# Steel die forgings – Tolerances on dimensions

Part 2: Upset forgings made on horizontal forging machines
English version of DIN EN 10243-2

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**EN 10243-2**

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This standard, together with DIN EN 10243-1, June 2000 edition, supersedes DIN 7526, January 1969 edition.

Gesenkschmiedeteile aus Stahl – Maßtoleranzen – Teil 2: Warm hergestellt in Waagerecht-Stauchmaschinen

**European Standard EN 10243-2 : 1999 has the status of a DIN Standard.**

*A comma is used as the decimal marker.*

## National foreword

This standard has been prepared by ECISS/TC 28.

The responsible German body involved in its preparation was the *Normenausschuss Eisen und Stahl* (Steel and Iron Standards Committee).

### Amendments

DIN 7526, January 1969 edition, has been superseded by the specifications of EN 10243-1 and EN 10243-2.

### Previous edition

DIN 7526: 1969-01.

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# EUROPEAN STANDARD
# NORME EUROPÉENNE
# EUROPÄISCHE NORM

EN 10243-2

September 1999

ICS 77.140.85

**English version**

## Steel die forgings – Tolerances on dimensions

Part 2: Upset forgings made on horizontal forging machines

Pièces forgées par estampage en acier – Tolérances dimensionnelles – Partie 2: Pièces exécutées à chaud sur machines horizontales à forger

Gesenkschmiedeteile aus Stahl – Maßtoleranzen – Teil 2: Warm hergestellt in Waagerecht-Stauchmaschinen

This European Standard was approved by CEN on 1999-08-22.

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

**Central Secretariat: rue de Stassart 36, B-1050 Brussels**



Ref. No. EN 10243-2 : 1999 E

## Content



## Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 28 “Steel forgings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2000, and conflicting national standards shall be withdrawn at the latest by March 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association. This European Standard is considered to be a supporting standard to those application and product standards which in themselves support an essential safety requirement of a New Approach Directive and which make reference to this European Standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## 1 Scope

**1.1** This European Standard specifies the dimensional tolerances for steel upset forgings made on horizontal forging machines.

The second part of this European Standard applies to hot upset forgings, in the delivery condition, made in carbon and alloy steels. The tolerances specified apply to forgings not exceeding 250 kg in mass or 2 500 mm maximum dimension. Tolerances for heavier or layer forgings are subjected to negociation.

This European Standard does not apply to steel drop and press forgings (see prEN 10243-1).

**1.2** For forgings produced in horizontal forging machines forging grade F tolerances only are provided. This tolerance grade provides an adequate standard of accuracy for the majority of applications and is capable of being complied with by commonly used forging equipment and production methods.

The tables showing dimensional tolerances are based on the R20 series of preferred numbers (see ISO 3).

The annex A gives for information some examples of application of these tolerances for different types of closed die forgings.

**1.3** Any occasional instances may necessitate the use of tolerances wider than those indicated, e.g. specially complicated designs ; steels having particularly difficult forging characteristics. In such cases these standard tolerances can form only a basis on which to agree modifications appropriate to the particular circumstances.

**1.4** This European Standard does not include ranges of special tolerances closer than grade F. Consideration of special tolerances whilst frequently encountered, are highly individual, and vary widely. They are best dealt with by consultation at the design stage and shall be agreed between the purchaser and the supplier. This approach will ensure that optimum use is made of the forging process in fulfilling the purchaser's special requirements at the lowest additional cost.

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

ISO 3 Preferred numbers - Series of preferred numbers

ISO 8015 Technical drawings - Fundamental tolerancing principle

## 3 Symbols

The symbols used along this European Standard are as follows :

| | | |
|---|---|---|
| $l$ | = | length dimension ; |
| $b$ | = | width dimension ; |
| $h$ | = | height dimension ; |
| $a$ | = | thickness dimension ; |
| $d$ | = | diameter ; |
| $r$ | = | radius ; |
| $p$ | = | step dimension ; |
| $u$ | = | height of burr ; |
| $v$ | = | width of burr ; |
| $t$ | = | theoretical length (of upset forgings) ; |
| $e$ | = | special thickness across die line ; |
| $m$ | = | mass (weight) ; |
| $\pi$ | = | circle factor ; |
| $\rho$ | = | density (specific gravity) ; |
| $S$ | = | shape complexity factor (see 5.3) ; |
| $M$ | = | category of steel (see 5.2) ; |
| $x$ *and* $y$ | = | shearing deformation. |

## 4 Definitions

For the purposes of this European Standard and specially for classification, the following definitions apply :

**4.1 upset portion of a forging** : An upset, or group of upsets, produced without the direction of presentation of the bar stock to the heading tool having been reversed endwise (see figure 1).

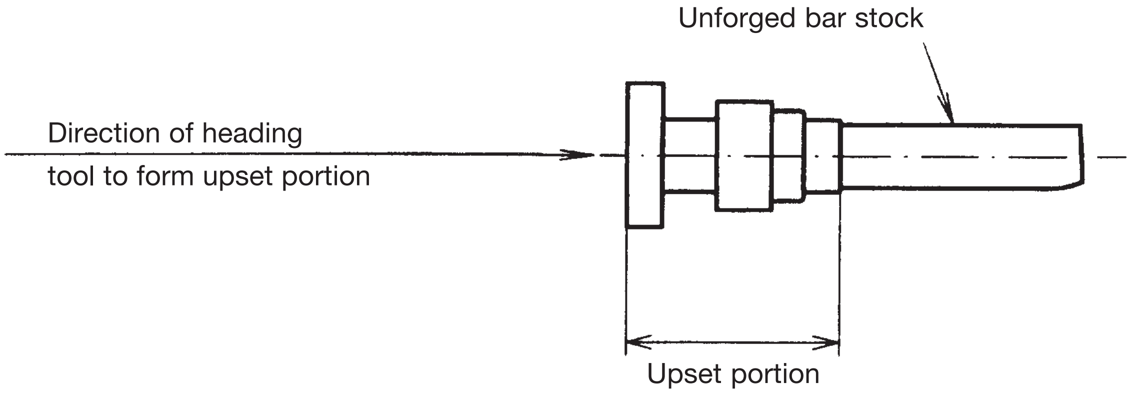



**Figure 1 : An upset portion of a forging**

**4.2 double-ended upset forgings** : Two separate upset portions which have been forged from opposite directions. In that case, the upset portion at each end shall be considered as an independent forging for the purpose of classification (see figure 2).

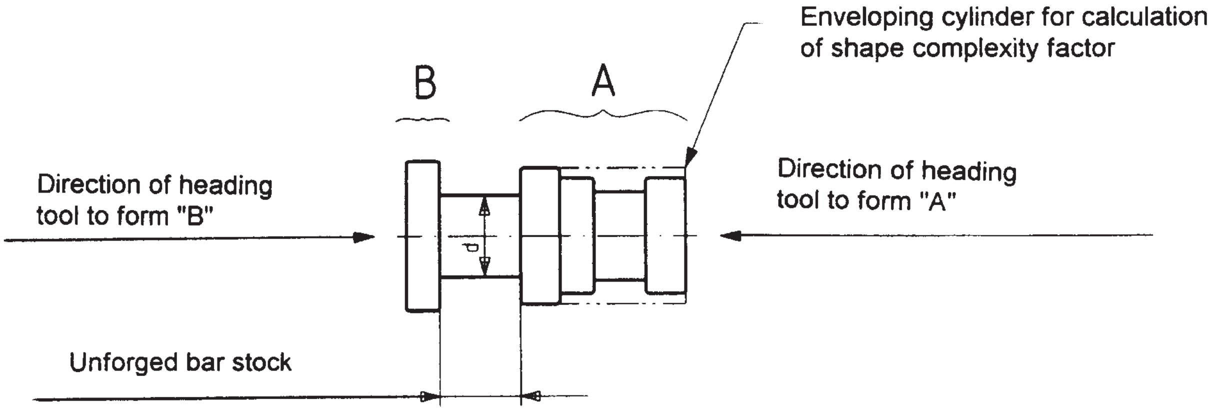



**Figure 2 : A double-ended upset forging**

EXCEPTION : If such a forging has either no unforged stock (see 4.3) retained or its length does not exceed its diameter, the tolerances shall be applied as if the forging had been produced as a single upset portion.

**4.3 unforged stock** : Any part of an upset forging which has been forged or formed prior to the upsetting operation (see figure 3).

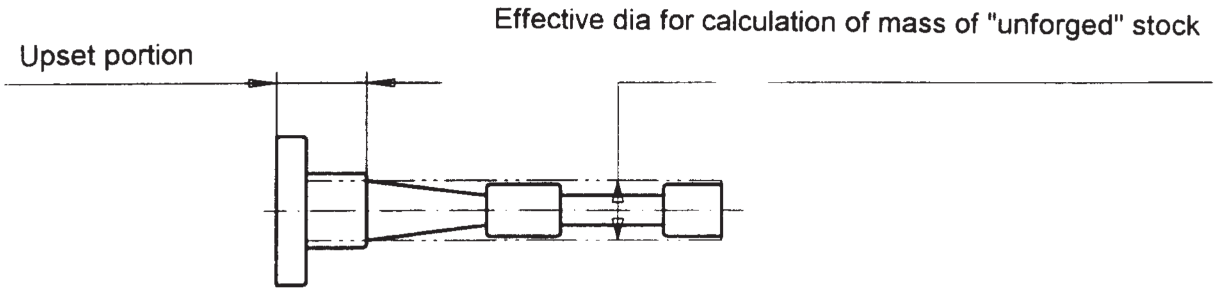



**Figure 3 : "Unforged" stock**

## 5 Information required in determining tolerances

To determine the tolerances applicable to a given upset forging in accordance with table 1 to 4, the following information is required in addition to the dimensions of the forging :

- mass of given upset portion(s) and mass of "unforged stock" (if any) (see 4.3 and 5.1) ;
- category of steel used ;
- shape complexity factor for a given upset portion of a forging.

