



BS 4360 : 1990

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British Standard Specification for Weldable structural steels

Aciers de construction soudables – Spécifications

Schweißbare Baustähle

British Standards Institution

BS 4360 : 1990

Foreword

This British Standard has been prepared under the direction of the Iron and Steel Standards Policy Committee and is identical to BS 4360 : 1986 except for the deletion of A, B, C and D and 50 DD grades for plates, sections and bars together with any references to them in the text.

This standard, together with BS EN 10 025, supersedes BS 4360 : 1986, which is withdrawn. For hollow sections a separate EN is being prepared.

The European equivalents of the B, C and D and 50 DD grades are specified in BS EN 10 025 which is the English language version of EN 10 025 and is published simultaneously with this standard.

Work is going on in Europe to prepare standards covering fine grain steels (covering the E, EE and F grades of BS 4360 : 1986), hot finished hollow sections and weathering steels.

As these projects achieve European Standard status it is anticipated that the English language versions will be published as follows.

- BS EN 10 113 Hot rolled products in weldable fine grain structural steels
 - Part 1 General delivery conditions
 - Part 2 Delivery conditions for normalized steels
 - Part 3 Delivery conditions for thermomechanically rolled steels
- BS EN 10 210 Hot finished structural hollow sections of non-alloy and fine grain structural steels
 - Part 1 Technical delivery conditions
 - Part 2 Dimensions and sectional properties
- BS EN 10 155 Weathering steels
- BS EN 10 137 Plates and wide flats made of weldable fine grained structural steels in the quenched and tempered condition
 - Part 1 Technical delivery conditions general requirements

It is anticipated that tolerances for plates, strip, wide flats, sections and bars will be part of a separate series of European Standards.

BS 4360 will consequently become smaller and smaller until eventually it will be withdrawn.

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

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Specification

Section one. General

1 Scope

This British Standard specifies requirements for weldable steels for general structural and engineering purposes in the form of hot-rolled plates, strip, wide flats, flats and bars and for structural steel sections complying with BS 4848 : Parts 2, 4 and 5 and BS 4 : Part 1. However, in the case of hollow sections formed from plate and with the seams metal arc welded, this standard covers only the requirements for the plate material.

The products are equally suitable for bolted and riveted structures.

This standard applies to material supplied ex-mill or from merchant's stock (see clause 12).

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 definitions given in BS 6562 : Part 2 apply together with the following.

2.1 parent product. The product rolled from one piece of steel.

2.2 manufacturer. The manufacturer of the steel products.

2.3 supplier. The manufacturer for material supplied ex-mill, the merchant for material supplied from a merchant's stock (see clause 1).

2.4 purchaser. The purchaser or his representative.

2.5 controlled rolling. A generic term for rolling procedures in which the temperatures and deformation during rolling are controlled to achieve desirable material properties.

2.6 temperature controlled rolling (TCR). A rolling procedure in which the final deformation is carried out in the normalizing temperature range, resulting in a material condition generally equivalent to that obtained by normalizing.

2.7 thermo-mechanical controlled rolling (TMCR). A rolling procedure in which significant deformation takes place at temperatures below the normalizing range permitting little, if any, recrystallization of austenite and conferring beneficial properties on the material. Unlike TCR, the properties conferred by TMCR cannot be reproduced by subsequent normalizing or other heat treatments.

3 General

The steel products shall comply with the general requirements of this standard and with the specific requirements applicable to the grade concerned. Where any of the options given in appendix B are called up at the time of the enquiry and order, the steel products shall, in addition, comply with the requirements of any such options.

4 Information to be supplied by the purchaser

4.1 General

The following information shall be supplied by the purchaser at the time of enquiry and order.

- (a) Details of the product form, dimensions and quantity.
- (b) The grade of steel (see tables 12, 14, 16, 18, 20 and 22).

4.2 Options

A number of options are specified in appendix B. In the event that the purchaser does not indicate his wish to implement any of these options and specify his requirements at the time of the enquiry and order, the supplier shall supply in accordance with the basic specification.

