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British Standard Specification for

Copper for electrical purposes: copper sections in bars, blanks and segments for commutators

Cuivre à usage électrotechnique: section de cuivre en barres, pièces brutes et profils pour commutateurs — Spécifications

Kupfer für die Elektrotechnik: Profile aus Kupfer, Stangen, Platinen und Lamellen für Kommutatoren

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Foreword

This British Standard, which has been prepared under the direction of the Non-ferrous Metals Standards Committee, supersedes BS 1434 : 1970 which is withdrawn.

This standard is a full technical revision of the 1970 edition and takes into account the corresponding requirements of IEC 356 : 1971 'Dimensions for commutators and slip-rings' published by the International Electrotechnical Commission (IEC). The principal objectives in preparing the revised edition were as follows:

(a) to extend the size and shape ranges covered in accordance with demand for copper section for uses ranging from mass produced commutators through to special purpose applications (where present limits appear to have satisfied demand, no changes have been made);

(b) to provide adequate choice within practical limits so that cost/accuracy and size demands can be optimized;

(c) to take, in each area of the specification, the best elements from both BS 1434 : 1970 and IEC 356 : 1971 and combine them to give an improved and more practical standard;

(d) to simplify presentation and eliminate redundant text while retaining the practical essentials.

Useful information has been included in appendix A which lists the preferred nominal heights (see **A.1**) for commutator sections supplied as bar or coil, and the preferred nominal diameters (see **A.2**) for finished commutators, in which material complying with this standard is supplied.

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Specification

1 Scope

This British Standard specifies requirements for flat sided wedge-shaped copper sections in bars (straight lengths and coils), blanks and segments, suitable for the manufacture of commutators for rotating machines, in the following size ranges:

(a) thick edge thickness (T) up to 15 mm;

(b) height (H) from 6 mm to 200 mm;

(c) height to thin edge ratio (H/t) up to 50.

This standard does not cover copper for flat face commutators, commonly rectangular section strip and bar, which is covered by BS 1432 and BS 1433.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1 commutator section. A solid, flat sided product of wedge-shaped cross section, with or without a stepped section (see figure 2).

2.2 commutator bar. Commutator section, intended for use in the manufacture of commutator blanks or segments, usually supplied in mill, multiple or specified lengths.

NOTE. Commutator bar in the smaller section sizes may be supplied in coils.

2.3 commutator blank. A short length, cut or fabricated from a commutator bar, that is of plain shape.

2.4 commutator segment. A short length, cut or fabricated from a commutator bar, that is shaped.

3 Information to be supplied by the purchaser

3.1 General

The information given in **3.2** and **3.3** shall be supplied by the purchaser in the enquiry and order to assist the manufacturer in supplying the correct material.

3.2 Commutator bars and blanks

The following information shall be provided:

(a) the quantity required;

(b) the material grade (see table 1);

(c) the length and whether this is to be supplied in mill lengths (see **6.1.1** and table 2), specified or multiple lengths (see **6.1.2** and table 3), blanks and segments (see **6.1.3**, table 4 and **3.3**);

(d) for the smaller sections, supplied in coil, the coil size and/or mass;

(e) the height (H) and tolerance class (see **6.3**, table 5 and figure 2);

(f) the thickness dimensions t_1 and t_3, or t and T (see **6.4**, table 6 and figure 2) and the tolerance class (see **6.4** and table 7);

(g) the angle, α (see **6.5**, table 8 and figure 3);

(h) the shape (flat or convex) of the thick edge (see **6.9** and figure 4).

3.3 Commutator segments

The following information shall be provided:

(a) the information detailed in items (a) to (h) of **3.2**;

(b) the length of the commutator segment, L_u (see **6.1.3**, table 4 and figure 1);

(c) the height of the commutator segment, H_u, and the tolerance class (see **6.3**, table 5 and figure 1);

(d) a drawing of the shaped segment required, especially if the blank is other than L-shaped.

4 General

Copper commutator bars (straight lengths and coils), blanks and segment shall comply with the material requirements specified in clause **5** and the tolerances on dimensions and shape specified in clause **6**.

Methods for sampling and the determination of hardness shall be as specified in clauses **7** and **8** respectively.

5 Material

The chemical composition and the hardness, determined either by the Vickers or the Brinell methods in accordance with clause **8**, shall be as given in table 1.