### 5.1 Mass of upset portion

The mass of the upset portion is calculated.

### 5.2 Category of steel used

The type of steel symbol used takes account of the fact that steels of high carbon and high alloy content are more difficult to deform and cause higher die wear than do steels with lower carbon content and lower alloying elements.

The category of steel used is determined as being within one of the following :

- group M1 : Steel with carbon content not more than 0,65 % **and** total of specified alloying elements (Mn, Ni, Cr, Mo, V, W) not more than 5 % by mass ;
- group M2 : Steel with carbon content above 0,65 % **or** total of specified alloying elements (Mn Ni, Cr, Mo, V, W) above 5 % by mass.

To determine the category in which a steel belongs the maximum permitted content of the elements in the steel specification shall be the values used.

## 5.3 Shape complexity factor

The shape complexity factor takes account of the fact that in forging thin sections and branched components, as compared to components having simple compact shapes, larger dimensional variations occur which are attributable to different rates of shrinkage, higher shaping forces and higher rates of die wear.

The shape complexity factor (S) of a forging is the ratio of the mass[1]) of the forging to the mass of the enveloping shape necessary to accommodate the maximum dimensions of the forging.

$$S = \frac{m_{forging}}{m_{enveloping\ shape}}$$

The enveloping shape of a circular forging is the circumscribing cylinder the mass of which calculated from the formula (see figure 4) :

$$m_{enveloping\ shape} = \frac{\pi \times d^2}{4} \times h \times \rho$$

where :

$d$ = diameter ;

$\rho$ = density (7,85 g/cm³) ;

$h$ = height, or length of cylinder.

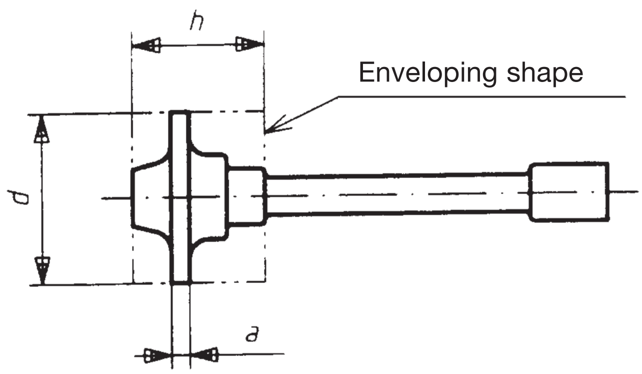



**Figure 4 : Determining shape complexity factor**

The resulting shape complexity factor is determined as falling within one of the following categories :

S4 : Up to and including 0,16 ;

S3 : Above 0,16 up to and including 0,32 ;

S2 : Above 0,32 up to and including 0,63 ;

---

[1] If desired, the shape complexity factor may be calculated as the ratio of the volume of the forging to the volume of the enveloping shape.

S1 : Above 0,63 up to and including 1.

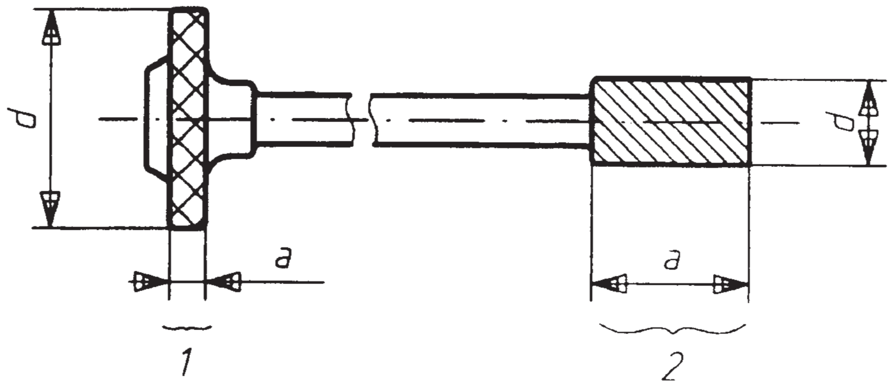
EXCEPTIONS : In determining the shape complexity factor for an upset portion there are exceptions to the above procedure when one of the following conditions applies :

1) *a/d* up to and including 0,20 ;

2) *a/d* greater than 2.

Where *d* is the greatest diameter of an upset portion, and *a* is the corresponding dimension of thickness or length crossing the die line between header die and grip dies.

In cases 1) and 2) the factor S4 is used and the mass is that of the cylinder *d* x *a* even if this is not the entire upset portion (see figure 5).




Case 1 Case 2

**Figure 5 : Exception in determining shape complexity factor**

When applying *a/d* ≤ 0,2, mass of upset should be considered as mass of flange only (*a* x *d* dia).

If *a/d* ≤ 0,2, use factor S4.

This special procedure is not applied if larger tolerances will result from use of the normal procedure as shown in 5.3, taking into account the whole of the upset portion (see figure 4).

## 6 Categories of tolerances

### 6.1 Scope of categories

The tolerances are related to the different kind of dimensions. They are classified into four groups accordingly each of them is displayed in the table.

#### 6.1.1 First group of tolerances (table 1)

Tolerances for :

- diameter ;

- step ;

- length ;
- mismatch and eccentricity ;
- local deviations from original bar stock diameter ;
- residual flash/trimmed flat ;
- internal dimensions including diameters of holes.

#### 6.1.2 Second group of tolerances (table 2)

Tolerances for :

- thickness.

#### 6.1.3 Third group of tolerances (table 3)

Tolerances for :

- straightness and flatness ;
- centre-to-centre.

#### 6.1.4 Other categories of tolerances

Tolerances for :

- fillet and edge radii (table 4) ;
- die line fins and trimming burrs (table 4) ;
- surface ;
- draft angle surfaces.
- eccentricity for deep holes ;
- deformation of sheared ends (table 4).

### 6.2 Definition of categories

#### 6.2.1 First group of tolerances (table 1)

##### 6.2.1.1 Diameter tolerances

Tolerances for dimensions of external diameter on all upset portions of a forging (i. e. excluding unforged stock) are taken from table 1. For external dimensions the tolerance dispersions are as shown in the table 1.

For internal dimensions the plus and minus signs are reversed. For diameters in that part of an upset portion formed in the grip dies, the tolerances are those for the maximum dimension of the given upset portion of the forging (see figure 6).

1 Upset portion "A"
2 Unforged bar stock
3 Upset portion "B"
4 Largest diameter
5 Upset portion
6 Bar stock

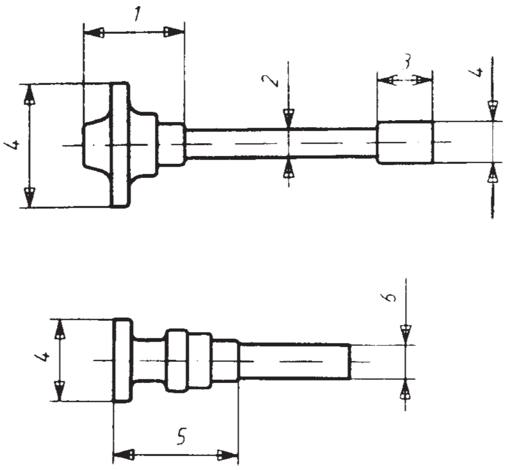



**Figure 6 : Application of tolerances based upon the largest diameter of an upset portion**

When applying tolerances to diameters in that part of an upset portion formed in the heading die, the tolerances for the greatest dimension of diameter should be applied, wherever possible, to all such dimensions of diameter. This should be done to obviate unnecessary minor variations between tolerances, thus facilitating drawing preparation and simplifying inspection procedures.

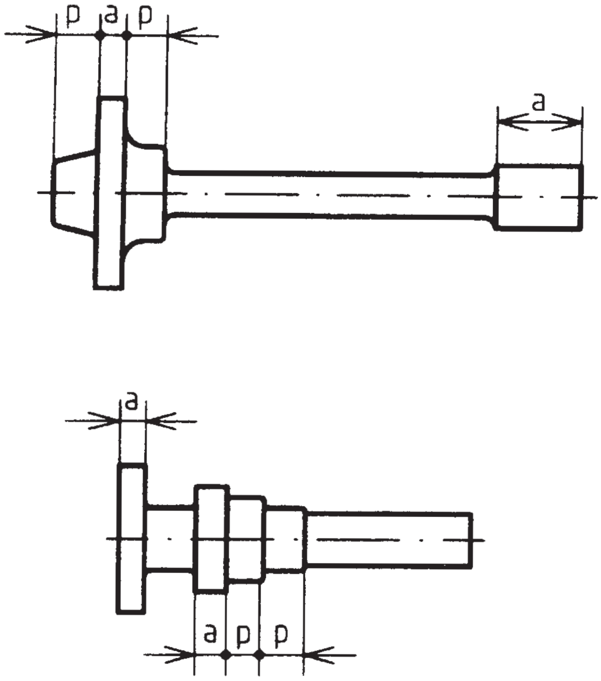
In those instances where the variation is of importance (e. g. where there is a large difference in dimensions of diameter), individual tolerances may be applied from table 1 to those dimensions where this is considered necessary. The application of such tolerances should be kept to a minimum and, in these instances, the tolerances shall be indicated clearly against the appropriate dimension(s) on the forging drawing.