5 Steelmaking process

5.1 Process

The steel shall be made by any process except the Bessemer process.

See also option B.1.

5.2 Rimming steel

Rimming steel shall not be supplied.

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6 Supply condition

NOTE. Purchasers who intend to re-heat any of the steels detailed in this standard over and above those levels implicit in preheating and/or welding in accordance with BS 5135 are advised to discuss the application and proposed re-heat treatment of the steel with the manufacturer.

6.1 Normal

The material shall be delivered in the supply condition given in tables 12, 14, 16, 18, 20 and 22 and the mechanical properties given in tables 13, 15, 17, 19, 21 and 23 refer only to material in the specified condition or alternative condition specified in 6.2. Where the supply condition is specified as rolled or hot finished, it is permissible for the manufacturer to normalize the material provided the specified properties are obtained after normalizing.

6.2 Alternative supply condition

It is permissible for the application of TCR to take the place of normalizing, except for reversing mill plates of sub-grade EE, at the supplier's discretion. In all cases the specified properties shall be obtained.

See also options B.2 and B.3.

NOTE. TCR material may be suitable for subsequent normalizing or hot forming in the normalizing temperature range since only slight deterioration of mechanical properties will occur. (See also note to clause 6.)

7 Chemical composition

7.1 Ladle analysis

The chemical composition of the steel shall be determined by ladle analysis and shall be as given in tables 12, 14, 16, 18, 20 and 22. The manufacturer shall supply details of the ladle analysis to the purchaser.

See also options B.4, B.5 and B.6.

7.2 Product analysis

Any product analysis carried out shall be determined on a test sample used for verification of the mechanical properties or from material at the location shown in appendix C or, if this is not possible, by sampling in accordance with BS 1837.

In the event of dispute, compliance with the standard shall be decided on the basis of an independent analysis using the methods described in BS Handbook No. 19.

The permitted deviations for product analysis and purchaser's check analysis shall be as given in table 1 and are applicable to the specified chemical composition limits given in tables 12, 14, 16, 18, 20 and 22.

Table 1. Permitted deviations in product analysis from specified ladle analysis percentages

Figure in parentheses refers to the note following this table.

Grade	Deviations from specified ladle analysis				
	C	Si	Mn	P	S
	%	%	%	%	%
40DD	0.03	-0 +0.05	0.10	0.010	0.010
40E	0.03	-0 +0.05	0.10	0.010	0.010
40EE	0.03	-0 +0.05	0.10	0.010	0.010
43C	0.03	-0 +0.05	0.10	0.010	0.010
43D	0.03	-0 +0.05	0.10	0.010	0.010
43DD	0.03	-0 +0.05	0.10	0.010	0.010
43E	0.03	-0 +0.05	0.10	0.010	0.010
43EE	0.03	-0 +0.05	0.10	0.010	0.010
50C	0.03	-0 +0.05	0.10	0.010	0.010
50D	0.03	-0 +0.05	0.10	0.010	0.010
50E	0.04	-0 +0.05	0.10	0.010	0.010
50EE (1)	0.04	-0 +0.05	0.10	0.010	0.010
50F	0.04	-0 +0.05	0.10	0.010	0.010
55C (1)	0.04	-0 +0.05	0.10	0.010	0.010
55EE (1)	0.04	-0 +0.05	0.10	0.010	0.010
55F	0.04	-0 +0.05	0.10	0.010	0.010
WR 50A	0.03	-0 +0.05	0.10	-0.005 +0.010	0.005
WR 50B	0.04	-0 +0.05	0.10	0.005	0.005
WR 50C (1)	0.04	-0 +0.05	0.10	0.005	0.005

(1) For hollow sections the deviation for carbon is 0.03 %.

The deviations, other than when maxima only are given in tables 12, 14, 16, 18, 20 and 22, shall apply either above or below the specified limits of the range, but not above and below for the same element from different sample products from the same cast. When maxima only are specified, the deviations shall only be positive. As indicated in table 1, this requirement shall not apply in the case of grade WR 50A in respect of phosphorus and all grades in respect of silicon. See also option B.7.

