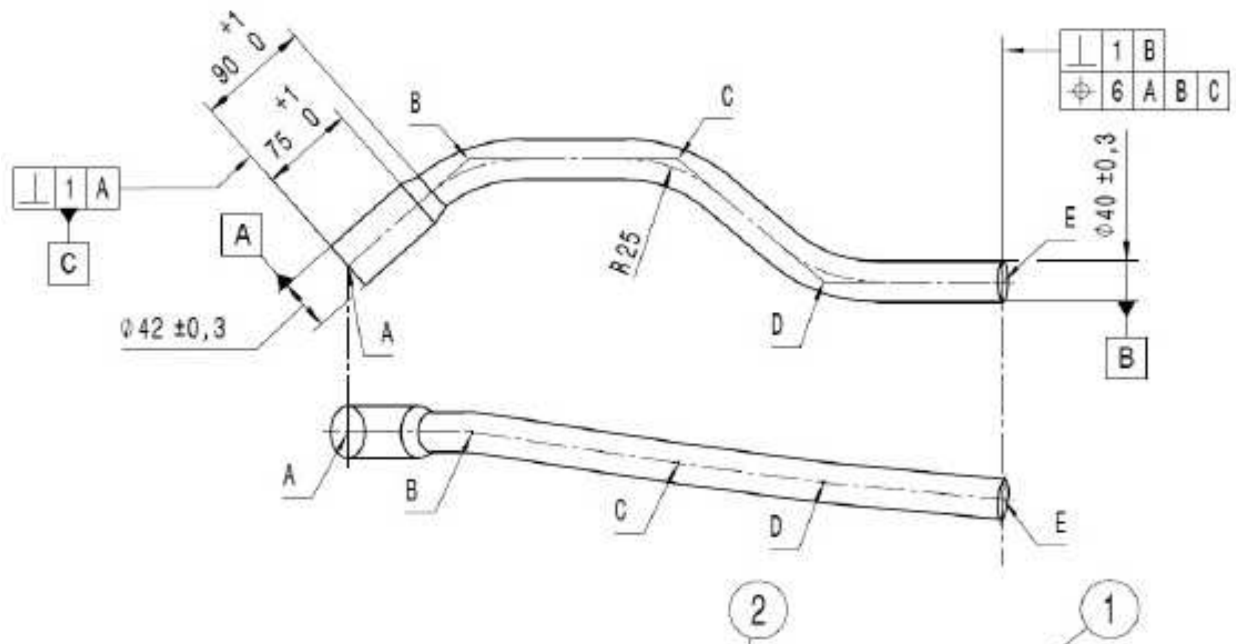
Depending on the functional requirements, different positional tolerances may be indicated for every individual length.

6.15.2 Total length and perpendicularity of the tubes' end faces

The permissible deviation of the total length of the tubes must be defined with a positional tolerance as shown in figure 139.

If exact perpendicularity between the end faces and the tube axis is required, the perpendicularity must also be specified; see figure 139.

3) Hereinafter, the term "tube" also refers to rods.



+z, +y, +x, -x, -y, -z	Wenn nicht anders angegeben:/ Unless otherwise specified: Allg. Biegeradius:/ General bend radius: R=80 ±10				
	Rundheit im Biegebereich / Roundness tolerance in the bending area ○ 2			R (Stange / bar) R (Rohr / tube) Øt A B C	
Theoretische Koordinaten / Theoretical coordinates				Positionstoleranz / Position tolerance	
Punkt / Point	x	y	z	Strecke / Distance	t
A	0	0	0	-	-
B	+74	0	+64	A◁–▷B	2
C	+178	-13	+64	B◁–▷C	4
D	+273	-23	-5,5	C◁–▷D	4
E	+338	-26	-5,5	D◁–▷E	2

Legend

1 General toleranced bend radius
2 General roundness tolerance in the bend area

Figure 139 – Example for the dimensioning and tolerancing of a bent tube

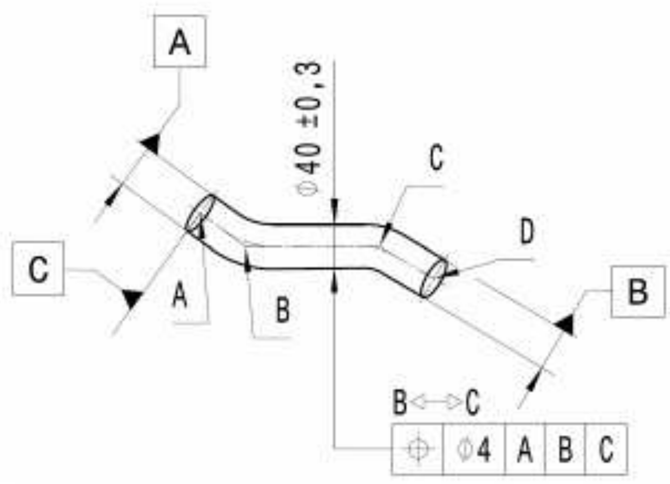


Figure 140

7 Collective information

Collective information (see DIN 30-10) can be used to reduce the dimensioning and tolerancing work for entering repeated information of the same type and to make the drawings easier to understand.

General collective information generally applies to the whole drawing, e.g., general tolerances for nominal dimensions without tolerance (figure 142, number 2), workpiece edge conditions (figure 142, number 3), surface roughness (figure 142, number 4), or information as in figure 141.

The collective information must be entered in the "Bemerkungen / Notes" drawing field.

7.1 Note on undimensioned geometries in the data set

If not all of the required nominal dimensions and theoretical dimensions with respect to the component geometry are present in a 2-D drawing, then all dimensions that are not indicated must be taken from the 3-D data set. To express this in the drawing, the text macro NO-F8 as per VW 01014 (see figure 141) or similar wording is entered in the "Bemerkungen / Notes" drawing field.

```
Nicht bemaszte Geometrien
dem Datensatz entnehmen
Unspecified geometry information to be
taken from the data record
```

Figure 141 – Text macro NO-F8

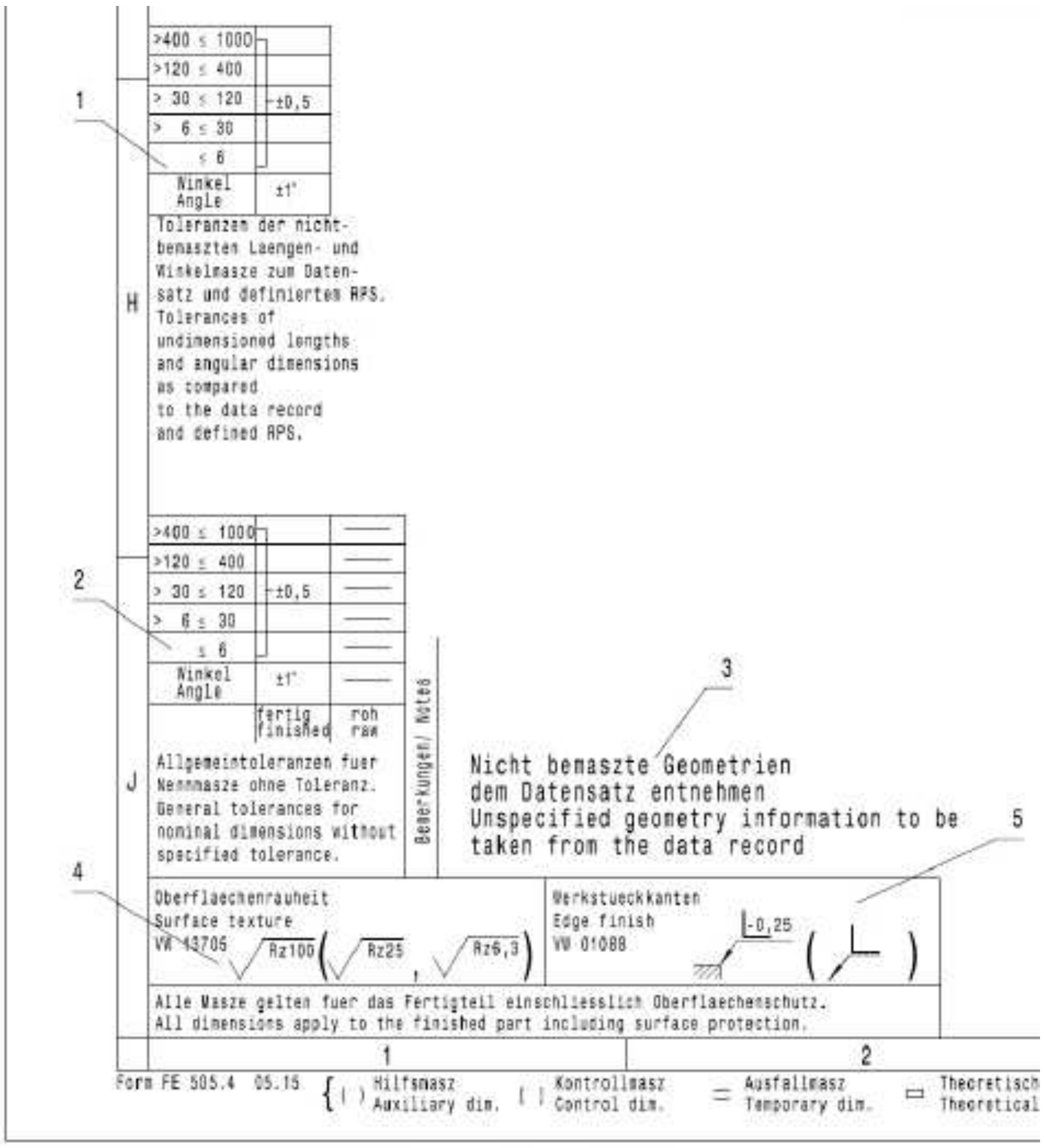
The text macro NO-F8 or similar wording must be used with the table for general tolerances of undimensioned linear and angular sizes as compared to the data set and defined RPS reference system (text macro NO-G11 as per VW 01014). For an example, see figure 142.

7.2 General tolerances for linear and angular sizes

7.2.1 General tolerances for nominal dimensions without tolerance specification

The permissible deviations of dimensions that are produced with typical workshop accuracy must be allocated to the nominal dimension ranges in the table for general tolerances (in the bottom left drawing corner) and entered into the "finished" column, see figure 142, number 2. Here, DIN ISO 2768-1 can be used as a template with general tolerances for linear and angular sizes. If smaller tolerances are required or larger tolerances are economical, these must be entered in the table. The permissible linear deviations must be indicated in mm and angular deviations must be indicated in degrees (°).