### 6.2.1.2 Tolerances on step dimensions

Step dimensions are formed within either the punch or gripping dies, but do not include dimensions formed by a combination of punch and gripping dies (see figure 7).

For a given upset portion, the tolerances for the greatest dimension shown on the agreed forging drawing from the parting plane to the extremity of that upset portion measured in a direction parallel to the axis of the bar stock, should be applied from table 1 with a dispersion of + 2/3, -1/3 to all step dimensions formed in one die.

Where more restrictive tolerances are required, they shall be indicated against the appropriate dimension on the drawing and shall be + 1/3, -1/3 of the total tolerances shown in table 1 (see figure 7).




*a* : thickness dimension
*p* : step dimension

**Figure 7 : Step and thickness dimensions**

NOTE : On gap dimensions : Tolerances on step dimensions do not apply to gap dimensions between flanges within any given upset portion. Wherever possible, the method of applying dimensions should avoid the use of gap dimensions, but if such dimensions are essential the tolerances shall be calculated by reference to the tolerances on the other dimensions.

### 6.2.1.3 Length tolerances

Length tolerances are applied to dimensions, parallel to the axis of the bar stock, from the inner face(s) of an upset portion to the extreme opposite end of the forging. Such tolerances are calculated as if the whole of the length in question considered is unforged stock (see figure 8).

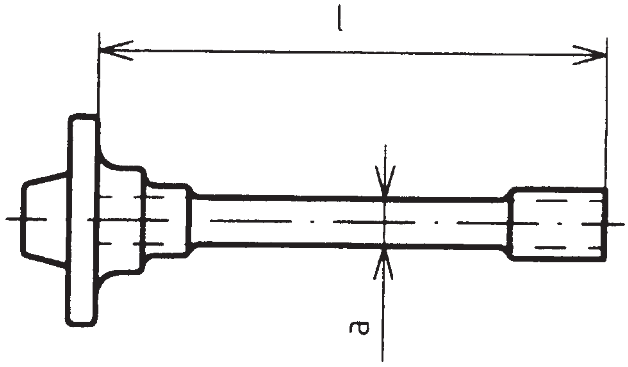



**Figure 8 : Length tolerances**

When the "unforged" stock varies in diameter, e. g. as a result of any other forming operation, the mass of such "unforged" stock shall be calculated as if it were all of the greatest diameter involved, provided that the diameter is not greater than that of the original bar stock which should be indicated on the forging drawing (see figure 3).

Length tolerances are taken from table 1. In the case of a forging having a separate upset portion at each end, dimensions may be taken from either upset portion to the opposite extremity but not from both upset portions. Normally in such cases length dimensions are applied from the inner flange face(s) of the main upset portion to the opposite extremity (see figures 9 and 10).

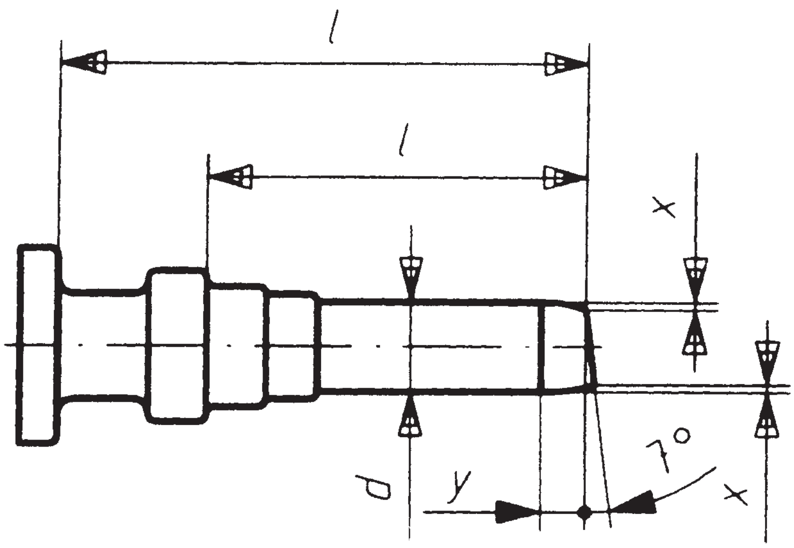



**Figure 9 : Typical length dimensions and tolerances for deformation of sheared ends**

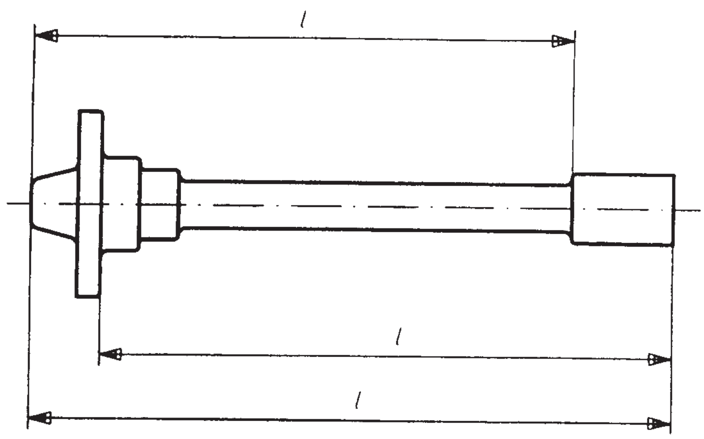



**Figure 10 : Application of length tolerances to double-ended upset forgings**

Where the surface at the extremity of the forging has been formed by shearing, tolerances apply from the short side of any taper which may result (see figure 9).

#### 6.2.1.4 Tolerances for mismatch and eccentricity (see figure 11)

Mismatch tolerances indicate the permissible extent of displacement of a point, in that part of a forging formed by one gripping die of a pair, from its correct position relative to the corresponding point in the other gripping die of the pair. Mismatch is measured in a direction parallel to the main die line of the gripping dies.

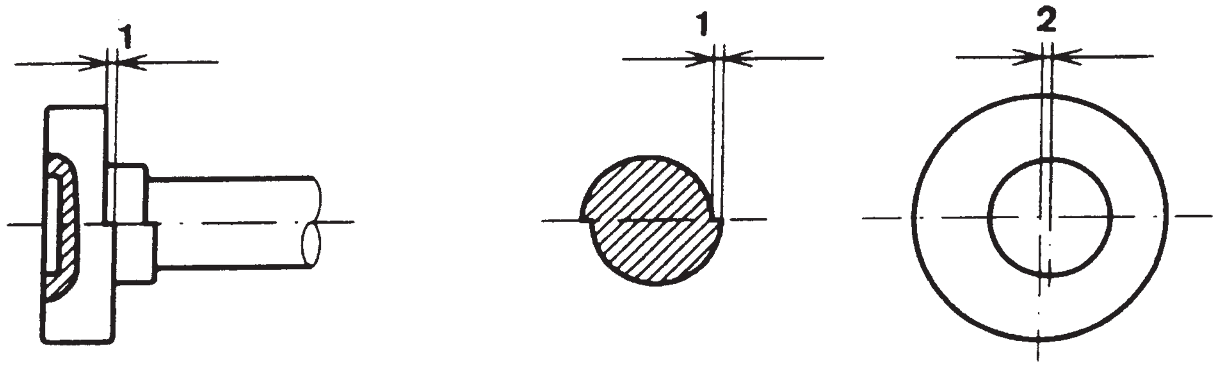



**Figure 11 : Mismatch and eccentricity**

Tolerances for mismatch are taken from table 1. Eccentricity tolerances indicate the permissible extent of axial displacement of contours formed by the heading tool, relative to the longitudinal axis of the forging.

Tolerances for eccentricity are equal in value to those for mismatch, and the values shall be doubled if measured as total indicator readings.

Mismatch and eccentricity tolerances are applied independently of, and in addition to, any other tolerances.

### 6.2.1.5 Tolerances for local deviations from original bar stock diameter

Local deviations from the original actual bar stock diameter adjoining an upset are allowed. The permissible increase or decrease in original actual diameter of bar stock adjoining an upset portion of a forging is the same as that applicable to the greatest external diameter of that upset portion.

Instances occur in which the negative tolerance for such local deviations cannot be permitted on unforged stock where it is not subsequently machined. In such cases it can be arranged by negotiation between the purchaser and the supplier that the entire tolerances is shown as a positive one.

The permissible length of local deviation from bar stock diameter adjoining an upset portion of a forging shall be equivalent to 1,5 times the bar stock diameter but with a maximum value of 100 mm (see figure 12).