8 Weldability

All steels complying with this standard are of weldable quality. Welding procedures and consumables appropriate for the various grades and qualities shall be used.

NOTE 1. BS 5135 specifies requirements for the process of manual, semi-automatic, automatic and mechanized arc welding of carbon and carbon manganese steels with carbon equivalents not exceeding 0.54 %. For steels with carbon equivalents above 0.54 %, BS 5135 recommends that the steelmaker, welding consumable supplier or other appropriate authoritative source be consulted. It is further pointed out that for carbon manganese steels with low carbon contents (less than about 0.10 %) additional precautions and modified procedures may be required.

NOTE 2. If weather resistant steels are to be used unpainted, it is necessary to select processes which achieve at least equivalent weathering properties of the permanently exposed surfaces.

9 Quality of finished steel

9.1 Plates, strip and wide flats

9.1.1 Surface condition. The surface condition of plates, strip and wide flats shall comply with BS 6512 except that for grades 50 and 55, repair by welding shall not be undertaken by the supplier without the permission of the purchaser.

See also options B.8 and B.9.

9.1.2 Internal soundness

9.1.2.1 Where ultrasonic testing is not specified by the purchaser at the time of ordering, reversing mill plates and wide flats shall be deemed to comply with the internal soundness of grade LC1 of BS 5996.

NOTE. Unless specified by the purchaser at the time of ordering, there is no obligation on the supplier to carry out ultrasonic testing. Where design considerations require plates to comply with a minimum ultrasonic acceptance level (including grade LC1 of BS 5996), verification by ultrasonic testing should be carried out. This requirement should be indicated at the time of ordering and option B.26 called up when ultrasonic testing is to be undertaken by the supplier.

9.1.2.2 For plates and strip produced on continuous mills, the material shall be sound and free from such internal defects as might preclude its use for the purpose for which it is intended.

9.2 Sections, hollow sections, flats and round and square bars

9.2.1 Defects. The material shall be sound and free from such internal and external defects or surface flaws as might preclude its use for the purpose for which it is intended.

9.2.2 Correction of minor defects

9.2.2.1 Sections (other than hollow sections), flats and round and square bars. It is permissible for the supplier to remove minor surface defects by grinding. In all cases the thickness shall not be reduced locally by more than 4 % below the minimum otherwise allowed by 17.1 of this standard, BS 4 : Part 1 and BS 4848 : Parts 4 and 5 (with a maximum removal of 3 mm) (see also 9.2.3).

9.2.2.2 Hollow sections. It is permissible for the supplier to remove minor surface defects by grinding to a remaining thickness of 12.5 % below the ordered thickness. In all cases the reduction below ordered thickness shall not exceed 3 mm. In no case shall the final outside dimension after grinding and, if appropriate, repair by welding in accordance with 9.2.4, be below the minimum allowed by BS 4848 : Part 2.

NOTE. Round and square bars intended for applications such as painting or cold heading may require a higher degree of freedom from surface imperfections which should be agreed between the purchaser and the supplier.

9.2.3 Additional procedure for sections (other than hollow sections) and flats. When the local reduction in thickness would be greater than 4 % or 3 mm, it is permissible for the supplier to remove surface defects by grinding. In all cases the thickness shall not be reduced locally by more than 7 % below the minimum otherwise allowed by BS 4 : Part 1 and BS 4848 : Parts 4 and 5.

See also option B.10.

9.2.4 Repair by welding. Except for round and square bars, it is permissible for the supplier to remove surface defects that cannot be corrected in accordance with 9.2.2 and 9.2.3 by grinding or chipping followed by welding subject to the following conditions.

(a) After complete removal of the defect and before welding, the thickness shall not have been reduced to less than 80 % of its nominal dimension.

(b) The welding shall be carried out in accordance with BS 5135 by competent operators approved to BS 4872 : Part 1 and the weld shall be ground smooth and flush with the adjacent surface of the product. The supplier shall follow documented welding procedures established in accordance with BS 4870 : Part 1 which are appropriate for the material being welded.

See also options B.8 and B.9.

