BRITISH STANDARD

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Incorporating Amendment Nos. 1 and 2

CONFIRMED
SEPTEMBER 1984

Specification for

Dimensional and quantity tolerances for steel drop and press forgings and for upset forgings made on horizontal forging machines

UDC 699.14 – 4 – 134:621.753.1 – 181

Co-operating organizations

The Iron and Steel Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

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British Cast Iron Research Association
British Construction Steelwork Association
British Electrical and Allied Manufacturers' Association
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The industrial organizations marked with an asterisk in the above list, together with the following were directly represented on the committee entrusted with the preparation of this British Standard:

British Internal Combustion Engine Manufacturers' Association
British Valve Manufacturers' Association
Machine Tool Trades Association

This British Standard, having been approved by the Iron and Steel Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 30 January 1967

The following BSI references relate to the work on this standard:
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Contents

Foreword

This standard makes reference to the following British Standards:

BS 2045, *Preferred numbers.*

BS 4114, *CM. Special slide rule for calculating tolerances (Metric units).*

BS 4114, *CI. Special slide rule for calculating tolerances (Inch units).*

This British Standard has been authorized by the Iron and Steel Industry Standards Committee. It is based on the co-operative project undertaken by the French, German and United Kingdom Drop Forging Associations.

Due acknowledgement is made to the work of the National Association of Drop Forgers and Stampers who were the instigators of the work which resulted in the proposals being prepared by the Special Tolerances Committee set up by the "Euroforge" Technical Committee.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 35 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Section 1. Dimensional tolerances for steel drop and press forgings

Scope

This British Standard specifies the dimensional and quantity tolerances for steel drop and press forgings and for upset forgings made on horizontal forging machines.

The tables showing dimensional tolerances in the British and metric system of measurement are not direct conversions as both are based on the R20 series of preferred numbers[1)].

1 General remarks — drop and press forgings

1.1 Scope of Section 1. This section applies to hot drop forgings, as delivered, made in carbon and alloy steels under hammers and presses. The tolerances specified apply to forgings not exceeding 250 kg (560 lb) in weight or 2 500 mm (100 in) maximum dimension. Tolerances for heavier or larger forgings are subject to negotiation.

The tolerances shown in this section cover both forgings to normal requirements and forgings to a closer range of tolerances. However, there are certain to be occasional instances which necessitate the use of tolerances wider than those indicated, e.g. specially complicated designs and 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.

Reference is made under "Special tolerances" to the procedure for dealing with requirements for tolerances closer than those given in the standard.

1.2 Tolerance grades. Alternative grades, F and E, of tolerances are provided for the various categories of dimensions as follows.

Quality F represents normal manufacturing standards for the production of steel drop forgings. This quality level can be achieved only by the use of sound production techniques and provides adequate dimensional accuracy for most applications.

Quality E provides closer tolerances to assist in accommodating those instances in which the normal manufacturing standards are inadequate. While quality E (close) tolerances may be applied to all dimensions on one forging, it is more economical to apply them only to those specific dimensions on which closer tolerances are essential. This quality should not be specified unless the additional forging cost entailed can be justified by a consequent saving in overall cost.

1.3 Special tolerances. The standard does not include ranges of special tolerances. Such requirements usually necessitate supplementary operations, e.g. hot or cold coining.

Considerations of this nature, 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 Information required in determining tolerances — drop and press forgings

To determine the tolerances applicable to a given forging in accordance with Table 1 to Table 6 or Table 7 to Table 12 the following information is required in addition to the dimensions of the forging:

1) Weight of forging.

2) Shape of die line.

3) Type of steel used.

4) Shape complexity factor of forging.

1) The *forging weight* is calculated.

2) The *shape of die line* is determined as falling within one of the following categories:

EITHER Flat or symmetrically cranked.

OR Asymmetrically cranked.

(See Figure 1 for examples.)

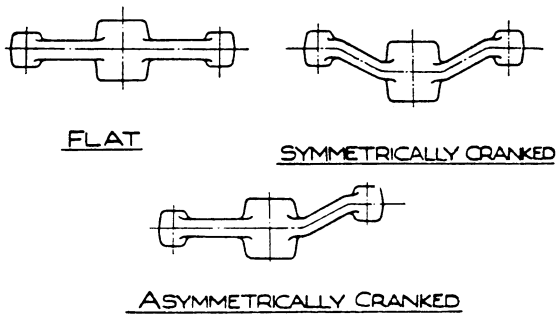


Figure 1 — Die lines

[1)] BS 2045 "*Preferred numbers*".

3) The *type of steel used* is determined as falling within one of the following categories:

EITHER 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 %.

OR M2 Steel with carbon content above 0.65 % *or* total of specified alloying elements (Mn, Ni, Cr, Mo, V, W) above 5 %.

To determine the category in which a steel falls, the maximum permitted contents of the elements in the steel specification shall be the values used.

4) The *complexity factor* of a forging is the ratio of the weight[2)] of the forging to the weight[2)] of the overall shape necessary to accommodate the maximum dimensions of the forging.

$$S = \frac{W_{forging}}{W_{overall\ shape}}$$

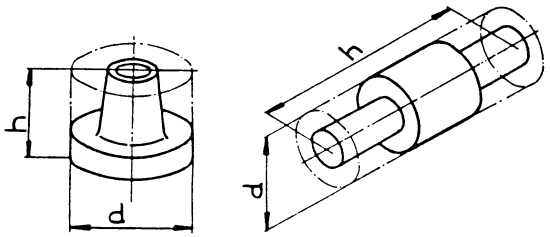


Figure 2 — Enveloping shapes of circular forgings

The enveloping shape of a *circular* forging (see Figure 2) is the circumscribing cylinder the weight of which is calculated from the formula:

$$W_{overall\ shape} = \frac{3.14d^2}{4}.h.\gamma$$

where γ = specific gravity (7.83 g/cm^2) (0.283 lb/in^3)

h = height, or length, of cylinder.

For a *non-circular* forging the overall shape is constituted by the smallest rectangular block that will encompass the forging (see Figure 3).

$W_{overall\ shape} = l.b.h.\gamma$

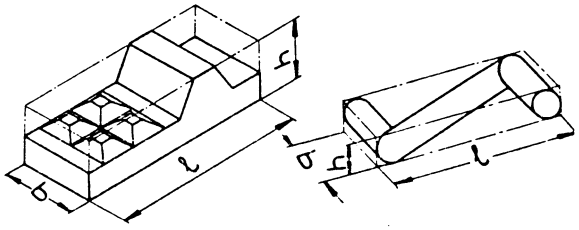


Figure 3 — Enveloping shapes of non-circular forgings

The resulting 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.

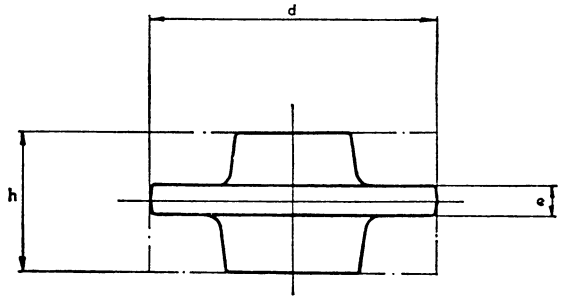
S2: Above 0.32 up to and including 0.63.

S1: Above 0.63 up to and including 1.

EXCEPTION

In determining the complexity factor for thin disks or flanges there is an exception to the above procedure when the expression e/d does not exceed 0.20, where d is the diameter and e is the corresponding thickness of the disk or flange.

In such cases the factor S4 is used; the weight to be taken into consideration is only that of a cylinder having diameter d and height e. This special procedure is not applied if larger tolerances will result from use of the normal procedure as shown in Clause **2** 4) (see Figure 4).



Exception based upon $\frac{e}{d} < 0{\cdot}2$ applies only if this provides larger tolerances than the normal procedure based on $d \times h$.

Figure 4 — Exception in determining complexity factor

[2)] If desired, the complexity factor may be calculated as the ratio of the volume of the forging to the volume of the overall shape.

3 Categories of tolerances — drop and press forgings

3.1 Scope of categories

3.1.1 ***First group of tolerances*** (Table 1 and Table 2 or Table 7 and Table 8)

Length, width and height tolerances
Mismatch tolerances
Residual flash (and trimmed flat) tolerances
Pierced hole tolerances.

3.1.2 ***Second group of tolerances*** (Table 3 and Table 4 or Table 9 and Table 10)

Thickness tolerances
Ejector mark tolerances.

3.1.3 ***Third group of tolerances*** (Table 5 or Table 11)

Straightness and flatness tolerances
Tolerances for centre-to-centre dimensions.

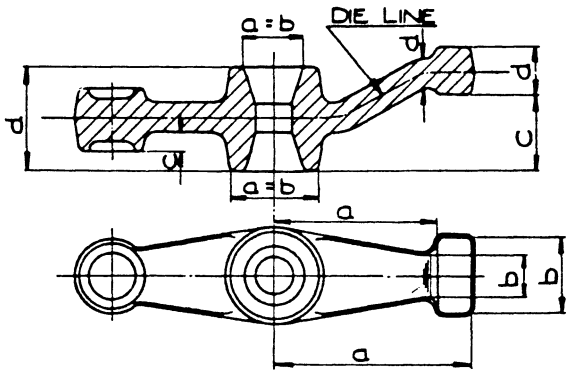
3.1.4 ***Other categories of tolerances***

Fillet and edge radii tolerances (Table 6 or Table 12)
Burr tolerances (Table 6 or Table 12)
Surface tolerances
Tolerances on draft angle surfaces
Eccentricity tolerances for deep holes
Tolerances for unforged stock
Tolerances for deformation of sheared ends.

3.2 Definition of categories

3.2.1 ***First group of tolerances*** (Table 1 and Table 2 or Table 7 and Table 8).

3.2.1.1 *Length, width and height tolerances* (see Figure 5).



a dimensions of length in one die
b dimensions of width in one die
c dimensions of height in one die
d dimensions of thickness across parting line

Figure 5 — Types of dimensions

Except for certain centre-to-centre dimensions (see **3.2.3.2**), length, width and height tolerances relate to all dimensions of length, width and height (including diameters) on one side of the parting line. All variations, including those due to die wear and shrinkage, are included in the length, width and height tolerances. Length and width tolerances are to be applied in directions parallel to the main die parting plane, or as nearly so as practical considerations will permit.

Length, width and height tolerances comprise the following:

Tolerances on dimensions to external and internal forged surfaces;

Tolerances on dimensions from an axis to a single surface;

Tolerances on dimensions of length, width and height of steps within one die.

Length, width and height tolerances are shown in Table 1 and Table 2 or Table 6 and Table 7 as applied to dimensions between external surfaces (see Figure 6), i.e. with a dispersion of + ⅔, – ⅓ for all length and width tolerances and also all height tolerances unless the more restrictive step height tolerances are required.

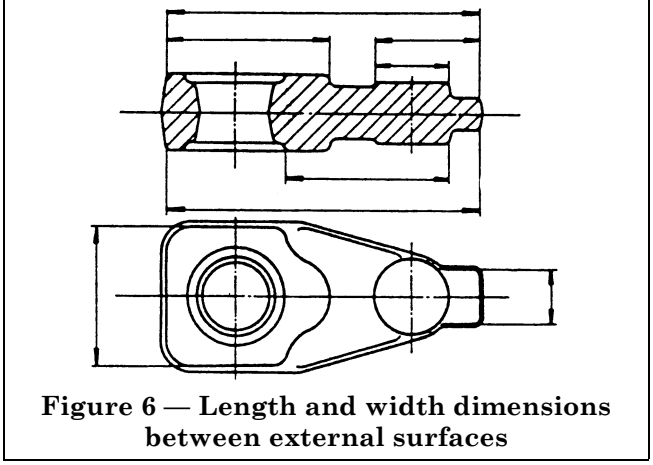


Figure 6 — Length and width dimensions between external surfaces

For dimensions between internal surfaces (see Figure 7), the signs should be reversed so that the tolerance dispersion is + ⅓, – ⅔.

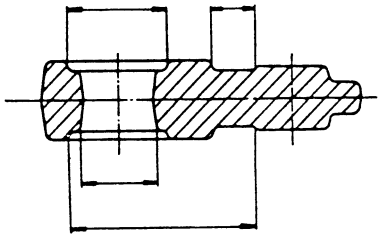


Figure 7 — Length and width dimensions between internal surfaces

When applying length, width and height tolerances to a forging, the tolerances for the *greatest* dimension of length (i.e. the overall length) should be applied, wherever possible, to *all* dimensions of length and similarly for dimensions of width and dimensions of height. 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 length), individual tolerances may be applied from Table 1 and Table 2 or Table 7 and Table 8 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.