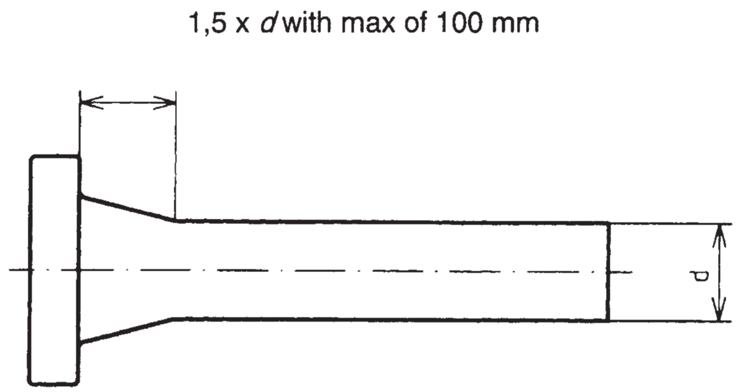



**Figure 12 : Local deviations from original actual bar stock diameter**

### 6.2.1.6 Residual flash and trimmed flat tolerances

Variations in trimming may produce either a residual flash or a trimmed flat. The positive (residual flash) and negative (trimmed flat) values permitted are given in table 1 or 4. The residual flash is measured from the body of the forging to the trimmed edge of the flash, as indicated in figure 13.

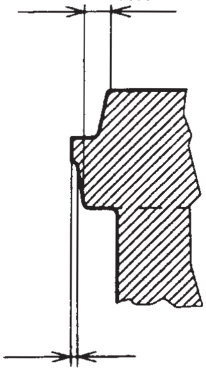



Figure 13 : Residual flash

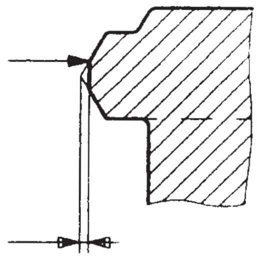



Figure 14 : Trimmed flat

The position of the trimmed flat is measured relative to the theoretical point at which the draft angles meet (see figure 14).

Residual flash and trimmed flat tolerances are applied independently of, and in addition to, any other tolerances.

#### 6.2.1.7 Tolerances on internal dimensions including diameters of holes

Tolerances on internal dimensions formed by the heading tool, including diameters of holes, shall be taken from table 1, but the positive and negative dispersion must be reversed. Normally the tolerances for the greatest dimension of diameter on the upset portion of the forging will be applied but, if more restrictive tolerances are required, those for the specific dimensions may be used. In the latter case the tolerances shall be indicated against the appropriate dimensions on the forging drawing.

### 6.2.2 Second group of tolerances (table 2)

#### 6.2.2.1 Thickness tolerances

Thickness tolerances are applied to those dimensions, parallel to the axis of the bar stock, of contours which are formed entirely within an upset portion and cross the parting line between header and grip dies.

Thickness tolerances are taken from table 2.

EXCEPTION : In the case of upset forgings having a flange and an upset projection on either side of the flange, the length of the projection being more than 1,5 times its diameter, all thickness tolerances except that for the overall thickness of the upset portion shall be calculated as if the length of the projection had been equal only to 1,5 times its diameter (see figure 15).

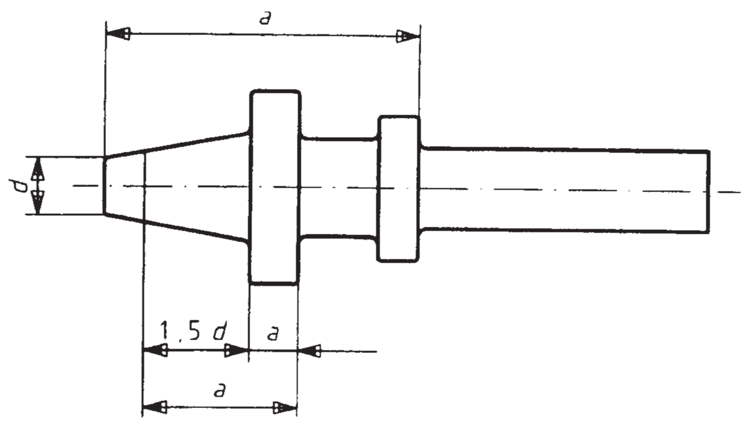



**Figure 15 : Exception to application of thickness tolerances**

If there are such projections on each side of the flange, the calculation is based on the projection having the larger diameter.
In both cases, the permissible deviations shall be mentioned besides the relative measurements in the drawings of the forgings.

### 6.2.3 Third group of tolerances (table 3)

#### 6.2.3.1 Straightness and flatness tolerances

Straightness tolerances relate to deviations of centre lines from the specified contour.

Flatness tolerances relate to deviations of surfaces from the specified contour.

When straightness tolerances or flatness tolerances are required, this shall be indicated on the agreed forging drawing and the method of checking must also be indicated.

Straightness and flatness tolerances are applied independently of, and in addition to, any other tolerances.

#### 6.2.3.2 Tolerances for centre-to-centre dimensions (table 3)

In all cases the centre-to-centre tolerances provided in table 3 of this standard shall only be applied when both centres are within the same upset portion and the line joining them is at right angles to the longitudinal axis of the forging (see figure 16).

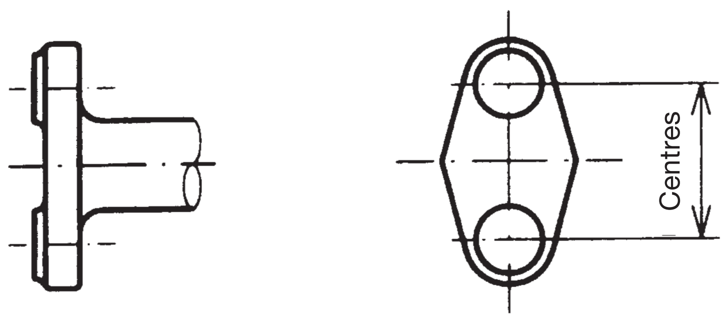



**Figure 16 : Tolerances for centre-to-centre dimensions**

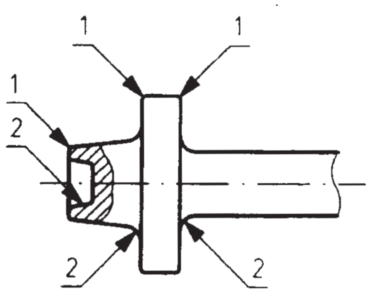
Such tolerances shall be indicated against the appropriate dimensions on the agreed forging drawing.

Centre-to-centre tolerances shall be applied independently of, and not aggregated with, any other tolerances.

### 6.2.4 Other categories of tolerances

#### 6.2.4.1 Fillet and edge radii tolerances (table 4)

Sharp edges and fillets on upset forgings are undesirable features and all fillet and edge radii should, therefore, be as generous as design requirements permit. Tolerances for fillet radii and edge radii are shown in table 4 and examples of such radii are shown in figure 17.




1 Edge radii
2 Fillet radii

**Figure 17 : Fillet and edge radii**

The minus tolerances do not apply to edge radii up to and including 3 mm where such radii are affected by subsequent removal of draft by trimming and punching. In such cases, the formation of a sharp edge is permitted.

#### 6.2.4.2 Tolerances for die line fins and trimming burrs (table 4)

An allowance is made for die line fins and trimming burrs formed at grip and header die parting lines (see figure 18).

1 Trimming burrs

2 Punching burrs

3 Die line fins

Section x - x

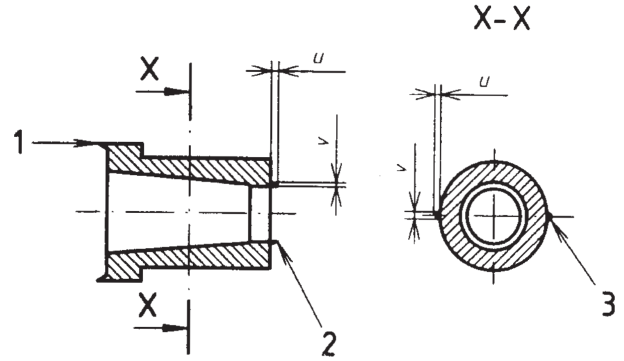



**Figure 18 : Trimming burrs, punching burrs, and die line fins**

Tolerances for the maximum permissible extent of such burrs or fins are based on the mass of the upset portion of the forging. They are applied unless the purchaser specifies otherwise.

The location of parting line fins and trimming burrs will be indicated to the purchaser on the forging drawing for approval before the commencement of production.

Tolerances for parting line fins and trimming burrs are applied independently of, and in addition to, any other tolerances.

When a forging is upset in closed dies, a fin is formed as indicated in figure 19.

The dimensions of such fins can be too large to be subject to normal tolerances of table 4 and are a matter for individual negotiation between the purchaser and the supplier.

Fin

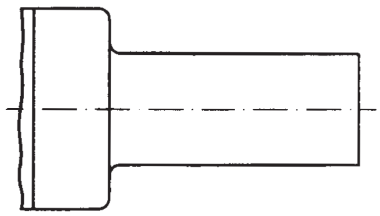


**Figure 19 : Fin**

### 6.2.4.3 Eccentricity tolerances for deep holes

For a hole formed by the heading tool, the depth of which is greater than the diameter an eccentricity tolerance of 0,5 % of hole depth shall be applied, but this value shall be doubled (1,0 %) if measured as a total indicator reading (see figure 20).

Eccentricity tolerances for deep holes shall be applied in addition to the normal tolerances for eccentricity (see 6.2.1.4).