The "raw" column is provided for entering process-related accuracy values for pressed parts, injection-molded parts, and forgings with surfaces that are left untreated. The relevant standards concerning "General tolerances" (see DIN SPEC 23605) must be observed in these cases.



Legend

1	General tolerances for undimensioned linear and angular sizes (text macro NO-G11 as per VW 01014)
2	General tolerances for linear and angular sizes without tolerance specification
3	Note on undimensioned design models in the data set (text macro NO-F8 as per VW 01014)
4	Surface roughness as per VW 13705 and VDA 2005
5	Workpiece edge states as per VW 01088

Figure 142 – Example for general tolerances for linear and angular sizes

7.2.2 General tolerances for undimensioned linear and angular sizes

The permissible deviations of undimensioned linear and angular sizes as compared to the data set and defined RPS reference system that are produced with typical workshop accuracy must be entered in the table for general tolerances (text macro NO-G11 as per VW 01014) the same as in section 7.2.1. The table (NO-G11) must be placed in the bottom left drawing field above the table for general tolerances for nominal dimensions without tolerance specification, as shown in figure 142, number 1, and must be filled accordingly. The table (NO-G11) must be used together with the text macro NO-F8 (see section 7.1).

7.3 Profile tolerances with respect to the data set and defined RPS reference system

Surface profile tolerances and trim tolerances as compared to the data set and defined RPS reference system are indicated in drawings as follows:

– If a symmetric surface profile tolerance for all not directly toleranced surfaces with respect to the data set and defined RPS reference system is required, the text macro NO-F27 as per VW 01014 and the appropriate value (±1/2 of the tolerance width) is entered in the drawing in the "Bemerkungen / Notes" field; for an example, see figure 143 and the text macro NO-F27 must be used together with the text macro NO-F8 (figure 141).

Toleranzen der Flaechen zum
Datensatz und definiertem
Tolerances of surfaces as compared
to the data record and defined
RPS ± 0,6 mm

Figure 143 – Text macro NO-F27

– If a symmetric surface profile tolerance for a certain surface with respect to the data set and defined RPS reference system is required, the text macro NO-F28 as per VW 01014 (see figure 144) is entered in the drawing in the "Bemerkungen / Notes" field and this surface is marked in the graphical representation with a narrow dash-two dot line. The text macro NO-F28 must be used together with the text macro NO-F8.

Toleranzen der gekennzeichneten
Flaechen zum Datensatz und definiertem
Tolerances of marked surfaces as
compared to the data record and defined
RPS ± 0,1 mm

Figure 144 – Text macro NO-F28

– In the case of asymmetrical surface profile tolerances of the surfaces as compared to the data set and defined RPS reference system, it is necessary to cut through the respective surface and to indicate the permissible deviations in the section by means of an arrow; for an example, see figure 145.

Schnitt A-A
Section A-A

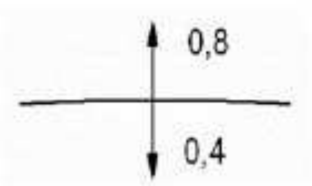


Figure 145 – Example for entering the asymmetrical, permissible deviations

The text macro required for this purpose – NO-F29 as per VW 01014, see figure 146 – is entered in the "Bemerkungen / Notes" drawing field.

Toleranzen der gekennzeichneten und begrenzten Flaechen nach
Angaben zum Datensatz und definiertem RPS siehe Schnitt
For tolerances of marked and limited surfaces as compared
to the data record and defined RPS see section
A-A

Figure 146 – Text macro NO-F29

– In the case of asymmetrical surface profile tolerances of the trim edges as compared to the data set, it is necessary to cut through the respective trim edge and to indicate the permissible deviations in the section by means of an arrow; for an example, see figure 147.

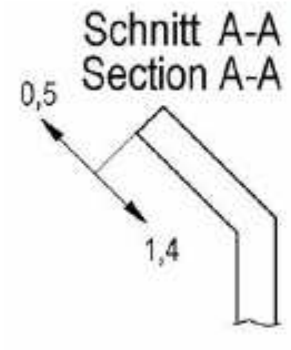


Figure 147

The toleranced range is specified by a wide dash-dot line and a symbol; for an example, see figure 148.

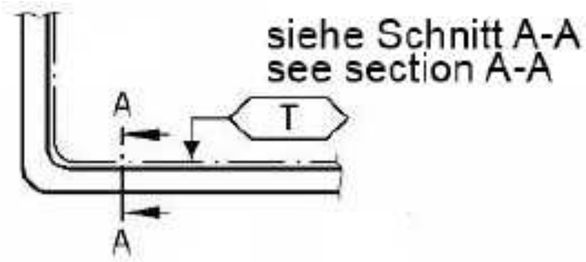


Figure 148

The text macro required for this purpose – NO-F30 as per VW 01014, see figure 149 – is entered together with the text macro NO-F8 (figure 141) in the "Bemerkungen / Notes" field.

Figure 149 – Text macro NO-F30

If different tolerances are required within the marked length range (wide dash-dot line), several sections are produced. The transitions must be marked with an "X"; for an example, see figure 150.

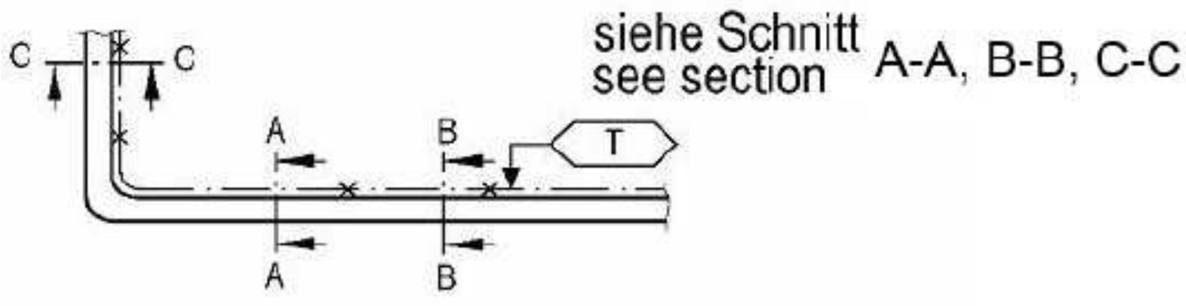


Figure 150

8 Applicable documents

The following documents cited in this standard are necessary to its application.

Some of the cited documents are translations from the German original. The translations of German terms in such documents may differ from those used in this standard, resulting in terminological inconsistency.

Standards whose titles are given in German may be available only in German. Editions in other languages may be available from the institution issuing the standard.

VW 01014	Drawings; Drawing Frames and Text Macros
VW 01031	Thread Designations; Overview
VW 01041	Metric ISO Thread; Explanation of the Thread System
VW 01045	Sheet Eyelets with Metric ISO Thread; High Type
VW 01050	Technical Drawings; Scales, Lines, Hatching, Break Lines
VW 01054	Engineering Drawings; Dimensioning and Tolerancing; Envelope Requirement and Independency Principle
VW 01055	Reference Point System (RPS); Specifications in Drawings and 3-D CAD Models
VW 01058	Drawings; Lettering
VW 01058 supplement 1	3-D Drawingless Process (3DZP)
VW 01088	Workpiece Edges; Definitions, Drawing Specifications
VW 01110-1	Threaded Joints; Design and Assembly Specifications
VW 01179	Metric ISO Thread; Properties and Dimension Limits for Helically Formed Threads
VW 13705	Specification of Surface Texture; Geometrical Product Specifications - Engineering Drawings
DIN 254	Geometrical product specifications (GPS) - Series of conical tapers and taper angles; Values for setting taper angles and setting heights
DIN 406-12	Engineering drawing practice; dimensioning; tolerancing of linear and angular dimensions
DIN 475-1	Widths across flats for bolts, screws, valves and fittings
DIN 76-1	Thread run-outs and thread undercuts - Part 1: For ISO metric threads in accordance with DIN 13-1
DIN 8140-1	Wire thread inserts for ISO metric screw threads - Part 1: Dimensions, technical specifications
DIN EN ISO 1101	Geometrical product specifications (GPS) - Geometrical tolerancing - Tolerances of form, orientation, location and run-out
DIN EN ISO 14405-1	Geometrical product specifications (GPS) - Dimensional tolerancing - Part 1: Linear Sizes
DIN EN ISO 14405-2	Geometrical product specifications (GPS) - Dimensional tolerancing - Part 2: Dimensions other than linear sizes

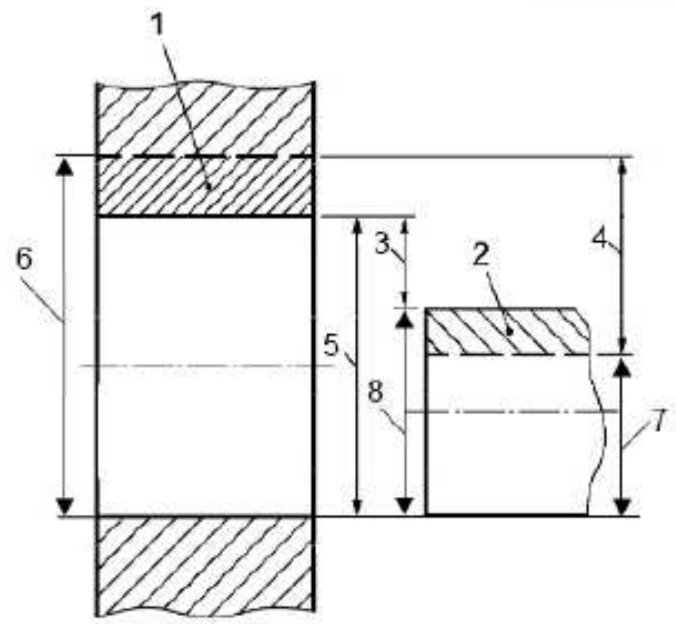
DIN EN ISO 14660-2	Geometrical Product Specifications (GPS) - Geometrical features - Part 2: Extracted median line of a cylinder and a cone, extracted median surface, local size of an extracted feature
DIN EN ISO 17450-1	Geometrical product specifications (GPS) - General concepts - Part 1: Model for geometrical specification and verification
DIN EN ISO 286-1	Geometrical product specification (GPS) - ISO code system for tolerances on linear sizes - Part 1: Basis of tolerances, deviations and fits
DIN EN ISO 286-2	Geometrical product specifications (GPS) - ISO code system for tolerances on linear sizes - Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts
DIN EN ISO 3098-2	Technical product documentation - Lettering - Part 2: Latin alphabet, numerals and marks
DIN EN ISO 5459	Geometrical product specifications (GPS) - Geometrical tolerancing - Datums and datum systems
DIN EN ISO 8015	Geometrical product specifications (GPS) - Fundamentals - Concepts, principles and rules
DIN ISO 272	Fasteners; Width across Flats for Hexagon Products
DIN ISO 2768-2	General tolerances; geometrical tolerances for features without individual tolerances indications
DIN SPEC 23605	Technical prduct specification (TPS) - Application guidance - Structured and commented overview of ISO- and DIN-Standards for technical product dokumentation (TPD) and geometrical product specification (GPS)
VDA 2005	Geometrical product specification - Technical drawings - Specification of surface texture; inclusive Appendix 1

