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Steel Forgings
Tolerances and Permissible Variations for Drop Forgings

DIN 7526

Schmiedestücke aus Stahl; Toleranzen und zulässige Abweichungen für Gesenkschmiedestücke

The content of this Standard is the outcome of joint studies by German, British and French experts. It has been prepared on behalf of the "EUROFORGE" Technical Committee - an association of European forgemasters.

To facilitate understanding between one country and another, the present Standard adopts not only the factual content but also the grouping and the same numbering of sections and tables from the jointly produced document. In so doing it has been necessary to accept the fact that the terms used and their explanations are not - as is the usual practice in a DIN standard - grouped in a special Section at the start of the text. Since this is an application standard it does not represent a disadvantage to the user if the terms are explained each time in the Sections in which the need for them arises by the nature of the subject. The repetition, in appropriate terms, of provisions from the Part entitled "Drop forgings produced in hammers and presses" in the Part entitled "Drop forgings produced in horizontal forging machines" is a consequence of the adoption of the grouping as used in the jointly produced draft and in fact means simplified reference for the user of the Standard. Sections denoted by a dot (•) in front of the Section number are conformal in content for both manufacturing processes.

This Standard is intended to supersede the existing standards DIN 7524 Part 1 to Part 3 dealing with permissible variations for drop forgings. For the initial manufacture of dies, DIN 7526 should be applied from the start. However to give users an opportunity to use up existing gauges and tooling it is permissible to work and supply on the basis of DIN 7524 Part 1 to Part 3 up to 31 December 1971. Only then will DIN 7524 Part 1 to Part 3 be withdrawn and superseded by DIN 7526 so that after this date only DIN 7526 will be valid.

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Dimensions in mm

Drop forgings produced in hammers and presses

1. General information relating to drop forgings produced in hammers and presses

1.1. Scope

Sections 1 to 5 of this Standard, taken in conjunction with Tables 1 to 6, apply to drop forgings in the delivery condition which are forged hot in hammers or presses from carbon steel or alloy steel.

The tolerances apply to drop forgings up to a weight of 250 kg and a maximum length of 2500 mm.

Tolerances for drop forgings heavier or larger than this, as well as tolerances for drop forgings with very complex shapes or of steels which are difficult to forge must be agreed between the manufacturer and the customer.

The tolerances allow for all variations permissible through die wear, die gap or different rates of shrinkage.

1.2. Forging grades

Two forging grades are distinguished, as follows:

Forging grade F with tolerances providing an adequate standard of accuracy for the majority of applications, and capable of being complied with by commonly used forging equipment and production methods;

Forging grade E with closer tolerances, compliance with which requires more expensive production.

The tolerances of forging grade E should be applied only to individual dimensions requiring a higher standard of accuracy than provided by forging grade F.

1.3. Special agreements

Closer tolerances for drop forgings or for individual dimensions of a drop forging than provided by forging grade E must be specially agreed between the customer and the manufacturer. This should take place prior to confirmation of the order, since such stipulations may influence not only the choice of forging method but also the shape of the drop forging and of the tooling.

N o t e : Tolerances for forging grade E and special agreements involve higher cost than forging grade F (e.g. additional processes, more expensive tooling and more accurate machines).

2. Data for determining the tolerances of drop forgings produced in hammers and presses

In order to determine from the Tables the dimensional tolerances applicable to a drop forging, the following data are necessary in addition to the dimensions of the drop forging:

2.1. Weight of the drop forging

This is calculated.

2.2. Flash

A distinction is made between flush, symmetrically offset and unsymmetrically offset shapes.

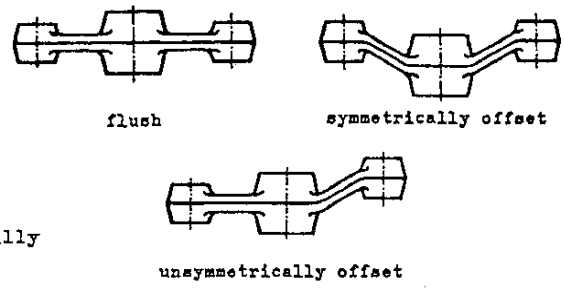


Figure 1. Flash

2.3. Intractability of material, steel grade

The intractability of the material takes account of the fact that in forging practice, steels of the high carbon and high alloy grades entail larger dimensional variations and higher rates of tooling wear than do steels with lower carbon content and lower amounts of alloying constituents.
Quantities characteristic of the intractability are the carbon content and the sum of the alloying constituents comprised by manganese, chromium, nickel, molybdenum, vanadium and tungsten.
Two groups of intractability are distinguished:

Group M 1: Steel with a carbon content of not more than 0.65 % by wt. and a total of alloying constituents Mn, Cr, Ni, Mo, V, W not exceeding 5 % by wt.;
Group M 2: Steel with a carbon content of more than 0.65 % by wt. or a total of alloying constituents Mn, Cr, Ni, Mo, V, W of more than 5 % by wt.

The criterion for deciding which of the two groups a particular steel belongs to is the maximum allowable content of carbon and the alloying constituents named.

2.4. Complexity of the drop forging

The complexity takes account of the fact that in the forging of thin section and branched components, as compared with components having simple compact shapes, larger dimensional variations occur which are attributable to different rates of shrinkage, higher shaping forces and higher rates of tool wear. This is expressed by the factor S. It is calculated according to the following formula:

$$S = \frac{m_S}{m_H}$$

In this expression m_S stands for the weight of the drop forging and m_H for the weight of the enveloping body formed from the largest dimensions of the drop forging.
Four groups of complexity are distinguished:

Group S 1: over 0.63 to 1
Group S 2: over 0.32 to 0.63
Group S 3: over 0.16 to 0.32
Group S 4: over 0 to 0.16

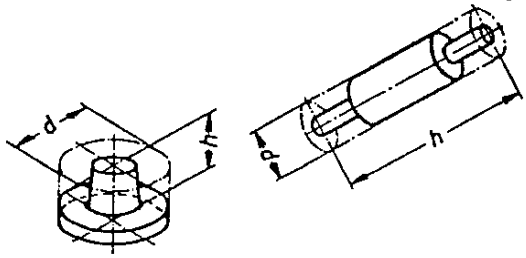


Figure 2. Enveloping bodies of round drop forgings

The enveloping bodies of round drop forgings (see Figure 2) are the circumscribed cylinders whose weight is calculated according to the following formula

$$m_H = \frac{d^2 \cdot \pi}{4} \cdot h \cdot \varrho$$

where:
d Diameter of enveloping body
h Height of enveloping body
ϱ Density (7.85 kg/dm^3)

The enveloping bodies of non-round drop forgings (see Figure 3) are the parallelepipeds with the smallest volume capable of circumscribing the drop forgings. Their weight is calculated according to the following formula:

$$m_H = b \cdot h \cdot l \cdot \varrho$$

where:
b Width of enveloping body
h Height of enveloping body
l Length of enveloping body
ϱ Density (7.85 kg/dm^3)

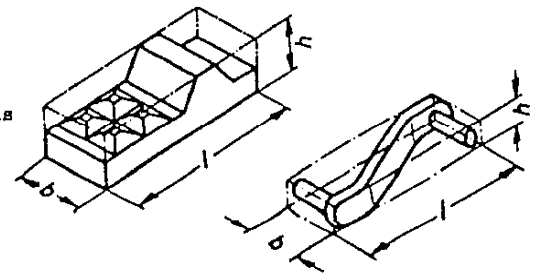


Figure 3. Enveloping bodies of non-round drop forgings

E x c e p t i o n : In the determining of tolerances for the thicknesses of thin discs or flanges (round or angled) there is an exceptional condition, namely when

$$\frac{a_2}{d} \leq 0.2$$

(see Figure 4). Here, d is the diameter of the disc or flange and a_2 is the corresponding thickness. In such cases the tolerances are determined not on the basis of the calculated complexity factor or of the weight of the forging, but instead by using the complexity group S 4 and a weight corresponding to a disc with a diameter d and a thickness a_2. This method is only applied however if the resulting tolerances are greater than those obtained by the usual method.

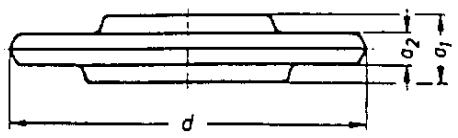


Figure 4. Exceptional case for thin discs or flanges

3. Tolerances for drop forgings made in hammers and presses

3.1. Division into groups

The tolerances for the different kinds of dimension are divided into four groups depending on the Tables to which they belong.

3.2. Explanations regarding tolerances

The tolerances on length, width, height and thickness dimensions comprise not only dimensional variations, but also - however excluding deflection and distortion, see Section 3.2.3.1 - variations of shape, such as:

variations from circularity
variations from circular cylindricity
variations from a plane
other variations from a prescribed outline.

These variations of shape must not exceed the limits imposed by the tolerances. In certain circumstances they may account for the entire tolerance range. Restrictions on variations of shape must be specially agreed and noted in the drawing.

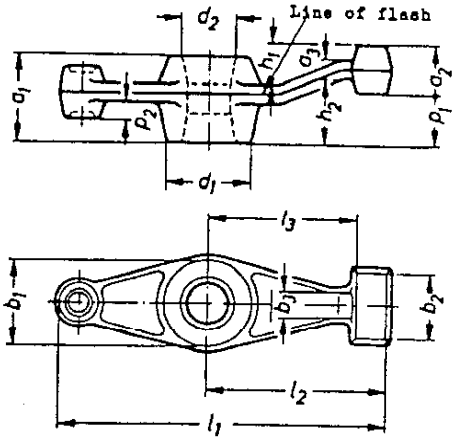


Figure 5. Kinds of dimension for drop forgings

3.2.1. F i r s t g r o u p (see Tables 1 and 2)

3.2.1.1. Tolerances for length, width and height dimensions

The tolerances for this group apply to length, width and height dimensions on one side of the flash.

a_1, a_2 etc. thickness dimensions (see Section 3.2.2.1)
b_1, b_2 etc. width dimensions
d_1, d_2 etc. diameter dimensions
h_1, h_2 etc. height dimensions
l_1, l_2 etc. length dimensions
p_1, p_2 etc. offset dimensions

Lengths and widths are dimensions running parallel or more or less parallel to the principal plane of the die parting. They may be either external dimensions (see Figure 6) or internal dimensions (see Figure 7).

Height dimensions are dimensions running perpendicular to the principal plane of the die parting and they comprise only such dimensions as do not intersect the flash (dimensions which intersect the flash are thickness dimensions).

Length, width and height dimensions also comprise:
offset dimensions which are dimensions for distances between equal-directed parallel faces in line with the length, width and height dimensions for distances between an axis and a face
dimensions for centre distances (see also Section 3.2.3.2)
dimensions for pierced holes (see Section 3.2.1.4).

It is normal to apply the tolerances of the largest length, width and height dimension in each case to all the length, width and height dimensions of a drop forging.

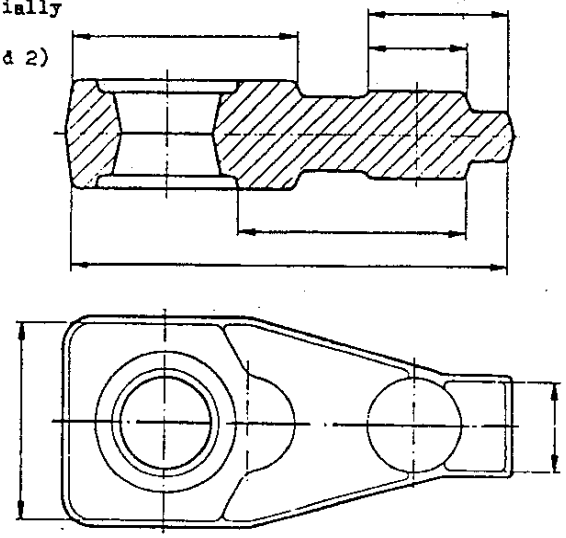


Figure 6. Dimensions between external faces

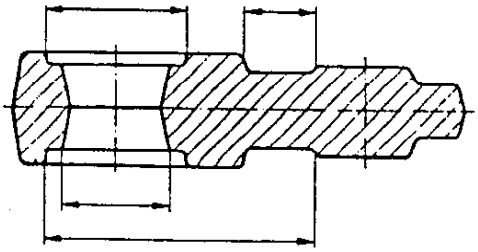


Figure 7. Dimensions between internal faces

The greatest height dimension of a drop forging is the measurement from the die parting to its most distant external face.
The tolerances of the largest width are generally applied to the diameters of round hubs or depressions of a drop forging. This avoids unneccessarily small tolerance differences and simplifies preparation of the forging drawing and the carrying out of the acceptance procedure.
The permissible variations are taken from Tables 1 or 2 and are entered in the forging drawing (see Section 5.4).
For internal dimensions the maximum and minimum values of the permissible variations are to be interchanged.
If closer tolerances are necessary for individual dimensions, these are derived from the corresponding nominal dimension ranges. If still closer tolerances are needed for distance dimensions from an axis to a surface or for offset dimensions, then the tolerances of these nominal dimension ranges are utilized to only $\pm 1/3$.
In both cases the permissible variations are to be entered in the forging drawing alongside the relevant dimensions.