NOTE. In certain applications repair by welding may not be appropriate or may require special inspection after completion. An example would be otherwise unwelded components of structures for which the choice of steel grade with respect to notch ductility would be determined by the presence or absence of welding or in which permissible stresses are limited by considerations of fatigue.

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10 Identification of cast

The manufacturer shall identify the ingots, billets, slabs, plates, steel sections, bars, etc., in such a way as to enable the finished steel to be traced to the cast from which it was made or, for hollow sections rolled by the continuous process, the casts from which they were made.

11 Marking

Each piece or parcel of steel shall be legibly marked with the manufacturer's name or trade mark, and with cast number or identification marks by which the steel can be traced to the cast or casts from which it was made.

In addition, the material shall be legibly marked with the grade number ringed with paint. When parcels of material are securely bundled, a tab attached to each bundle and marked as above shall be sufficient marking.

NOTE. It is recommended that in the case of weather resistant steels, the purchaser should consult the supplier concerning agreement to the method of marking to be used.

See also option B.11.

12 Test certificates

12.1 Manufacturer's supply

The manufacturer shall supply the purchaser with a test certificate endorsed by the manufacturer stating the process

of manufacture and giving the steel grade, ladle analysis and the results of each of the mechanical tests applicable to the material purchased. The certificate shall indicate the numbers or identification marks of the casts to which it applies, corresponding with the numbers to be found on the material supplied. In the case of sections with tapered flanges, the certificate shall indicate whether the sample for test purposes is taken from the web or flange.

12.2 Merchant supply

If any steel is supplied from a merchant's stock, the merchant shall satisfy the purchaser by means of numbers or identification marks on the steel or tab when parcels of steel are bundled, combined with a manufacturer's test certificate, that such steel has been tested and complies with all the requirements of this standard applicable to the material specified. If the merchant has altered the condition or dimensions of the steel in any way, it is his responsibility to ensure that the material he supplies still complies with this standard.

13 Mass of steel

The mass of steel shall be calculated on the basis that the steel has a density of 7850 kg/m^3 .

Section two. Specific requirements for dimensional and shape tolerances

14 Tolerances for plates and strip

14.1 General

Tolerances for plates and strip produced on continuous mills shall comply with BS 1449 : Part 1.

Tolerances for plates produced on non-continuous mills shall comply with 14.2 to 14.6.

14.2 Length tolerances for plates

The length tolerances on ordered length for plates shall be as given in table 2.

The length of a plate shall be taken as the length of the largest rectangle contained within the plate.

See also option B.12.

14.3 Width tolerances for plates

The width tolerances on ordered width for plates shall be as given in table 3.

Width shall be measured perpendicular to the major axis of the plate.

See also option B.12.

Table 2. Length tolerances for plates	
Ordered length	Tolerances
mm	mm
Less than 4 000	-0 + 20
4 000 to less than 6 000	-0 + 30
6 000 to less than 8 000	-0 + 40
8 000 to less than 10 000	-0 + 50
10 000 to less than 15 000	-0 + 75
15 000 up to and including 20 000	-0 + 100

Table 3. Width tolerances for plates	
Ordered width	Tolerances
mm	mm
600 to less than 2000	-0 +20
2000 to less than 3000	-0 +25
3000 up to and including 4000	-0 +30

14.4 Thickness tolerances for plates

The thickness tolerances on ordered thickness of plates shall be as given in table 4.

Thickness shall be measured at any point more than 15 mm from the edges of the plate.

See also options B.13 and B.14.