Appendix A (informative) Envelope requirement explanations

A.1 Taylor Principle

Most workpieces are assembled with other components. Many of the surfaces on machine parts play a functionally relevant role in terms of fit. This means that two toleranced geometrical features (mating surfaces) are joined one inside the other so that one of the features will surround the other at least partially. Normally, these mating surfaces will be cylindrical ("round fit") or plane-parallel ("plane fit"). When geometrical features of two different workpieces need to be mated, a special fit characteristic may be required for the component's function, i.e., clearance fit, transition fit, or interference fit; see DIN EN ISO 286-1.

The minimum clearance for clearance fits is the clearance that results when the dimensions of both mating surfaces are right at the maximum material limit; see figure A.1.



Legend

1	Hole tolerance	5	Minimum hole dimension
2	Shaft tolerance	6	Maximum hole dimension
3	Minimum clearance	7	Minimum shaft dimension
4	Maximum clearance	8	Maximum shaft dimension

Figure A.1 – Diagram showing how to define a clearance fit

The minimum clearance, however, will only be present if the parts do not have any additional shape deviations, i.e., are not, e.g., curved or untrue. In order for the clearance to be adhered to, it would be necessary to determine the maximum possible dimensions of the two geometrical features being mated, e.g., a shaft and a hole, i.e., these maximum possible dimensions are the **effective size** yielded by the maximum material size and the maximum shap deviations.

Long before there were form and positional tolerances, Taylor recognized this principle and, in 1905, invented the Taylor Principle with his patent application:

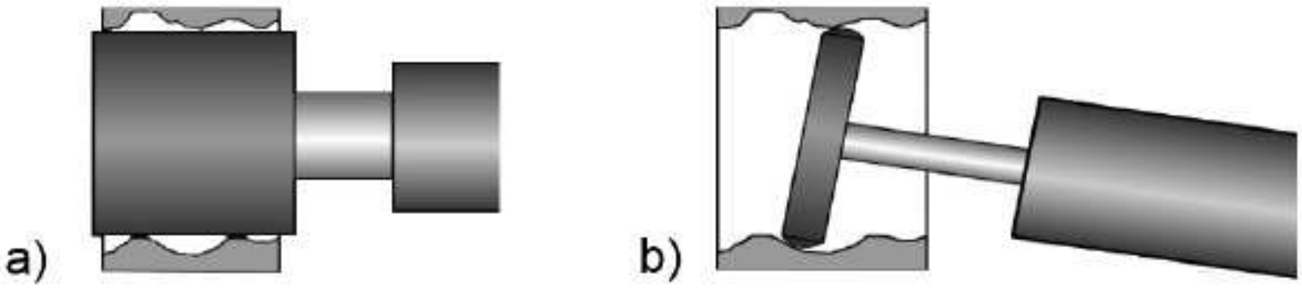
"The go inspection is a mating inspection with a gage that goes over the entire geometrical feature; the no go inspection is an individual inspection in the two-point method."

The Taylor Principle limits the maximum dimension for each of the two mating features. This limit is referred to as an "envelope." The envelope is equal to the maximum material size, i.e., the size at which the geometrical feature's material has its greatest dimension (material volume) – outwards in

the case of shafts, inwards in the case of holes. In order to be compatible with the fit, the geometrical feature must not pass through the envelope. The envelope represents the gage's go-side as per the Taylor Principle (figure A.2 a). This means:

– A shaft must remain within this envelope or, at the most, touch it and
– A hole must remain outside this envelope or, at the most, touch it.

This will ensure a fit and adherence to the maximum material size. In addition, no actual local size (two-point size) must exceed the least material size in the case of holes or fall below it in the case of shafts. The two-point size represents the gage's no-go-side as per the Taylor Principle (figure A.2 b).



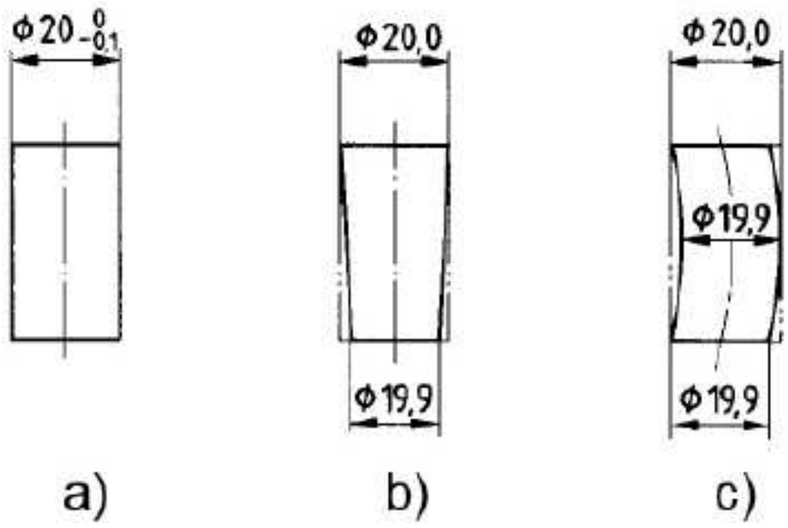
Legend

a)	Go inspection as per the Taylor Principle	b)	No-go inspection as per the Taylor Principle

Figure A.2 – Taylor Principle for a hole

If there is **an external feature-of-size of type "cylinder"** (figure A.3 a), the geometrically ideal envelope (cylinder) with the maximum material size (maximum dimension) of 20 mm must not be passed through at any point (figure A.3 b and c). The least material size (minimum dimension) – 19.9 mm in this case – must not be fallen below at any point (figure A.3 b and c).

Unless otherwise specified, shape deviations and parallelism deviations in opposite envelope lines fall within the dimensional tolerance.



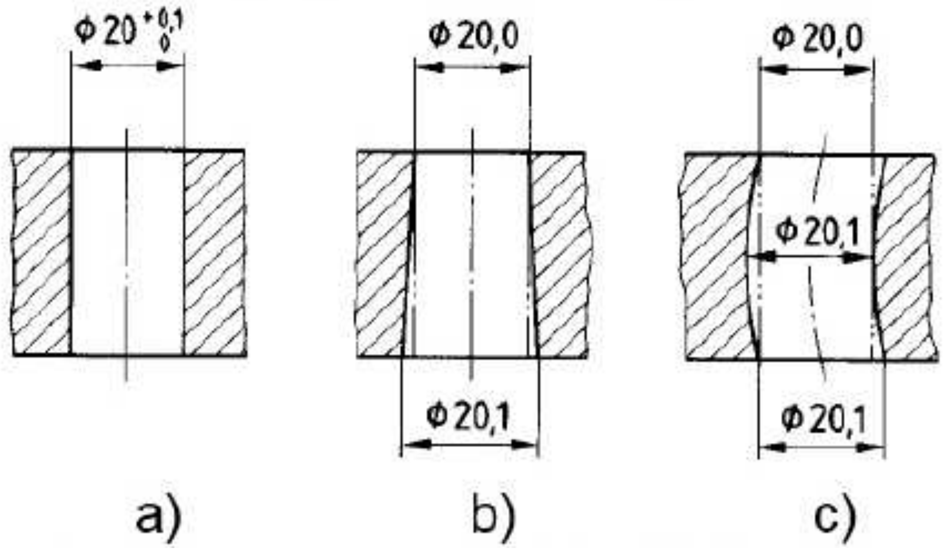
Legend

a)	Drawing note	b), c)	Interpretation

Figure A.3 – Envelope principle with an external feature-of-size of type "cylinder" (shaft)

If there is **an internal feature-of-size of type "cylinder"** (figure A.4 a), the geometrically ideal envelope (cylinder) with the maximum material size (minimum dimension) of 20 mm must not be fallen below. In addition, the least material size (maximum dimension) of 20.1 mm must not be exceeded at any point (figure A.4 b and c).

Unless otherwise specified, shape deviations and parallelism deviations in opposite envelope lines fall within the dimensional tolerance.



Legend

a) Drawing note b), c) Interpretation

Figure A.4 – Envelope requirement with an internal feature-of-size of type "cylinder" (hole)

A.1.1 Feature-of-size

A **feature-of-size** is a geometrical feature that is geometrically defined in an exact manner with a linear length dimension or angular dimension only (what is referred to as a **size**).

A feature-of-size can be a cylinder, two parallel opposite planes, a sphere, a cone, or a wedge.

The envelope requirement can only be used for features-of-size

- **of type "cylindrical surface" (cylinders such as holes and shafts) or**
- **of type "two parallel opposite planes" (widths such as slot width, groove width, tongue width, key width).**

The geometrical features must be able to physically pass a go-gage check as per the Taylor Principle.

The envelope requirement cannot be used for

- **Features-of-size such as cones, wedges, spheres**
- **Non-features-of-size such as**
  - **Complex geometrical features** (for examples, see Figure A.5) and
  - **Distances that are dimensions other than linear sizes** (for examples, see figure A.6 to figure A.8 and DIN EN ISO 14405-2).