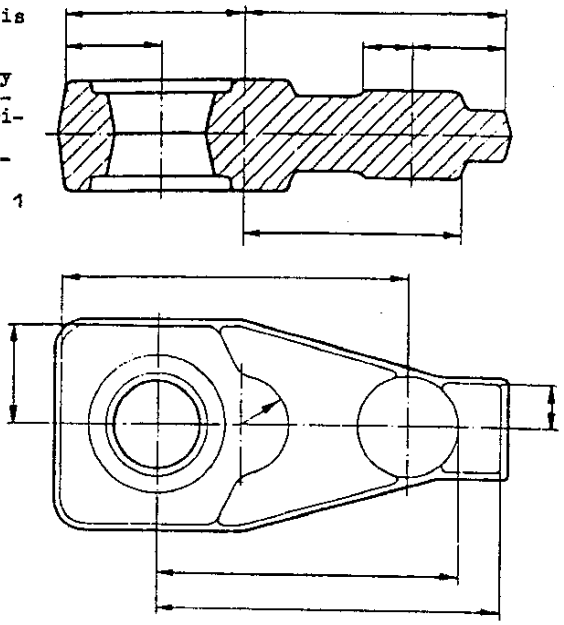


Figure 8. Dimensions between an axis and a face

3.2.1.2. Permissible mismatch
The permissible mismatch states the amount by which a point on one side of the flash may be displaced relative to the corresponding point on the other side in a direction parallel with the die parting. It is found from Tables 1 or 2 to suit the weight of the drop forging and the disposition of the flash, and it applies in the length and width directions.
The permissible mismatch is used independently of other tolerances.
In measurements of mismatch the accuracy depends on the extent to which an appropriate allowance is made for an accumulation of material caused by unequal die wear. For this reason the measurements should be made at points on the drop forging which are least affected by die wear.
The mismatch on the forging is best determined as follows:

$$\text{Mismatch} = \frac{l_1 - l_2}{2} \text{ or } \frac{b_1 - b_2}{2}$$

where:

b_1 or l_1 stand for the larger, and
b_2 or l_2 stand for the smaller projected width or length dimension as measured parallel with the die parting

• 3.2.1.3. Permissible residual flash (flash projection) and permissible depth of chamfer
Variations in trimming can produce either a residual flash or a chamfered face. The permissible values, positive for residual flash and negative for depth of chamfer, are given in Tables 1 and 2.
The residual flash is measured from the body of the forging to the edge of the flash (see Figure 10).
The depth of chamfer is measured from the chamfered face to the theoretical point at which the die drafts meet (see Figure 11).
The permissible residual flash and the permissible depth of chamfer are used independently of, and additionally to, other tolerances.

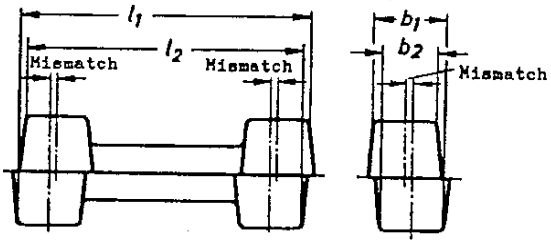


Figure 9. Mismatch

• 3.2.1.4. Tolerances for hole dimensions
Hole dimensions are internal dimensions between the faces produced by piercing or trimming. It is normal to apply the tolerances of the greatest width (diameter) to all hole dimensions of a drop forging.
For this purpose the maximum and minimum values of the permissible variations are interchanged one with the other.
If smaller variations are necessary for particular hole dimensions, these are taken from the corresponding nominal dimension ranges of Tables 1 or 2. They must be entered in the forging drawing alongside the relevant dimension.

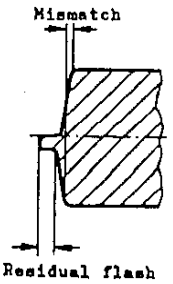


Figure 10. Residual flash (flash projection)

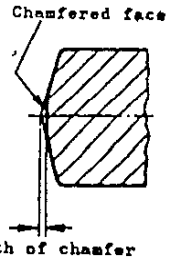


Figure 11. Depth of chamfer

3.2.2. S e c o n d g r o u p (see Tables 3 and 4)

• 3.2.2.1. Tolerances for thickness dimensions
Tolerances for thickness dimensions (see Figure 5) apply to all the dimensions of a drop forging which cross the flash. The tolerance for the largest thickness dimension is determined from Tables 3 or 4 and in view of the great influence which the die gap exerts on the variations in the thickness dimensions it should also be applied to all other thickness dimensions of the drop forging.
Closer tolerances for individual thickness dimensions require additional operations and must be specially agreed between customer and manufacturer (see Section 1.3).

E x c e p t i o n : When drop forgings have a projection on one side of a flange (e.g. journal or hub, see Figure 12) the length of which is greater than 1.5 times its smaller diameter (diameter of enveloping circle in the case of a non-round projection) only the tolerance for the greatest thickness dimension a_1 is determined in the usual manner. On the other hand, in determining the tolerances for the other thickness dimensions a reference dimension t is used which represents the sum of the thickness of the flange a_2 and 1.5 times the smaller diameter of the projection.
If projections are present on both sides of a flange and their length is greater than 1.5 times their smaller diameter, the reference dimension t is calculated on the basis of the diameter of the larger projection.
In both cases the permissible variations for the calculated dimension are to be entered each time in the Table (see Section 5.4), but for the greatest thickness dimension they are to be entered against the dimension in the forging drawing.

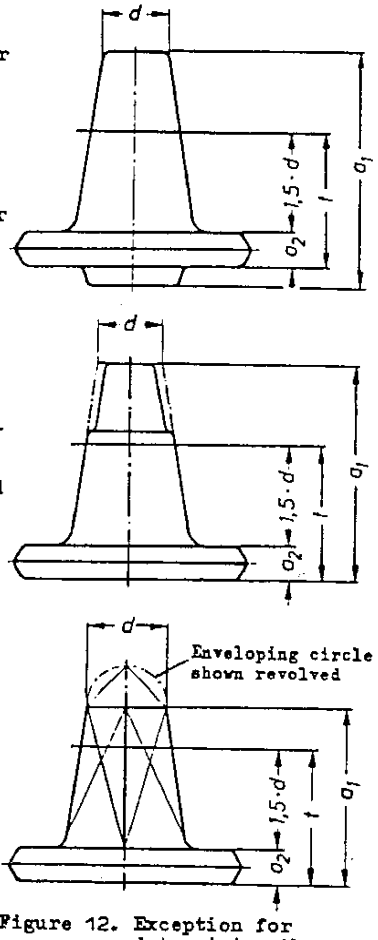


Figure 12. Exception for determining the tolerances for thickness dimensions

3.2.2.2. Permissible height and depth of ejector marks
When drop forgings are forged in dies with ejectors, the position and dimensions of the resulting ejector marks are to be entered in the forging drawing. In the course of the manufacturing process the ejector marks commonly occur both raised and indented. The permissible height or depth is subject to the values of Tables 3 or 4 with a $\pm 1/2$ distribution.
If the customer requires the ejector marks to be either raised only or indented only, the values shall apply in their full magnitude unless agreed otherwise. They are applied independently of, and in addition to, the other tolerances.

3.2.3. T h i r d g r o u p (see Table 5)

• 3.2.3.1. Permissible deflection and permissible distortion
The permissible deflection, i.e. the permissible departure of the centre line of a drop forging from a straight line (see Figure 13) and the permissible distortion, i.e. the permissible variation of the surface from its prescribed disposition are to be found from Table 5 to suit the greatest length or greatest width of the drop forging.

The permissible deflection and the permissible distortion must be entered in the forging drawing.
Deflection and distortion are applied independently of, and in addition to, the other tolerances. They do not comprise the variations of shape mentioned in Section 3.2.

3.2.3.2. Tolerances for centre distances
Centre distances are dimensions between two axes or two centre lines or between an axis and a centre line. Normally, the tolerances of the greatest length and width dimensions are applied to centre distances, but with a $\pm 1/2$ distribution.

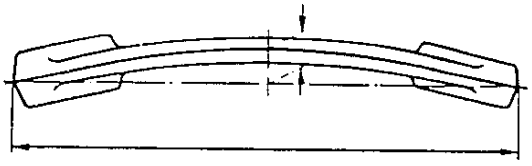


Figure 13. Deflection

If closer tolerances are needed, the permissible variations of the corresponding nominal dimension ranges of Table 5 are applied to centre distances up to 1250 mm, whilst for centre distances over 1250 mm the tolerances of the corresponding nominal dimension ranges of Tables 1 or 2 are used with a $\pm 1/2$ distribution.
If smaller permissible variations are required for centre distances, they must be entered against the dimensions in the forging drawing.

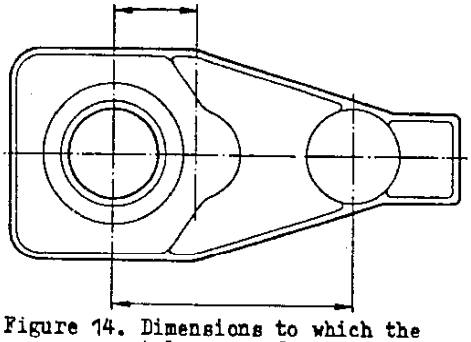


Figure 14. Dimensions to which the tolerances for centre distances are applied

Tolerances for centre distances are applied independently of other tolerances. They are applicable only to centre distances such that the line joining them lies within the drop forging (see Figure 14). Tolerances for centre distances such that the line joining them

lies outside the drop forging (see Figure 15) must be specially agreed.

3.2.4. Fourth group (see Table 6 and text)

• 3.2.4.1. Permissible variations for fillets and corner radii

The permissible variations for fillets and corner radii (see Figure 16) are calculated according to the particulars of Table 6.

The minus tolerances are not applied to corner radii up to 3 mm if such radii are influenced by subsequent trimming or piercing. In such cases a sharp edge is allowed.
The radii of fillets and corners should be made as large as possible in view of the high rate of die wear.

3.2.4.2. Permissible height and width of trimming fins

During trimming or piercing, trimming fins may arise on edges in the immediate vicinity of the flash. The permissible height and width of trimming fins is to be determined from Table 6 to suit the weight of the drop forging. They are applied independently of, and in addition to, the other tolerances.
The position of trimming fins must be indicated in the forging drawing.

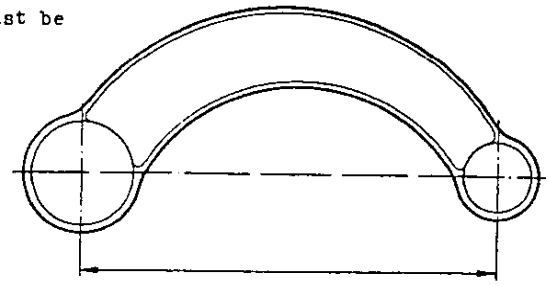


Figure 15. Dimension for which the tolerance must be specially agreed

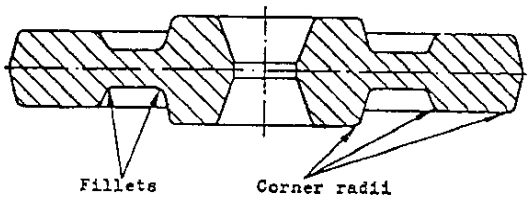


Figure 16. Fillets and corner radii

• 3.2.4.3. Permissible depth of surface defects

Surface defects are depressions which may occur on the forged faces, e.g. as a result of scale formation. They are permissible within the following limits:
In the case of surfaces which are to be machined in a subsequent operation, down to a depth which preserves at least half of the specified machining allowance;
in the case of surfaces which are not to be machined in a subsequent operation, to a maximum of 1/3 of the tolerance for the greatest thickness.