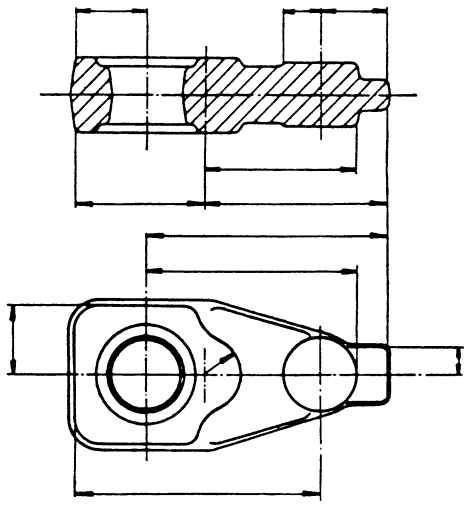


Figure 8 — Length and width dimensions from a centre to a surface

For dimensions from a centre to a surface (see Figure 8) and for dimensions on steps within one die, the tolerances for the greatest length, width and height shall apply wherever possible. Where more restrictive tolerances are required, they shall be indicated against the appropriate dimension on the drawing and shall be + ⅓, – ⅓ of the total tolerances shown in Table 1 and Table 2 or Table 7 and Table 8.

3.2.1.2 *Mismatch tolerances.* Mismatch tolerances indicate the permissible extent of misalignment between any point on one side of the parting line and the corresponding point on the opposite side, in directions parallel to the main parting line of the dies.

Mismatch tolerances are applied independently of any other tolerances.

Measurement. In measuring mismatch, accuracy depends upon making due allowance for surplus metal caused by uneven die wear. For that reason measurements should be made at areas of the forging least affected by die wear.

Formula for calculating mismatch. With reference to Figure 9, mismatch at any position relative to the length or width of a forging may be calculated as follows:

$$m = \frac{a_2 - a_1}{2}$$

where m = mismatch;

a_1 = lesser *projected* length or width dimension, measured parallel to the main parting line of the dies;

a_2 = corresponding greater *projected* length or width dimension, measured parallel to the main parting line of the dies.

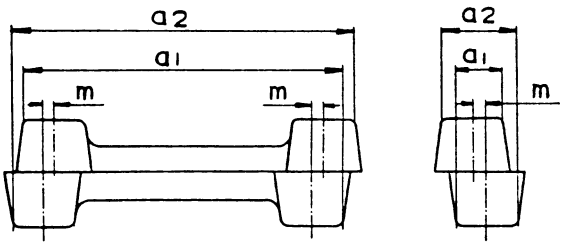


Figure 9 — Mismatch

3.2.1.3 *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 and Table 2 or Table 7 and Table 8. The residual flash is measured from the body of the forging to the trimmed edge of the flash, as indicated in Figure 10. The position of the trimmed flat is measured relative to the theoretical point at which the draft angles meet (see Figure 11).

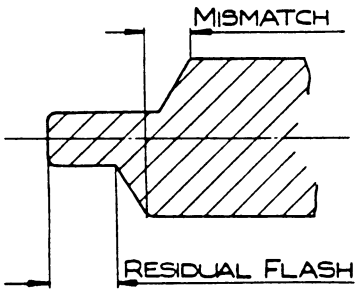


Figure 10 — Residual flash

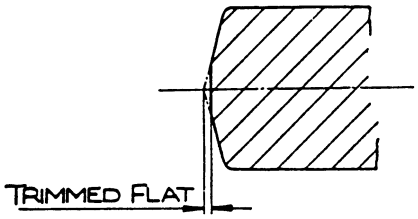


Figure 11 — Trimmed flat

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

3.2.1.4 *Pierced hole tolerances.* Tolerances for dimensions of pierced holes shall be taken from Table 1 or Table 2, or Table 7 or Table 8 but the positive and negative dispersions shall be reversed. Normally the tolerances for the greatest dimension of length (or diameter) of the forging will be applied but, if more restrictive tolerances are required, those for the specific dimension of the pierced hole may be used. In the latter case the tolerances shall be indicated against the appropriate dimension on the forging drawing.

3.2.2 ***Second group of tolerances*** (Table 3 and Table 4 or Table 9 and Table 10).

3.2.2.1 *Thickness tolerances* (see Figure 5). Thickness tolerances govern permissible variations in any dimension which crosses the parting line of the dies. All variations in thickness, due to die-closure, die-wear and shrinkage are included in the thickness tolerances.

The characteristics of the drop forging process require that, for any given forging, *all* tolerances for thickness dimensions are uniform. The tolerances are determined from Table 3 and Table 4 or Table 9 and Table 10 in accordance with the *greatest* thickness dimension of the forging.

Where more restrictive tolerances are required for application to individual dimensions of thickness, supplementary operations are involved. Such special tolerances should be negotiated between the purchaser and the supplier in accordance with **1.3**.

EXCEPTION

In the case of forgings having a flange from which projects either a) a deep hub the height of which is more than 1.5 times its diameter or b) a non-circular projection, the height of which is more than 1.5 times its enveloping diameter, all thickness tolerances other than that of the overall thickness will be calculated as if the height of the hub or projection had been equal only to 1.5 times its diameter (or enveloping diameter) and *not* to the greatest thickness dimension (see Figure 12).

3.2.2.2 *Ejector mark tolerances.* When forging dies incorporate ejectors, an allowance is required for the marks made on the forgings; these marks may be either sunken or raised. The total tolerances permitted are shown in Table 3 and Table 4 or Table 9 and Table 10.

The height or the depth of an ejector mark, relative to the surrounding surface, shall not exceed one-half of the total tolerance permitted, unless stated otherwise on the agreed forging drawing.

The nominal diameter and the location of ejector marks will be indicated to the purchaser on the forging drawing before the commencement of production.

Ejector mark tolerances are applied independently of, and in addition to, any other tolerances.

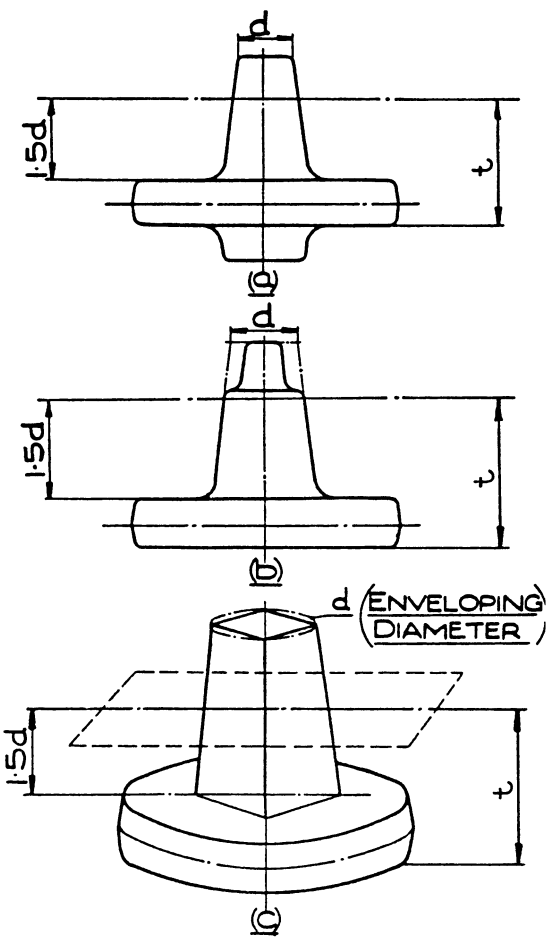


Figure 12 — Application of thickness tolerances to deep hubs. Base all thickness tolerances except those for overall thickness on dimension t shown above

3.2.3 ***Third group of tolerances*** (Table 5 or Table 11)

3.2.3.1 *Straightness and flatness tolerances.* Straightness tolerances relate to deviations of centre lines from the specified contour (see Figure 13). Flatness tolerances relate to deviations of surfaces from the specified contour.

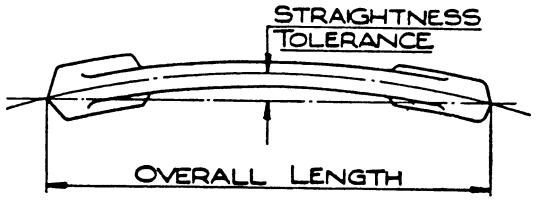


Figure 13 — Application of straightness tolerances

When straightness tolerances or flatness tolerances are required, this shall be indicated on the agreed forging drawing.

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

3.2.3.2 *Tolerances for centre-to-centre dimensions.* The tolerances for centre-to-centre dimensions, up to and including 1 250 mm (50 in), shall be taken from Table 5 or Table 11 and shall be indicated against the appropriate dimension on the agreed forging drawing. When no tolerance is indicated against the dimension concerned, the tolerance for the *maximum* length (or width) of the forging shall be applied (from Table 1 or Table 2, or Table 7 or Table 8), but the dispersion will be plus and minus one-half of the total tolerance, and *not* as shown in the tables. For centre-to-centre dimensions greater than 1 250 mm (50 in) length, tolerances from Table 1 or Table 2, or Table 7 or Table 8, with equal plus and minus dispersions, shall be applied. The centre-to-centre tolerances provided in this standard apply only when a straight line joining the two centres falls within the profile of the forging (see Figure 14).

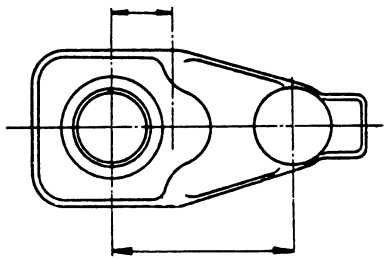


Figure 14 — Dimensions to which centre-to-centre tolerances are applicable

In other instances (see Figure 15) centre-to-centre tolerances, if required either by the purchaser or the supplier, shall be negotiated before the commencement of production.

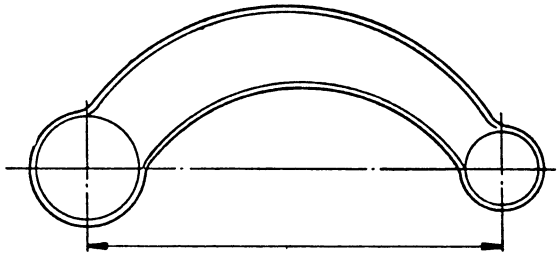


Figure 15 — Dimensions to which centre-to-centre tolerances are not applicable (other than by negotiation)

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

3.2.4 ***Other categories of tolerances***

3.2.4.1 *Fillet and edge radii tolerances* (Table 6 or Table 12). Sharp edges and corners on drop 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 6 or Table 12 and examples of such radii are shown in Figure 16.

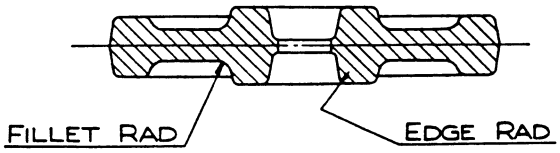


Figure 16 — Fillet and edge radii

The minus tolerances do not apply to edge radii up to and including 3 mm (⅛ in) when such radii are affected by subsequent removal of draft by trimming or punching. In such cases the minus tolerance is modified to allow for the formation of a square corner.

Tolerances for fillet and edge radii shown in Table 12 are applicable to both quality E and quality F.

3.2.4.2 *Burr tolerances* (Table 6 or Table 12). An allowance is made for the burr or drag formed, during trimming or punching, on the edges of certain forgings; for example, when an edge is close to the trim line. Tolerances for the maximum permissible extent of burr relative to such edges are based on the weight of the forging, in accordance with Table 6 or Table 12 and are applied unless the purchaser specifies otherwise. The location of burrs will be indicated to the purchaser on the forging drawing for approval before the commencement of production.

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

3.2.4.3 *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.

3.2.4.4 *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.

3.2.4.5 *Eccentricity tolerances for deep holes.* For a hole, the depth of which is greater than the greatest 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. Instances occur in which this tolerance is inadequate. In such cases, special tolerances shall be negotiated with the purchaser before the commencement of production.

Eccentricity tolerances for deep holes shall be applied in addition to the normal tolerances for mismatch (see Figure 17).