Table 1. Chemical compositions and minimum hardness

Material grade (see item (b) of **3.2**)	Chemical composition	Minimum hardness	
		Vickers	Brinell
		HV	HB
1	Cu-ETP-2 or Cu-FRHC (C101/2) of BS 6017	85	80
2	Cu-Ag-3 of BS 6017	85	80

6 Tolerances on dimensions and shape

6.1 Length

6.1.1 *Mill lengths.* The proportions of bars of different actual lengths that are permitted in any one delivery shall be as given in table 2 (see item (c) of **3.2**).

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Table 2. Permitted proportions of bars of different actual lengths in any one delivery of mill lengths (see item (c) of **3.2**)

Actual bar length		Permitted proportions
>	⩽	
m	m	%
—	1	Nil
1	2	40 max.
2	4	60 min.
4	—	Nil

6.1.2 *Specified or multiple lengths.* The tolerances on specified length shall be as given in table 3 (see item (c) of **3.2**).

Table 3. Tolerances on length for specified lengths (see item (c) of **3.2**)

Specified length		Tolerance	
>	⩽	Plus	Minus
m	m	mm	mm
—	3	8	0
3	4	14	0

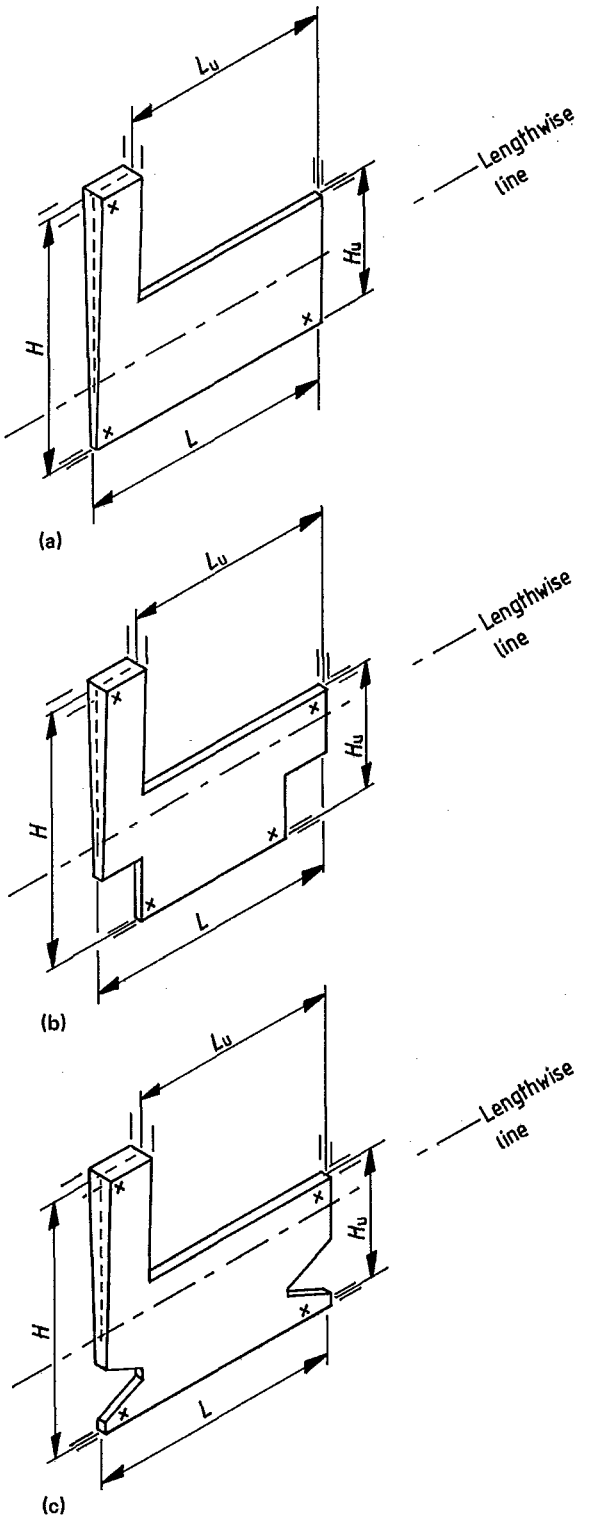
For lengths ordered in multiples of a single segment length, the purchaser shall include his cutting allowance within the stated unit lengths.