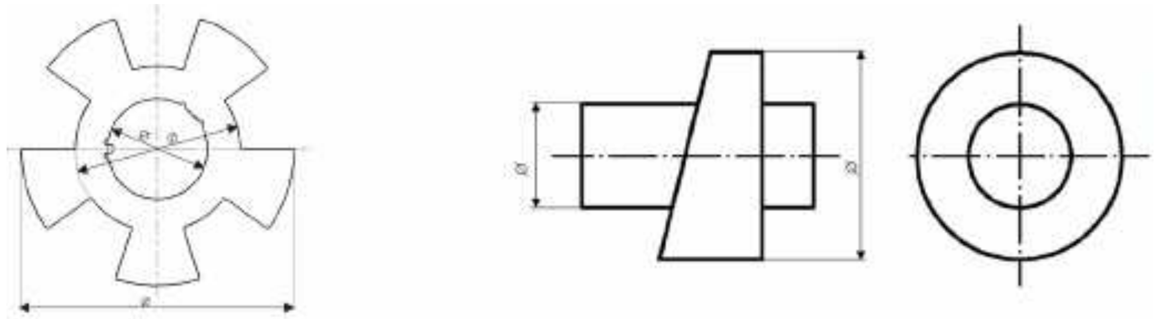


Figure A.5 – Non-feature-of-size examples

"Other than linear sizes" means distances between

- two real geometrical features – what are referred to as step dimensions (see figure A.6),
- a real geometrical feature and a derived geometrical feature (see figure A.7),
- two derived geometrical features (see figure A.8).

Real geometrical features are geometrical features that actually physically exist on a component.

Derived geometrical features are axes, center planes, symmetry planes, and center points that do not actually physically exist on the component. These geometrical features must be metrologically derived from the real geometrical features during a tolerance examination using association criteria. DIN EN ISO 14660-2 uses the least-squares criterion as the default association criterion. For association criteria, see section A.1.2.

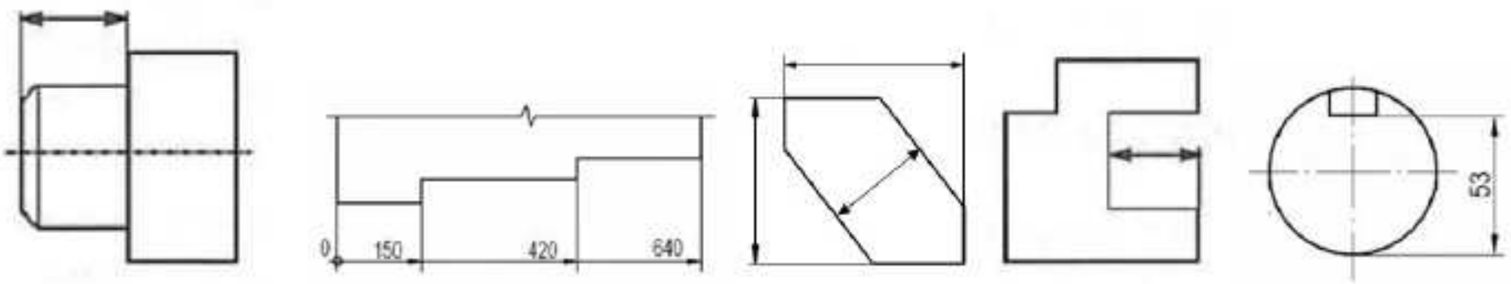


Figure A.6 – Distances between two real geometrical features (step dimensions)

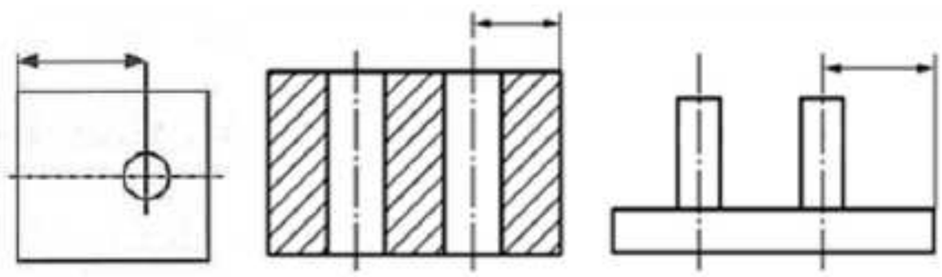


Figure A.7 – Distances between a real geometrical feature and a derived geometrical feature

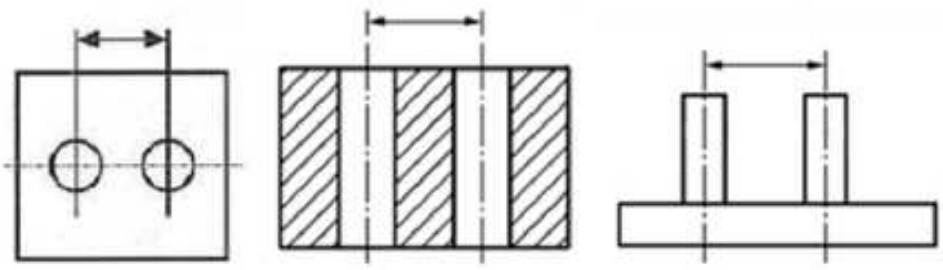
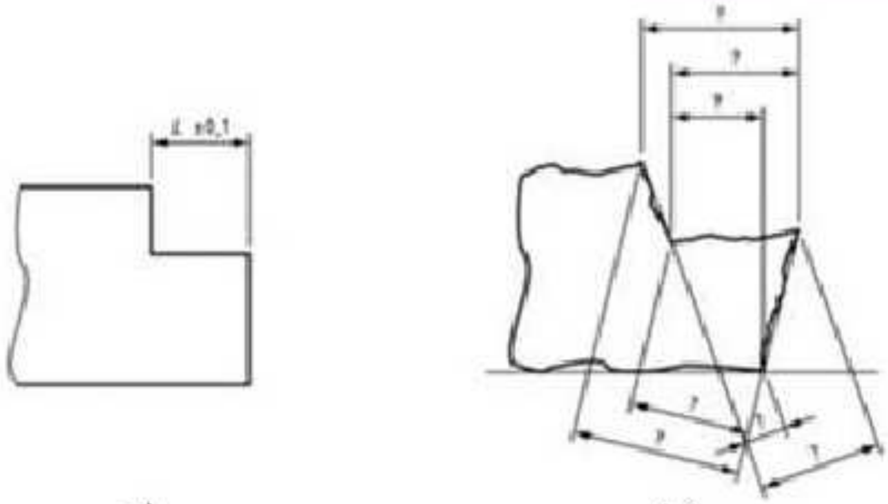


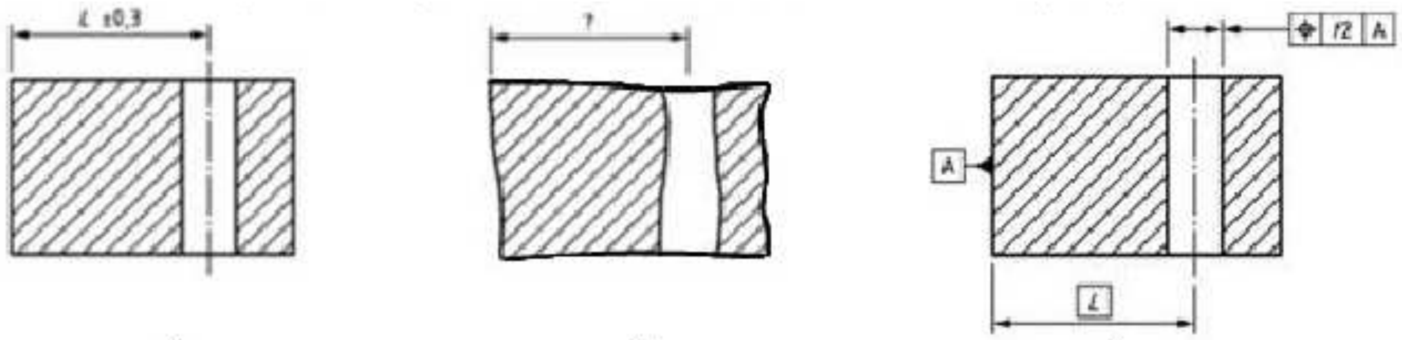
Figure A.8 – Distances between two derived geometrical features

The use of what is referred to as "plus/minus tolerancing" for distances other than linear sizes will result in ambiguities during verification. In order to avoid these ambiguities, it is recommended to use geometric tolerancing. For examples, see figure A.9, figure A.10, and figure A.11.



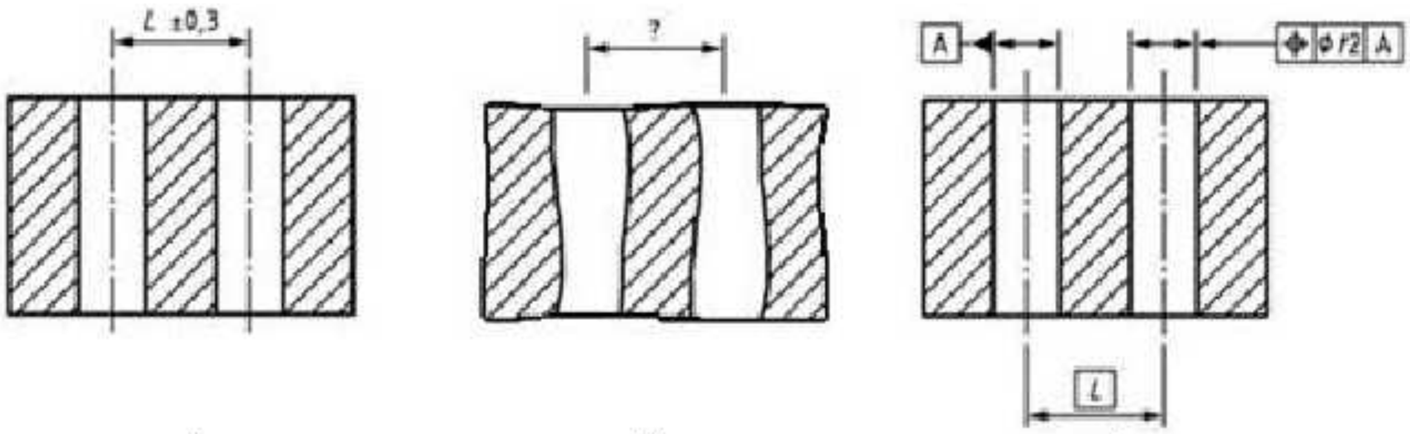
a) b) c)

Figure A.9 – Example showing the linear distance between two integral geometrical elements



a) b) c)

Figure A.10 – Example showing the linear distance between an integral geometrical element and a derived geometrical element



a) b) c)