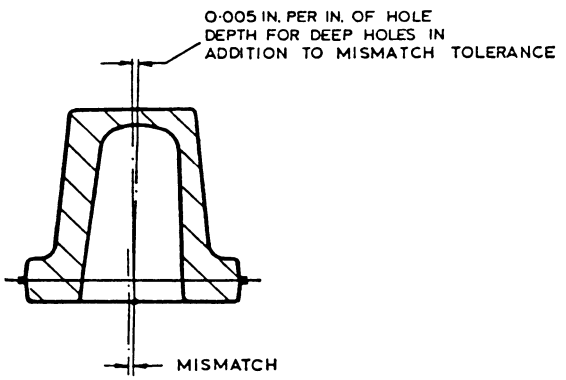


Figure 17 — Eccentricity tolerance for deep holes

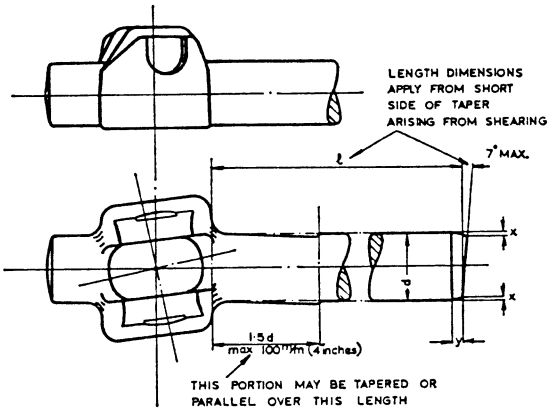


Figure 18 — Tolerances for unforged stock and sheared ends

3.2.4.6 *Tolerances for unforged stock* (Table 1 and Table 7). Unforged stock is that part of a forging which has not been intentionally deformed by the forging process.

When a forging incorporates a length of unforged stock, local deviations from the *actual* bar stock diameter or section are allowed adjacent to the forged portion.

The permissible increase or decrease in original *actual* diameter or section of bar stock adjoining such forged portions is the same as the tolerance applicable to the adjoining forged portion on dimensions at right angles to the polar axis of the unforged stock.

Instances occur in which the negative tolerances 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 tolerance is shown as a positive one.

The permissible length of local deviation from the bar stock diameter or section adjoining a forged portion shall be equivalent to 1.5 times the bar stock diameter or largest cross-sectional dimension, but with a maximum value of 100 mm (4 in) (see Figure 18).

When a forging is produced at the extremity of a portion of unforged stock, the length tolerance from any inner face of the forged portion to that extremity shall be determined from Table 1 and Table 7 employing material factor M1 and complexity factor S1. Only tolerances to grade F shall be applied. The weight of the total length in question shall be calculated as if of unforged stock, irrespective of whether this is the ease or not.

3.2.4.7 *Tolerances for deformation of sheared ends.* An allowance is made for distortion occurring 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 A and Figure 18.

Table A — Tolerances for deformation of sheared ends

Nominal stock diameter *(d)*		*x* **max.**	*y* **max.**
mm	in		
⩽ 36	⩽ 1.4	0.07*d*	*d*
> 36	> 1.4	0.05*d*	0.7*d*

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.

4 Use of tables — drop and press forgings

4.1 Table 1 and Table 2 or Table 7 and Table 8. Tolerances for length, width and height, residual flash (and trimmed flat), and mismatch. Normal tolerances to grade F are shown in Table 1 and Table 7 and close tolerances to grade E are shown in Table 2 and Table 8.

The same method applies for the use of all tables according to the grade of tolerances required.

To determine length, width and height tolerances, reference is first made to the appropriate category in the weight column. The horizontal line is then followed to the right. If the "difficulty of material" factor is M1, the same horizontal line is followed further to the right. If the "difficulty of material" factor 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 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 (wherever possible the *greatest* dimension of length, width or height — see **3.2.1.1**). (See also Figure 19.)

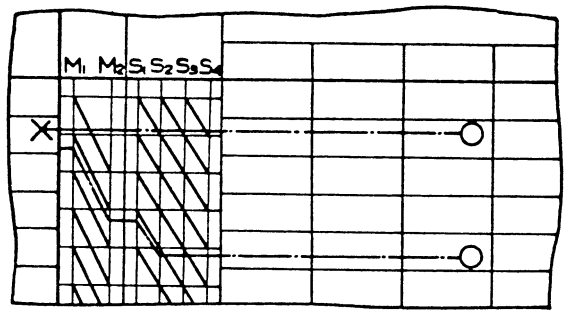


Figure 19 — Use of tables

To determine tolerances for residual flash (and trimmed flat) and for mismatch from Table 1 and Table 2 or Table 7 and Table 8 it is again necessary to commence at the appropriate category in the weight column, but then to move horizontally to the left in the table. According to whether the die line is flat/symmetrically cranked or asymmetrically cranked the correct tolerances for residual flash (and trimmed flat) and for mismatch are read from the appropriate columns.

4.2 Table 3 and Table 4 or Table 9 and Table 10. Tolerances for thickness and ejector marks. Normal tolerances to grade F are shown in Table 3 and Table 9 and close tolerances to grade E are shown in Table 4 and Table 10.

Tolerances for thickness, based on the greatest dimension of thickness, are obtained from the appropriate table for the grade required by the same method as that described above for length, width and height tolerances in Table 1 and Table 2 or Table 7 and Table 8.

Tolerances for ejector marks are obtained by referring to the appropriate category in the weight column and moving horizontally one column to the left.

4.3 Table 5 and Table 11. Tolerances for straightness and flatness; tolerances for centre-to-centre dimensions. Tolerances for straightness and flatness are obtained from the upper part of Table 5 or Table 11 by referring to the appropriate horizontal line for quality F or quality E, whichever is required, and by reading the tolerance under the vertical column heading for the dimension concerned.

Tolerances for centre-to-centre dimensions are obtained as indicated in **3.2.3.2**.

4.4 Table 6 and Table 12. Tolerances for fillet and edge radii; tolerances for burrs. 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 6 or Table 12. 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 burrs are shown in the lower part of Table 6 or Table 12. Reference is first made to the appropriate category in the weight column and the tolerances are read off from the vertical columns headed "a" and "b".

5 Design procedure — drop and press forgings

5.1 Information required by the forger. In order to assist the forging supplier 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.

5.2 Preparation of forging drawings. It is recommended that the drop 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 customer wishes to prepare his own fully dimensioned forging drawing, it is no less necessary that the drawing of the finished machined component and the other information referred to above should be made available to the supplier.

5.3 Indication of dimensions on forging drawings. It is imperative to note that, with the exception concerning draft angle surfaces referred to in **3.2.4.4**, the tolerances indicated in this 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 the 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.

5.4 Indication of tolerances on forging drawings. All forging drawings should be endorsed "Tolerances conform with BS 4114 unless otherwise indicated."

For correct endorsement of forging drawings the following form of presentation of tolerances at the foot of the drawing is recommended:

	Category	Tolerances
UNLESS OTHERWISE STATED	Length and overall diameters Widths Heights Mismatch Residual flash and trimmed flat Thickness Straightness Flatness Fillet and edge radii Surfaces	

Any tolerances which are only applicable to specific dimensions shall be indicated on the drawing against the particular dimensions concerned.

Ejector mark tolerances and burr tolerances should be shown on the forging drawing against the specific locations.

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

5.5 Importance of forging drawing. The drawing of the forged part which has been accepted by the customer 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.

Appendix A Deviations of form — drop and press forgings

The tolerances for lengths, widths, heights, and thicknesses cover not only the differences of dimensions, 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 fields of tolerances unless otherwise agreed between the supplier and the purchaser.

Where restrictions in deviations of form have been agreed, this shall be noted on the drawing.

Deviations of straightness or flatness as given in Table 5 or Table 11 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 **3.2.4.3**) nor any roughness of surface.

Section 2. Dimensional tolerances for steel upset forgings made on horizontal forging machines

6 General remarks — upset forgings

6.1 Scope of Section 2. This section applies to hot upset forgings, as delivered, made in carbon and alloy steels on horizontal forging machines.

The tolerances shown in this section cover upset forgings to normal requirements. However, there are certain to be occasional instances which 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.

Reference is made under "Special tolerances" to the procedure for dealing with requirements for tolerances closer than those given in the standard.

6.2 Special tolerances. This section does not include ranges of special tolerances. Considerations of this nature, 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 purchasers' special requirements at the lowest additional cost.

7 Definitions and principles of application — upset forgings

7.1 Definition of an upset portion of a forging. For the purpose of classification, an upset portion of a forging comprises 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 20).

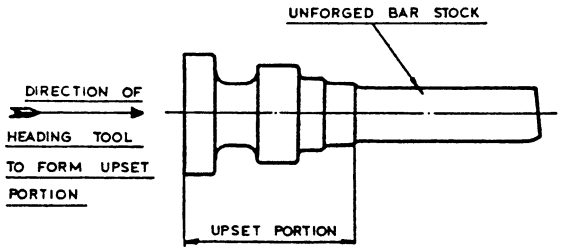


Figure 20 — An upset portion of a forging

7.2 Application of tolerances to double-ended upset forgings. In the case of double-ended upset forgings, where two separate upset portions have been forged from opposite directions, the upset portion at each end shall be considered as an independent forging for the purpose of classification (see Figure 21).

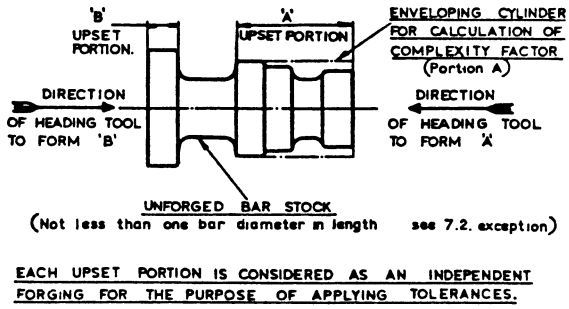


Figure 21 — A double-ended upset forging

EXCEPTION

If such a forging has either no unforged stock (see **7.3**) 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.

7.3 Definition of unforged stock. For the purpose of classification any part of an upset forging which has been forged or formed prior to the upsetting operation shall be regarded as unforged stock (see Figure 22).

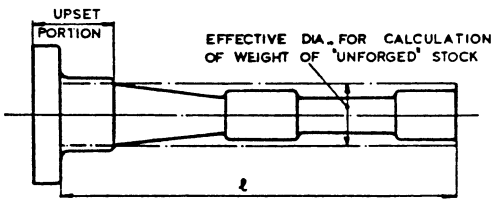


Figure 22 — "Unforged " stock

8 Information required in determining tolerances — upset forgings

To determine the tolerances applicable to a given upset forging, the following information is required in addition to the dimensions of the forgings:

1) Weight of given upset portion(s) and weight of "unforged" stock (if any) (see **7.3** and **9.2.1.3**).

2) Type of steel used.

3) Shape complexity factor for a given upset portion of a forging.

1) The *weight of the upset portion* is calculated.

2) The *type of steel used* is determined as falling in one of the following categories:

EITHER 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 %.

OR M2 Steel with carbon content above 0.65 % *or* total of specified alloying elements (Mn, Ni, Cr, Mo, V, W) above 5 %.

To determine the category in which a steel falls, the maximum permitted contents of the elements in the steel specification shall be the values used.

3) The *complexity factor* for a given upset portion of a forging (see Figure 21) is the ratio of the weight[3] of that portion to the weight[3] of the overall shape necessary to accommodate the maximum dimensions of that portion.

$$S = \frac{W_{forging}}{W_{overall\ shape}}$$

The enveloping shape of an upset portion (see Figure 23) is the enveloping cylinder the weight of which is calculated from the formula:

$$W_{overall\ shape} = \frac{3.14d^2}{4} \cdot h.\gamma$$

where γ = specific gravity (7.83 g/cm^2) (0.283 lb/in^3);

h = height, or length, of cylinder.

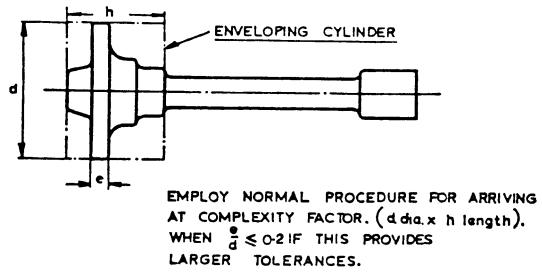


Figure 23 — Exception in determining complexity factor

The resulting 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

S1: Above 0.63 up to and including 1.

EXCEPTIONS

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

1) e/d up to and including 0.20,

2) e/d greater than 2,

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

In cases 1) and 2) the factor S4 is used and the weight is that of the cylinder $d \times e$ even if this is not the entire upset portion (see Figure 24).

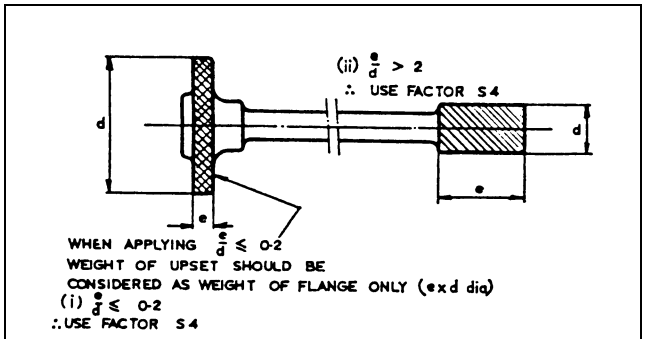


Figure 24 — Exception in determining complexity factor

This special procedure is not applied if larger tolerances will result from use of the normal procedure as shown in **8** 3), taking into account the whole of the upset portion (see Figure 23).