6.1.3 *Blanks and segments.* For values of the length dimensions L and L_u (see figure 1), up to and including 500 mm, the tolerances shall be as given in table 4 (see item (c) of **3.2** and item (b) of **3.3**).

NOTE. For values of L and L_u over 500 mm, the tolerances are not specified and should be agreed between the manufacturer and the purchaser.

Table 4. Tolerances on length for blanks and segments (see item (c) of **3.2** and item (b) of **3.3**)

Length, L or L_u		Tolerance
>	⩽	
mm	mm	mm
—	100	± 0.3
100	200	± 0.5
200	500	± 1.0



X denotes corners for measurement of twist.

Figure 1. Segments (see items (b) and (c) of **3.3**)

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6.2 End squareness for blanks and segments

The ends of blanks and segments shall be cut square to the edges within 0.006 mm per 1 mm of the height dimensions H or H_u shown in figure 2.

6.3 Height

The tolerances on the height dimensions H and H_u shown in figures 1 and 2 shall be as given in table 5 (see item (e) of **3.2** and item (c) of **3.3**).

Table 5. Tolerances on height (see item (e) of **3.2** and item (c) of **3.3**)

Height, H or H_u		Tolerance			
		Normal		Close	
>	≤	H	H_u	H	H_u
mm	mm	mm	mm	mm	mm
–	80	± 0.4	± 0.4	± 0.12	± 0.3
80	125	± 0.8	± 0.8	± 0.2	± 0.3
125	200	± 1.2	± 1.2	± 0.3*	± 0.3

* Not normally available for sections where the thickness t (see figure 2) at the thin edge is less than 3 mm.

6.4 Thickness

The thickness t_1 and t_3, measured at the positions h and h_3, as shown in figure 2 and table 6, shall be within the tolerances given in table 7 (see item (f) of **3.2**).

The thickness, t_4, measured at the h_4 position as shown in figure 2, shall be within the following tolerances:

plus tolerance as given for t_1 and t_3 in table 7

minus tolerance 0.10 mm in all cases

6.5 Angle

The deviation from the specified angle shall be determined from the thickness measurements t_1 and t_3 (see figure 2 and table 6) by calculating the algebraic difference between the errors in the thicknesses, Δt_3 and t_1 (i.e. the differences between the nominal and the observed values), as shown in figure 3. The deviation shall not exceed the negative tolerances given in table 8 (see item (g) of **3.2**).

NOTE. Products may be supplied with a positive angle tolerance by agreement between manufacturer and purchaser at the time of enquiry and order.

Table 6. Thickness measurement positions for commutator bar segments or blanks (see also figure 2)

H_u	h_1	h_2	h_3	h_4
mm	mm	mm	mm	
< 10	$(1/8\ H_u)$*	$(1/2\ H_u)$*	$(7/8\ H_u)$*	$(H - h_1$ for all sizes)
10	3	5	7	
11.2	3	6	9	
12.5	3	6	9	
14	3	7	11	
16	3	8	13	
18	3	9	15	
20	3	10	17	
22.4	3	11	19	
25	3	12	21	
28	3	14	25	
31.5	3	16	29	
35.5	3	18	33	
40	6	20	34	
45	6	22	38	
50	6	25	44	
56	6	28	50	
63	6	31	58	
71	6	36	66	
80	6	40	74	
90	6	45	84	
100	6	50	94	
112	6	56	106	
125	6	63	120	
>125	6	$(1/2\ H_u)$*	$(H_u - 6)$*	

* Values rounded to the nearest whole millimetre.

NOTE 1. For heights that are intermediate between successive values in the above table, thickness measurement positions corresponsing to the next lower value of H_u are used.

NOTE 2. If the lower reference plane is used for the measurement of stepped sections, the thickness measurement positions for t_1, t_2 and t_3 are h_o (nominal) + h_2 and h_o (nominal) + h_3 respectively.