• 3.2.4.4. Tolerances for the slope of surfaces

Variations causing the slope of surfaces to depart from their specified disposition are permissible within the tolerances for the greatest length, width or height of a drop forging.
Variations larger than this, e.g. on the occurrence of severe die wear, must be agreed between the manufacturer and customer.

• 3.2.4.5. Permissible alignment error (Position of axes of deep holes)

For holes having a depth greater than their largest diameter (see Figure 17) variations from parallelism of the hole axis and the centre line of the forging are permitted. Such variations are allowed up to 0.5 % of the hole depth and are in addition to the mismatch.

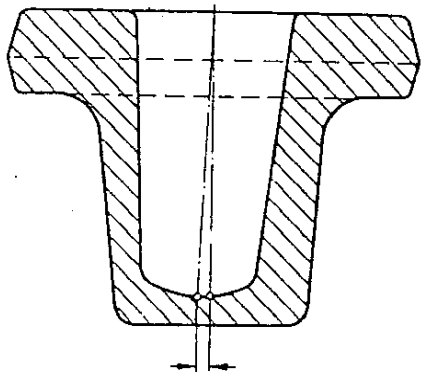


Figure 17. Alignment error

3.2.4.6. Tolerances for non-shaped part

If part of a drop forging does not undergo shaping with the rest, but instead retains its original cross-section, the part immediately adjoining the shaped portion may exhibit local diameter or cross-section variations. These variations may occur in a length up to 1.5 · d, but subject to a maximum of 100 mm, and they must lie within the tolerances for the greatest width or thickness dimension (see Figure 18). The distribution of these tolerances may differ from the distribution of the tolerances for the shaped portion if so agreed between the customer and the manufacturer.
Tolerances for the length l (see Figure 18) from the end of the non-shaped part up to a corresponding face on the shaped part are to be taken from Table 1, using material group M 1, complexity group S 1 and a weight corresponding to a bar-shaped body of the same length and with a cross-section equal to that of the original workpiece. The permissible variations must be entered against the corresponding length dimension.

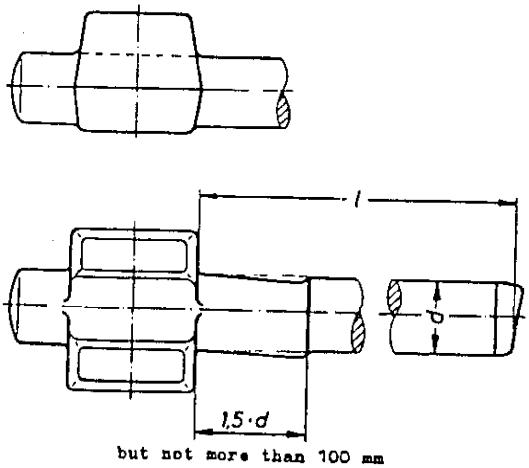


Figure 18. Example illustrating the non-shaped part and sheared ends

If the non-shaped part has a sheared end, the length shall be measured from the shorter side of the resulting sloped face (see Figure 18).

• 3.2.4.7. Permissible deformation of sheared ends
Permissible variations from the original shape, which are allowed to occur on the sheared end of a shank (see Figure 18), are calculated according to Table 6 to suit the diameter of the shank. They are applied independently of, and in addition to, the other tolerances.

For sheared face a slope up to 7° is permitted. Sheared ends must be indicated in the forging drawing.

4. Use of Tables for determining the tolerances of drop forgings made in hammers and presses

4.1. Tables 1 and 2

For determining the tolerances for length, width and height dimensions the procedure is to move right from the corresponding weight column in Table 1 and then cross the materials group column either horizontally at M 1 or obliquely downwards at M 2, depending on the steel grade, as far as the column corresponding to the complexity. This column in turn is then crossed either horizontally at Group S 1 or obliquely downwards to one of the other complexity groups, whereupon the tolerances and permissible variations are found by further movement horizontally in the corresponding nominal dimension range.
Example of the use of Table 1 – forging grade F – for determining the permissible variations for the length, width and height dimensions of a drop forging.

Data required:

Maximum length	390 mm
Maximum width	110 mm
Maximum thickness	110 mm
Maximum height	80 mm
Weight of drop forging	11.2 kg
Steel grade	C 45
Intractability of material (C < 0.65 % by wt. and sum of alloying constituents < 5 % by wt.)	Group M 1
Weight of enveloping body (3.9 · 1.1 · 1.1 · 7.85)	37 kg
Complexity factor $\left(\frac{11.2}{37} < 0.32\right)$	Group S 3

From the Table the permissible variations (see Figure 19) are found as:

$$\text{Length } {}^{+3}_{-1.5} \text{ mm}$$

$$\text{Width } {}^{+2.4}_{-1.2} \text{ mm}$$

$$\text{Height } {}^{+2.1}_{-1.1} \text{ mm}$$

Normally the permissible variations are found from the Tables for the greatest dimensions and are applied to all the other length, width and height dimensions. If too large for individual dimensions, the permissible variations of the nominal dimension ranges of Table 1 appropriate to the dimensions concerned are applied and separately entered against the dimensions in the forging drawing.
If the tolerances of forging grade F (see Table 1) are too large, the tolerances of forging grade E may be used. These are taken from Table 2 in the same way.
The permissible residual flash, permissible depth of chamfer and permissible mismatch for forging grade F are taken from Table 1. The procedure is to move to the left from the corresponding weight column as far as the columns for residual flash, depth of chamfer and mismatch. In so doing, the column headed flash is crossed either horizontally or obliquely downwards, depending on whether the flash is trimmed flush, symmetrically or unsymmetrically. The smaller values for forging grade E are obtained in a similar manner from Table 2.

4.2. Tables 3 and 4

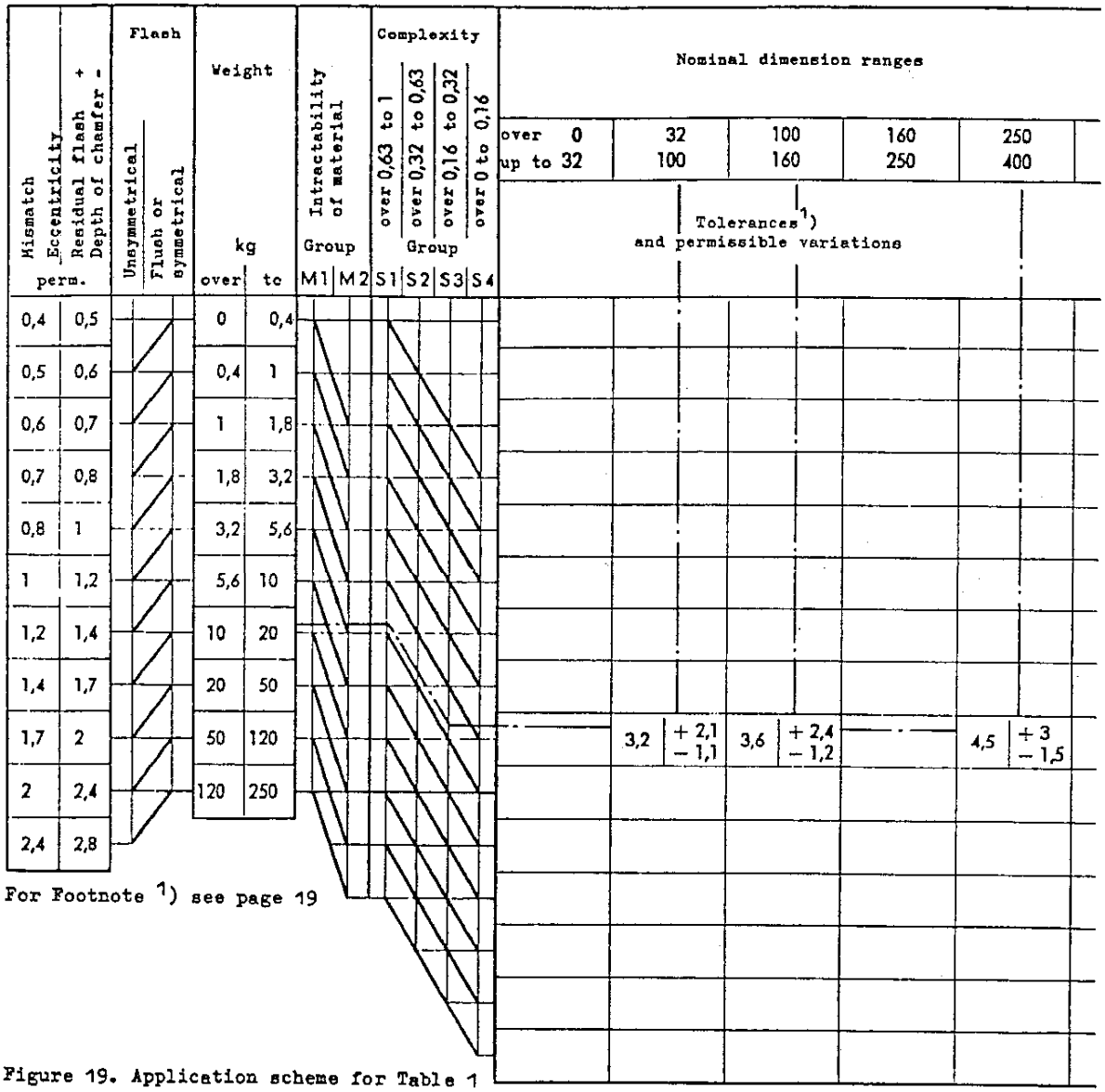
The tolerance for the greatest thickness dimension is derived from Table 3 for forging grade F or from Table 4 for forging grade E in the same manner as the tolerances for length, width and height dimensions were derived from Tables 1 or 2. The tolerance for the greatest thickness dimension is also applied to all other thickness dimensions. Different tolerancing is not permitted.
The permissible height and depth of ejector marks are obtained from Tables 3 or 4 according to the forging grade. The procedure is to move left from the corresponding weight column until the column headed ejector marks is reached. In this connection it should be noted that the values in the Tables may only be applied in a ±1/2 distribution in cases in which the ejector marks may be either raised or indented.

4.3. Table 5

Values for permissible deflection and for permissible distortion are obtained from the corresponding columns of Table 5 for both forging grade F and forging grade E (see Section 3.2.3.1). They must be entered in the forging drawing.
For centre distances smaller permissible variations for centre distances up to 1250 mm can be taken from the corresponding columns of Table 5 for forging grade F and E in cases in which the tolerances normally applied according to Section 3.2.3.2 are too large. They must be entered against the corresponding dimensions in the forging drawing.

• 4.4. Table 6

The permissible variations for fillets and corner radii are calculated from the data of Table 6.



For Footnote 1) see page 19

Figure 19. Application scheme for Table 1

The permissible height and width of trimming fins are derived from Table 6 to suit the weight of the drop forging.
Values for permissible deformation of sheared ends are calculated from the data of Table 6.

5. Guidelines for drawings for drop forgings produced in hammers and presses

5.1. General

The design of drop forgings from the viewpoint of the production process, die design and test methods calls for sound knowledge of the special conditions applying to drop forging. It is therefore in the customer's interest to involve the manufacturer's practical experience at the design stage by letting the latter have not only the drawing showing the finished part together with full details of the material, but also additional particulars regarding the intended use, the type of machining envisaged and the position of datum and clamping faces.

5.2. Preparation of the forging drawing

The forging drawing is best prepared by the manufacturer. On completion it is submitted to the customer for checking and approval. If the forging drawing is prepared by the customer, the additional information called for in Section 5.1 should again be made available.