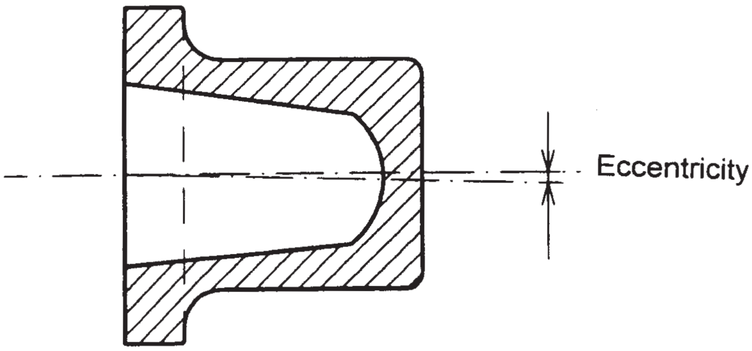



**Figure 20 : Eccentricity tolerances for deep holes**

#### 6.2.4.4 Tolerances for deformation of sheared ends

An allowance is made for distortion occuring at the end of the unforged stem of a forging due to shearing. Tolerances for the maximum permissible extent of such distortion are based on the nominal diameter of the unforged stock in accordance with table 4 and figure 9.

When tolerances for sheared ends are required, this will be indicated to the purchaser on the forging drawing before the commencement of production.

Tolerances for sheared ends are applied independently of, and in addition to, any other tolerances.

#### 6.2.4.5 Surface tolerances

Surface tolerances relate to depth of scale pits and depth of surface dressing. They apply within the limits stated below unless the purchaser specifies otherwise.

On forged surfaces which are to be machined subsequently, scale pits and surface dressing shall be permitted, but the maximum depth shall be such that at least one-half of the nominal machining allowance remains. Dimensional checks regarding depth of scale pits or any other point in question should be made in relation to the machining locations.

On forged surfaces which are not machined subsequently, scale pits and surface dressing shall be permitted to a depth equal to one-third of the total value of the thickness tolerance.

#### 6.2.4.6 Tolerances on draft angle surfaces

It is normal practice to apply the tolerances for a nominal dimension of length or width, shown on the agreed forging drawing, to any corresponding dimension required between points on the adjacent draft angle surfaces. Many instances of heavy die wear occur in which these tolerances are inadequate. The supplier will draw the attention of the purchaser to such instances and it will be necessary to negotiate greater tolerances on the draft angle surfaces to meet these circumstances. Such special tolerances shall be agreed between the supplier and the purchaser before the commencement of production.

### 6.3 Deviation of form

The tolerances for lengths, diameters, steps and thickness cover not only the differences of dimension, but also the deviations of form which are :

- out of round ;
- deviations from cylindricity ;
- deviations from parallelism ;
- other deviations from specified contour.

These deviations are not to exceed the limits given by the tolerances. In extreme cases they can cover the whole field of tolerances unless otherwise agreed between the supplier and the purchaser.

Deviations of straightness or flatness as given in table 3 are not included in the above-mentioned faults of form. Also the deviations of form do not include scale pits and depth of surface dressing (see 6.2.4.5) nor any roughness of surface.

Where restrictions in deviations of form have been agreed these will be to ISO 8015 and noted on the drawing.

## 7 Use of tables

### 7.1 Table 1 : Tolerances for diameter, length, residual flash (and trimmed flat), mismatch and eccentricity

Tolerances are shown in table 1. To determine diameter and length tolerances reference is first made to the appropriate category in the mass column. The horizontal line is then followed to the right. If the category of steel used is M1, the same horizontal line is followed further to the right. If the category of steel used is M2, the heavy diagonal line is followed downward to the point of intersection with the vertical line M2 and the horizontal line thus met is followed to the right (i. e. if the factor is M2 the horizontal line used is moved two places downward). A similar procedure is followed for the factor of shape complexity so that downward displacement of the horizontal line used is nil, one place, two places and three places for factors S1, S2, S3 and S4 respectively. By further movement to the right, the correct tolerance is found under the appropriate vertical column heading for the dimension concerned (see figure 21).

EXAMPLE OF APPLICATION : Example of the use of table 1 for determining the tolerances for diameter, height, length dimensions of a forging with an forged portion and an unforged portion.

Data required :

| | |
|---|---|
| Maximum diameter | 61 mm |
| Maximum height (no height dimensions indicated in the drawing) | - |
| Maximum thickness | 78 mm |

| | |
|---|---|
| Maximum length | 535 mm |
| Mass of the shaped head (calculated) | 1,08 kg |
| Mass of the enveloping body (cylinder with diameter of 61 mm and length of 78 mm) (calculated) | 1,79 kg |
| Mass of a bar (cylinder with diameter of 29 mm and length of 535 mm) calculated for determining the tolerances for length dimensions | 2,78 kg |
| Shape complexity factor at 1,08 : 1,79 = 0,6 (see 5.3) | Group S2 |
| Category of steel used for (25CrMo4 with C content = 0,19 % by mass < 0,65 % by mass and total MoCr = 1,8 % by mass, < 5 % by mass) (see 5.2) | Group M1 |
| Die line | Straight |

From table 1, the tolerances (see figure 21) are found to be :

Diameter $^{+1,2}_{-0,6}$ mm

Length $^{+1,9}_{-0,9}$ mm

Permissible tolerances, based on the greatest dimensions are usually obtained from the appropriate table and applied to all the length, width and height dimensions.

| Mismatch | Residual flash (+) Trimmed flat (-) | Mass (kg) | Category of steel used | | Shape complexity factor | | | | Nominal dimensions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Above-to (incl) | M1 | M2 | S1 > 0,63 ≤ 1 | S2 > 0,32 ≤ 0,63 | S3 > 0,16 ≤ 0,32 | S4 ≤ 0,16 | 0 ≤ 32 | > 32 ≤ 100 | > 100 ≤ 160 | > 160 ≤ 250 | > 250 ≤ 400 | > 400 ≤ 630 | > 630 ≤ 1 000 | > 1 000 ≤ 1 600 | > 1 600 ≤ 2 500 |
| | | | | | | | | | Tolerances 1) | | | | | | | | |
| 0,4 | 0,5 | 0-0,4 | | | | | | | $1,1^{+0,7}_{-0,4}$ | $1,2^{+0,8}_{-0,4}$ | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | - | - | - |
| 0,5 | 0,6 | 0,4-1,0 | | | | | | | $1,2^{+0,8}_{-0,4}$ | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | - | - | - |
| 0,6 | 0,7 | 1,0-1,8 | | | | | | | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | - | - |
| 0,7 | 0,8 | 1,8-3,2 | | | | | | | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | - |
| 0,8 | 1,0 | 3,2-5,6 | | | | | | | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ |
| 1,0 | 1,2 | 5,6-10 | | | | | | | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ |
| 1,2 | 1,4 | 10-20 | | | | | | | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ |
| 1,4 | 1,7 | 20-50 | | | | | | | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ |
| 1,7 | 2,0 | 50-120 | | | | | | | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ |
| 2,0 | 2,4 | 120-250 | | | | | | | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ |
| | | | | | | | | | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ |
| | | | | | | | | | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ |
| | | | | | | | | | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ | $11,0^{+7,3}_{-3,7}$ |
| | | | | | | | | | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ | $11,0^{+7,3}_{-3,7}$ | $12,0^{+8,0}_{-4,0}$ |
| | | | | | | | | | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ | $11,0^{+7,3}_{-3,7}$ | $12,0^{+8,0}_{-4,0}$ | $14,0^{+9,3}_{-4,7}$ |

1) Tolerances are 2/3 and 1/3 (rounded values). Minus and plus signs, given in the table above are applicable to external dimensions. For internal dimensions reverse the values.

**Figure 21 : Use of tables**

To determine tolerances for residual flash (and trimmed flat) and for mismatch or eccentricity from table 1, it is again necessary to commence at the appropriate category in the mass column, but then to move horizontally to the left in the table. According to whether the die line between header die and gripping dies is straight, symmetrically cranked or asymmetrically cranked the correct tolerances for residual flash (and trimmed flat) and for mismatch are read from the appropriate column (see also figure 21).

### 7.2 Table 2 : Tolerances for thickness

Tolerances are shown in table 2. Tolerances for thickness are obtained from the table by the same method as that described above for diameter, length tolerances, etc., in table 1.

### 7.3 Table 3 : Tolerances for straightness and flatness ; tolerances for centre-to-centre dimensions

Tolerances for straightness and flatness are obtained from the upper part of table 3 by referring to the appropriate horizontal line and by reading the tolerance under the vertical column heading for the dimension concerned.

Tolerances for centre-to-centre dimensions are obtained from the lower part of table 3 by referring to the appropriate horizontal line for grade F and by reading the tolerance under the vertical column heading for the dimension concerned.

### 7.4 Table 4 : Tolerances for fillet and edge radii ; tolerances for die line fins, trimming burrs ; tolerances for sheared ends

Tolerances for fillet and edge radii are shown as percentages of the dimension concerned and are obtained by reference to the upper part of table 4. Reference is made to the appropriate dimension in the left-hand column "*r*" ; the positive and negative components of the tolerance are shown on the right as percentages of the nominal radius.

Tolerances for die line fins and trimming burrs are shown in the median part of table 4. Reference is first made to appropriate category in the mass column and the tolerances are read off from the vertical columns headed "*U*" and "*V*".