Legend

a) Drawing note with plus/minus tolerancing (ambiguous)
b) Verification (ambiguous)
c) Drawing note with geometric tolerancing (unambiguous)

Figure A.11 – Example showing the linear distance between two derived geometrical elements

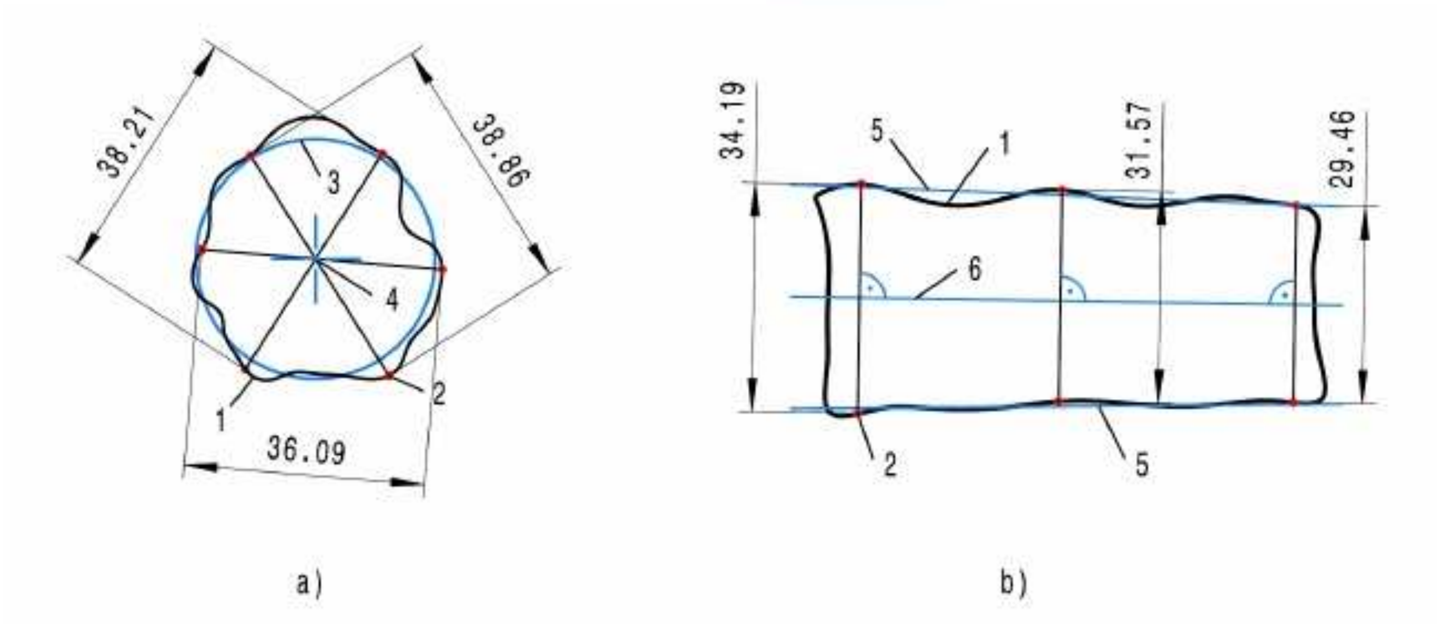
A.1.2 Sizes

A **size** is a linear dimension that defines the theoretically ideal form and size of a feature-of-size in an exact manner.

A distinction can be made between the following types of sizes based on the method used to determine them (see table A.1).

An **actual local size** is a length dimension measured at the location (two-point size)

A **two-point size** (local size) is the distance between two opposite points on the real feature-of-size, e.g., of type "cylinder" or of type "two parallel opposite planes"; for examples, see figure A.12. The distance's orientation is defined perpendicular to the axis or center plane (see DIN EN ISO 14660-2, local diameter of an extracted cylinder and local size of two parallel extracted surfaces). A feature-of-size can have an infinite number of two-point sizes that are different from each other in terms of their numeric value, see figure A.12.



Legend

a)	Feature-of-size of type "cylinder"	3	Associated least-squares circle
b)	Feature-of-size of type "two parallel opposite planes"	4	Center of least-squares circle
		5	Associated least-squares planes
1	Real workpiece surface	6	Center plane (symmetry plane) from two least-squares planes
2	Measuring points		

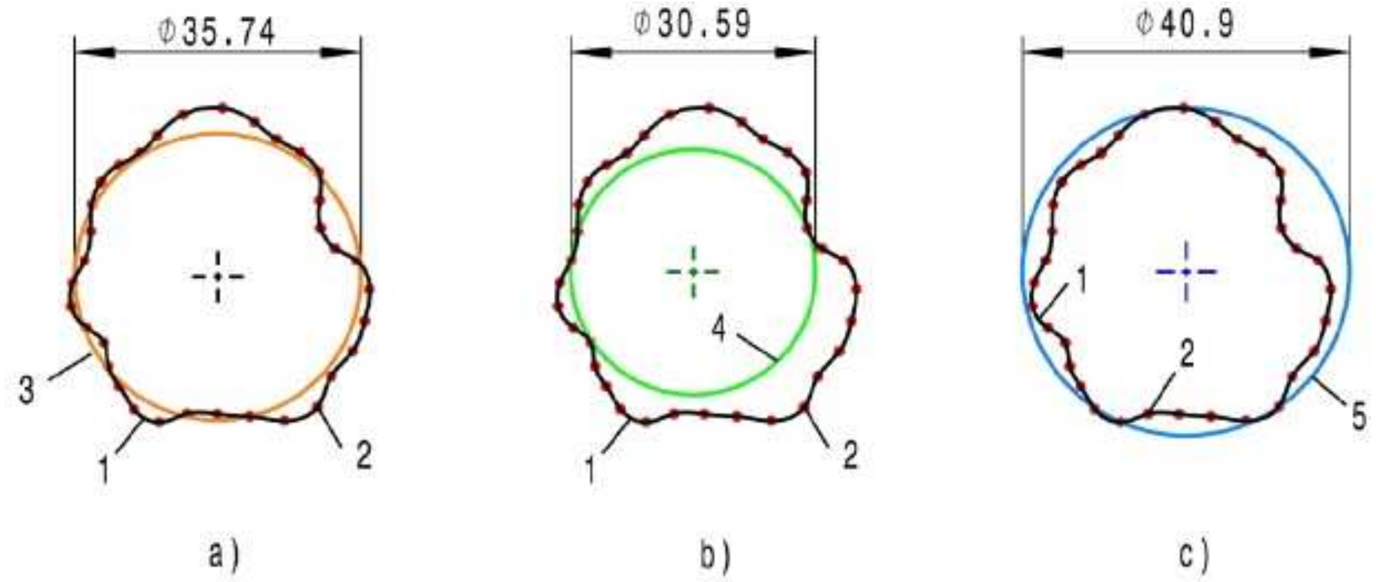
Figure A.12 – Examples of local two-point sizes

A direct global size is a size of the geometrical feature associated with the feature-of-size. It is calculated based on measuring points on the real feature-of-size by association with an ideal geometrical feature (what is referred to as a "substitute element") of the same type as that of the feature-of-size.

The following association criteria, which are described in DIN EN ISO 14405-1, can be used for the association operation:

– Least-squares method (for an example, see figure A.13 a)
– Maximum inscribed geometrical feature (for an example, see figure A.13 b)
– Minimum circumscribed geometrical feature (for an example, see figure A.13 c)

The results obtained will depend on the selected association criterion; see figure A.13.

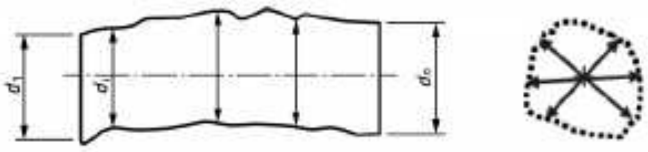
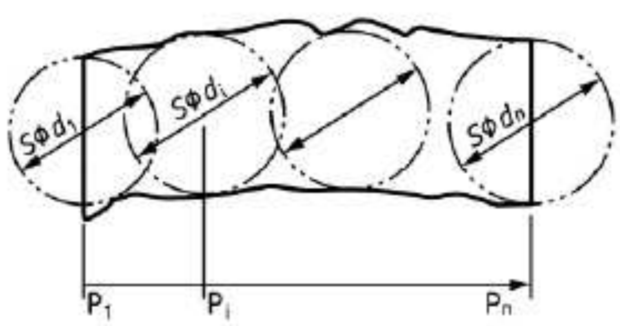


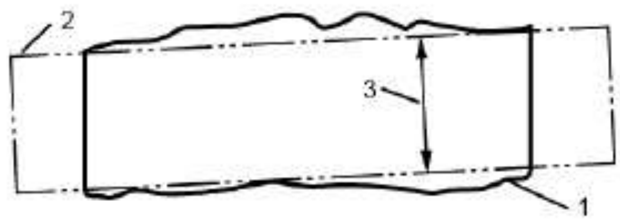
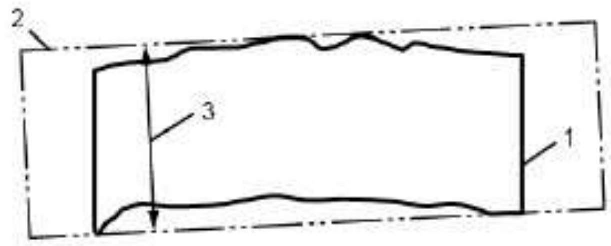
Legend

a)	"Least-squares" association criterion	2	Measuring points
		3	Associated least-squares circle
b)	"Maximum inscribed geometrical feature" association criterion	4	Associated maximum-inscribed-geometrical-feature circle
c)	"Minimum circumscribed geometrical feature" association criterion	5	Associated minimum-circumscribed-geometrical-feature circle
1	Real workpiece surface		

Figure A.13 – Example showing association criteria used with a circular geometrical feature

Table A.1 – Types of sizes

Sizes		Example
Local size	Two-point size (two-point size) (LP)	 d - Values of two-point local size
Local size	Spherical size (LS)	 d - Values of spherical local size

Sizes		Example
Direct global sizes	Size calculated using the least-squares method (GG)	 1 - Real feature-of-size 2 - Associated feature-of-size 3 - Least-squares size
	Maximum inscribed size (GX)	 1 - Real feature-of-size 2 - Associated feature-of-size 3 - Maximum inscribed size
	Minimum circumscribed size (GN)	 1 - Real feature-of-size 2 - Associated feature-of-size 3 - Minimum circumscribed size

A.1.3 Specification modifiers for sizes as per DIN EN ISO 14405-1

When using the independency principle, sizes without modifiers on the drawing must be interpreted as two-point sizes. This is a default definition for sizes.