9 Categories of tolerances — upset forgings

9.1 Scope of categories

9.1.1 ***First group of tolerances*** (Table 1 or Table 7)

Diameter tolerances
Tolerances on step dimensions
Length tolerances
Tolerances for mismatch and eccentricity
Tolerances for local deviations from original bar stock diameter
Residual flash tolerances
Tolerances on internal dimensions including diameters of holes.

9.1.2 ***Second group of tolerances*** (Table 3 or Table 9) Thickness tolerances.

9.1.3 ***Third group of tolerances*** (Table 5 or Table 11)

Straightness and flatness tolerances
Tolerances for centre-to-centre dimensions.

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

9.1.4 ***Other categories of tolerances***

Fillet and edge radii tolerances (Table 6 or Table 12)

Tolerances for parting line fins and trimming burrs (Table 6 or Table 12)

Eccentricity tolerances for deep holes

Tolerances for deformation of sheared ends

Surface tolerances

Tolerances on draft angle surfaces.

9.2 Definition of categories

9.2.1 ***First group of tolerances*** (Table 1 or Table 7)

9.2.1.1 *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 or Table 7. In the case of asymmetric forgings, the tolerances for the diameter of the enveloping cylinder are applicable. For external dimensions the tolerance dispersions are as shown in the table.

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 25).

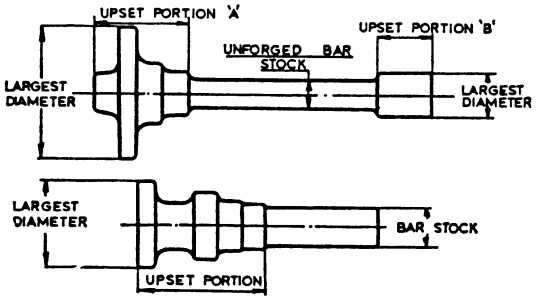


Figure 25 — Application of tolerances based upon the largest diameter of an upset portion

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 or Table 7 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.

9.2.1.2 *Tolerances on step dimensions.* 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 or Table 7 with a dispersion of + ⅔, –⅓ 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 + ⅓, – ⅓ of the total tolerances shown in Table 1 or Table 7 (see Figure 26).

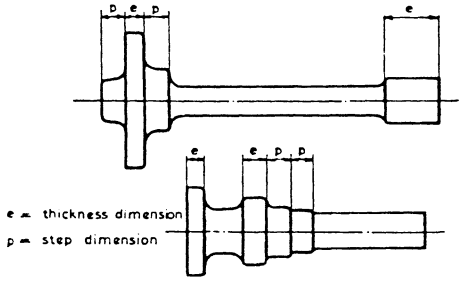


Figure 26 — Step and thickness dimensions

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.

9.2.1.3 *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 consisted of unforged stock (see Figure 27).

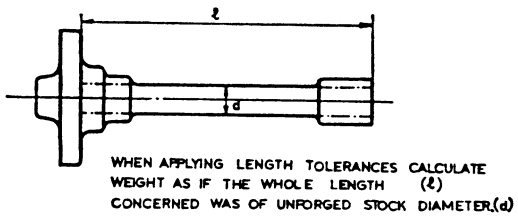


Figure 27 — Length tolerances

When the "unforged" stock varies in diameter, e.g. as a result of any other forming operation, the weight 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 22).

Length tolerances are taken from Table 1 or Table 7. 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 Figure 28 and Figure 29).

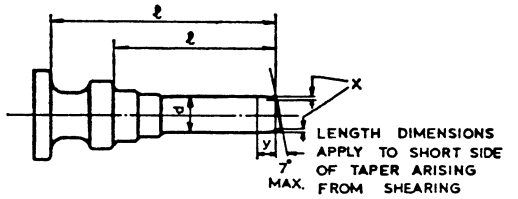


Figure 28 — Typical length dimensions and tolerances for deformation of sheared ends

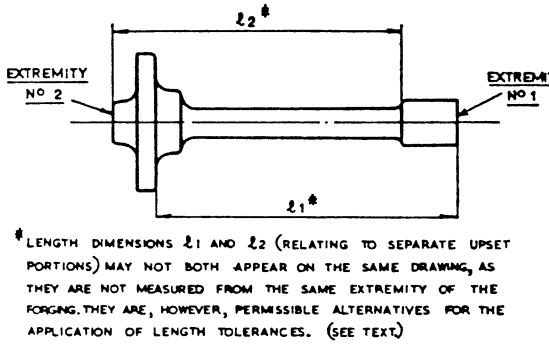


Figure 29 — Application of length tolerances to double-ended upset forgings

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 28).

9.2.1.4 *Tolerances for mismatch and eccentricity* (see Figure 30).

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 parting line of the gripping dies.

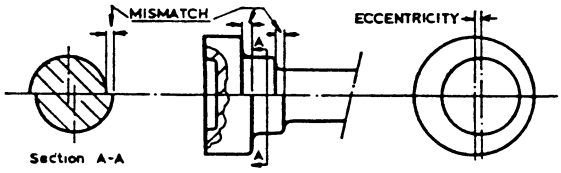


Figure 30 — Mismatch and eccentricity

Tolerances for mismatch are taken from Table 1 or Table 7. Eccentricity tolerances indicate the permissible extent of axial displacement of contours formed by the heading tool, relative to the polar 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.

9.2.1.5 *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 tolerances 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 tolerance is shown as a positive one.

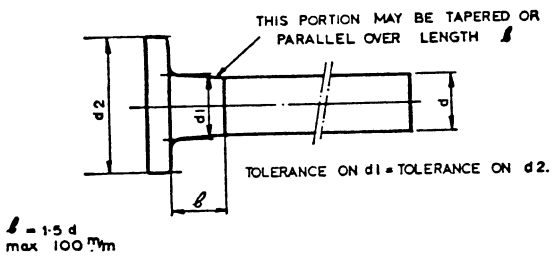


Figure 31 — Local deviations from original actual bar stock diameter

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 (4 in) (see Figure 31).

9.2.1.6 *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 Table 7. The residual flash is measured from the body of the forging to the trimmed edge of the flash, as indicated in Figure 32.

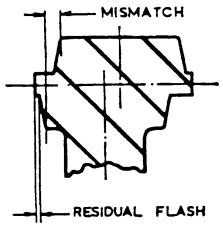


Figure 32 — Residual flash

The position of the trimmed flat is measured relative to the theoretical point at which the draft angles meet (see Figure 33).

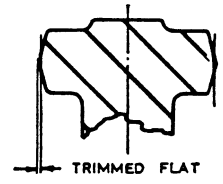


Figure 33 — Trimmed flat

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

9.2.1.7 *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 or Table 7, but the positive and negative dispersions 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.

9.2.2 ***Second group of tolerances*** (Table 3 or Table 9)

9.2.2.1 *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 3 or 9.

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 will be calculated as if the length of the projection had been equal only to 1.5 times its diameter (see Figure 34).

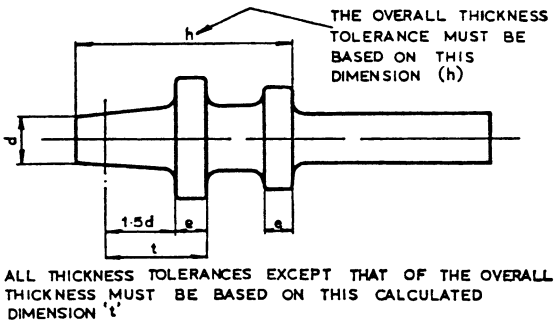


Figure 34 — Exception to application of thickness tolerances

If there are such projections on each side of the flange, the calculation is based on the projection having the larger diameter.

9.2.3 ***Third group of tolerances*** (Table 5 or Table 11)

9.2.3.1 *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.

9.2.3.2 *Tolerances for centre-to-centre dimensions.* Tolerances for centre-to-centre dimensions are taken from Table 5 or Table 11. In all cases the centre-to-centre tolerances provided in 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 polar axis of the forging (see Figure 35).

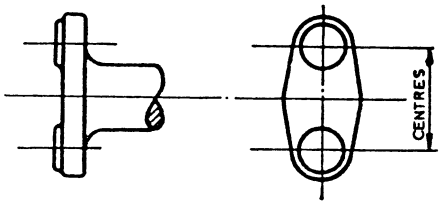


Figure 35 — Tolerances for centre-to-centre dimensions

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.

9.2.4 ***Other categories of tolerances***

9.2.4.1 *Fillet and edge radii tolerances* (Table 6 or Table 12). Sharp edges and corners 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 5 or Table 12 and examples of such radii are shown in Figure 36.

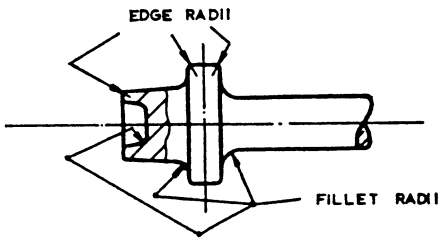


Figure 36 — Fillet and edge radii

The minus tolerances do not apply to edge radii up to and including 3 mm (⅛ in) where such radii are affected by subsequent removal of draft by trimming and punching. In such cases the minus tolerance is modified to allow for the formation of a square corner.

9.2.4.2 *Tolerances for parting line fins and trimming burrs* (Table 6 or Table 12). An allowance is made for parting line fins and trimming burrs formed at grip and header die parting lines (see Figure 37).

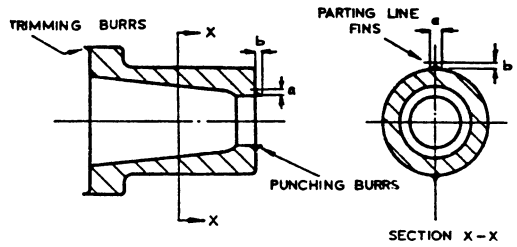


Figure 37 — Trimming burrs, punching burrs, and parting line fins

Tolerances for the maximum permissible extent of such burrs or fins are based on the weight of the upset portion of the forging and are in accordance with Table 6 or Table 12 (burr tolerances). 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 38.

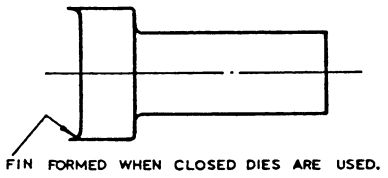


Figure 38 — Fin

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

9.2.4.3 *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 39).

Eccentricity tolerances for deep holes shall be applied in addition to the normal tolerances for eccentricity.

9.2.4.4 *Tolerances for deformation of sheared ends.* An allowance is made for distortion occurring 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 B and Figure 28.

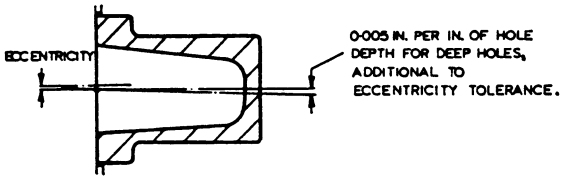


Figure 39 — Eccentricity tolerance for deep holes

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.

Table B — Tolerances for deformation of sheared ends

Nominal stock diameter*(d)*		*x* **max.**	*y* **max.**
mm	in		
⩽ 36	⩽ 1.4	0.07*d*	*d*
> 36	> 1.4	0.05*d*	0.7*d*

9.2.4.5 *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.

9.2.4.6 *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.

10 Use of tables-upset forgings

10.1 Table 1 and Table 7. Tolerances for diameter, length, residual flash (and trimmed flat), mismatch and eccentricity. Tolerances are shown in Table 1 or Table 7. To determine diameter and length tolerances reference is first made to the appropriate category in the weight column. The horizontal line is then followed to the right. If the "difficulty of material" factor is M1, the same horizontal line is followed further to the right. If the "difficulty of material" factor 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 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 40).

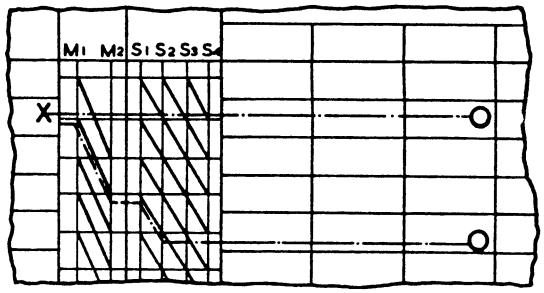


Figure 40 — Use of tables

To determine tolerances for a) residual flash (and trimmed flat) and b) for mismatch or eccentricity from Table 1 or Table 7 it is again necessary to commence at the appropriate category in the weight 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 flat/symmetrically cranked or asymmetrically cranked the correct tolerances for residual flash (and trimmed flat) and for mismatch are read from the appropriate columns.