5.3. Indication of dimensions in the forging drawing

When dimensions are being entered in the forging drawing it should be noted that the tolerances of this Standard, with the exception of tolerances relating to the slope of faces, may only be applied to such dimensions as are specially entered in the drawing. The manner of entering dimensions is therefore of the utmost importance with regard to the checking of dimensions on forgings.

For checking dimensions for which no measurements are entered in the forging drawing, only such tolerances may be applied as are calculated on the basis of the tolerances of dimensions which are entered.
In view of the fact that the tolerances for the greatest length, width and height dimensions are normally applied also to all other measurements relating to these kinds of dimension, it is expedient that these greatest dimensions should always be entered. If these greatest dimensions are not entered in the forging drawing it is permissible to find the tolerances by calculation.

5.4. Indication of permissible variations in the forging drawing

The forging drawing shall have noted in it the permissible variations according to DIN 7526, with the exception of those specially identified.
The permissible variations must be entered in the forging drawing.

It is recommended that the permissible variations applied to several or to all measurements of a particular kind of dimension, as well as the data (weight, complexity etc.) necessary for determining the tolerances, should be entered in a Table (see example).

Kinds of dimension	Permissible variations
Length dimensions	
Width dimensions	
Height dimensions	
Thickness dimensions	
Mismatch	

The permissible variations which are applied only to individual dimensions must be entered against these dimensions.
The position of ejector marks and trimming fins must be indicated.
All permissible variations agreed between manufacturer and customer which do not correspond to the Standard must be entered in the drawing and are to be specially marked.
The manner of marking shall be indicated in the forging drawing.

Drop forgings produced in horizontal forging machines

Items produced in horizontal forging machines commonly consist of shaped parts and a non-shaped part and therefore, in line with general usage and to distinguish them from "drop forgings produced in hammers and presses" they are referred to in the Section below as "forgings".

6. General information relating to forgings produced in horizontal forging machines

6.1. Scope

Sections 6 to 11 of this Standard in conjunction with Tables 1, 3, 5 and 6 apply to forgings in the delivery condition which are forged hot in horizontal forging machines from carbon steel or alloy steel.
Tolerances for forgings with complex shapes or of steels which are difficult to forge must be specially agreed between the manufacturer and the customer.
The tolerances allow for all variations permissible through die wear, die gap or different rates of shrinkage.
For forgings produced in horizontal forging machines only forging grade F is provided.

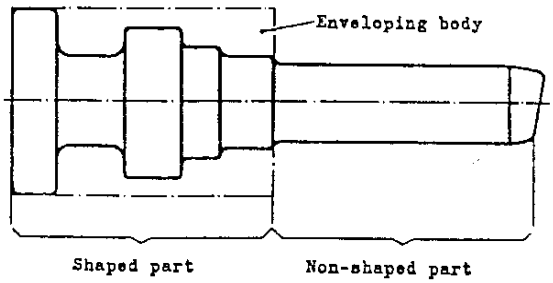


Figure 20. A shaped part

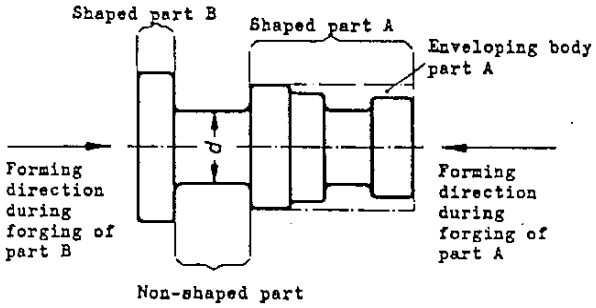


Figure 21. Two shaped parts

6.2. Special agreements

Closer tolerances for forgings or for individual dimensions of a forging than provided by forging grade F must be specially agreed between the customer and the manufacturer. This should take place prior to confirmation of the order, since such stipulations may influence not only the choice of forging method but also the shape of the forging and of the tooling.

N o t e : Special agreements often involve higher cost than forging grade F (e.g. additional processes, more expensive tooling and more accurate machines).

7. Terminology and its application to forgings produced in horizontal forging machines

7.1. Shaped part of a forging

The shaped part consists of one or more accumulations of material which are forged without change of forming direction.

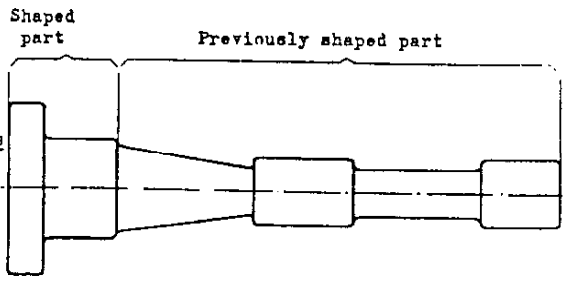


Figure 22. Previously shaped part

7.2. Forging with two shaped parts

In the case of forgings which have two parts shaped in opposite directions, and which are

joined by a non-shaped part the length of which is equal to or greater than its diameter, the tolerances are determined separately for each of the shaped parts.
In the case of forgings which have two parts shaped in opposite directions, and which directly adjoin each other or which are joined by a non-shaped part having a length smaller than its diameter, the tolerances are determined as if the forging consists only of a single shaped part.

7.3. Non-shaped part of a forging

The non-shaped part is that part which has not undergone any change of shape in the horizontal forging machine, regardless of whether it still retains the original bar cross-section or has undergone previous forming.

8. Data for determining the tolerances of forgings produced in horizontal forging machines

In order to determine from the Tables the dimensional tolerances applicable to a forging, the following data are necessary in addition to the dimensions:

8.1. Weight of the shaped part

The weight is calculated; if two shaped parts are present (see Section 7.2.) their weights are calculated separately.
In calculating the weight of a non-shaped part, Sections 7.3 and 9.2.1.3 are to be noted.

• 8.2. Intractability of material, steel grade

The intractability of the material takes account of the fact that in forging practice steels of the high carbon and high alloy grades entail larger dimensional variations and higher rates of tooling wear than do steels with lower carbon content and lower amounts of alloying constituents. Quantities characteristic of the intractability are the carbon content and the sum of the alloying constituents comprised by manganese, chromium, nickel, molybdenum, vanadium and tungsten.
Two groups of intractability of material are distinguished:
Group M 1: Steel with a carbon content of not more than 0.65 % by wt. and a total of alloying constituents Mn, Cr, Ni, Mo, V, W not exceeding 5 % by wt.;
Group M 2: Steel with a carbon content of more than 0.65 % by wt. or a total of alloying constituents Mn, Cr, Ni, Mo, V, W of more than 5 % by wt.

The criterion for deciding which of the two groups a particular steel belongs to is the maximum allowable content of carbon and the alloying constituents named.

8.3. Complexity of the forging

The complexity takes account of the fact that in the forging of thin section and branched components, as compared with components having simple compact shapes, larger dimensional variations occur which are attributable to different rates of shrinkage, higher shaping forces and higher rates of tool wear. This is expressed by the factor S. It is calculated according to the following formula:

$$S = \frac{m_S}{m_H}$$

where m_S stands for the weight of the shaped part and m_H for the weight of the enveloping body enclosing the shaped part.
Four groups of complexity are distinguished:

Group S 1: over 0.63 up to 1
Group S 2: over 0.32 up to 0.63
Group S 3: over 0.16 up to 0.32
Group S 4: over 0 up to 0.16

The enveloping bodies of round forgings are the circular cylinders formed by the greatest diameter and the greatest length of the shaped part (see Figures 20 and 21).
In the case of non-round or unsymmetrical forgings the greatest diameter is replaced by the diameter of the enveloping circle. The weight of the enveloping body is calculated according to the following formula:

$$m_H = \frac{d^2 \cdot \pi}{4} \cdot h \cdot \varrho$$

where:
d diameter of circular cylinder or enveloping circle
h height or length of enveloping body
ϱ density (7.85 kg/dm³)

E x c e p t i o n : In the determining of tolerances for the thickness dimensions of non-shaped parts with thin flanges or cylindrical shapes there are exceptional conditions, namely when the ratio of

$$\frac{a_1}{d_1} \text{ is } \leq 0.2 \text{ or } \frac{a_2}{d_2} \text{ is } > 2$$

(see Figure 23). Here d is the greatest diameter of the shaped part and a is the thickness of the flange or the length of the cylindrical shape.
In such cases the tolerances are determined not on the basis of the calculated complexity factor and not on the basis of the weight of the shaped part, but instead by using the complexity group S 4 and a weight corresponding to a body with a diameter d and thickness a (or length).

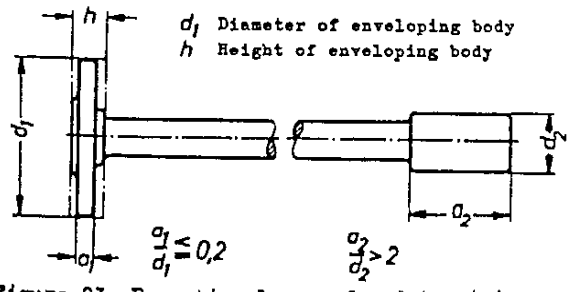


Figure 23. Exceptional case for determining complexity

This method however is only used when it results in larger tolerances than yielded by the usual method.

9. Tolerances for forgings produced in horizontal forging machines

9.1. Division into groups

The tolerances for the different kinds of dimension are divided into four groups depending on the Tables to which they belong.

9.2. Explanations regarding tolerances

The tolerances on diameter, shoulder and thickness dimensions comprise not only dimensional variations, but also - however excluding deflection and distortion, see Section 9.2.3.1 - variations of shape such as:
variations from circularity
variations from circular cylindricity
variations from a plane
other variations from a prescribed outline.

These variations of shape must not exceed the limits imposed by the tolerances. In certain circumstances they may account for the entire tolerance range. Restrictions on variations of shape must be specially agreed and noted in the drawing.

9.2.1. First group (see Table 1)

9.2.1.1. Tolerances for diameter dimensions
For determining tolerances, the term diameter dimensions is applied also to length and width dimensions of non-round or unsymmetrical forgings.
In the case of such forgings the diameter of the enveloping circle takes the place of the length and width dimensions as the reference dimension.
The permissible variations for the greatest diameter (diameter of enveloping circle) of the shaped part (see Figure 25) are obtained from Table 1 and are entered in the forging drawing.
For internal dimensions, the largest and smallest values of the permissible variations are to be interchanged with one another.
In view of the influence exerted by the jaw die gap, these dimensions are also applied to all other diameter dimensions (length and width dimensions) of the part shaped in the jaw die.
Normally they are also applied to all diameter dimensions of the part shaped in the punch die. This avoids unnecessarily small tolerance differences and simplifies preparation of the forging drawing besides facilitating the acceptance procedure. If smaller variations are necessary for individual dimensions, these are obtained from the corresponding nominal dimension ranges and entered in the forging drawing alongside the corresponding dimensions.