Modifiers (see table A.2) can be used to modify/complement the default definition if necessary.

The conditions that must be applied to the individual sizes, e.g., Ⓔ or other modifiers, must be preferably defined in the simultaneous engineering team (SET) together with Test Planning and Quality Assurance.

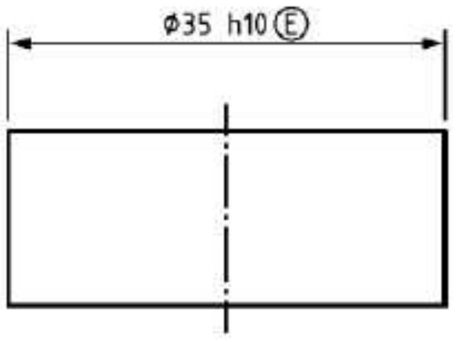
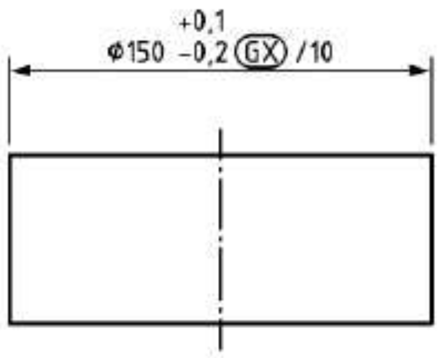
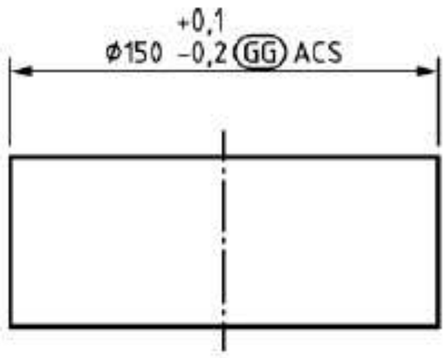
Table A.2 contains a selection of modifiers from DIN EN ISO 14405-1.

Table A.2 – Modifiers for sizes

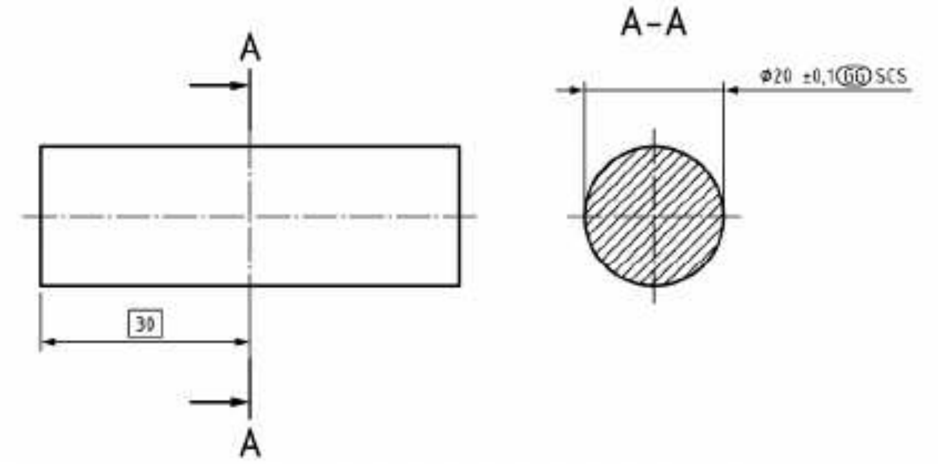
Modifier	Description
(LP)	Local two-point size When using the independency principle, all sizes must be interpreted as two-point sizes as default even if this modifier is not included. Because of this, this modifier is only used in combination with, e.g., (GX) and (GN) (see section B.1.4) or with rank-order sizes such as (SX) and (SN).
(LS)	Local size, defined by a sphere Used for: Flexible tubes, hoses

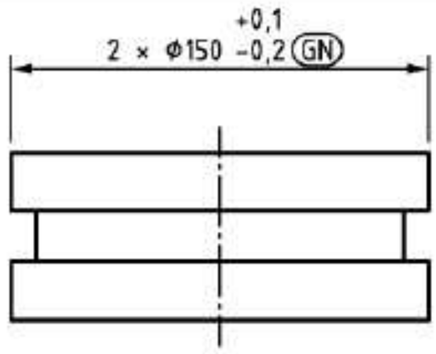
Modifier	Description
(GG)	Dimension (size) of the geometrical feature associated using the least-squares method
(GX)	Dimension (size) of the maximum inscribed geometrical feature Used only for clearance fits in combination with (LP), (see figure A.15). Not recommended, as implementing it in production measuring equipment is difficult.
(GN)	Dimension (size) of the minimum circumscribed geometrical feature Used only for clearance fits in combination with (LP), (see figure A.14). Not recommended, as implementing it in production measuring equipment is problematic.

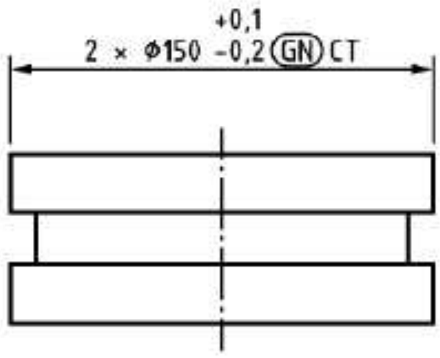
Table A.3 – General modifiers for sizes

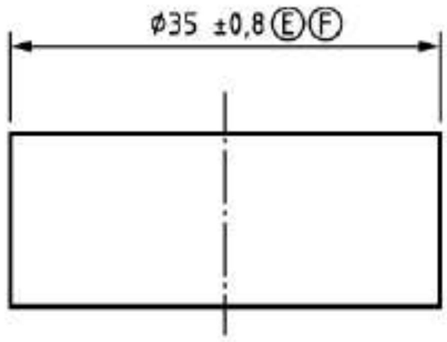
Modifier and description	Drawing note example
Ⓔ Envelope requirement	10 ±0.1Ⓔ
	
/length any limited sub-area of the geometrical feature	10 ±0.1(GG)/5
	
ACS Any cross section	10 ±0.1(GX)ACS
	

<table>
<tr><th>Modifier and description</th><th>Drawing note example</th></tr>
<tr><td rowspan="2">SCS

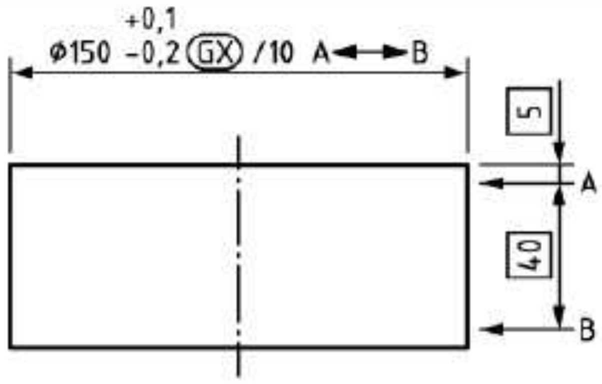
Specific cross section</td><td>10 ±0.1(GX)SCS</td></tr>
<tr><td>
</td></tr>
<tr><td rowspan="2">Number ×

More than one geometrical feature</td><td>2 × 10 ±0.1Ⓔ</td></tr>
<tr><td>
</td></tr>
<tr><td rowspan="2">CT

Common tolerance
(see DIN EN ISO 14405-1)</td><td>10 ±0.1Ⓔ CT</td></tr>
<tr><td>
</td></tr>
<tr><td rowspan="2">Ⓕ

Free-state condition</td><td>10 ±0.1(LP)(SA)Ⓕ</td></tr>
<tr><td>
</td></tr>
</table>

<table>
<tr><th>Modifier and description</th><th>Drawing note example</th></tr>
<tr><td rowspan="2">◀—▶
or
◁—▷

between</td><td>10 ± 0.1A◀—▶B</td></tr>
<tr><td></td></tr>
</table>

A.1.4 Envelope requirement drawing note

As per the definition for the envelope requirement as per DIN EN ISO 14405-1, the envelope requirement can be used for an

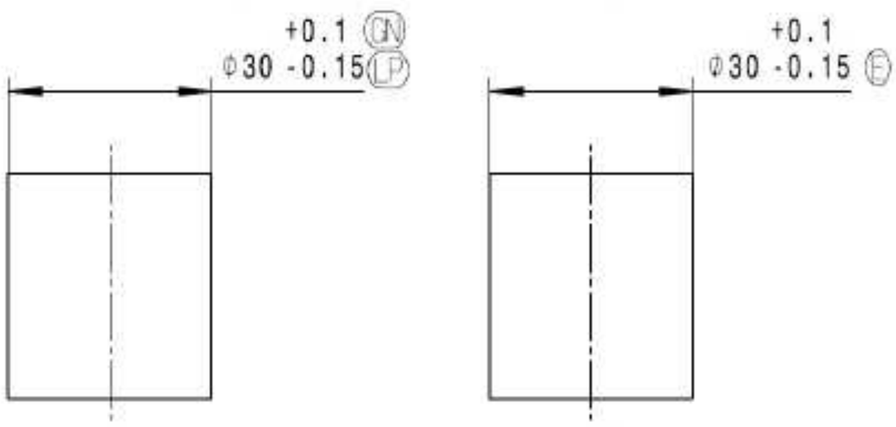
- **External feature-of-size** (shaft, key width) as a simultaneous use of a combination of the two-point size Ⓛⓟ at the lower limit of size (LLS) and the minimum circumscribed dimension (GN) at the upper limit of size (ULS)

- **Internal feature-of-size** (hole, groove width) as a simultaneous use of a combination of the two-point size Ⓛⓟ at the upper limit of size (ULS) and the maximum inscribed dimension (GX) at the lower limit of size (LLS)

Based on these specifications in DIN EN ISO 14405-1, a distinction must be made between the following

– **Envelope requirement**, expressed with the help of a combination of dimension modification symbols, see figure A.14 a) and figure A.15 a). Here, the conformity is checked by a measurement. The envelope can be simulated only with a limited number of measuring points with the help of corresponding measurement software.