Tolerances for sheared ends are shown in the lower part of table 4.

## 8 Design procedure

### 8.1 Information required by the forger

In order to assist the forging manufacturer to utilize his experience to best effect, both in designing his dies and tools and in establishing forging inspection procedures, it is in the purchaser's interest to supply the following information :

- a finished machined drawing ;

- details and dimensions of machining locations (prior notice should be given of any subsequent changes in these location points) ;

- any other relevant information on machining operations and function of the component.

### 8.2 Preparation of forging drawing

It is recommended that the forger should prepare the forging drawing which should then be submitted to the purchaser for approval and, if necessary, for joint consultation.

In instances where the purchaser wishes to prepare his own fully dimensioned forging drawing, it is still necessary that the drawing of the finished machined component and the other information referred to above should be made available to the forger.

## 8.3 Indication of dimensions on forging drawings

It is imperative to note that, with the exception concerning draft angle surfaces referred to in 6.2.4.6, the tolerances indicated in this European Standard shall be applied only to those dimensions specifically indicated on the agreed forging drawing.

For this reason the method of indicating dimensions on the forging drawing has a vital bearing on the dimensional control of the forging.

Tolerances for dimensions not shown on the forging drawing cannot be taken from this European Standard but can be determined, if required, only by calculation based on the dimensions and tolerances which are already shown on the agreed forging drawing.

## 8.4 Indication of tolerances on forging drawings

All forging drawings for upset forgings should be endorsed "tolerances conform to EN 10243-2" unless otherwise indicated.

For correct endorsement of forging drawings it is recommended to follow the presentation of tolerances at the foot of the drawing as given in annex A, e.g. example 1 : drive shaft.

Any tolerances which are only applicable to specific dimensions (e. g. thickness tolerances) shall be indicated on the drawing against the particular dimensions concerned.

Tolerances for die line fins and trimming burrs should be shown on the forging drawing against the specific locations.

Any special tolerances agreed between the purchaser and the forger shall be indicated clearly on the forging drawing and will, wherever possible, be indicated against the specific dimensions concerned.

## 8.5 Importance of forging drawing

The drawing of the forged part which has been accepted by the purchaser is the only valid document for inspection of the forged part. This drawing is also the only valid document for tolerances on parts of the forging remaining unmachined.

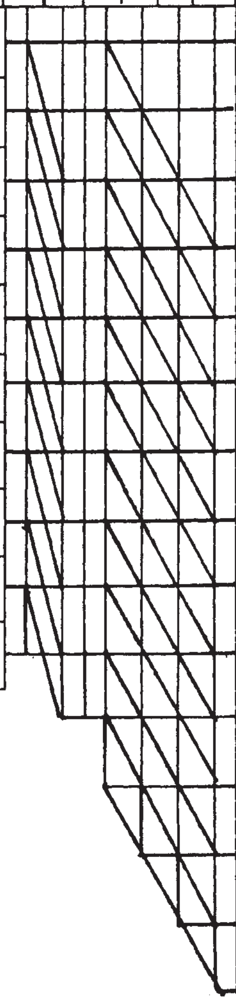
**Table 1 : Upset forgings - Forging grade F - Tolerances for length, width, height, mismatch, residual flash and trimmed flat**

Dimensions in millimetres

| Mismatch | Residual flash (+) / Trimmed flat (-) | Mass (kg) Above-to (incl) |
|---|---|---|
| 0,4 | 0,5 | 0-0,4 |
| 0,5 | 0,6 | 0,4-1,0 |
| 0,6 | 0,7 | 1,0-1,8 |
| 0,7 | 0,8 | 1,8-3,2 |
| 0,8 | 1,0 | 3,2-5,6 |
| 1,0 | 1,2 | 5,6-10 |
| 1,2 | 1,4 | 10-20 |
| 1,4 | 1,7 | 20-50 |
| 1,7 | 2,0 | 50-120 |
| 2,0 | 2,4 | 120-250 |

Category of steel used: M1 | M2

Shape complexity factor: S1 (> 0.63 ≤ 1) | S2 (> 0.32 ≤ 0.63) | S3 (> 0.16 ≤ 0.32) | S4 (≤ 0.16)



Nominal dimensions – Tolerances 1)

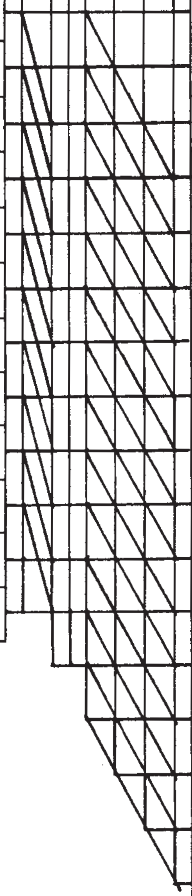
| 0 ≤ 32 | > 32 ≤ 100 | > 100 ≤ 160 | > 160 ≤ 250 | > 250 ≤ 400 | > 400 ≤ 630 | > 630 ≤ 1 000 | > 1 000 ≤ 1 600 | > 1 600 ≤ 2 500 |
|---|---|---|---|---|---|---|---|---|
| $1,1^{+0,7}_{-0,4}$ | $1,2^{+0,8}_{-0,4}$ | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | - | - | - |
| $1,2^{+0,8}_{-0,4}$ | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | - | - | - |
| $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | - | - |
| $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | - |
| $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ |
| $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ |
| $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ |
| $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ |
| $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ |
| $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ |
| $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ |
| $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ |
| $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ | $11,0^{+7,3}_{-3,7}$ |
| $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ | $11,0^{+7,3}_{-3,7}$ | $12,0^{+8,0}_{-4,0}$ |
| $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ | $11,0^{+7,3}_{-3,7}$ | $12,0^{+8,0}_{-4,0}$ | $14,0^{+9,3}_{-4,7}$ |

1) Tolerances are 2/3 and 1/3 (rounded values). Minus and plus signs, given in the table above are applicable to external dimensions. For internal dimensions reverse the values.

## Table 2 : Upset forgings - Forging grade F - Tolerances for thickness

Dimensions in millimetres

| Category of steel used | | Shape complexity factor | | | |
|---|---|---|---|---|---|
| M1 | M2 | S1 > 0.63 ≤ 1 | S2 > 0.32 ≤ 0.63 | S3 > 0.16 ≤ 0.32 | S4 ≤ 0.16 |



| Ejector marks | Mass (kg) Above-to (incl) | Nominal dimensions 0 ≤ 16 | > 16 ≤ 40 | > 40 ≤ 63 | > 63 ≤ 100 | > 100 ≤ 160 | > 160 ≤ 250 | > 250 |
|---|---|---|---|---|---|---|---|---|
| | | Tolerances 1) | | | | | | |
| 1,0 | 0-0,4 | $1,0^{+0,7}_{-0,3}$ | $1,1^{+0,7}_{-0,4}$ | $1,2^{+0,8}_{-0,4}$ | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ |
| 1,2 | 0,4-1,2 | $1,1^{+0,7}_{-0,4}$ | $1,2^{+0,8}_{-0,4}$ | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ |
| 1,6 | 1,2-2,5 | $1,2^{+0,8}_{-0,4}$ | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ |
| 2,0 | 2,5-5 | $1,4^{+0,9}_{-0,5}$ | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ |
| 2,4 | 5-8 | $1,6^{+1,1}_{-0,5}$ | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ |
| 3,2 | 8-12 | $1,8^{+1,2}_{-0,6}$ | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ |
| 4,0 | 12-20 | $2,0^{+1,3}_{-0,7}$ | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ |
| 5,0 | 20-36 | $2,2^{+1,5}_{-0,7}$ | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ |
| 6,4 | 36-63 | $2,5^{+1,7}_{-0,8}$ | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ |
| 8,0 | 63-110 | $2,8^{+1,9}_{-0,9}$ | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ |
| 10 | 110-200 | $3,2^{+2,1}_{-1,1}$ | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ |
| 12,6 | 200-250 | $3,6^{+2,4}_{-1,2}$ | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ |
| | | $4,0^{+2,7}_{-1,3}$ | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ |
| | | $4,5^{+3,0}_{-1,5}$ | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ |
| | | $5,0^{+3,3}_{-1,7}$ | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ |
| | | $5,6^{+3,7}_{-1,9}$ | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ | $11,0^{+7,3}_{-3,7}$ |
| | | $6,3^{+4,2}_{-2,1}$ | $7,0^{+4,7}_{-2,3}$ | $8,0^{+5,3}_{-2,7}$ | $9,0^{+6,0}_{-3,0}$ | $10,0^{+6,7}_{-3,3}$ | $11,0^{+7,3}_{-3,7}$ | $12,0^{+8,0}_{-4,0}$ |

1) Tolerances are 2/3 and 1/3 (rounded values).