10.2 Table 3 and Table 9. Tolerances for thickness. Tolerances are shown in Table 3 and Table 9. Tolerances for thickness are obtained from the table by the same method as that described above for diameter, length tolerances, etc., in Table 1 or Table 7.

10.3 Table 5 and Table 11. Tolerances for straightness and flatness; tolerances for centre-to-centre dimensions. Tolerances for straightness and flatness are obtained from the upper part of Table 5 and Table 11 by referring to the appropriate horizontal line for quality F 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 5 or Table 11 by referring to the appropriate horizontal line for quality F, and by reading the tolerance under the vertical column heading for the dimension concerned.

10.4 Table 6 and Table 12. Tolerances for fillet and edge radii; tolerances for parting line fins and trimming burrs. 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 6 or Table 12. 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 parting line fins and trimming burrs are shown in the lower part of Table 6 or Table 12. Reference is first made to the appropriate category in the weight column and the tolerances are read off from the vertical columns headed "a" and "b".

11 Design procedure — upset forgings

11.1 General. In arriving at a suitable design procedure for upset forgings, **5.1**, **5.2**, **5.3** and **5.5** for hammer and press forgings apply.

11.2 Indication of tolerances on drawings for upset forgings. All drawings for upset forgings should be endorsed "Tolerances conform to BS 4114 unless otherwise indicated."

For correct endorsement of forging drawings the following form of presentation of tolerances at the foot of the drawing is recommended:

UNLESS OTHERWISE STATED	Tolerance category	Upset portion A	Upset portion B
	External dimensions Step dimensions		
	Mismatch and eccentricity		
	Local deviations from actual bar stock diameter		
	Residual flash		
	Internal dimensions		
	Fillet and edge radii		
	Surfaces		

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 parting 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 supplier shall be indicated clearly on the forging drawing and will, wherever possible, be indicated against the specific dimensions concerned.

Appendix B Deviations of form — upset forgings

The tolerances for lengths, diameters, steps and thicknesses cover not only the differences of dimensions, 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 fields of tolerances unless otherwise agreed between the supplier and the purchaser.

Where restrictions in deviations of form have been agreed, this must be noted on the drawing.

Deviations of straightness or flatness as given in Table 5 or Table 11 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 **9.2.4.5**) nor any roughness of surface.

Section 3. Tables of tolerances for use when specifying in metric units

NOTE The tolerances shown in Table 1 to Table 6 can be calculated by means of a slide rule BS 4114 CM.

Table 1 — Length, width, height, mismatch, residual flash and trimmed flat of drop, press and upset forgings (normal tolerances)

DROP, PRESS & UPSET FORGINGS – TOLERANCES FOR: LENGTH, WIDTH & HEIGHT*

MISMATCH; RESIDUAL FLASH & TRIMMED FLAT (*DIA & LENGTH FOR UPSET FORGINGS)

NOTE: CENTRE TO SURFACE; STEP IN ONE DIE; $+\frac{1}{3}$, $-\frac{1}{3}$ OF TOTAL TOLERANCE (BUT SEE CLAUSES 3.2.1.1 AND 9.2.1.2)

INTERNAL DIMENSION: REVERSE + AND – SIGNS.

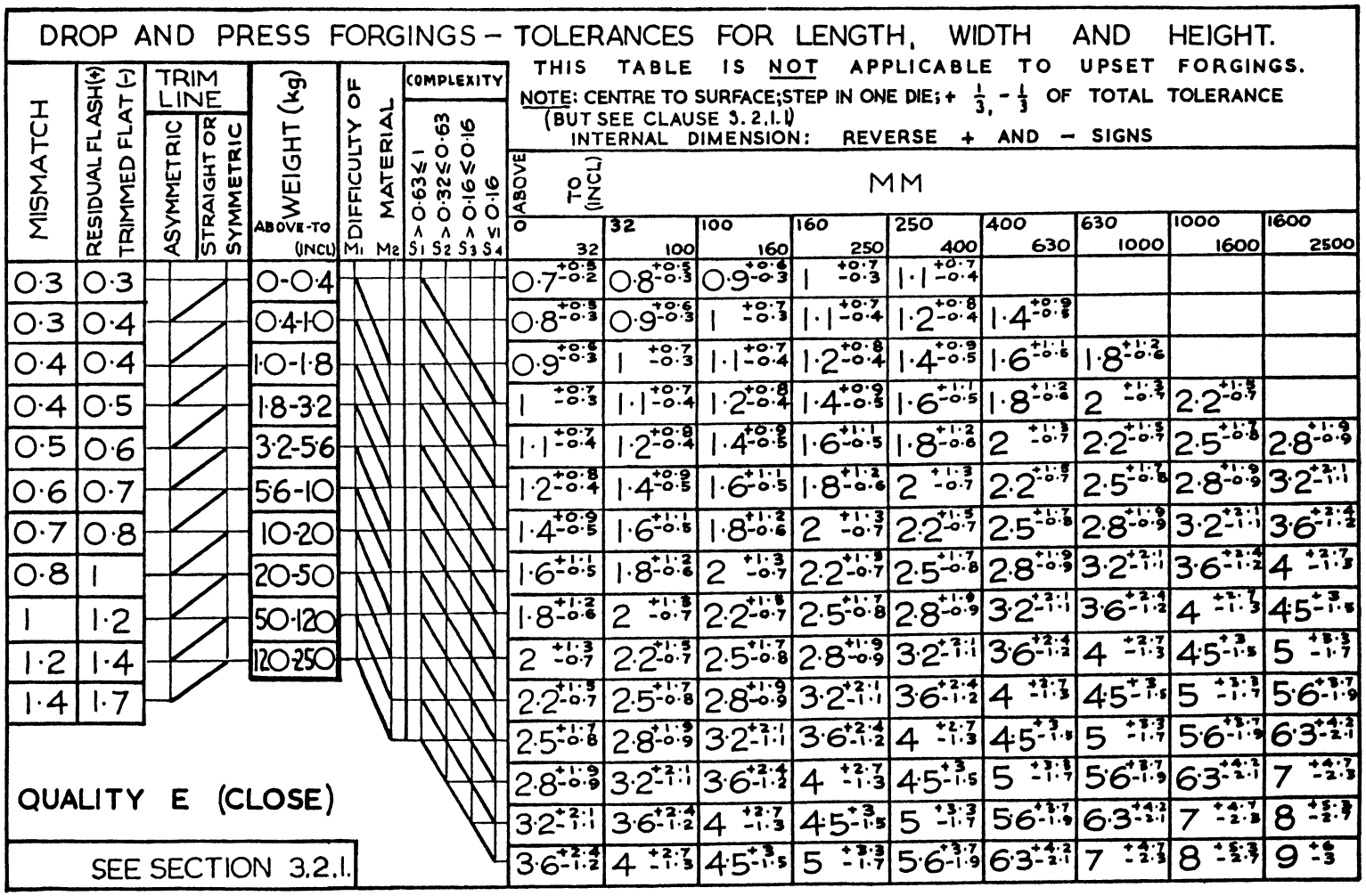
MISMATCH	RESIDUAL FLASH (+) TRIMMED FLAT (–)	TRIM LINE: ASYMMETRIC	TRIM LINE: STRAIGHT OR SYMMETRIC	WEIGHT (kg) ABOVE-TO (INCL.)	DIFFICULTY OF MATERIAL M1	DIFFICULTY OF MATERIAL M2	COMPLEXITY S1 >0·63 ≤ 1	COMPLEXITY S2 >0·32 ≤ 0·63	COMPLEXITY S3 >0·16 ≤ 0·32	COMPLEXITY S4 ≤0·16
0·4	0·5			0-0·4						
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			3·2-5·6						
1	1·2			5·6-10						
1·2	1·4			10-20						
1·4	1·7			20-50						
1·7	2			50-120						
2	2·4			120-250						
2·4	2·8									

QUALITY F (NORMAL)

SEE SECTIONS 3.2.1, AND 9.2.1.

MM: ABOVE	TO (INCL.)	0 – 32	32 – 100	100 – 160	160 – 250	230 – 400	400 – 630	630 – 1000	1000 – 1600	1600 – 2500
		$1{\cdot}1^{+0{\cdot}7}_{-0{\cdot}4}$	$1{\cdot}2^{+0{\cdot}8}_{-0{\cdot}4}$	$1{\cdot}4^{+0{\cdot}9}_{-0{\cdot}6}$	$1{\cdot}6^{+1{\cdot}1}_{-0{\cdot}5}$	$1{\cdot}8^{+1{\cdot}2}_{-0{\cdot}6}$	$2^{+1{\cdot}3}_{-0{\cdot}7}$			
		$1{\cdot}2^{+0{\cdot}8}_{-0{\cdot}4}$	$1{\cdot}4^{+0{\cdot}9}_{-0{\cdot}5}$	$1{\cdot}6^{+1{\cdot}1}_{-0{\cdot}5}$	$1{\cdot}8^{+1{\cdot}2}_{-0{\cdot}6}$	$2^{+1{\cdot}3}_{-0{\cdot}7}$	$2{\cdot}2^{+1{\cdot}5}_{-0{\cdot}7}$			
		$1{\cdot}4^{+0{\cdot}8}_{-0{\cdot}5}$	$1{\cdot}6^{+1{\cdot}1}_{-0{\cdot}5}$	$1{\cdot}8^{+1{\cdot}2}_{-0{\cdot}6}$	$2^{+1{\cdot}3}_{-0{\cdot}7}$	$2{\cdot}2^{+1{\cdot}5}_{-0{\cdot}7}$	$2{\cdot}5^{+1{\cdot}7}_{-0{\cdot}8}$	$2{\cdot}8^{+1{\cdot}9}_{-0{\cdot}9}$		
		$1{\cdot}6^{+1{\cdot}1}_{-0{\cdot}5}$	$1{\cdot}8^{+1{\cdot}2}_{-0{\cdot}6}$	$2^{+1{\cdot}3}_{-0{\cdot}7}$	$2{\cdot}2^{+1{\cdot}5}_{-0{\cdot}7}$	$2{\cdot}5^{+1{\cdot}7}_{-0{\cdot}8}$	$2{\cdot}8^{+1{\cdot}9}_{-0{\cdot}9}$	$3{\cdot}2^{+2{\cdot}1}_{-1{\cdot}1}$	$3{\cdot}6^{+2{\cdot}4}_{-1{\cdot}2}$	
		$1{\cdot}8^{+1{\cdot}2}_{-0{\cdot}6}$	$2^{+1{\cdot}3}_{-0{\cdot}7}$	$2{\cdot}2^{+1{\cdot}5}_{-0{\cdot}7}$	$2{\cdot}5^{+1{\cdot}7}_{-0{\cdot}8}$	$2{\cdot}8^{+1{\cdot}9}_{-0{\cdot}9}$	$3{\cdot}2^{+2{\cdot}1}_{-1{\cdot}1}$	$3{\cdot}6^{+2{\cdot}4}_{-1{\cdot}2}$	$4^{+2{\cdot}7}_{-1{\cdot}3}$	$4{\cdot}5^{+3}_{-1{\cdot}5}$
		$2^{+1{\cdot}3}_{-0{\cdot}7}$	$2{\cdot}2^{+1{\cdot}5}_{-0{\cdot}7}$	$2{\cdot}5^{+1{\cdot}7}_{-0{\cdot}8}$	$2{\cdot}8^{+1{\cdot}9}_{-0{\cdot}9}$	$3{\cdot}2^{+2{\cdot}1}_{-1{\cdot}1}$	$3{\cdot}6^{+2{\cdot}4}_{-1{\cdot}2}$	$4^{+2{\cdot}7}_{-1{\cdot}3}$	$4{\cdot}5^{+3}_{-1{\cdot}5}$	$5^{+3{\cdot}3}_{-1{\cdot}7}$
		$2{\cdot}2^{+1{\cdot}5}_{-0{\cdot}7}$	$2{\cdot}5^{+1{\cdot}7}_{-0{\cdot}8}$	$2{\cdot}8^{+1{\cdot}9}_{-0{\cdot}9}$	$3{\cdot}2^{+2{\cdot}1}_{-1{\cdot}1}$	$3{\cdot}6^{+2{\cdot}4}_{-1{\cdot}2}$	$4^{+2{\cdot}7}_{-1{\cdot}3}$	$4{\cdot}5^{+3}_{-1{\cdot}5}$	$5^{+3{\cdot}3}_{-1{\cdot}7}$	$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$
		$2{\cdot}5^{+1{\cdot}7}_{-0{\cdot}8}$	$2{\cdot}8^{+1{\cdot}9}_{-0{\cdot}9}$	$3{\cdot}2^{+2{\cdot}1}_{-1{\cdot}1}$	$3{\cdot}6^{+2{\cdot}4}_{-1{\cdot}2}$	$4^{+2{\cdot}7}_{-1{\cdot}3}$	$4{\cdot}5^{+3}_{-1{\cdot}5}$	$5^{+3{\cdot}3}_{-1{\cdot}7}$	$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$	$6{\cdot}3^{+4{\cdot}2}_{-2{\cdot}1}$
		$2{\cdot}8^{+1{\cdot}9}_{-0{\cdot}9}$	$3{\cdot}2^{+2{\cdot}1}_{-1{\cdot}1}$	$3{\cdot}6^{+2{\cdot}4}_{-1{\cdot}2}$	$4^{+2{\cdot}7}_{-1{\cdot}3}$	$4{\cdot}5^{+3}_{-1{\cdot}5}$	$5^{+3{\cdot}3}_{-1{\cdot}7}$	$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$	$6{\cdot}3^{+4{\cdot}2}_{-2{\cdot}1}$	$7^{+4{\cdot}7}_{-2{\cdot}3}$
		$3{\cdot}2^{+2{\cdot}1}_{-1{\cdot}1}$	$3{\cdot}6^{+2{\cdot}4}_{-1{\cdot}2}$	$4^{+2{\cdot}7}_{-1{\cdot}3}$	$4{\cdot}5^{+3}_{-1{\cdot}5}$	$5^{+3{\cdot}3}_{-1{\cdot}7}$	$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$	$6{\cdot}3^{+4{\cdot}2}_{-2{\cdot}1}$	$7^{+4{\cdot}7}_{-2{\cdot}3}$	$8^{+5{\cdot}3}_{-2{\cdot}7}$
		$3{\cdot}6^{+2{\cdot}4}_{-1{\cdot}2}$	$4^{+2{\cdot}7}_{-1{\cdot}3}$	$4{\cdot}5^{+3}_{-1{\cdot}5}$	$5^{+3{\cdot}3}_{-1{\cdot}7}$	$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$	$6{\cdot}3^{+4{\cdot}2}_{-2{\cdot}1}$	$7^{+4{\cdot}7}_{-2{\cdot}3}$	$8^{+5{\cdot}3}_{-2{\cdot}7}$	9^{+6}_{-3}
		$4^{+2{\cdot}7}_{-1{\cdot}3}$	$4{\cdot}5^{+3}_{-1{\cdot}5}$	$5^{+3{\cdot}3}_{-1{\cdot}7}$	$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$	$6{\cdot}3^{+4{\cdot}2}_{-2{\cdot}1}$	$7^{+4{\cdot}7}_{-2{\cdot}3}$	$8^{+5{\cdot}3}_{-2{\cdot}7}$	9^{+6}_{-3}	$10^{+6{\cdot}7}_{-3{\cdot}3}$
		$4{\cdot}5^{+3}_{-1{\cdot}5}$	$5^{+3{\cdot}3}_{-1{\cdot}7}$	$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$	$6{\cdot}3^{+4{\cdot}2}_{-2{\cdot}1}$	$7^{+4{\cdot}7}_{-2{\cdot}3}$	$8^{+5{\cdot}3}_{-2{\cdot}7}$	9^{+6}_{-3}	$10^{+6{\cdot}7}_{-3{\cdot}3}$	$11^{+7{\cdot}3}_{-3{\cdot}7}$
		$5^{+3{\cdot}3}_{-1{\cdot}7}$	$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$	$6{\cdot}3^{+4{\cdot}2}_{-2{\cdot}1}$	$7^{+4{\cdot}7}_{-2{\cdot}3}$	$8^{+5{\cdot}3}_{-2{\cdot}7}$	9^{+6}_{-3}	$10^{+6{\cdot}7}_{-3{\cdot}3}$	$11^{+7{\cdot}3}_{-3{\cdot}7}$	12^{+8}_{-4}
		$5{\cdot}6^{+3{\cdot}7}_{-1{\cdot}9}$	$6{\cdot}3^{+4{\cdot}2}_{-2{\cdot}1}$	$7^{+4{\cdot}7}_{-2{\cdot}3}$	$8^{+5{\cdot}3}_{-2{\cdot}7}$	9^{+6}_{-3}	$10^{+6{\cdot}7}_{-3{\cdot}3}$	$11^{+7{\cdot}3}_{-3{\cdot}7}$	12^{+8}_{-4}	$14^{+9{\cdot}3}_{-4{\cdot}7}$