– **Envelope requirement**, expressed with the help of the modification symbol Ⓔ, see figure A.14 b) and figure A.15 b). Here, the conformity inspection is performed with a gage (a full solid measure). In this case, the envelope is simulated completely by the gage.

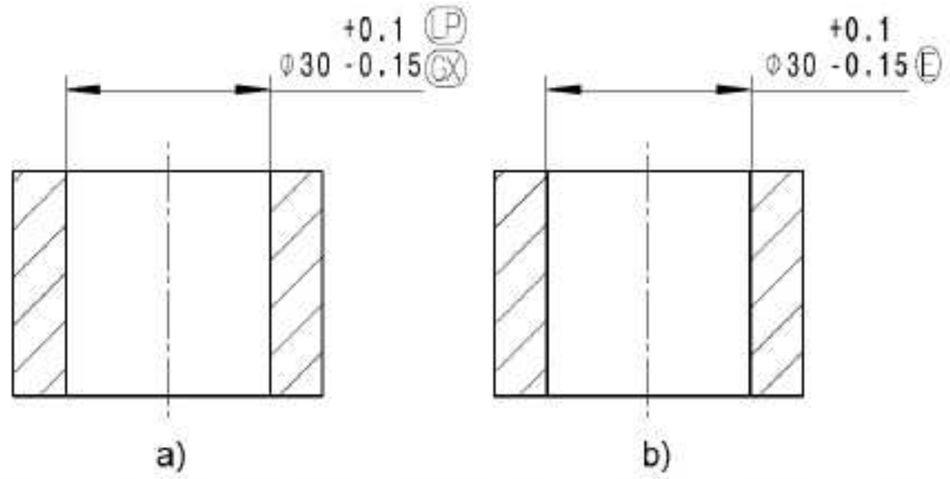


a) b)

Legend

a)	Tolerancing with sizes and modifiers	b)	Tolerancing for a gage inspection

Figure A.14 – Examples of drawing notes for the envelope requirement



Legend

a)	Tolerancing with sizes and modifiers	b)	Tolerancing for a gage inspection

Figure A.15 – Examples of drawing notes for the envelope requirement

The two envelope requirement variants have the same meaning, but specify different verification methods. This means that the results obtained are not equivalent. Because of this, the envelope requirement or modifiers must be preferably defined, for the individual sizes, in the SET together with Test Planning and Quality Assurance. It must be taken into account that, when using tolerancing based on the independency principle, the form of the geometrical feature is not limited by dimensional tolerances. Because of this, shape deviations must be independently toleranced in a functionally oriented manner.

Using process control is not possible when using the tolerancing designed for a gage inspection, as this inspection method does not provide any measured values, but only an "okay (OK)" or "not okay (NOK)" inspection result instead. Process control requires measurement results so that the process situation can be determined. Using what are referred to as "mating sizes" – (GX) or (GN) – and the two-point size (LP) makes it possible to perform process control.

A.2 Independency principle explanations

The independency principle is defined in DIN EN ISO 8015. When using the independency principle, every requirement (geometrical product specifications (GPS)) specified on a drawing for dimensional, form, and positional tolerances on a geometrical feature must be met independently of other requirements unless a special note indicating otherwise (e.g., the dimension modifiers in DIN EN ISO 14405-1, such as Ⓔ – envelope requirement (see figure A.16), CZ – common tolerance zone as per DIN EN ISO 1101 (see table A.3), or Ⓜ – maximum material condition as per ISO 2692) has been additionally entered.

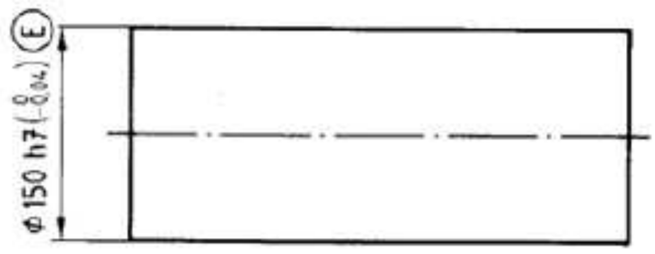
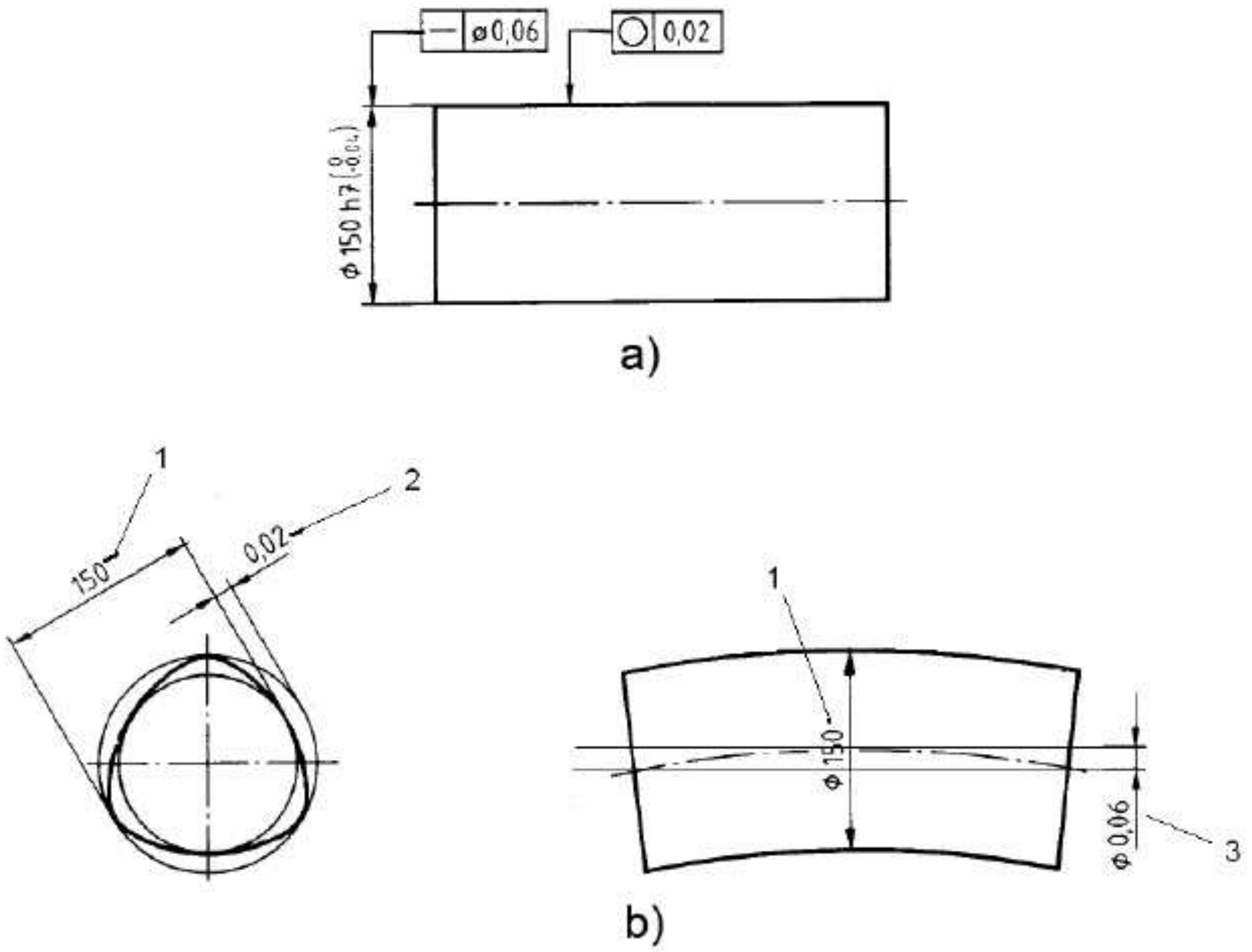


Figure A.16 – Envelope requirement drawing note

A.2.1 Length dimension tolerances

If no special specifications (modifiers) are placed after the length dimension tolerance, the dimensional tolerance only limits the actual local sizes (two-point sizes) of a geometrical feature, but not the feature's shape and orientation deviations, e.g., roundness, cylindricity, straightness, and parallelism deviations for the envelope lines of a cylindrical geometrical feature or flatness and parallelism deviations for two parallel opposite planes.

For example, a shaft can have, in any cross section, a shape deviation in the form of a curve of constant width within the roundness tolerance, and it can be bent by the magnitude of the straightness tolerance, regardless of whether the shaft has reached the maximum material size or not; see figure A.17.



Legend

a)	Drawing specification
b)	Meaning of drawing specification
1	Maximum dimension (local actual size)
2	Maximum permissible roundness deviation
3	Maximum permissible straightness deviation of cylinder axis

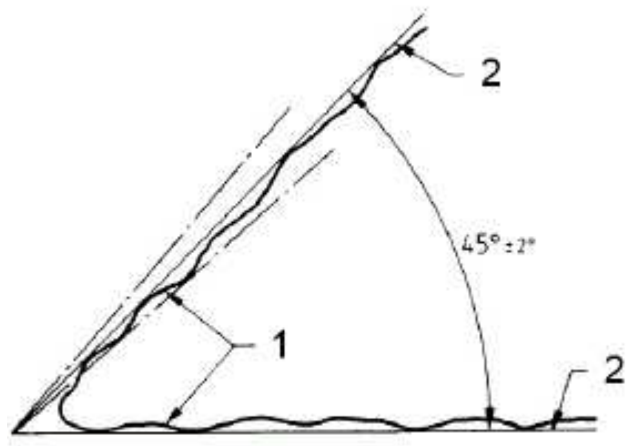
Figure A.17 – Meaning of drawing specification when using the independency principle

This means that the shape and parallelism deviations must always be limited with appropriate individual form and parallelism tolerances of the general tolerances for form and position as per DIN ISO 2768-2.

A.2.2 Angular dimension tolerance

An angular dimension tolerance specified in units of angle covers only the general orientation of lines or of surface line elements, and not their shape deviations; see figure A.18.

The general orientation of the line derived from the actual surface (actual line) is the orientation of the contact line with a geometrically ideal form (see figure A.18). The greatest distance between the contact line and the actual line must be as small as possible.



Legend

1 Actual lines
2 Contact lines

Figure A.18

Shape deviations must be limited with individual form tolerances or general tolerances for form as per DIN ISO 2768-2.