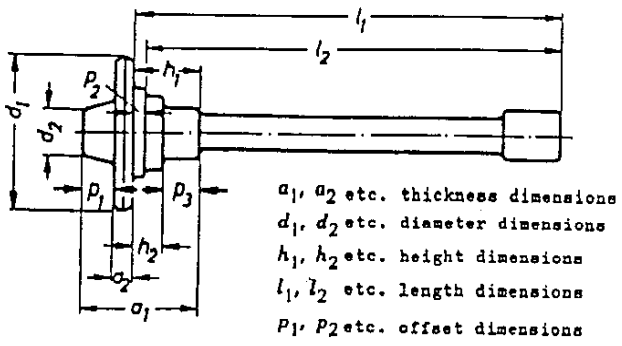


Figure 24. Kinds of dimension of forging

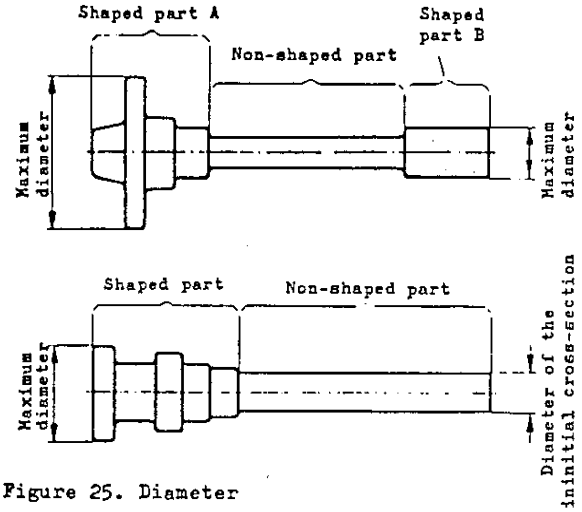


Figure 25. Diameter

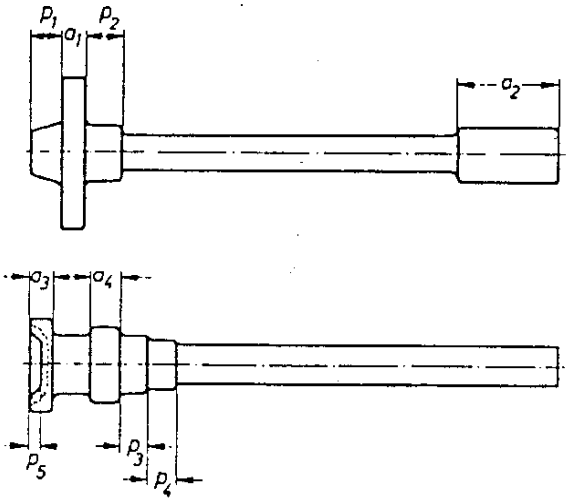


Figure 26. Shoulder and thickness dimensions

9.2.1.2. Tolerances for shoulder dimensions
Shoulder dimensions are dimensions between equal-directed faces within the punch or jaw die (see Figure 26). Normally the tolerances of the greatest height dimension are applied to shoulder dimensions. This height dimension is the distance from the die parting to the remotest external face of the shaped part (see Figure 24).
If closer tolerances are necessary for individual shoulder dimensions, the tolerances of the corresponding nominal dimension ranges are applied instead of the tolerances of the greatest height, but only to the extent of $\pm 1/3$.
These permissible variations are entered in the forging drawing alongside the corresponding dimensions.

Note on gap dimensions: The tolerances for shoulder dimensions cannot be applied to gap dimensions, which are the distances between opposing faces within the punch or jaw die. Entry of gap dimensions should be avoided as far as possible. If the use of gap dimensions is essential it may be necessary, for the purpose of avoiding redundant cumulative tolerances, to leave adjacent dimensions out of account.
Tolerances for gap dimensions should be separately agreed.

9.2.1.3. Tolerances for length dimensions
Tolerances for length dimensions are applied only to the dimensions on forgings which consist of shaped and non-shaped parts, the dimensions concerned being those denoting the distance between the end of the forging and the remotest surface facing the latter and disposed at right angles to the axis (see Figure 27).
Tolerances for length dimensions are found from Table 1 by using a weight corresponding to a bar-shaped body having the diameter of the non-shaped part and the length to be toleranced.

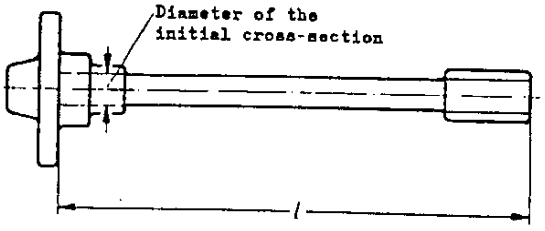


Figure 27. Length dimension

If the non-shaped part exhibits different diameters as a result of a preceding shaping operation, the ruling diameter for the purpose of weight calculation is the largest diameter, provided that this is not greater than that of the initial workpiece.
The permissible variations for length dimensions are to be entered in the forging drawing alongside the related dimensions.
If the non-shaped part has a sheared end (see Section 9.2.4.4) the length is measured from the shorter side of the resulting slope (see Figure 28).
The length dimensions l_1 and l_2 (see Fig.29) should not appear simultaneously in a forging drawing. The tolerance on the overall length l_3 cannot be obtained from Table 1, but instead is calculated by adding together the tolerances on length, thickness and shoulder dimensions (see Figure 29).

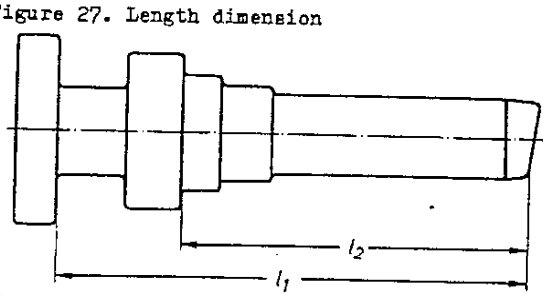


Figure 28. Length dimensions on a forging with sheared end

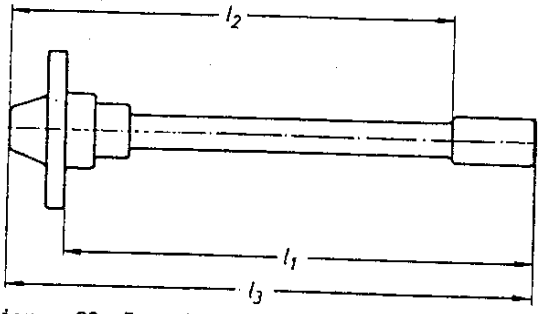


Figure 29. Length dimensions on a forging with two shaped parts

9.2.1.4. Permissible mismatch and permissible eccentricity
The permissible mismatch (see Figure 30) defines, for that part of a forging shaped in the jaw die, the amount by which a particular point on the part shaped in one half of the die may be displaced relative to the corresponding point on the part shaped in the other half of the die. Mismatch can arise both in the forging direction and also at right angles to the latter. It is measured parallel to the parting of the jaw die. The permissible mismatch applies in the forging direction and at right angles to the forging direction.

The permissible eccentricity (see Figure 30) gives the amount by which the axis of that part of the forging shaped in the punch die may be displaced relative to the axis of the part shaped in the jaw die.
The permissible mismatch and permissible eccentricity corresponding to the weight of the shaped part concerned are taken from the mismatch and eccentricity columns of Table 1. They are applied independently of, and in addition to, the other tolerances.

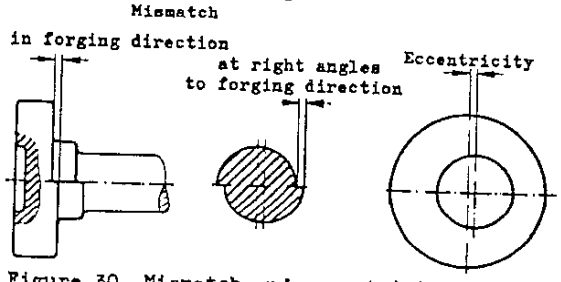


Figure 30. Mismatch and eccentricity

9.2.1.5. Tolerances for local variations on the non-shaped part
The tolerance on the largest diameter (diameter of enveloping body) of the shaped part is also applied over a length of 1.5 d, but not exceeding 100 mm (see Figure 31), to local variations which may occur on the adjacent portion of the non-shaped part. Over this length the shank may be displaced obliquely or parallel.
The subdivision of the tolerances for the non-shaped part can be agreed differently from that of the shaped part. It must however be marked on the forging drawing.

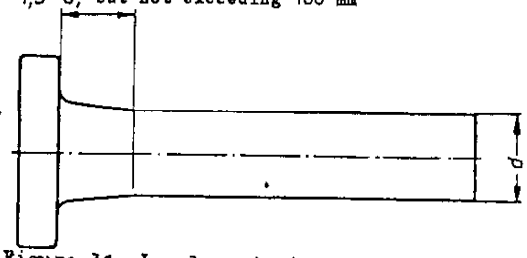


Figure 31. Local variations on the non-shaped part

• 9.2.1.6. Permissible residual flash (flash projection) and permissible depth of chamfer

Differences in trimming may bring about either a residual flash or a chamfered face. The permissible values, positive for residual flash and negative for depth of chamfer, are given in Table 1.
The residual flash is measured from the body of the forging to the edge of the flash (see Figure 32).

The depth of chamfer is measured from the chamfered face to the theoretical point at which the die drafts meet (see Figure 33).
The permissible residual flash and the permissible depth of chamfer are used independently of, and in addition to, the other tolerances.

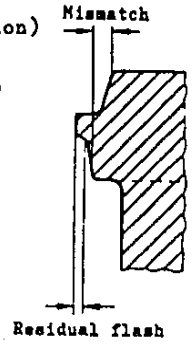


Figure 32. Residual flash

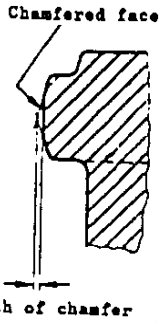


Figure 33. Depth of chamfer

• 9.2.1.7. Tolerances for hole dimensions

Hole dimensions are internal dimensions between the faces produced by piercing or trimming. It is normal to apply the tolerances of the largest diameter (diameter of enveloping circle) to all hole dimensions of a forging. For this purpose the maximum and minimum values of the permissible variations are interchanged one with the other.

If smaller variations are necessary for particular hole dimensions, these are taken from the corresponding nominal dimension ranges of Table 1. They must be entered in the forging drawing alongside the relevant dimensions.

9.2.2. S e c o n d g r o u p (see Table 3)

• 9.2.2.1. Tolerances for thickness dimensions

Tolerances for thickness dimensions apply to the dimensions of a forging which cross the flash between the punch and jaw die. The tolerance for the largest thickness dimension is determined from Table 3 and in view of the great influence which the die gap exerts on the variations in the thickness dimensions it should also be applied to all other thickness dimensions of the forging.

Closer tolerances for individual thickness dimensions require additional operations and must be specially agreed between customer and manufacturer (see Section 6.2.)

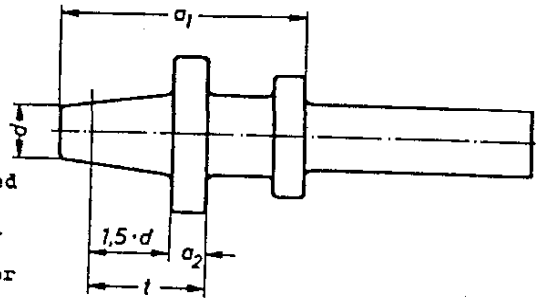


Figure 34. Exception for determining the tolerances for thickness dimensions

E x c e p t i o n : When forgings have a projection on one side of flange (e.g. journal or hub, see Figure 34) the length of which is greater than 1.5 times its smaller diameter (diameter of enveloping circle in the case of a non-round projection) only the tolerance for the greatest thickness dimension a_1 is determined in the usual manner. On the other hand, in determining the tolerances for all the other thickness dimensions a reference dimension t is used which represents the sum of the thickness of the flange a_2 and 1.5 times the smaller diameter of the projection.
If projections are present on both sides of a flange and their length is greater than 1.5 times their smaller diameter, the reference dimension t is calculated on the basis of the diameter of the larger projection.
In both cases the permissible variations for the calculated dimension are to be entered each time in the Table (see Section 11.2), but for the greatest thickness dimension they are to be entered against the dimension in the forging drawing.

9.2.3. T h i r d g r o u p (see Table 5)

• 9.2.3.1. Permissible deflection and permissible distortion

The permissible deflection, i.e. the permissible departure of the centre line of a forging from a straight line, and the permissible distortion, i.e. the permissible variation of the surface from its prescribed disposition, are to be found from Table 5.
The permissible deflection and the permissible distortion must be entered in the forging drawing.
Deflection and distortion are applied independently of, and in addition to, the other tolerances. They do not comprise the variations of shape mentioned in Section 9.2.

9.2.3.2. Tolerances for centre distances

Centre distances are dimensions between two axes or two centre lines or between an axis and a centre line. Normally, the tolerances of the greatest diameter are applied to centre distances, but with a $\pm 1/2$ distribution.
If smaller permissible variations are required, they are taken from the corresponding nominal dimension ranges of Table 5. Tolerances for centre distances are applied independently of other tolerances. They are applicable only to centre distances such that the line joining them lies within the forging and is at right angles to the forming direction (see Figure 35).