Table 2 — Length, width and height of drop and press forgings (close tolerances)



DROP AND PRESS FORGINGS – TOLERANCES FOR LENGTH, WIDTH AND HEIGHT.

THIS TABLE IS NOT APPLICABLE TO UPSET FORGINGS.

NOTE: CENTRE TO SURFACE; STEP IN ONE DIE; + $\frac{1}{3}$, − $\frac{1}{3}$ OF TOTAL TOLERANCE (BUT SEE CLAUSE 3.2.1.1)

INTERNAL DIMENSION: REVERSE + AND − SIGNS

MISMATCH	RESIDUAL FLASH (+) TRIMMED FLAT (−)	TRIM LINE: ASYMMETRIC	TRIM LINE: STRAIGHT OR SYMMETRIC	WEIGHT (kg) ABOVE – TO (INCL)	DIFFICULTY OF MATERIAL	COMPLEXITY
					≤ M2	S1 > 0·63 ≤ 1 · S2 > 0·32 ≤ 0·63 · S3 > 0·16 ≤ 0·16 · S4 ≤ 0·16
0·3	0·3			0–0·4		
0·3	0·4			0·4–1·0		
0·4	0·4			1·0–1·8		
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					

QUALITY E (CLOSE)

SEE SECTION 3.2.1.

MM: ABOVE 0 – TO (INCL) 32	32 – 100	100 – 160	160 – 250	250 – 400	400 – 630	630 – 1000	1000 – 1600	1600 – 2500
$0·7^{+0·5}_{-0·2}$	$0·8^{+0·5}_{-0·3}$	$0·9^{+0·6}_{-0·3}$	$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$				
$0·8^{+0·5}_{-0·3}$	$0·9^{+0·6}_{-0·3}$	$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$			
$0·9^{+0·6}_{-0·3}$	$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·6}$	$1·8^{+1·2}_{-0·6}$		
$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	
$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$
$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$
$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$
$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$
$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$
$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$
$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$
$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$	$6·3^{+4·2}_{-2·1}$
$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$	$6·3^{+4·2}_{-2·1}$	$7^{+4·7}_{-2·3}$
$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$	$6·3^{+4·2}_{-2·1}$	$7^{+4·7}_{-2·3}$	$8^{+5·3}_{-2·7}$
$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$	$6·3^{+4·2}_{-2·1}$	$7^{+4·7}_{-2·3}$	$8^{+5·3}_{-2·7}$	9^{+6}_{-3}

Table 3 — Thickness for drop, press and upset forgings and ejector marks for drop and press forgings (normal tolerances)

DROP, PRESS & UPSET FORGINGS – TOLERANCES FOR: THICKNESS; EJECTOR MARKS*

*(DROP AND PRESS FORGINGS ONLY)

EJECTOR MARKS	WEIGHT (kg) ABOVE – TO (INCL)	DIFFICULTY OF MATERIAL M1	DIFFICULTY OF MATERIAL M2	COMPLEXITY S1 > 0·63 ≤ 1	COMPLEXITY S2 > 0·32 ≤ 0·63	COMPLEXITY S3 > 0·16 ≤ 0·32	COMPLEXITY S4 ≤ 0·16
1	0-0·4						
1·2	0·4-1·2						
1·6	1·2-2·5						
2	2·5-5						
2·4	5-8						
3·2	8-12						
4	12-20						
5	20-36						
6·4	36-63						
8	63-110						
10	110-200						
12·6	200-250						

QUALITY F (NORMAL)

SEE SECTIONS 3.2.2. AND 9.2.2.

ABOVE (0) – TO (INCL) 16	16 – 40	40 – 63	63 – 100	100 – 160	160 – 250	> 250
MM	MM	MM	MM	MM	MM	MM
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 $^{+1.3}_{-0.7}$
1·1 $^{+0.7}_{-0.4}$	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 $^{+1.5}_{-0.7}$
1·2 $^{+0.8}_{-0.4}$	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 $^{+1.7}_{-0.8}$
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 $^{+1.9}_{-0.9}$
1·6 $^{+1.1}_{-0.5}$	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 $^{+2.1}_{-1.1}$
1·8 $^{+1.2}_{-0.6}$	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 $^{+2.4}_{-1.2}$
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 $^{+2.7}_{-1.3}$
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 $^{+5.3}_{-2.7}$
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 $^{+8}_{-4}$

Table 4 — Thickness and ejector marks for drop and press forgings (close tolerances)

DROP AND PRESS FORGINGS – TOLERANCES FOR THICKNESS AND EJECTOR MARKS

THIS TABLE IS NOT APPLICABLE TO UPSET FORGINGS

EJECTOR MARKS	WEIGHT (kg) ABOVE-TO (INCL)	DIFFICULTY OF MATERIAL M1 M2	COMPLEXITY S1 >0·63≤1	S2 >0·32≤0·63	S3 >0·16≤0·32	S4 ≤0·16
1	0-0·4					
1·2	0·4-1·2					
1·6	1·2-2·5					
2	2·5-5					
2·4	5-8					
3·2	8-12					
4	12-20					
5	20-36					
6·4	36-63					
8	63-110					
10	110-200					
12·6	200-250					

QUALITY E (CLOSE)

SEE SECTION 3.2.2.

MM ABOVE	0	16	40	63	100	160	250
TO (INCL)	16	40	63	100	160	250	> 250
0	$0·6^{+0·4}_{-0·2}$	$0·7^{+0·5}_{-0·2}$	$0·8^{+0·5}_{-0·3}$	$0·9^{+0·6}_{-0·3}$	$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$
16	$0·7^{+0·5}_{-0·2}$	$0·8^{+0·5}_{-0·3}$	$0·9^{+0·6}_{-0·3}$	$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$
40	$0·8^{+0·5}_{-0·3}$	$0·9^{+0·6}_{-0·3}$	$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$
63	$0·9^{+0·6}_{-0·3}$	$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$
100	$1^{+0·7}_{-0·3}$	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$
160	$1·1^{+0·7}_{-0·4}$	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$
250	$1·2^{+0·8}_{-0·4}$	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$
> 250	$1·4^{+0·9}_{-0·5}$	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$
	$1·6^{+1·1}_{-0·5}$	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$
	$1·8^{+1·2}_{-0·6}$	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$
	$2^{+1·3}_{-0·7}$	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$
	$2·2^{+1·5}_{-0·7}$	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$
	$2·5^{+1·7}_{-0·8}$	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$
	$2·8^{+1·9}_{-0·9}$	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$
	$3·2^{+2·1}_{-1·1}$	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$	$6·3^{+4·2}_{-2·1}$
	$3·6^{+2·4}_{-1·2}$	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$	$6·3^{+4·2}_{-2·1}$	$7^{+4·7}_{-2·3}$
	$4^{+2·7}_{-1·3}$	$4·5^{+3}_{-1·5}$	$5^{+3·3}_{-1·7}$	$5·6^{+3·7}_{-1·9}$	$6·3^{+4·2}_{-2·1}$	$7^{+4·7}_{-2·3}$	$8^{+5·3}_{-2·7}$

Table 5 — Straightness, flatness and centre to centre dimensions for drop, press and upset forgings

DROP, PRESS AND UPSET FORGINGS

NOTE. QUALITY E DOES NOT APPLY TO UPSET FORGINGS

RANGE OF TOLERANCES FOR STRAIGHTNESS AND FLATNESS

LENGTH ABOVE TO (INCL)		MM														
		0 100	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
QUALITY	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	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

RANGE OF TOLERANCES FOR CENTRE TO CENTRE DIMENSIONS

LENGTH ABOVE TO (INCL)		MM										
		0 100	100 160	160 200	200 250	250 315	315 400	400 500	500 630	630 800	800 1000	1000 1250
QUALITY	F	±0·3 0·6	±0·4 0·8	±0·5 1	±0·6 1·2	±0·8 1·6	±1 2	±1·2 2·4	±1·6 3·2	±2 4	±2·5 5	±3·2 6·4
	E	±0·25 0·5	±0·3 0·6	±0·4 0·8	±0·5 1	±0·6 1·2	±0·8 1·6	±1 2	±1·2 2·4	±1·6 3·2	±2 4	±2·5 5

SEE SECTIONS 3.2.3. AND 9.2.3.