Appendix B (informative) Problem concerning standards when it comes to the general applicability of the envelope requirements without a drawing note as per DIN 7167

For Volkswagen Group drawings, the envelope requirement automatically applied to all features-of-size of type "cylinder" (cylindrical surface – shaft or hole) or type "two parallel opposite planes" (widths such as slot width, groove width, tongue width, key width) for decades until the end of 2011 as per DIN 7167[4)]: 1987-01. This provision applied as per DIN 7167 without a drawing note.

However, DIN 7167 had to be withdrawn at the end of 2011 because the following international standards concerning GPS, which reverse the procedure in DIN 7167, were published: DIN EN ISO 286-1: 2010-11, DIN EN ISO 14405-1: 2011-04, and DIN EN ISO 8015: 2011-09. This resulted in the following condition: When a drawing does not contain a note indicating the general applicability of the envelope requirement or the use of independency principle, the independency principle automatically applies as per DIN EN ISO 8015. The independency principle is also implicitly invoked as a result of the invocation principle in DIN EN ISO 8015, as soon as a portion of the ISO GPS system is invoked in a mechanical engineering product specification (e.g., drawing), either by specifying an ISO code for fit tolerances – e.g., H7– or with a reference to general tolerances (e.g., ISO 2768 – m).

This new rule is the exact opposite of the old rule as per DIN 7167. As per the independency principle, the envelope requirement does not apply automatically. The dimensions of features-of-size with ± tolerances and the fit tolerances as per DIN EN ISO 286-1 (ISO code, e.g., H7) now apply as two-point sizes and must be verified with a two-point measurement.

This means that when a supplier now manufactures a product as per an old drawing that was toleranced as per DIN 7167, the supplier is automatically working as per the independency principle as per DIN EN ISO 8015, since the drawing will not contain a note indicating the use of the envelope requirement.

Because of this, as per DIN EN ISO 14405-1, all old drawings that were drafted as per DIN 7167 without a note indicating the general applicability of the envelope requirement must be identified with the following note (see figure 3) above the title block or, if financially possible, must be revised as per the independency principle, i.e., if the envelope requirement must continue to apply to specific sizes, the Ⓔ modifier must be included after the dimensional tolerance.

This put the validity of all drawings into question that were toleranced as per DIN 7167 and that did not have a note regarding the envelope requirement. It would mean that all drawings based on DIN 7167 must be provided with this marking.

B.1 Modifications to Volkswagen standards (VW 01014, VW 01054, and VW 01155)

As a solution to the problem described above, modifications were made to the relevant Volkswagen standards. These modifications were gradually implemented even before the aforementioned ISO GPS standards were published.

4) DIN 7167: 1987-01 – Relationship between tolerances of size, form, and parallelism; envelope requirement without individual indication on the drawing

1st step – adding the "envelope principle" tolerancing principle to VW 01054 (February 2009)

In order to clearly specify that the envelope requirement without a drawing note as per DIN 7167[5)] applies to the Volkswagen Group's drawings, the following addition was added to standard VW 01054, issue 2009-02, in February 2009:

> The "envelope" tolerancing principle according to DIN 7167 – Relationship Between Tolerances of Size, Form, and Parallelism; Envelope Requirement Without Individual Indication on the Drawing – applies to drawings of the Volkswagen Group.

Figure B.1

2nd step – rule for drawings with creation date of March 2011 or later

In order to comply with the new ISO GPS standards (especially DIN EN ISO 14405-1: 2011-04), the following addition was added to VW 01054, issue 2011-03, in March 2011:

> The "envelope" tolerancing principle as per DIN EN ISO 14405-1 "Dimensional Tolerancing - Linear Sizes" must be used for all drawings of the Volkswagen Group, see Figure 1.
>
> Size ISO 14405 Ⓔ
>
> Figure 1

Figure B.2

In order to ensure that the general applicability of the envelope requirement is entered into Volkswagen Group drawings, the following addition was added to VW 01054, issue 2011-03:

> This tolerancing principle must be ensured by using the current drawing frame as per VW 01014 containing the text "Tolerierungsgrundsatz nach VW 01054. Tolerancing principle as per VW 01054", see Figure 2. For this reason, always use the current drawing frames as defined in the latest issue of VW 01014 for new drawings and for drawing changes. If this is not possible in exceptional
> cases, the text macro NO-A11 as per VW 01014 "Tolerierungsgrundsatz nach VW 01054. Tolerancing principle as per VW 01054" must be inserted in the drawing's "Notes" field (may also be simply typed). In addition, standard VW 01054 must be entered in the "References" field.

Figure B.3

In May 2011, the note indicating the general applicability of the envelope requirement used by default at Volkswagen was added to all drawing frames as per VW 01014, issue 2011-05, and standard VW 01054 was added to the "Unterlagen / References" field (see figure B.4).

5) In earlier issues of the standard, the general applicability of the envelope requirement to sizes was specified to be the "envelope principle."

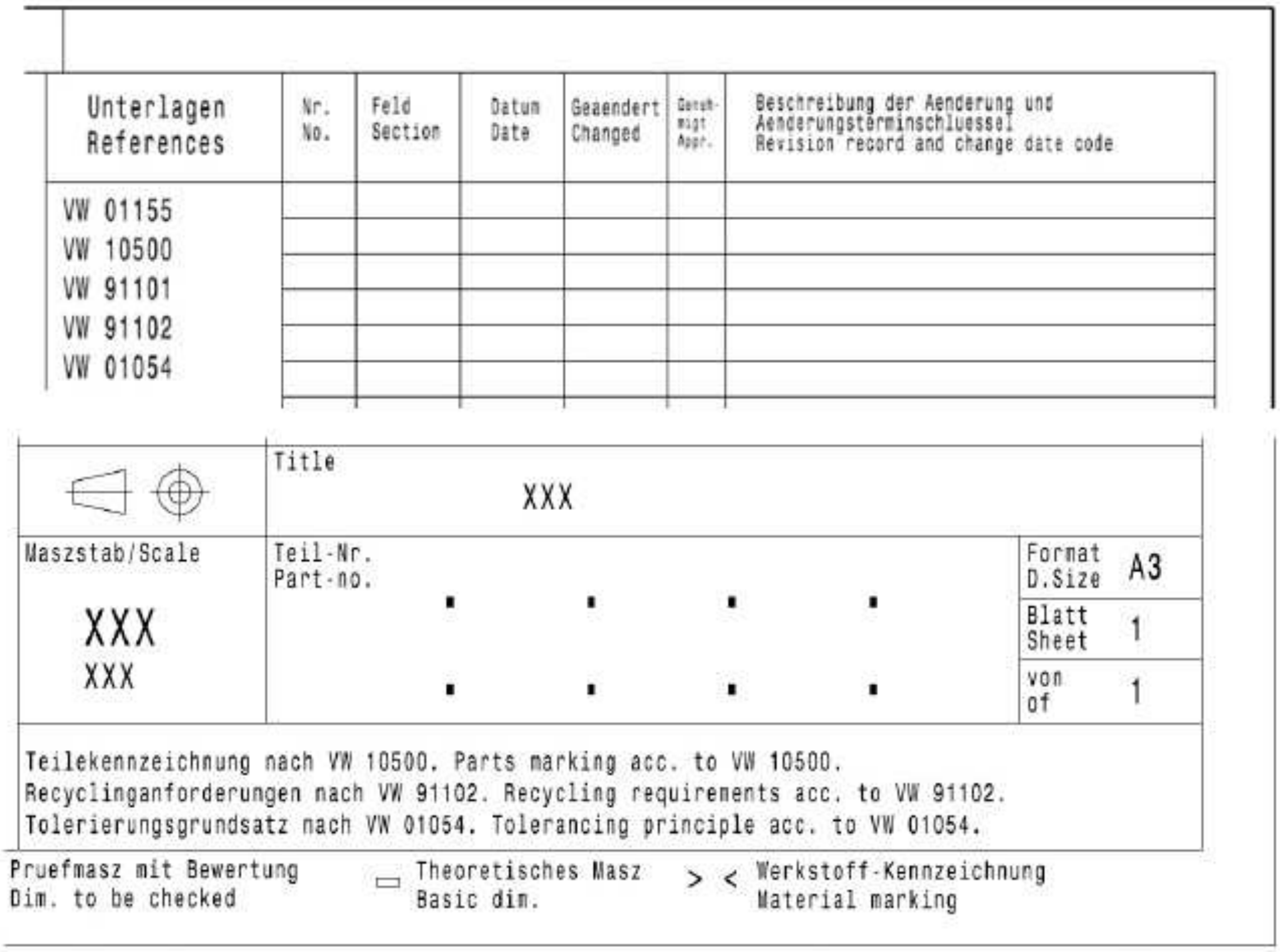


Figure B.4

3rd step – Rule for Volkswagen Group drawings drafted (released) before June 2011

Since drawings drafted (released) before March 2011 do not contain a note indicating the general applicability of the envelope requirement as per DIN 7167, the following addition was added to standard VW 01155 in June 2011, issue 2011-06, which is referenced by default on all drawings.

> **The "envelope" tolerancing principle as per VW 01054 "Engineering Drawings, Dimensioning" applies to all drawings of the Volkswagen Group first released prior to the publication of this revised issue of VW 01155, and which do not contain a reference to the applicable tolerancing principle.**

Figure B.5

This way, the general applicability of the envelope requirement without a drawing note was confirmed for all drawings drafted (released) before 2011 by making an appropriate change in the relevant standard, making it possible to avoid having to revise (add a note to) the drawings.

The aforementioned modifications to the Volkswagen standards (VW 01014, VW 01054, and VW 01155) ensured that the Volkswagen Group's old drawings that do not contain a note indicating the general applicability of the applicable envelope requirements as per DIN 7167 would continue to be valid and that new drawings would clearly specify the general applicability of the envelope requirement used at Volkswagen.

4th step – adding the independency principle to VW 01054

By adding the independency principle to this issue of the standard, the general applicability of the envelope requirement to new drawings (i.e., drawings drafted after this standard's date of

publication) has ceased to apply. This means that, after this issue is published, each drawing must specify, in its title block, whether it uses the general applicability of the envelope requirement to sizes or the independency principle.

5th step – setting the independency principle as the default tolerancing principle for the Volkswagen Group

As a result of international standard ISO 8015, the independency principle applies as the default tolerancing principle. In the next development step, this default specification will also apply to Volkswagen drawings. However, it will still be possible to use the envelope requirement for individual geometrical features (sizes) if required in order to ensure the corresponding fit function.