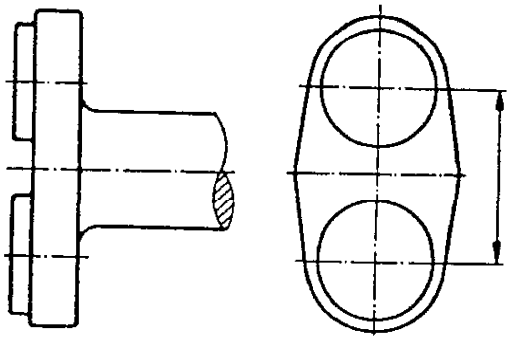


Figure 35. Dimension to which the tolerances for centre distances are applied

9.2.4. Fourth group (see Table 6 and text)

• 9.2.4.1. Permissible variations for fillets and corner radii

The permissible variations for fillets and corner radii (see Figure 36) are calculated according to the particulars of Table 6.
The minus tolerances are not applied to corner radii up to 3 mm if such radii are influenced by subsequent trimming or piercing. In such cases a sharp edge is allowed.
The radii of fillets and corners should be made as large as possible in view of the high rate of die wear.

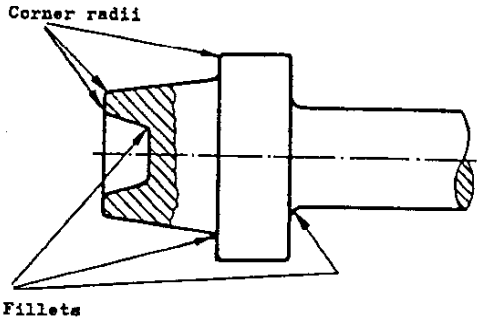


Figure 36. Fillets and corner radii

9.2.4.2. Permissible height and width of trimming fins and parting line fins

The permissible height and width of trimming fins which may arise on edges in the immediate vicinity of the flash, and of parting line fins which may form along the jaw parting on that part of the forging shaped in the jaw die (see Figure 37) are found from Table 6 to suit the weight of the shaped part. They are applied independently of, and in addition to, the other tolerances.

The position of residual flash and parting line fins must be indicated on the forging drawing.

The flash formed during forging in closed dies (see Figure 38) may exceed the values of Table 6. Its position and size must therefore be separately agreed between manufacturer and customer.

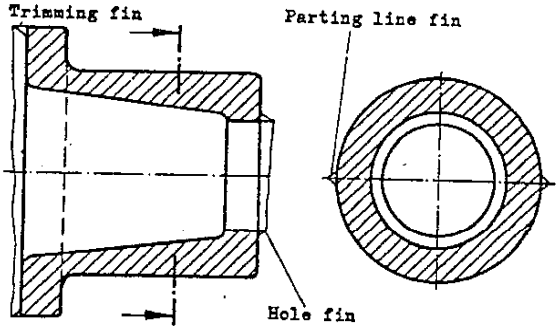


Figure 37. Trimming fins and parting line fins

• 9.2.4.3. Permissible alignment error (position of axes of deep holes)

For holes having a depth greater than their largest diameter (see Figure 39) variations from parallelism of the hole axis and the centre line of the forging are permitted.
Such variations are allowed up to 0.5 % of the hole depths and are in addition to the mismatch.

• 9.2.4.4. Permissible deformation of sheared ends

Permissible variations from the original shape, which are allowed to occur on the sheared end of a shank, are calculated according to Table 6 to suit the diameter of the shank. They are applied independently of, and in addition to, the other tolerances.
For the sheared face a slope up to 7° is permitted.
Sheared ends must be indicated in the forging drawing.

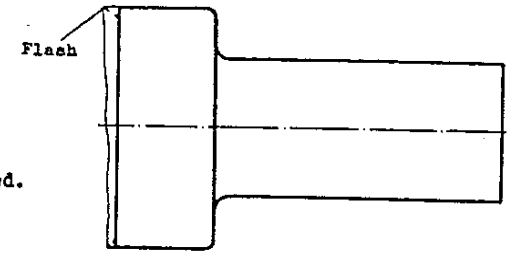


Figure 38. Flash formation when forging in closed dies

• 9.2.4.5. Permissible depth of surface defects

Surface defects are depressions which may occur on the forged faces, e.g. as a result of scale formation. They are permissible within the following limits:
In the case of surfaces which are to be machined in a subsequent operation, down to a depth which preserves at least half of the specified machining allowance;
in the case of surfaces which are not to be machined in a subsequent operation, to a maximum of 1/3 of the tolerances for the greatest thickness.

• 9.2.4.6. Tolerances for the slope of surfaces

Variations causing the slope of surfaces to depart from their specified disposition are permissible within the tolerances for the largest dimensions at right angles to the shaping direction and for the greatest height of the forging.
Variations larger than this, e.g. on the occurrence of severe die wear, must be agreed between the manufacturer and customer.

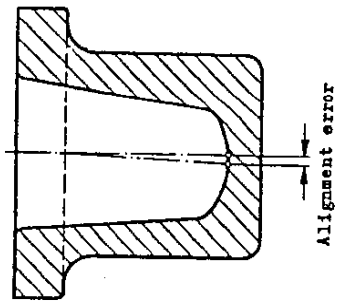


Figure 39. Alignment error

10. Use of Tables for determining the tolerances of forgings made in horizontal forging machines

10.1. Table 1

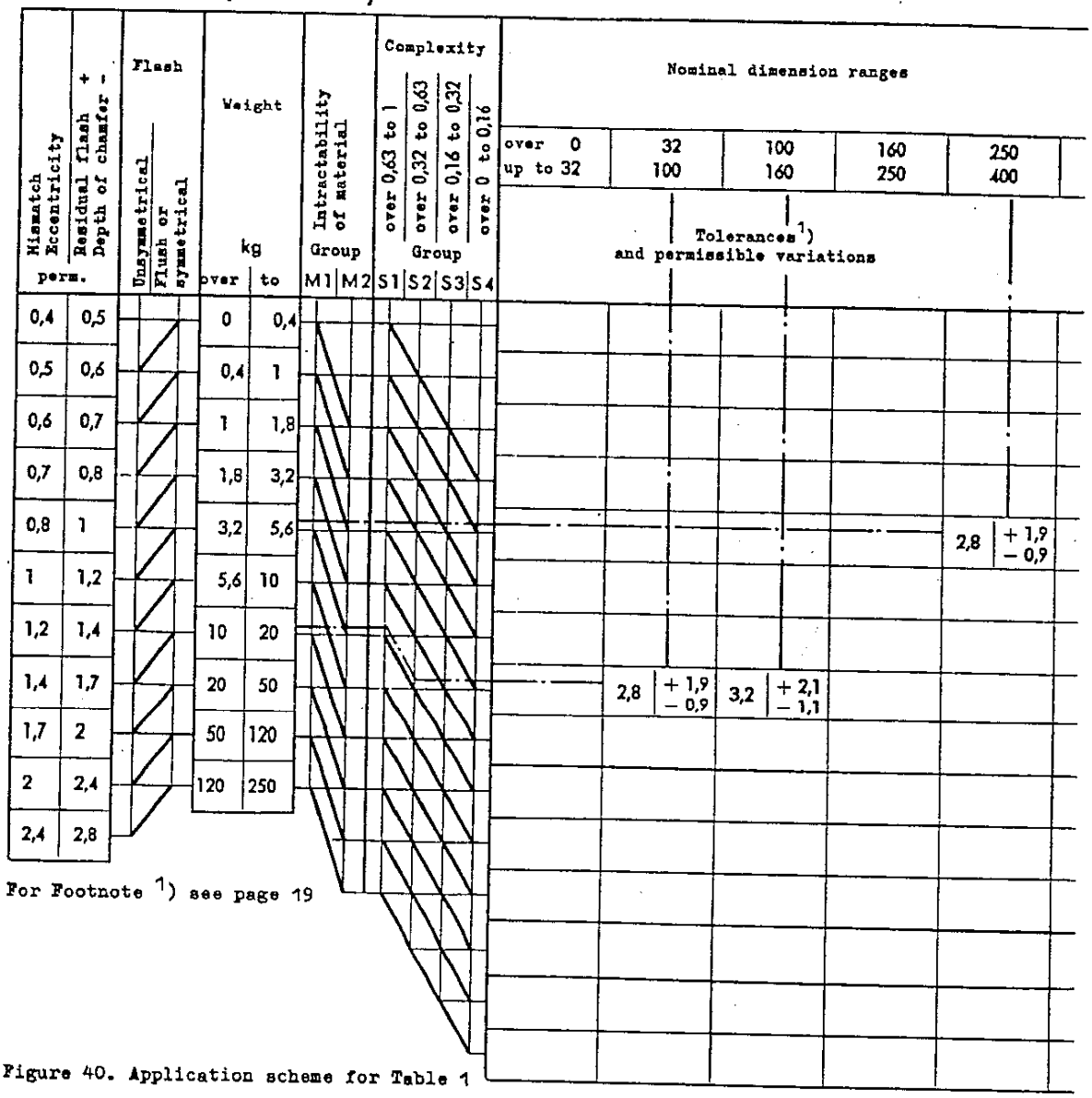
For determining the tolerances for diameter and height dimensions (shoulder dimensions) the procedure is to move right from the corresponding weight column in Table 1 and then cross the column for intractability of material, either horizontally at M 1 or obliquely downwards at M 2, depending on the steel grade, as far as the column corresponding to the complexity. This column in turn is then crossed either horizontally at group S 1 or obliquely downwards to one of the other complexity groups, whereupon the tolerances and permissible variations are found by further movement horizontally in the corresponding nominal dimension range.

Tolerances for length dimensions are likewise found from Table 1 by moving from the weight column corresponding to the weight as calculated according to Section 9.2.1.3 and crossing the columns for intractability of material and complexity either horizontally or obliquely downwards until the nominal dimension range corresponding to the length dimension is reached.

Example of the use of Table 1 for determining the permissible variations for the diameter, height and length dimensions of a forging with a shaped and a non-shaped part.

Data required:

Maximum diameter	150 mm
Maximum thickness	170 mm
Maximum height	90 mm
Length (from end of forging to its most remote face)	330 mm
Weight of the shaped part	11.8kg
Weight of the non-shaped part (see Section 9.2.1.3, diameter 50 mm, length to be tolerated 330 mm)	5.1 kg
Steel grade	42CrMo4
Intractability of material (C < 0.65 % by wt. and sum of alloying constituents < 5 % by wt.)	Group M 1
Weight of enveloping body $\left(\frac{1.5^2 \cdot 3.14}{4} \cdot 1.7 \cdot 7.85\right)$	23,6 kg
Complexity factor $\left(\frac{11.8}{23.6} < 0.63\right)$	Group S 2



For Footnote 1) see page 19

Figure 40. Application scheme for Table 1

From the Table the permissible variations (see Figure 40) are found as:

Diameter	$^{+2.1}_{-1.1}$ mm
Height (shoulder dimension)	$^{+1.9}_{-0.9}$ mm
Length	$^{+1.9}_{-0.9}$ mm

Normally the permissible variations are found from the Table for the greatest dimensions and are applied to all the other diameter and shoulder dimensions. If too large for individual diameters of the part shaped in the punch die, the permissible variations of the nominal dimension ranges appropriate to the dimensions concerned are applied. If these variations are still too large for individual shoulder dimensions, the closer tolerances of the nominal dimension ranges corresponding to them are applied, but only to the extent of ±1/3. Smaller permissible variations must be separately entered against the dimensions in the forging drawing.
The permissible residual flash, permissible depth of chamfer, permissible mismatch and permissible eccentricity are taken from Table 1. The procedure is to move left from the corresponding weight column as far as the columns for residual flash, depth of chamfer and mismatch, and eccentricity. In so doing, the column headed flash is crossed either horizontally or obliquely downwards, depending on whether the flash is trimmed flush, symmetrically or unsymmetrically.

10.2. Table 3

The tolerance for the greatest thickness dimension is derived from Table 3 in the same way as the tolerances for diameter, height and length dimensions were derived from Table 1.