## Table 3 : Upset forgings - Tolerances for straightness, flatness and centre-to-centre dimensions

Dimensions in millimetres

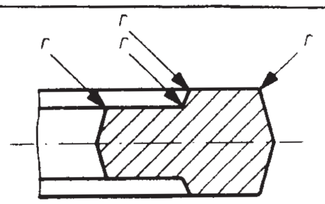
| Range tolerances for straightness and flatness | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length above to (included) | | Nominal dimensions | | | | | | | | | | | | | | |
| | | 0<br>100 | 100<br>125 | 125<br>160 | 160<br>200 | 200<br>250 | 250<br>315 | 315<br>400 | 400<br>500 | 500<br>630 | 630<br>800 | 800<br>1 000 | 1 000<br>1 250 | 1 250<br>1 600 | 1 600<br>2 000 | 2 000<br>2 500 |
| | | Tolerances | | | | | | | | | | | | | | |
| Grade | F | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | 1,1 | 1,2 | 1,4 | 1,6 | 1,8 | 2,0 | 2,2 | 2,5 | 2,8 | 3,2 |

| Range of tolerances for centre-to-centre dimensions | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length above to (included) | | Nominal dimensions | | | | | | | | | | |
| | | 0<br>100 | 100<br>160 | 160<br>200 | 200<br>250 | 250<br>315 | 315<br>400 | 400<br>500 | 500<br>630 | 630<br>800 | 800<br>1 000 | 1 000<br>1 250 |
| | | Tolerances | | | | | | | | | | |
| Grade | F | 0,6 ± 0,3 | 0,8 ± 0,4 | 1,0 ± 0,5 | 1,2 ± 0,6 | 1,6 ± 0,8 | 2,0 ± 1,0 | 2,4 ± 1,2 | 3,2 ± 1,6 | 4,0 ± 2,0 | 5,0 ± 2,5 | 6,4 ± 3,2 |

## Table 4 : Upset forgings - Tolerances for fillet, edge radii and burrs

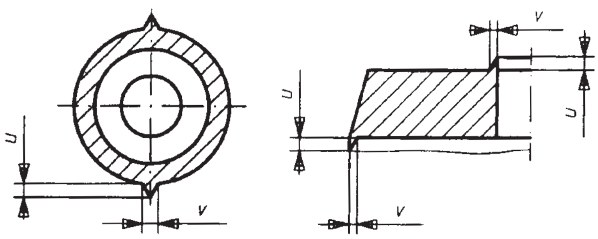
Fillet and edge radii tolerances

| *r*(mm) | + | - |
|---|---|---|
| $r \leq 10$ | 50 % | 25 % |
| $10 < r \leq 32$ | 40 % | 20 % |
| $32 < r \leq 100$ | 32 % | 15 % |
| $r > 100$ | 25 % | 10 % |



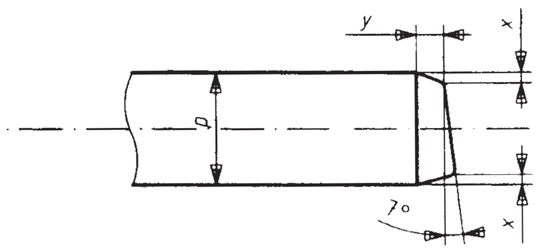

Burr tolerances (and parting line fins for upset forgings)

| Mass (kg)<br>*m* | *u*<br>mm | *v*<br>mm |
|---|---|---|
| $m \leq 1$ | 1 | 0,5 |
| $1 < m \leq 6$ | 1,6 | 0,8 |
| $6 < m \leq 40$ | 2,5 | 1,2 |
| $40 < m \leq 250$ | 4 | 2 |




Tolerances for deformations of sheared ends

| Nominal diameter of the unforged stock | Tolerances *x* | Tolerances *y* |
|---|---|---|
| ≤ 36 | 0,07*d* | *d* |
| > 36 | 0,05*d* | 0,7 |



## Annex A (informative)

## Examples of application

### A.0 Content

General remarks concerning the examples :

Example 1 Drive shaft

Example 2 Flanged shaft

### A.1 General remarks concerning the examples

This annex illustrates the procedure for obtaining the dimensional tolerances for typical forged components. The tolerance grade and tolerances given on the drawings are examples only and should not be regarded as either mandatory, recommended or minimum requirements since in practice the tolerances will depend on both the capability of the forging equipment and the requirements of the purchaser.

Reference dimensions included in the examples are given in brackets. These are dimensions which would lead to over definition geometrically, or contradictions when given a tolerance. They are not used for check measurements on the actual forging, but for tool construction when forging dimensions are not measurable.

Where any special tolerances are applicable they are indicated in the example by a small solid black circle alongside the tolerance.

## A.2 Example 1 : Drive shaft

Material 25CrMo4 according to EN 10083-1.

### A.2.1 General

In this particular example it is assumed, that the product be forged in a horizontal forging machine with abutment at the rear. It consists of the shaped head and the non-shaped shaft. The tolerances applying to the shaft diameter are those consistent with its method of manufacture - rolling tolerances according to EN XXXX. In the case of forgings with longer shaft which cannot be forged using rearward abutment, an extended clamping range adjoins the area undergoing deformation. Experience indicates that in this range the minus variation for the diameter of the shaft must remain considerably larger than that of the primary material. For this range, special tolerances are to be provided.

### A.2.2 Information necessary for determining the tolerances

| | |
|---|---|
| Maximum diameter : | 61 mm |
| Maximum height (no height dimensions indicated in the drawing) : | - |
| Maximum thickness : | 78 mm |
| Mass of the shaped head (calculated) : | 1,08 kg |
| Mass of the enveloping body (cylinder with diameter of 61 mm and length of 78 mm) (calculated) : | 1,79 kg |
| Mass of a bar (cylinder with diameter of 29 mm and length of 535 mm) calculated for determining the tolerances for length dimensions : | 2,78 kg |
| Shape complexity factor at 1.08 : 1,79 = 0,6 (see 5.3) : | Group S 2 |
| Category of steel for 25CrMo4 with C content = 0,19 % by mass < 0,65 % by mass and total MnCr = 1,8 % by mass < 5 % by mass (see 5.2) : | Group M 1 |
| Die line : | Straight |

### A.2.3 Determining the tolerances for forging grade F from the tables according to EN 10243-2

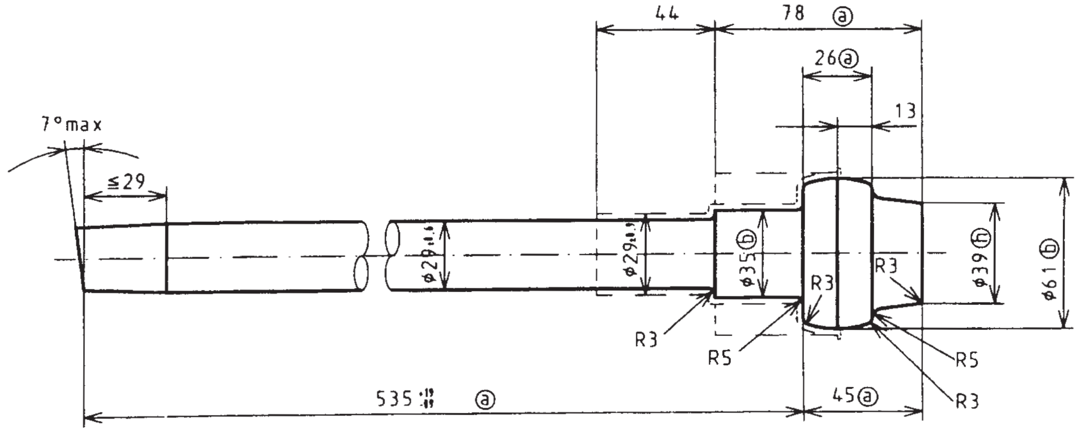
| Dimensions | Permissible Variations (mm) at forging grade F |
|---|---|
| Diameter (width) dimensions : | Table 1 : $^{+1,2}_{-0,6}$ |
| Thickness dimensions : | Table 3 : $^{+1,2}_{-0,6}$ |
| Mismatch : | Table 1 : 0,6 |
| Residual flash/depth of chamfer : | Table 1 : 0,7 |
| Straightness : | Table 5 : 1,6 |
| Die line fin, height :<br>width | Table 6 : 1,6<br>0,8 |
| Length dimension 535 mm (see 6.2.1.3 application of S1, M1, 2,78 kg) : | - 0,9 |
| Deformation of the sheared end, length :<br>depth : | Table 6 : 29<br>2 |
| Length of the range of local deformation of the shaft 1,5 x 29 mm (see 6.2.1.5) : | = 44 |

### A.2.4 Entry of tolerances on the forging drawing

To the extent that columns are available, all tolerances are entered in the table on the forging drawing, with the exception of tolerances for length. These are entered against the dimension 535 mm. The sheared end is drawn and the permissible size of the deformation entered. The regions in which die line flash and local deformations at the shaft transition are permitted are denoted on the forging drawing by dimension arrowheads. If neither an area of die line fins or any die line is indicated, any existing fin must be cleaned off.

Tolerances for the overall length (535 mm + 45 mm = 580 mm) cannot be obtained from the table. If needed, they are determined by adding the tolerances for the length 535 mm and thickness 45 mm (580 mm + 3,1 mm / - 1,5 mm).

If only the overall length were to be entered, the dimension 535 mm would have to be calculated in order to be able to determine the tolerances for the overall length.




*) Permissible length of the range of local deformations.