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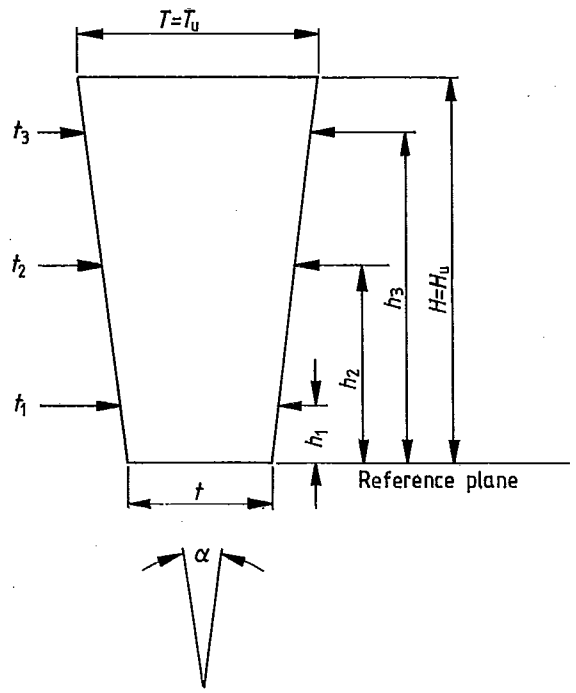
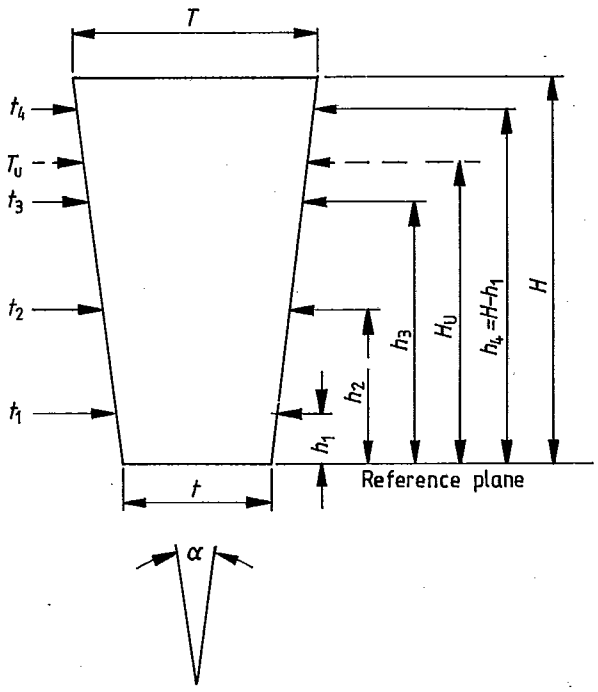
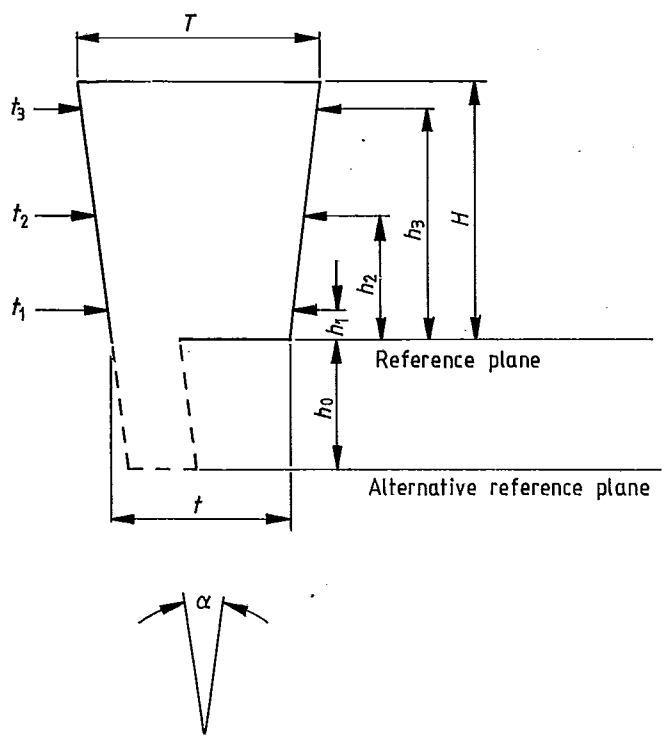


(a) Commutator bar and blanks



(b) Commutator blanks to be shaped, or segments



(c) Stepped commutator bar

Figure 2. Main dimensions of cross sections of commutator bar, segments or blanks and measuring positions for thickness, angle and shape (see also items (e) and (f) of **3.2** and table 6)

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Table 7. Tolerances on thickness (see item (f) of **3.2**)