Table 6 — Fillet, edge radii and burrs for drop, press and upset forgings

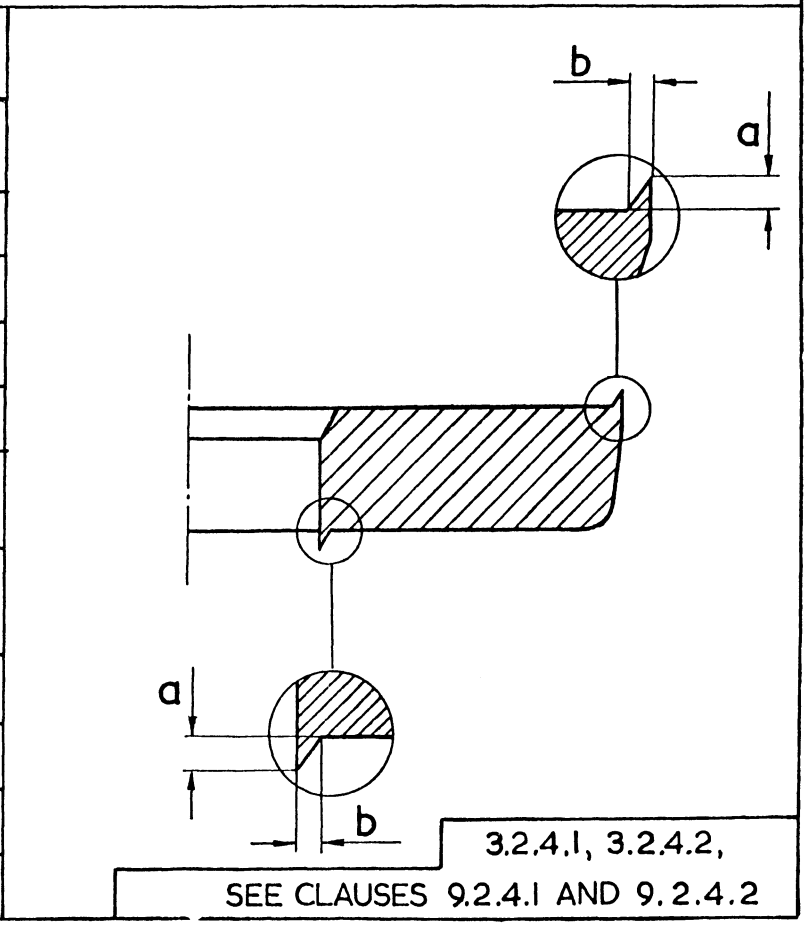
DROP, PRESS AND UPSET FORGINGS

FILLET AND EDGE RADII TOLERANCES

r MM ABOVE — TO (INCL)	+	−
0 — 10	50%	25%
10 — 32	40%	20%
32 — 100	32%	15%
> 100	25%	10%

BURR TOLERANCES
(AND PARTING LINE FINS FOR UPSET FORGINGS)

WEIGHT (kg) ABOVE — TO (INCL)	a	b
0 — 1	1	0·5
1 — 6	1·6	0·8
6 — 40	2·5	1·2
40 — 250	4	2



Section 4. Tables of tolerances for use when specifying in inch units

NOTE The tolerances shown in Table 7 to Table 12 can be calculated by means of a slide rule BS 4114 CI.

Table 7 — Length, width, height, mismatch, residual flash and trimmed flat of drop, press and upset forgings (normal tolerances)

DROP, PRESS & UPSET FORGINGS – TOLERANCES FOR: LENGTH, WIDTH & HEIGHT*
MISMATCH; RESIDUAL FLASH & TRIMMED FLAT. (* DIA. & LENGTH FOR UPSET FORGINGS)
NOTE: CENTRE TO SURFACE; STEP IN ONE DIE; + $\frac{1}{3}$ – $\frac{1}{3}$ OF TOTAL TOLERANCE (BUT SEE CLAUSES 3.2.1.1 AND 9.2.1.2)
INTERNAL DIMENSION: REVERSE + AND – SIGNS.

MISMATCH	RESIDUAL FLASH (+) TRIMMED FLAT (–)	WEIGHT (lb) ABOVE-TO (INCL)
016	020	0-0·9
020	025	0·9-2·2
025	028	2·2-4
028	032	4-7
032	040	7-12
040	050	12-22
050	056	22-45
056	070	45-110
070	080	110-250
080	100	250-560
100	110	

TRIM LINE: ASYMMETRIC / STRAIGHT OR SYMMETRIC

DIFFICULTY OF MATERIAL: M_1 M_2

COMPLEXITY: S_1 > 0·63 ⩽ 1; S_2 > 0·32 ⩽ 0·63; S_3 > 0·16 ⩽ 0·32; S_4 ⩽ 0·16

INCHES

ABOVE / TO (INCL)	0–1·2	1·2–4	4–6·3	6·3–10	10–16	16–25	25–40	40–63	63–100
	·045 +·030 –·015	·050 +·034 –·016	·056 +·038 –·018	·063 +·042 –·021	·070 +·047 –·023	·080 +·054 –·026			
	·050 +·034 –·016	·056 +·038 –·018	·063 +·042 –·021	·070 +·047 –·023	·080 +·054 –·026	·090 +·060 –·030			
	·056 +·038 –·018	·063 +·042 –·021	·070 +·047 –·023	·080 +·054 –·026	·090 +·060 –·030	·100 +·067 –·033	·110 +·074 –·036		
	·063 +·042 –·021	·070 +·047 –·023	·080 +·054 –·026	·090 +·060 –·030	·100 +·067 –·033	·110 +·074 –·036	·120 +·080 –·040	·140 +·094 –·046	
	·070 +·047 –·023	·080 +·054 –·026	·090 +·060 –·030	·100 +·067 –·033	·110 +·074 –·036	·120 +·080 –·040	·140 +·094 –·046	·160 +·107 –·053	·180 +·120 –·060
	·080 +·054 –·026	·090 +·060 –·030	·100 +·067 –·033	·110 +·074 –·036	·120 +·080 –·040	·140 +·094 –·046	·160 +·107 –·053	·180 +·120 –·060	·200 +·134 –·066
	·090 +·060 –·030	·100 +·067 –·033	·110 +·074 –·036	·120 +·080 –·040	·140 +·094 –·046	·160 +·107 –·053	·180 +·120 –·060	·200 +·134 –·066	·220 +·147 –·073
	·100 +·067 –·033	·110 +·074 –·036	·120 +·080 –·040	·140 +·094 –·046	·160 +·107 –·053	·180 +·120 –·060	·200 +·134 –·066	·220 +·147 –·073	·250 +·167 –·083
	·110 +·074 –·036	·120 +·080 –·040	·140 +·094 –·046	·160 +·107 –·053	·180 +·120 –·060	·200 +·134 –·066	·220 +·147 –·073	·250 +·167 –·083	·280 +·187 –·093
	·120 +·080 –·040	·140 +·094 –·046	·160 +·107 –·053	·180 +·120 –·060	·200 +·134 –·066	·220 +·147 –·073	·250 +·167 –·083	·280 +·187 –·093	·320 +·214 –·106
	·140 +·094 –·046	·160 +·107 –·053	·180 +·120 –·060	·200 +·134 –·066	·220 +·147 –·073	·250 +·167 –·083	·280 +·187 –·093	·320 +·214 –·106	·360 +·240 –·120
	·160 +·107 –·053	·180 +·120 –·060	·200 +·134 –·066	·220 +·147 –·073	·250 +·167 –·083	·280 +·187 –·093	·320 +·214 –·106	·360 +·240 –·120	·400 +·267 –·133
	·180 +·120 –·060	·200 +·134 –·066	·220 +·147 –·073	·250 +·167 –·083	·280 +·187 –·093	·320 +·214 –·106	·360 +·240 –·120	·400 +·267 –·133	·450 +·300 –·150
	·200 +·134 –·066	·220 +·147 –·073	·250 +·167 –·083	·280 +·187 –·093	·320 +·214 –·106	·360 +·240 –·120	·400 +·267 –·133	·450 +·300 –·150	·500 +·334 –·166
	·220 +·147 –·073	·250 +·167 –·083	·280 +·187 –·093	·320 +·214 –·106	·360 +·240 –·120	·400 +·267 –·133	·450 +·300 –·150	·500 +·334 –·166	·560 +·374 –·186

QUALITY F (NORMAL)

SEE SECTIONS 3.2.1. AND 9.2.1.

Table 8 — Length, width and height of drop and press forgings (close tolerances)

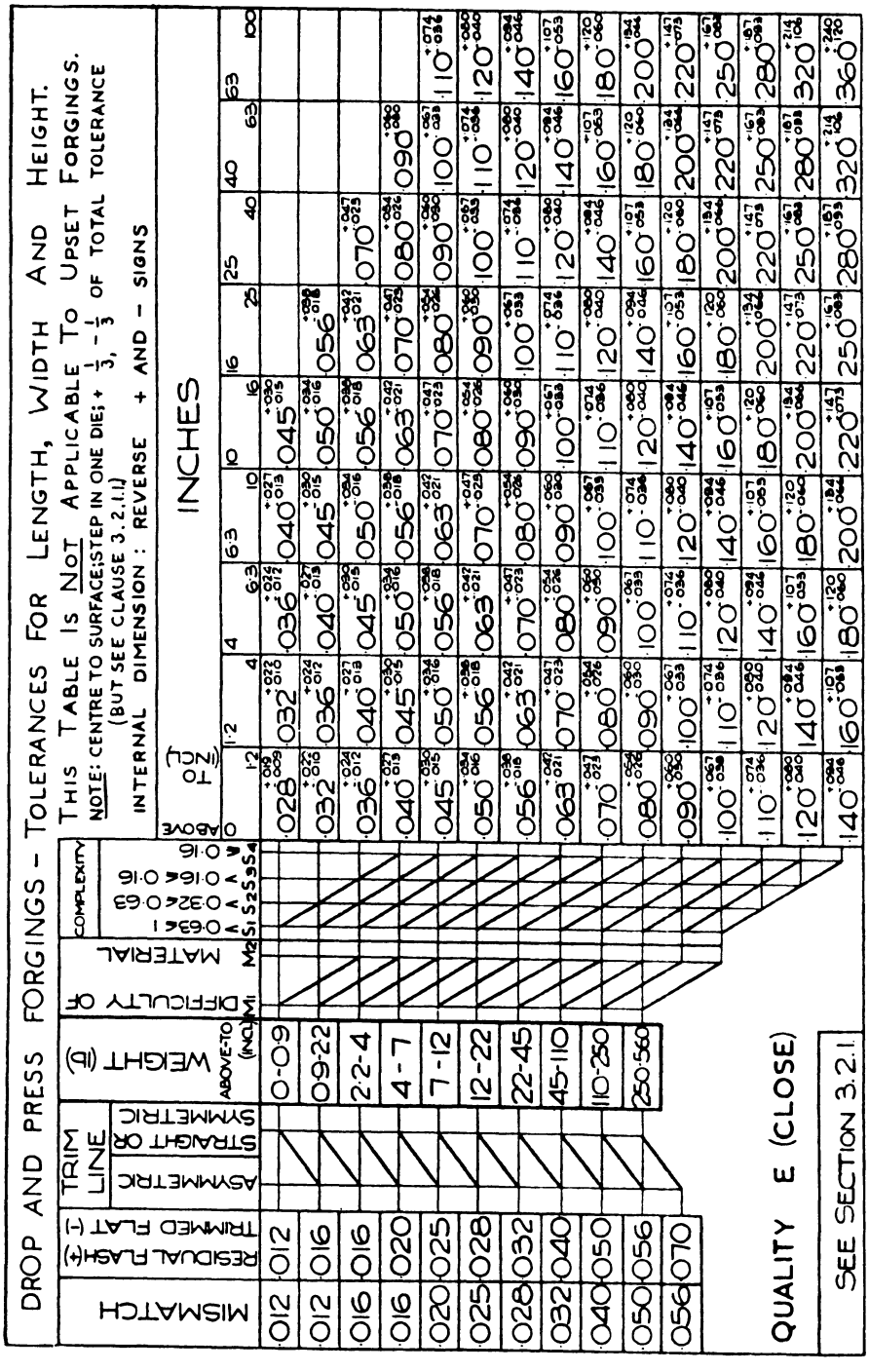


Table 9 — Thickness for drop, press and upset forgings and ejector marks for drop and press forgings (normal tolerances)

DROP, PRESS & UPSET FORGINGS – TOLERANCES FOR: THICKNESS ; EJECTOR MARKS*

*(DROP AND PRESS FORGINGS ONLY)

EJECTOR MARKS	WEIGHT (lb) ABOVE–TO (INCL)
·040	0 – 0·9
·050	0·9 – 2·8
·063	2·8 – 5·6
·080	5·6 – 11
·100	11 – 18
·120	18 – 28
·160	28 – 45
·200	45 – 80
·250	80 – 140
·320	140 – 250
·400	250 – 450
·500	450 – 560