*(l)* = Length dimensions
*(b)* = Width dimensions
*(a)* = Thickness dimensions

**EXAMPLE 1 : Drive shaft**

| Tolerances and permissible variations acccording to EN 10243-2 | | | | | |
|---|---|---|---|---|---|
| Forging mass | | Mass of enveloping body | Shape complexity factor | Category of steel used | Forging grade |
| Part A | 1,08 kg | 1,79 kg | Group S 2 | Group M 1 | F |

| Type of dimension | Tolerances and permissible variations<br>Part A | Type of dimension | | Tolerances and permissible variations<br>Part A |
|---|---|---|---|---|
| Length dimensions 1) | - | Trimming burr | Height | - |
| | | | Width | - |
| Width/diameter dimensions 1) | + 1,2<br>− 0,6 | Die line fin | Height | 1,6 |
| | | | Width | 0,8 |
| Height dimensions 1) | - | Special tolerances | | No |
| Thickness/diameter dimensions | + 1,2<br>− 0,6 | Fillets and edge radii according to table 4 | | |
| Mismatch 2) | 0,6 | Depth of surface imperfections according to 6.2.4.5 | | |
| Residual flash (+),<br>Depth of chamfer (-) 2) | 0,7 | | | |
| Straightness and flatness 2) | 1,6 | | | |

1) For internal dimensions , interchange numerical values for + and - variations.

2) Additional to other tolerances.

## A.3 Example 2 : Flanged shaft

Material C45E to EN 10083-1:1991.

### A.3.1 General

The flanged shaft is normally forged in horizontal machines with abutment at the rear. Within the terms of this standard it consists of two shaped parts and a non-shaped shaft. For determining the tolerances for thickness dimensions the exceptional ruling of 6.2.2.1 is to be applied to the shaped part A (flange) and that of 6.3 to the shaped part B (head) : Accordingly it is necessary to calculate the reference dimensions (flange thickness + 1,5 % smallest journal diameter) for part A. For part B an additional mass calculation can be dispensed with, since its mass, the mass of its enveloping body and that of the reference body are identical. In order to be able to determine the tolerance for the length 850 mm it is necessary to calculate the mass of a bar with a diameter of 30,5 mm and a length of 850 mm.

### A.3.2 Information necessary for determining the tolerances

#### A.3.2.1 Data for part A

| | |
|---|---|
| Maximum width/diameter : | 130,4 mm |
| Maximum height (calculated from 98 mm + 13,5 mm) (see 6.2.1.2) : | 111,5 mm |
| Maximum thickness (not indicated in the dawing) : | - |
| Reference dimension for thickness dimensions (calculated from 13,5 mm + 1,5 x 30,5 mm) (see 6.2.2.1) : | 59,25 kg |
| Mass (calculated) : | 2,02 kg |
| Mass of the enveloping body (disc with diameter of 130,4 mm and thickness of 18,5 mm plus theoretical mass of shaft 98 mm) (calculated) : | 12,4 kg |
| Shape complexity factor at 2,02 : 12,4 = 0,163 (see 5.3) : | Group S 3 |
| Category of steel for C45E with C content = 0,5 % by mass < 0,65 % by mass and total MnCrMoNi = 1,43 % by mass. < 5 % by mass. (see 5.2) : | Group M 1 |
| Die line : | Straight |

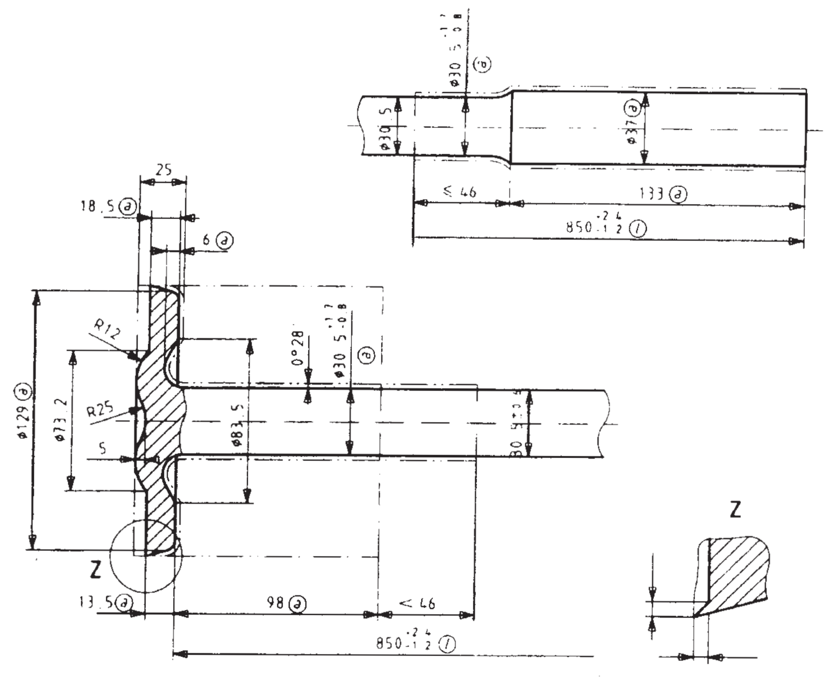
#### A.3.2.2 Data for part B

| | |
|---|---|
| Maximum diameter : | 37 mm |
| Maximum height (no height dimensions indicated in the drawing) : | - |
| Maximum thickness : | 133 mm |
| Mass (calculated) : | 1,12 kg |
| Mass of the enveloping body (calculated) : | 1,12 kg |
| Shape complexity factor at 1,12 : 1,12 = 1 (see 5.3) : | Group S 1 |
| Category of steel used, as for part A : | Group M 1 |
| Die line : | Straight |

### A.3.3 Determining the tolerances for forging grade F from the tables according to EN 10243-2

| Dimensions | Permissible variations [mm] at forging grade F 1) | | |
|---|---|---|---|
| | forging | part A | part B |
| Length dimensions (M 1, S 1 and 4,88 kg see 6.2.1.3) : | Table 1 : + 2,4 − 1,2 | | |
| Width/diameter dimensions : | | Table 1 : + 1,7 − 0,8 | Table 1 : + 1,1 − 0,5 |
| Height dimensions : | | Table 1 : + 1,7 − 0,8 | |
| Thickness/diameter dimensions | | | |
| (to exception rule see 6.2.2.1) : | | Table 3 : + 1,3 − 0,7 | |
| (not in force to 5.3) : | | | Table 3 : + 1,2 − 0,6 |
| (to exception rule see 5.3) : | | | Table 3 : + 1,7 − 0,8 |
| Mismatch : | | Table 1 : 0,7 | Table 1 : 0,6 |
| Residual flash/depth of chamfer : | | Table 1 : 0,8 | Table 1 : 0,7 |
| Straightness and flatness : | Table 5 : 2,0 | | |
| Trimming burrs (only part A) and die line fin : Height : | | Table 6 : 1,6 | Table 6 1,6 |
| Width : | | 0,8 | 0,8 |

1) For forgings made in horizontal forging-machines the forging grade E is not applicable.




*) Permissible length of the range of local deformations.

*(l)* = Length dimensions
*(b)* = Width dimensions
*(h)* = Height dimensions
*(a)* = Thickness dimensions

**EXAMPLE 2 : Flanged shaft**

| Tolerances and permissible variations according to 10243-2 | | | | | |
|---|---|---|---|---|---|
| Forging mass | | Mass of enveloping body | Shape complexity factor | Category of steel | Forging grade |
| Part A | 2,02 kg | 12,4 kg | Group S 3 | Group M 1 | F |
| Part B | 1,12 kg | 1,12 kg | Group S 1 (S 4) | | |

| Type of dimension | Tolerances and permissible variations Part A | Part B | Type of dimension | | Tolerances and permissible variations Part A | Part B |
|---|---|---|---|---|---|---|
| Length dimensions 1) | - | - | Trimming burr | Height | 1,6 | - |
| Width/diameter dimensions 1) | + 1,7<br>− 0,8 | + 1,1<br>− 0,5 | | Width | 0,8 | - |
| Height dimensions 1) | + 1,7<br>− 0,8 | - | Die line fin | Height | 1,6 | 1,6 |
| | | | | Width | 0,8 | 0,8 |
| | | | Special tolerances | | No | |
| Thickness/diameter dimensions | + 1,3<br>− 0,7 | + 1,7<br>− 0,8$^{54}$ | Fillets and edge radii according to table 4. | | | |
| Mismatch 2) | 0,7 | 0,6 | Depth of surface imperfections according to section 6.2.4.5 | | | |
| Residual flash (+), depth of chamfer (-) 2) | 0,8 | 0,7 | | | | |
| Straightness and flatness 2) | 2 | | | | | |
| 1) For internal dimensions, interchange numerical values for + and - variations.<br>2) Additional to other tolerances. | | | | | | |

## A.3.4 Entry of tolerances on the forging drawing

### A.3.4.1 For part A

All the tolerances determined are entered in the corresponding columns of the table on the forging drawing. The ranges in which trimming burrs and parting line fins may occur, and also the area of local deformations at the transition from the shaped part to the shaft are denoted on the forging drawing. It is expedient to enter the length of the range in which deformations are allowed to occur.

#### A.3.4.2 For part B

All the tolerances determined from the tables, but for the single thickness dimension involved only the larger variations according to the exceptional ruling, are entered in the column of the table belonging to part B. With regard to parting line fins and local deformation, the provisions of 8.1 apply. Trimming burrs are not permitted.

#### A.3.4.3 For the forging

The tolerances for the length are entered against the dimension on the forging drawing and the permissible straightness in the corresponding column of the table.

It is recommended that the diameter tolerances for the non-shaped shaft should also be entered on the forging drawing.