Height, H		Angle, α		Tolerance on thicknesses t_1 and t_3 (see figure 2)		
>	⩽	>	⩽	Normal	Close	Extra close
mm	mm	degree	degree	mm	mm	mm
6	20	3.6	–	± 0.032	± 0.016	–
		1.8	3.6	± 0.025	± 0.012	–
20	40	3.6	–	± 0.050	± 0.032	± 0.020
		1.8	3.6	± 0.040	± 0.025	± 0.016
		–	1.8	± 0.032	± 0.020	± 0.012
40	80	3.6	–	± 0.050	± 0.032	± 0.025
		1.8	3.6	± 0.040	± 0.025	± 0.020
		–	1.8	± 0.032	± 0.020	± 0.016
80	140	3.6	–	± 0.063	± 0.040	± 0.025
		1.8	3.6	± 0.050	± 0.032	± 0.020
		–	1.8	± 0.040	± 0.025	± 0.020
140	200	1.8	3.6	–	± 0.040	± 0.025
		–	1.8	–	± 0.032	± 0.020

Table 8. Tolerances on specified angle (see item (g) of **3.2**)

Height, H or H_u		Angle, α		Negative tolerance on specified angle, $\Delta t_3 - \Delta t_1$		
>	⩽	>	⩽	Normal	Close	Extra close
mm	mm	degree	degree	mm	mm	mm
6	20	3.6	–	0.032	0.020	–
		–	3.6	0.025	0.016	–
20	40	3.6	–	0.050	0.032	0.020
		1.8	3.6	0.040	0.025	0.020
		–	1.8	0.032	0.020	0.020
40	80	3.6	–	0.050	0.032	0.025
		1.8	3.6	0.040	0.025	0.020
		–	1.8	0.032	0.020	0.020
80	140	3.6	–	0.063	0.040	0.025
		1.8	3.6	0.050	0.032	0.020
		–	1.8	0.040	0.025	0.020
140	200	1.8	3.6	–	0.050	0.040
		–	1.8	–	0.040	0.032

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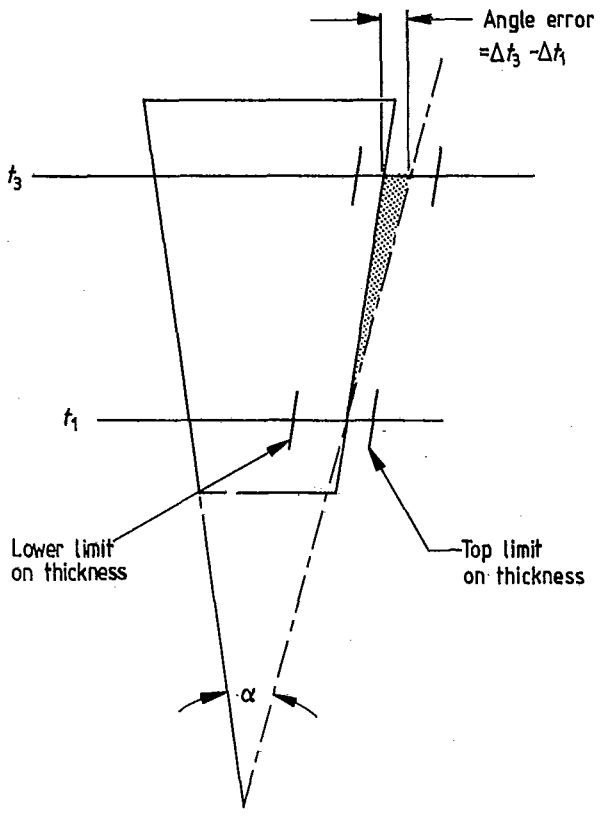

Figure 3. Deviation from specified angle (see item (g) of **3.2**)

6.6 Shape of side faces

The shape of the side faces, i.e. the convexity or concavity and flatness over height, shall be determined from the thickness measurements t_1, t_2 and t_3 (see figure 2 and table 6) by calculating a shape error, Δf, given by:

$$\Delta f = \Delta t_2 - \frac{(\Delta t_1 + \Delta t_3)}{2}$$

where Δt_1, Δt_2 and Δt_3 are the differences between the nominal and observed thicknesses, undersize values being negative and oversize values being positive.

The shape error, Δf, shall not exceed the tolerances given in table 9.

In addition, any gap at position h_2 (see figure 2 and table 6) between a straight edge spanning the positions h_1 to h_3 and the actual side face shall not exceed the value, in mm, given by:

$$x - \frac{\Delta f}{2}$$

where x, the shape constant, is given in table 9.