The tolerance for the greatest thickness dimension is also applied to all other thickness dimensions. Different tolerancing is not permitted.

10.3. Table 5

Values for permissible deflection and for permissible distortion are obtained for forging grade F from the corresponding columns of Table 5 (see Section 9.2.3.1). They must be entered in the forging drawing.
For centre distances, smaller permissible variations for forging grade F are taken from the corresponding columns of Table 5 in cases in which the tolerances normally applied according to Section 9.2.3.2 are too large (see Section 9.2.3.2). They must be entered against the corresponding dimensions in the forging drawing.

• 10.4. Table 6

The permissible variations for fillets and corner radii are calculated from the data of Table 6.
The permissible height and width of trimming fins and parting line fins are derived from Table 6 to suit the weight of the shaped part.
Values for permissible deformation of sheared ends are calculated from the data of Table 6.

• 11. Guidelines for drawings for forgings produced in horizontal forging machines

11.1. General

The design of forgings from the viewpoint of the most suitable production process, die design and test methods calls for sound knowledge of the special conditions applying to forging. It is therefore in the customer's interest to involve the manufacturer's practical experience at the design stage by letting the latter have not only the drawing showing the finished part together with full details of the material, but also additional particulars regarding the intended use, the type of machining envisaged and the position of datum and clamping faces.
The forging drawing is best prepared by the manufacturer. On completion it is submitted to the customer for checking and approval. If the forging drawing is prepared by the customer, the additional information quoted should again be made available.

11.2. Indication of dimensions and permissible variations in the forging drawing

When dimensions are being entered in the forging drawing it should be noted that the tolerances of this Standard, with the exception of tolerances relating to the slope of faces, may only be applied to such dimensions as are specially entered in the drawing. The manner of entering dimensions is therefore of the utmost importance with regard to the checking of dimensions on forgings.
For checking dimensions for which no measurements are entered in the forging drawing, only such tolerances may be applied as are calculated on the basis of the tolerances of dimensions which are entered.
In view of the fact that the tolerances for the greatest diameter and height dimensions are normally applied also to all other measurements relating to these kinds of dimension, it is expedient that these greatest dimensions should always be entered.
If these greatest dimensions are not entered in the forging drawing it is permissible to find the tolerances by calculation.

The forging drawing shall have noted in it:

The permissible variations corresponding to DIN 7526, with the exception of those specially identified.
The permissible variations must be entered in the forging drawing. It is recommended that the permissible variations applied to several or to all measurements of a particular kind of dimension, as well as the data (weight, complexity etc.) necessary for determining the

tolerances, should be entered in a Table (see example).

Kinds of dimension	Permissible variations Shaped part	
	A	B
Diameter dimensions		
Height dimensions (Shoulder dimensions)		
Thickness dimensions		
Mismatch, eccentricity		
Residual flash, depth of chamfer		

The permissible variations which are applied only to individual dimensions must be entered against these dimensions.
The position of trimming fins and parting line fins must be indicated.
All permissible variations agreed between manufacturer and customer which do not correspond to the Standard must be entered in the drawing and are to be specially marked.
The manner of marking shall be indicated in the forging drawing.

Tables

Table 1. For steel drop forgings produced in hammers and presses and in horizontal forging machines

Forging grade F, tolerances and permissible variations for length, width and height dimensions (diameters), mismatch, eccentricity, residual flash and depth of chamfer

Mismatch / Eccentricity perm.	Residual flash + / Depth of chamfer −	Flash: Unsymmetrical	Flash: Flush or symmetrical	Weight kg over	Weight kg to	Intractability of material Group M1	Intractability of material Group M2	Complexity Group S1: over 0,63 to 1	Complexity Group S2: over 0,32 to 0,63	Complexity Group S3: over 0,16 to 0,32	Complexity Group S4: over 0 to 0,16	Nominal dimension ranges: over 0 to 32	32 100	100 160	160 250	250 400	400 630	630 1000	1000 1600	1600 2500
												Tolerances[1] and permissible variations								
0,4	0,5			0	0,4							1,1 ± 0,7 / ± 0,4	1,2 ± 0,8 / ± 0,4	1,4 ± 0,9 / ± 0,5	1,6 ± 1,1 / ± 0,5	1,8 ± 1,2 / ± 0,6	2 ± 1,3 / ± 0,7	–	–	–	–	–	–
0,5	0,6			0,4	1							1,2 ± 0,8 / ± 0,4	1,4 ± 0,9 / ± 0,5	1,6 ± 1,1 / ± 0,5	1,8 ± 1,2 / ± 0,6	2 ± 1,3 / ± 0,7	2,2 ± 1,5 / ± 0,7	–	–	–	–	–	–
0,6	0,7			1	1,8							1,4 ± 0,9 / ± 0,5	1,6 ± 1,1 / ± 0,5	1,8 ± 1,2 / ± 0,6	2 ± 1,3 / ± 0,7	2,2 ± 1,5 / ± 0,7	2,5 ± 1,7 / ± 0,8	2,8 ± 1,9 / ± 0,9	–	–	–	–
0,7	0,8			1,8	3,2							1,6 ± 1,1 / ± 0,5	1,8 ± 1,2 / ± 0,6	2 ± 1,3 / ± 0,7	2,2 ± 1,5 / ± 0,7	2,5 ± 1,7 / ± 0,8	2,8 ± 1,9 / ± 0,9	3,2 ± 2,1 / ± 1,1	3,6 ± 2,4 / ± 1,2	–	–
0,8	1			3,2	5,6							1,8 ± 1,2 / ± 0,6	2 ± 1,3 / ± 0,7	2,2 ± 1,5 / ± 0,7	2,5 ± 1,7 / ± 0,8	2,8 ± 1,9 / ± 0,9	3,2 ± 2,1 / ± 1,1	3,6 ± 2,4 / ± 1,2	4 ± 2,7 / ± 1,3	4,5 ± 3 / ± 1,5
1	1,2			5,6	10							2 ± 1,3 / ± 0,7	2,2 ± 1,5 / ± 0,7	2,5 ± 1,7 / ± 0,8	2,8 ± 1,9 / ± 0,9	3,2 ± 2,1 / ± 1,1	3,6 ± 2,4 / ± 1,2	4 ± 2,7 / ± 1,3	4,5 ± 3 / ± 1,5	5 ± 3,3 / ± 1,7
1,2	1,4			10	20							2,2 ± 1,5 / ± 0,7	2,5 ± 1,7 / ± 0,8	2,8 ± 1,9 / ± 0,9	3,2 ± 2,1 / ± 1,1	3,6 ± 2,4 / ± 1,2	4 ± 2,7 / ± 1,3	4,5 ± 3 / ± 1,5	5 ± 3,3 / ± 1,7	5,6 ± 3,7 / ± 1,9
1,4	1,7			20	50							2,5 ± 1,7 / ± 0,8	2,8 ± 1,9 / ± 0,9	3,2 ± 2,1 / ± 1,1	3,6 ± 2,4 / ± 1,2	4 ± 2,7 / ± 1,3	4,5 ± 3 / ± 1,5	5 ± 3,3 / ± 1,7	5,6 ± 3,7 / ± 1,9	6,3 ± 4,2 / ± 2,1
1,7	2			50	120							2,8 ± 1,9 / ± 0,9	3,2 ± 2,1 / ± 1,1	3,6 ± 2,4 / ± 1,2	4 ± 2,7 / ± 1,3	4,5 ± 3 / ± 1,5	5 ± 3,3 / ± 1,7	5,6 ± 3,7 / ± 1,9	6,3 ± 4,2 / ± 2,1	7 ± 4,7 / ± 2,3
2	2,4			120	250							3,2 ± 2,1 / ± 1,1	3,6 ± 2,4 / ± 1,2	4 ± 2,7 / ± 1,3	4,5 ± 3 / ± 1,5	5 ± 3,3 / ± 1,7	5,6 ± 3,7 / ± 1,9	6,3 ± 4,2 / ± 2,1	7 ± 4,7 / ± 2,3	8 ± 5,3 / ± 2,7
2,4	2,8											3,6 ± 2,4 / ± 1,2	4 ± 2,7 / ± 1,3	4,5 ± 3 / ± 1,5	5 ± 3,3 / ± 1,7	5,6 ± 3,7 / ± 1,9	6,3 ± 4,2 / ± 2,1	7 ± 4,7 / ± 2,3	8 ± 5,3 / ± 2,7	9 ± 6 / ± 3
												4 ± 2,7 / ± 1,3	4,5 ± 3 / ± 1,5	5 ± 3,3 / ± 1,7	5,6 ± 3,7 / ± 1,9	6,3 ± 4,2 / ± 2,1	7 ± 4,7 / ± 2,3	8 ± 5,3 / ± 2,7	9 ± 6 / ± 3	10 ± 6,7 / ± 3,3
												4,5 ± 3 / ± 1,5	5 ± 3,3 / ± 1,7	5,6 ± 3,7 / ± 1,9	6,3 ± 4,2 / ± 2,1	7 ± 4,7 / ± 2,3	8 ± 5,3 / ± 2,7	9 ± 6 / ± 3	10 ± 6,7 / ± 3,3	11 ± 7,3 / ± 3,7
												5 ± 3,3 / ± 1,7	5,6 ± 3,7 / ± 1,9	6,3 ± 4,2 / ± 2,1	7 ± 4,7 / ± 2,3	8 ± 5,3 / ± 2,7	9 ± 6 / ± 3	10 ± 6,7 / ± 3,3	11 ± 7,3 / ± 3,7	12 ± 8 / ± 4
												5,6 ± 3,7 / ± 1,9	6,3 ± 4,2 / ± 2,1	7 ± 4,7 / ± 2,3	8 ± 5,3 / ± 2,7	9 ± 6 / ± 3	10 ± 6,7 / ± 3,3	11 ± 7,3 / ± 3,7	12 ± 8 / ± 4	14 ± 9,3 / ± 4,7

[1]) The tolerances have a 2/3 and 1/3 distribution (rounded values). The prefixed signs apply only to external dimensions; for internal dimensions the values are interchanged. For centre distances the tolerances have a ±1/2 distribution (see Sections 3.2.3.2 and 9.2.3.2).

Table 2. For steel drop forgings produced in hammers and presses

Forging grade E, tolerances and permissible variations for length, width and height dimensions (diameters), mismatch, residual flash and depth of chamfer

This Table does not apply to forgings produced in horizontal forging machines.

Mismatch perm.	Residual flash / Depth of chamfer + -	Flash: Unsymmetrical	Flash: Flush or symmetrical	Weight kg over	Weight kg to	Intractability of material Group M1	M2	Complexity Group S1 (over 0,63 to 1)	S2 (over 0,32 to 0,63)	S3 (over 0,16 to 0,32)	S4 (over 0 to 0,16)
0,3	0,3			0	0,4						
0,3	0,4			0,4	1						
0,4	0,4			1	1,8						
0,4	0,5			1,8	3,2						
0,5	0,6			3,2	5,6						
0,6	0,7			5,6	10						
0,7	0,8			10	20						
0,8	1			20	50						
1	1,2			50	120						
1,2	1,4			120	250						
1,4	1,7										

Nominal dimension ranges: over 0 to 32	32 to 100	100 to 160	160 to 250	250 to 400	400 to 630	630 to 1000	1000 to 1600	1600 to 2500
Tolerances[2] and permissible variations								
0,7	+ 0,5 − 0,2	0,8	+ 0,5 − 0,3	0,9	+ 0,6 − 0,3	1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	–	–	–	–	–	–	–	–
0,8	+ 0,5 − 0,3	0,9	+ 0,6 − 0,3	1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	–	–	–	–	–	–
0,9	+ 0,6 − 0,3	1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	–	–	–	–
1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	–	–
1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9
1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1
1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2
1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3
1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5
2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7
2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9
2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1
2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3
3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3	8	+ 5,3 − 2,7
3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3	8	+ 5,3 − 2,7	9	+ 6 − 3

[2] The tolerances have a 2/3 and 1/3 distribution (rounded values). The prefixed signs apply only to external dimensions; for internal dimensions the values are interchanged. For centre distances the tolerances have a ±1/2 distribution (see Section 3.2.3.2).