DIFFICULTY OF MATERIAL: M1, M2

COMPLEXITY: S1 > 0·63 ≤ 1; S2 > 0·32 ≤ 0·63; S3 > 0·16 ≤ 0·32; S4 ≤ 0·16

INCHES

ABOVE 0, TO (INCL) 0·63	0·63 – 1·6	1·6 – 2·5	2·5 – 4	4 – 6·3	6·3 – 10	>10
·040 +·027 −·013	·045 +·030 −·015	·050 +·034 −·016	·056 +·038 −·018	·063 +·042 −·021	·070 +·047 −·023	·080 +·054 −·026
·045 +·030 −·015	·050 +·034 −·016	·056 +·038 −·018	·063 +·042 −·021	·070 +·047 −·023	·080 +·054 −·026	·090 +·060 −·030
·050 +·034 −·016	·056 +·038 −·018	·063 +·042 −·021	·070 +·047 −·023	·080 +·054 −·026	·090 +·060 −·030	·100 +·067 −·033
·056 +·038 −·018	·063 +·042 −·021	·070 +·047 −·023	·080 +·054 −·026	·090 +·060 −·030	·100 +·067 −·033	·110 +·074 −·036
·063 +·042 −·021	·070 +·047 −·023	·080 +·054 −·026	·090 +·060 −·030	·100 +·067 −·033	·110 +·074 −·036	·120 +·080 −·040
·070 +·047 −·023	·080 +·054 −·026	·090 +·060 −·030	·100 +·067 −·033	·110 +·074 −·036	·120 +·080 −·040	·140 +·094 −·046
·080 +·054 −·026	·090 +·060 −·030	·100 +·067 −·033	·110 +·074 −·036	·120 +·080 −·040	·140 +·094 −·046	·160 +·107 −·053
·090 +·060 −·030	·100 +·067 −·033	·110 +·074 −·036	·120 +·080 −·040	·140 +·094 −·046	·160 +·107 −·053	·180 +·120 −·060
·100 +·067 −·033	·110 +·074 −·036	·120 +·080 −·040	·140 +·094 −·046	·160 +·107 −·053	·180 +·120 −·060	·200 +·134 −·066
·110 +·074 −·036	·120 +·080 −·040	·140 +·094 −·046	·160 +·107 −·053	·180 +·120 −·060	·200 +·134 −·066	·220 +·147 −·073
·120 +·080 −·040	·140 +·094 −·046	·160 +·107 −·053	·180 +·120 −·060	·200 +·134 −·066	·220 +·147 −·073	·250 +·167 −·083
·140 +·094 −·046	·160 +·107 −·053	·180 +·120 −·060	·200 +·134 −·066	·220 +·147 −·073	·250 +·167 −·083	·280 +·187 −·093
·160 +·107 −·053	·180 +·120 −·060	·200 +·134 −·066	·220 +·147 −·073	·250 +·167 −·083	·280 +·187 −·093	·320 +·214 −·106
·180 +·120 −·060	·200 +·134 −·066	·220 +·147 −·073	·250 +·167 −·083	·280 +·187 −·093	·320 +·214 −·106	·360 +·240 −·120
·200 +·134 −·066	·220 +·147 −·073	·250 +·167 −·083	·280 +·187 −·093	·320 +·214 −·106	·360 +·240 −·120	·400 +·267 −·133
·220 +·147 −·073	·250 +·167 −·083	·280 +·187 −·093	·320 +·214 −·106	·360 +·240 −·120	·400 +·267 −·133	·450 +·300 −·150
·250 +·167 −·083	·280 +·187 −·093	·320 +·214 −·106	·360 +·240 −·120	·400 +·267 −·133	·450 +·300 −·150	·500 +·334 −·166

QUALITY F (NORMAL)

SEE SECTIONS 3.2.2. AND 9.2.2.

Table 10 — Thickness and ejector marks for drop and press forgings (close tolerances)

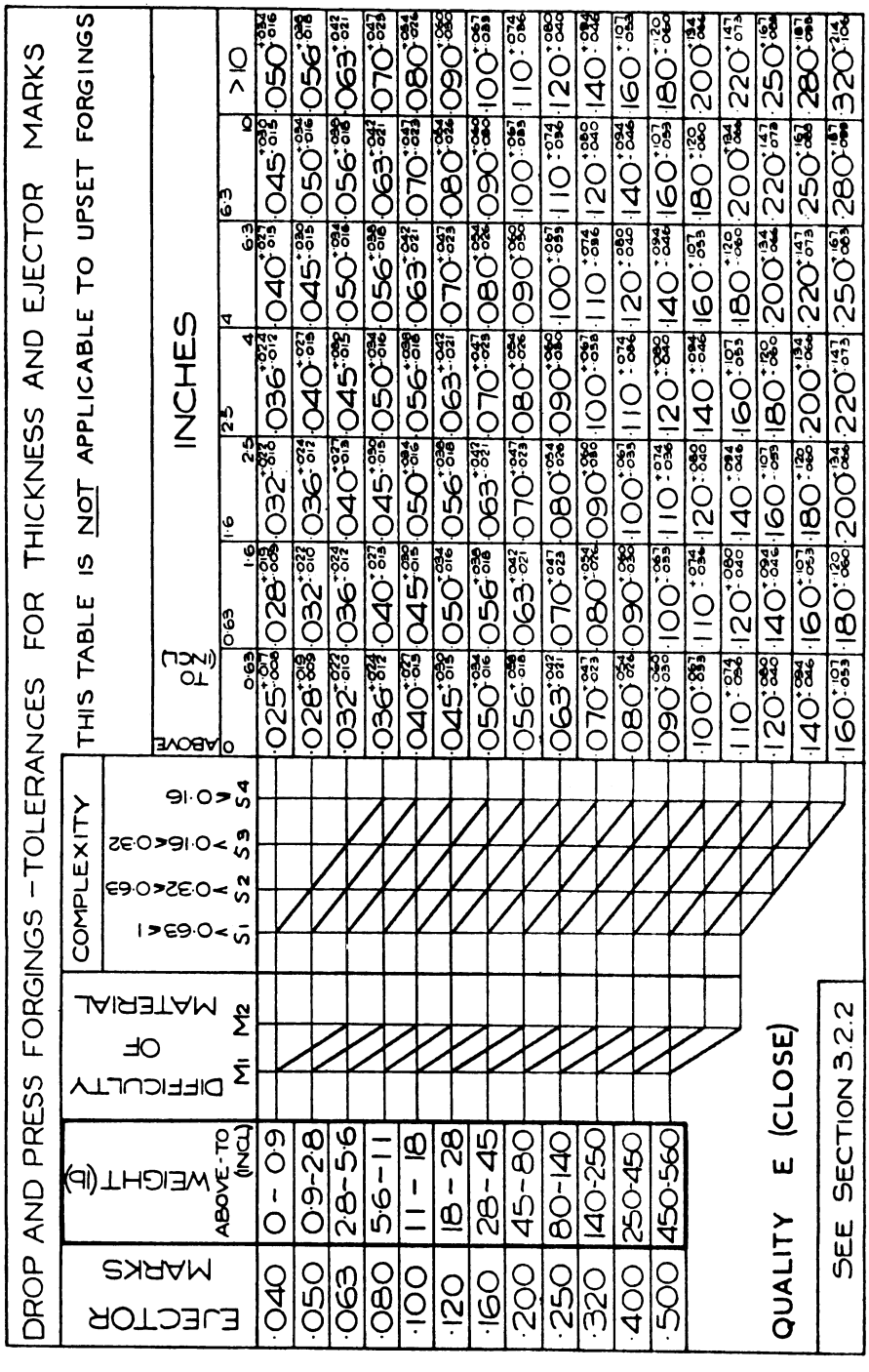


Table 11 — Straightness, flatness and centre to centre dimensions for drop, press and upset forgings

DROP, PRESS AND UPSET FORGINGS

NOTE. QUALITY E DOES NOT APPLY TO UPSET FORGINGS

RANGE OF TOLERANCES FOR STRAIGHTNESS AND FLATNESS

LENGTH		INCHES														
ABOVE		0	4·0	5·0	6·3	8·0	10·0	12·0	16·0	20·0	25·0	32·0	40·0	50·0	63·0	80·0
TO (INCL)		4·0	5·0	6·3	8·0	10·0	12·0	16·0	20·0	25·0	32·0	40·0	50·0	63·0	80·0	100·0
QUALITY	F	·025	·028	·032	·036	·040	·045	·050	·056	·063	·070	·080	·090	·100	·110	·120
	E	·016	·020	·020	·025	·025	·028	·032	·036	·040	·045	·050	·056	·063	·070	·080

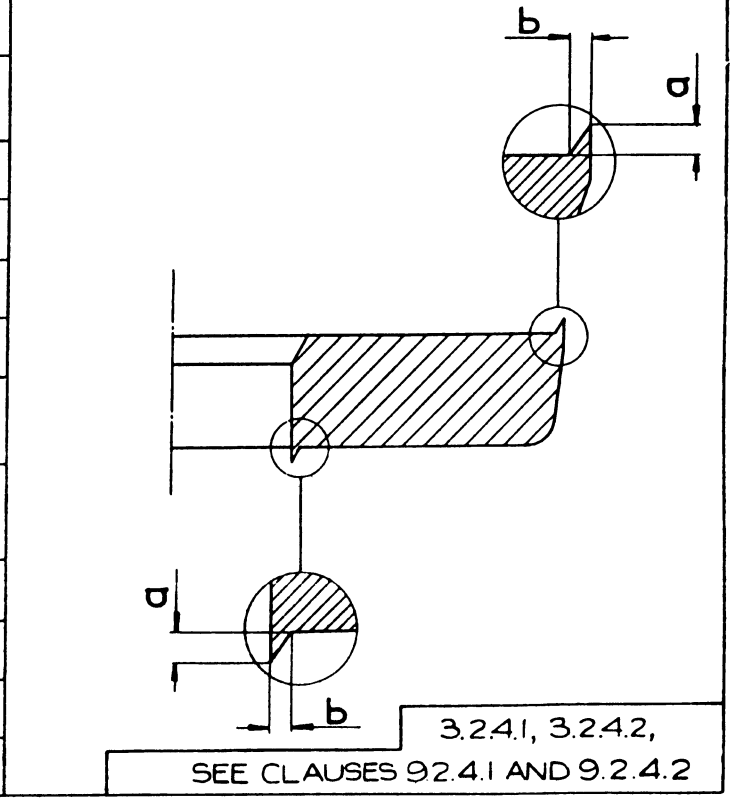
RANGE OF TOLERANCES FOR CENTRE TO CENTRE DIMENSIONS

LENGTH		INCHES										
ABOVE		0	4·0	6·3	8·0	10·0	12·0	16·0	20·0	25·0	32·0	40·0
TO (INCL)		4·0	6·3	8·0	10·0	12·0	16·0	20·0	25·0	32·0	40·0	50·0
QUALITY	F	±·012 ·024	±·015 ·030	±·020 ·040	±·025 ·050	±·030 ·060	±·040 ·080	±·050 ·100	±·060 ·120	±·080 ·160	±·100 ·200	±·125 ·250
	E	±·010 ·020	±·012 ·024	±·015 ·030	±·020 ·040	±·025 ·050	±·030 ·060	±·040 ·080	±·050 ·100	±·060 ·120	±·080 ·160	±·100 ·200

SEE SECTIONS 3.2.3. AND 9.2.3.

Table 12 — Fillet, edge radii and burrs for drop, press and upset forgings

DROP, PRESS AND UPSET FORGINGS.		
FILLET AND EDGE RADII TOLERANCES		
r INCHES ABOVE — TO(INCL)	+	−
0 — 0·4	50%	25%
0·4 — 1·2	40%	20%
1·2 — 4·0	32%	15%
>4·0	25%	10%
BURR TOLERANCES (AND PARTING LINE FINS FOR UPSET FORGINGS)		
WEIGHT (lb) ABOVE — TO(INCL)	a	b
0 — 2·2	·040	·020
2·2 — 14	·063	·032
14 — 90	·100	·050
90 — 560	·160	·080



Section 5. Quantity tolerances for steel drop and press forgings and for upset forgings made on horizontal forging machines

12 Quantity tolerances

Quantity tolerances shall be the permissible over/under-run allowed on each order. Any delivery quantity within the limits of over, under-run shall be regarded as completing the order. The tolerances shall be in accordance with Table 13.

Intermediate quantities shall be assessed pro rata to the nearest smaller quantity shown in the table.

Table 13 — Quantity tolerances for steel drop and press forgings and for upset forgings made on horizontal forging machines

Number of pieces on order	Quantity tolerances	
	Over-run pieces	Under-run pieces
50	4	2
100	6	3
300	18	9
600	24	12
1 000	40	20
5 000	100	50
10 000	200	100
15 000	300	150
20 000	400	200
Any quantity over 25 000	500	250

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