Table 9. Tolerance on shape error and shape constants for the shape of the side faces

Height, H or H_u		Angle, α		Tolerance on shape error, Δf	Shape constant, x
>	≤	>	≤		
mm	mm	degree	degree	mm	mm
6	20	3.6 –	– 3.6	± 0.025 ± 0.020	0.025
20	40	3.6 –	– 3.6	± 0.032 ± 0.020	0.040
40	80	3.6 –	– 3.6	± 0.032 ± 0.020	0.050
80	140	3.6 –	– 3.6	± 0.040 ± 0.025	0.063
140	200	3.6 –	– 3.6	± 0.050 ± 0.040	0.080

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6.7 Straightness of bar

The maximum deviation from straightness, measured between two points separated by the distances given in table 10 along a central longitudinal line on the edges and faces, shall not exceed the values given in table 10.

Table 10. Maximum deviation from straightness of bar

Bar length, l		Maximum deviation from straightness			
		Measurement distances			
>	⩽	l	100 mm	500 mm	2000 mm
mm	mm	% l	mm	mm	mm
—	100	0.1	—	—	—
100	500	—	0.1	0.5	—
500	—	—	0.1	0.5	0.8

6.8 Twist

The maximum twist, i.e. the maximum deviation of one corner of either side face from a plane passing through the three other corners of that side face, shall not exceed the values given in table 11 for bars and segments.

6.9 Shape of convex thick edge

The shape of the convex thick edge shall comply with the following (see item (h) of **3.2**):

(a) the highest point shall be within ± 0.2T of the line of symmetry, as shown in figure 4;

(b) the radius of curvature of the highest point, r, shall not exceed 2 mm or 0.5T, whichever is the smaller;

(c) the total contour of the thick edge, including the highest point shall be within the 1 mm tolerance band shown in figure 4.

6.10 Shape of the thin edge

The total contour of the thin edge shall be within the tolerance band of 1 mm or 0.5t, whichever is the smaller, shown in figure 5.

Table 11. Maximum twist for bars, blanks and segments

Product	Length of bar, l, or length plus height of segment or blank, $L + H$	Maximum twist*	
		For any 100 mm part of the length	For any 500 mm part of the length
	mm	mm	mm
Bar	$l \leqslant 500$	0.5	—
	$l > 500$	0.5	2.5
Blanks and segments	$(L + H) \leqslant 100$	0.05	0.05
	$(L + H) > 100$	0.05 % of $(L + H)$	—

* For segments, see figure 1.

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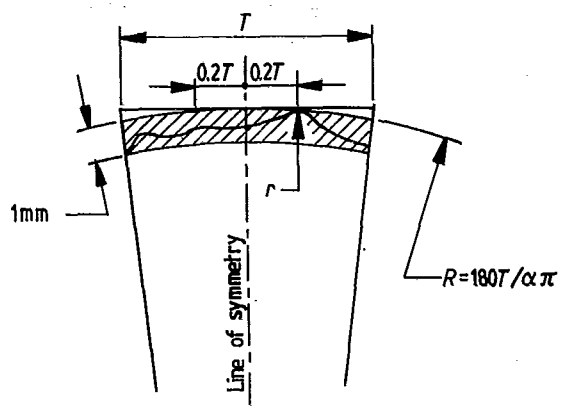

Figure 4. Tolerance on shape of the convex thick edge (see item (h) of **3.2**)

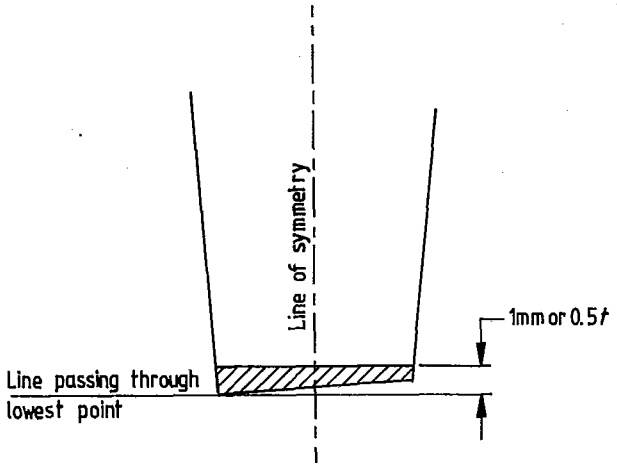

Figure 5. Tolerance band for the shape of the thin edge

7 Sampling

7.1 General

The materials shall be sampled as specified in **7.2** and **7.3.**

NOTE. The sampling of mill, specified or multiple lengths is not specified but it is recommended that, unless otherwise agreed, one sample should be taken per 100 lengths or fraction thereof. Specified or multiple lengths shortened by sampling are accepted as good delivery.