This Table does not apply to forgings produced in horizontal forging machines.

Table 3. For steel drop forgings produced in hammers and presses and in horizontal forging machines

Forging grade F, tolerances and permissible variations for thickness dimensions[3] and ejector marks

Ejector marks	Weight		Intractability of material		Complexity				Nominal dimension ranges													
					over 0,63 to 1	over 0,32 to 0,63	over 0,16 to 0,32	over 0 to 0,16	over 0 to 16		16 to 40		40 to 63		63 to 100		100 to 160		160 to 250		250	
perm.	kg over	kg to	Group M1	Group M2	Group S1	Group S2	Group S3	Group S4	Tolerances[4] and permissible variations													
1	0	0,4							1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7
1,2	0,4	1,2							1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7
1,6	1,2	2,5							1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8
2	2,5	5							1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9
2,4	5	8							1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1
3,2	8	12							1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2
4	12	20							2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3
5	20	36							2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5
6,4	36	63							2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7
8	63	110							2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9
10	110	200							3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1
12,6	200	250							3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3
									4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3	8	+ 5,3 − 2,7
									4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3	8	+ 5,3 − 2,7	9	+ 6 − 3
									5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3	8	+ 5,3 − 2,7	9	+ 6 − 3	10	+ 6,7 − 3,3
									5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3	8	+ 5,3 − 2,7	9	+ 6 − 3	10	+ 6,7 − 3,3	11	+ 7,3 − 3,7
									6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3	8	+ 5,3 − 2,7	9	+ 6 − 3	10	+ 6,7 − 3,3	11	+ 7,3 − 3,7	12	+ 8 − 4

[3] Observe the exception for thickness dimensions in Sections 2.4 and 8.3.

[4] The tolerances have a 2/3 and 1/3 distribution (rounded values).

Table 4. For steel drop forgings produced in hammers and presses

Forging grade E, tolerances and permissible variations for thickness dimensions[5] and ejector marks

This Table does not apply to forgings produced in horizontal forging machines.

Ejector marks	Weight kg		Intractability of material		Complexity				Nominal dimension ranges													
					over 0,63 to 1	over 0,32 to 0,63	over 0,16 to 0,32	over 0 to 0,16	over 0 up to 16		16 40		40 63		63 100		100 160		160 250		250	
									Tolerances[6] and permissible variations													
perm.	over	to	Group M1	Group M2	Group S1	Group S2	Group S3	Group S4														
1	0	0,4							0,6	+ 0,4 − 0,2	0,7	+ 0,5 − 0,2	0,8	+ 0,5 − 0,3	0,9	+ 0,6 − 0,3	1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4
1,2	0,4	1,2							0,7	+ 0,5 − 0,2	0,8	+ 0,5 − 0,3	0,9	+ 0,6 − 0,3	1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5
1,6	1,2	2,5							0,8	+ 0,5 − 0,3	0,9	+ 0,6 − 0,3	1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5
2	2,5	5							0,9	+ 0,6 − 0,3	1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6
2,4	5	8							1	+ 0,7 − 0,3	1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7
3,2	8	12							1,1	+ 0,7 − 0,4	1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7
4	12	20							1,2	+ 0,8 − 0,4	1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8
5	20	36							1,4	+ 0,9 − 0,5	1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9
6,4	36	63							1,6	+ 1,1 − 0,5	1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1
8	63	110							1,8	+ 1,2 − 0,6	2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2
10	110	200							2	+ 1,3 − 0,7	2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3
12,6	200	250							2,2	+ 1,5 − 0,7	2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5
									2,5	+ 1,7 − 0,8	2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7
									2,8	+ 1,9 − 0,9	3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9
									3,2	+ 2,1 − 1,1	3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1
									3,6	+ 2,4 − 1,2	4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3
									4	+ 2,7 − 1,3	4,5	+ 3 − 1,5	5	+ 3,3 − 1,7	5,6	+ 3,7 − 1,9	6,3	+ 4,2 − 2,1	7	+ 4,7 − 2,3	8	+ 5,3 − 2,7

[5]) Observe the exception for thickness dimensions in Sections 2.4 and 8.3.

[6]) The tolerances have a 2/3 and 1/3 distribution (rounded values).

This Table does not apply to forgings produced in horizontal forging machines.

Table 5. For steel drop forgings produced in hammers and presses and in horizontal forging machines

Permissible deflection and permissible distortion

Forging grade	Nominal dimension ranges over 0 up to 100	100 125	125 160	160 200	200 250	250 315	315 400	400 500	500 630	630 800	800 1000	1000 1250	1250 1600	1600 2000	2000 2500
	Tolerances														
F	0,6	0,7	0,8	0,9	1	1,1	1,2	1,4	1,6	1,8	2	2,2	2,5	2,8	3,2
E [1])	0,4	0,5	0,5	0,6	0,6	0,7	0,8	0,9	1	1,1	1,2	1,4	1,6	1,8	2

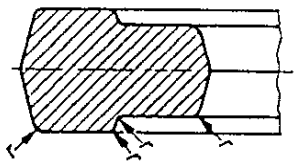
Permissible variations for centre distances

Forging grade	Nominal dimension ranges over 0 up to 100	100 160	160 200	200 250	250 315	315 400	400 500	500 630	630 800	800 1000	1000 1250
	Permissible variations										
F	± 0,3	± 0,4	± 0,5	± 0,6	± 0,8	± 1	± 1,2	± 1,6	± 2	± 2,5	± 3,2
E [1])	± 0,25	± 0,3	± 0,4	± 0,5	± 0,6	± 0,8	± 1	± 1,2	± 1,6	± 2	± 2,5

[1]) These rows do not apply to forgings produced in horizontal forging machines.

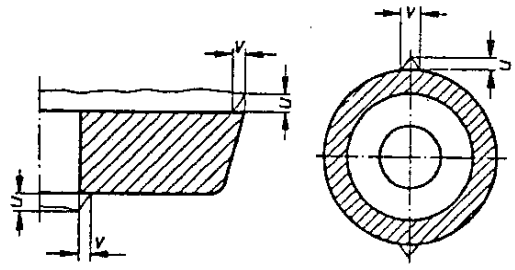
Table 6. For steel drop forgings produced in hammers and presses and in horizontal forging machines

Permissible variations for fillets and corner radii



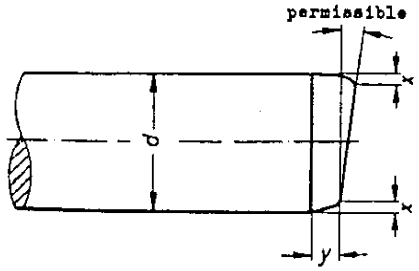
Nominal dimension ranges r over	up to	permissible variations	
0	10	+ 0,5 · r	− 0,25 · r
10	32	+ 0,4 · r	− 0,2 · r
32	100	+ 0,32 · r	− 0,15 · r
100		+ 0,25 · r	− 0,1 · r

Permissible height and width of trimming fins and parting line fins



Weight kg over	up to	Permissible height u	width v
0	1	1	0,5
1	6	1,6	0,8
6	40	2,5	1,2
40	250	4	2

Permissible deformation of sheared ends



Nominal diameter d	permissible dimension x	y
up to 36	0,07 · d	1 · d
over 36	0,05 · d	0,7 · d

Explanations

1. Background

The first DIN standard on drop forgings, namely DIN 7524 Part 1 to Part 4, was issued in 1944. Following this, on the initiative of the drop forging industry, dimensional variations occurring on drop forgings of diverse types and sizes produced under practical conditions in a number of forging plants were ascertained by the Drop Forging Research Centre in Hannover, and the principal factors responsible for them were determined*). On the basis of these results, the "Machining allowances and dimensional variations - TeRiG -" Working Group in the ADB-VDI Forging Committee prepared a draft of DIN 7526, Issue of October 1963, which was published in DIN-Mitteilungen Vol. 42 (1963) No. 10, pages 496 to 500. The few objections in response to this were dealt with and the draft standard was sanctioned by the "Tolerances and Fits" Committee in the DIN German Institute for Standardization e.V.
At that time the drop forging associations of the Federal Republic of Germany, France and Great Britain agreed on closer co-operation under the auspices of EUROFORGE. The technical committee of this organization appointed a sub-committee to work out jointly agreed tolerances for drop forgings. This sub-committee was headed by Mr. K.J. Abbott and its members consisted of German, British and French experts. By drawing on the experience of all parties and applying the knowledge gained in the preparation of the draft of DIN 7526, Issue of October 1963, a joint draft was produced which retained the basic structure of the 1963 tolerance system. This has been adopted by the drop forging industries of all three countries. It is being presented in each country to the relevant standards organization for issue as a national standard. In this connection it is deemed of decisive importance that not only should the numerical values of the Tables be identical, but also that the Sections of the text should bear the same numbering so that reference can be made to them in the conduct of international business.

2. Basic idea

The dimensional variations of forgings are determined primarily from the nominal dimensions. They are however also dependent on the weight, the steel grade forged and the complexity of the workpieces. Before a drawing is toleranced it is therefore necessary to determine the following data in the first instance:
the nominal dimensions to be toleranced
the weight
the disposition of the flash
the intractability of material, whether Group M 1 or M 2, according to steel grade
the complexity which expresses the influence exerted by the geometry of the forging.
All these influences are taken into account in a diagram the basic idea of which had already been applied in the field of gear tooth tolerances. The tolerance values are contained in Tables the columns of which are subdivided according to nominal dimension ranges and the rows of which represent different accuracy grades.
For drop forgings the different kinds of dimension need to be separately toleranced.
These kinds of dimension comprise:
Length, width, height and hole dimensions
Thickness dimensions, i.e. dimensions which cross the flash
Mismatch
Residual flash and depth of chamfer
(in the case of mismatch, residual flash and depth of chamfer a distinction is made depending on whether the flash is trimmed flush, symmetrically or unsymmetrically)
Ejector marks
Deflection and distortion
Centre distances
These are dispersed among various Tables; e.g. Table 1 contains tolerances for length, width and height dimensions as well as for mismatch, residual flash and depth of chamfer; Table 3 contains tolerances for thickness dimensions and ejector marks, whilst tolerances for deflection and distortion as well as for centre distances are given in Table 5 and tolerances for fillets and corner radii, trimming fins and parting line fins, also for deformation of sheared ends in Table 6.
A further subdivision of the Tables arises from the fact that, depending on the quality of manufacture, two quality grades are distinguished:
forging grade F
which is the grade corresponding to "standard forgings" in the usage hitherto adopted, and
forging grade E
which is the grade corresponding to "precision forgings" as termed in the usage adopted hitherto.
To avoid errors in use, the Tables for this purpose have been separated as follows:
Forging grade F in Tables 1 and 3
Forging grade E in Tables 2 and 4.
For forgings with identical data, the tolerances for forging grade E are 0.63 times those for forging grade F; this is the same progression as between two ISO quality grades.
Only forging grade F is provided for forgings produced in horizontal forging machines.
Only preferred numbers are used as the tolerance values in the Tables. The progression from row to row and from column to column is 1.12 (R 20 Series). The ranges of the input variables have been graded to correspond with the dependencies established on the basis of practical observation.
This Standard is subdivided into:
Drop forgings produced in hammers and presses
Drop forgings produced in horizontal forging machines
Tables
Whereas in the case of machined workpieces the tolerance for each individual dimension is obtained from the relevant nominal dimension range, a simplified method is offered in the case of forgings. All length, width and height dimensions are to have the same tolerances as applied to the greatest length, width and height dimension. In the case of thickness dimensions this is particularly important because the effect of variations in flash thickness is exerted on all thickness dimensions.
This avoids the effort of providing all dimensions of like kind with tolerance information; instead it is sufficient to state in a small table on the drawing that, for example, "tolerance on all length dimensions = ... mm".
Naturally it is permissible for individual dimensions also to be provided with tolerances where necessary. Thus, for example, in the case of a forging grade complying with forging grade F, individual dimensions can can be toleranced from forging grade E or in special cases provided with a tolerance to be separately agreed.

*) Huwendiek: Investigation concerning the dimensional accuracy of drop forging practice, Schmiedetechnische Mitteilungen (1964) No. 6, pages 669-675.