7.2 Material supplied in coils

One sample shall be taken per 10 coils or fraction thereof.

7.3 Blanks or segments

One sample shall be taken per 1000 blanks, or segments, or fraction thereof.

8 Determination of hardness

The hardness shall be determined by means of either the Brinell hardness test in accordance with BS 240, or the Vickers hardness test in accordance with BS 427. Routine measurements shall be made on the side face of the bar, segment or blank.

In cases of dispute, the Vickers hardness test shall be the referee method. The hardness shall be determined in the cross-hatched area as shown in figure 6 and shall be calculated as the average of two hardness measurements made on each of the different samples, i.e. a total of four hardness measurements.

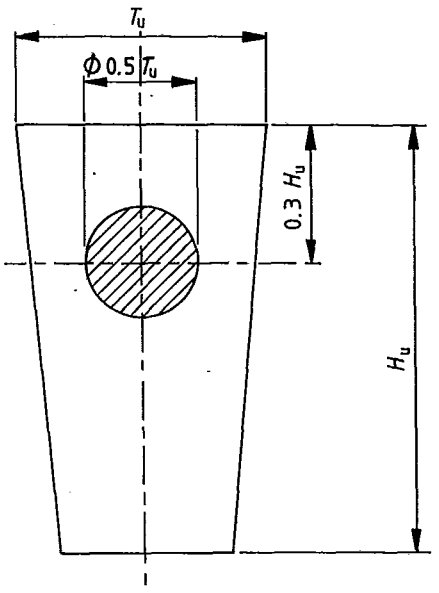

Figure 6. Measuring area for Vickers hardness (referee method)

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Appendix A. Preferred nominal sizes

A.1 The heights of sections for commutator bars should be selected either from the preferred heights given in table 12 or, for intermediate heights, in accordance with the R40 series of preferred numbers given in BS 2045.

Table 12. Preferred nominal heights, *H*, in mm, of sections for commutator bars

6.3	22.4	80
7.1	25	90
8	28	100
9	31.5	112
10	35.5	125
11.2	40	140
12.5	45	160
14	50	180
16	56	200
18	63	
20	71	

A.2 The diameters of finished commutators should be selected either from the preferred diameters given in table 13 or, for intermediate diameters less than 50 mm, in accordance with the R40 series of preferred numbers given in BS 2045.

Table 13. Preferred nominal diameters, in mm, of finished commutators

12.5	80	500
14	90	560
16	100	630
18	112	710
20	125	800
22.4	140	900
25	160	1000
28	180	1120
31.5	200	1250
35.5	224	1400
40	250	1600
45	280	1800
50	315	2000
56	355	2240
63	400	2500
71	450	

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Publications referred to

BS 240 Method for Brinell hardness test
BS 427 Method for Vickers hardness test
BS 1432 Copper for electrical purposes. Strip with drawn or rolled edges
BS 1433 Copper for electrical purposes. Rod and bar
BS 2045 Preferred numbers
BS 6017 Specification for copper refinery shapes
IEC 356* Dimensions for commutators and slip-rings

* Referred to in the foreword only.

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The following BSI references relate to the work on this standard:
Committee reference NFM/34 Draft for comment 82/77388 DC

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Non-ferrous Metals Standards Committee (NFM/—) to Technical Committee NFM/34, upon which the following bodies were represented:

British Non-ferrous Metals Federation
Copper Development Association
Inco Europe Limited
London Metal Exchange
Non-ferrous Metal Stockists
Coopted members

The following bodies were also represented in the drafting of the standard, through sub-committees and panels:

Association of Bronze and Brass Founders
Association of Supervisory and Executive Engineers
BEAMA Transmission & Distribution Association
BNF Metals Technology Centre
British Bronze & Brass Ingot Manufacturers
British Malleable Tube Fittings Association
British Valve Manufacturers' Association Ltd.
Copper Smelters' and Refiners' Association
Institute of British Foundrymen
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