14.5 Edge camber tolerances for plates

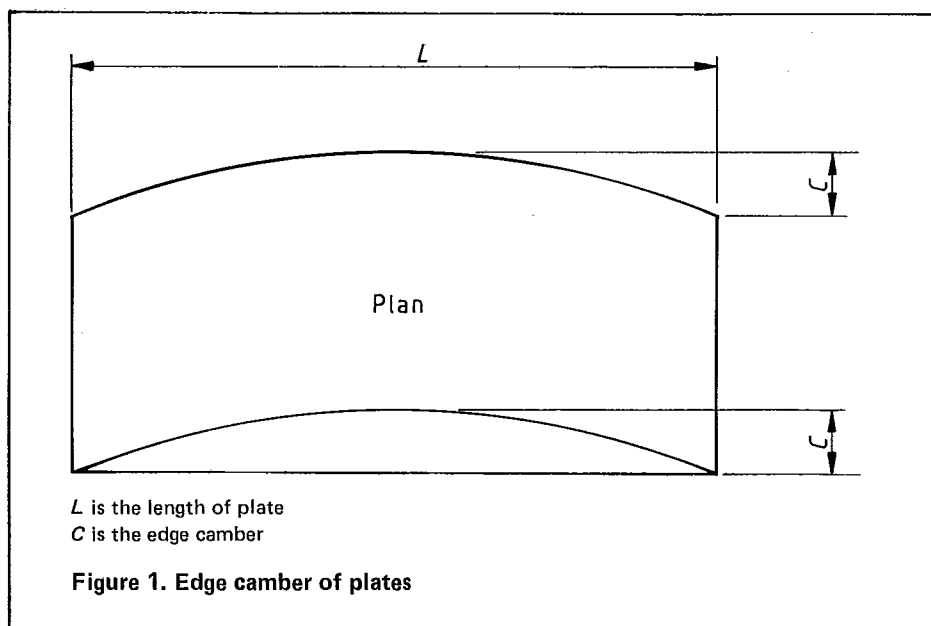
Edge camber shall be limited so that it shall be possible to inscribe the dimensions of the ordered plate within the delivered size.

The edge camber, *C*, shall be taken as the maximum deviation between one longitudinal edge and the straight line joining the two ends of this edge (see figure 1).

14.6 Flatness tolerances for plates

The flatness tolerances for plates shall not exceed the normal flatness tolerances given in table 5 for the straight-edge selected.

To measure flatness, the plate resting under its own weight shall be placed on a flat horizontal surface. Deviations with respect to flatness shall be determined by measuring the distance between the plate and a straightedge resting on the plate, the straightedge being placed in any direction.



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Only the portion situated between the two points of contact shall be taken into consideration. Deviations shall be measured at a point a minimum of 20 mm from the longitudinal edges and a minimum of 100 mm from transverse edges.

When distances between points of contact are between 500 mm and 1000 mm, the deviation shall be obtained

by taking the distance between points of contact and calculating proportionally from the deviation given for a 1000 mm straightedge in table 5.

See also option **B.15**.

NOTE. It is pointed out that bad handling and storage can adversely affect the flatness of plates.

Table 4. Thickness tolerances for plates

Ordered thickness	Width of plate (in mm)				
	Up to and including 2000	Over 2000 up to and including 2500	Over 2500 up to and including 3000	Over 3000 up to and including 3500	Over 3500 up to and including 4000
mm	mm	mm	mm	mm	mm
Less than 5	±0.40	±0.50	±0.50	—	—
5 to less than 8	±0.45	±0.60	±0.80	±0.80	—
8 to less than 25	±0.55	±0.65	±0.80	±0.85	±0.95
25 to less than 40	±0.55	±0.70	±0.80	±0.85	±0.95
40 to less than 80	±0.60	±0.80	±0.85	±0.95	±1.05
80 up to and including 150	±1.10	±1.15	±1.20	±1.25	±1.25

Table 5. Normal flatness tolerances for plates

Ordered thickness	Straight-edge length selected	Permitted deviations for ordered widths (in mm)							
		Less than 1500	1500 to less than 2000	2000 to less than 2500	2500 to less than 2750	2750 to less than 3000	3000 to less than 3250	3250 to less than 3500	3500 to less than 4000
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
3 to less than 4	1000	7	8	10	—	—	—	—	—
	2000	14	18	22	—	—	—	—	—
4 to less than 6	1000	7	7	8	10	—	—	—	—
	2000	14	16	21	25	—	—	—	—
6 to less than 8	1000	7	7	8	8	8	—	—	—
	2000	14	14	16	17	20	—	—	—
8 to less than 10	1000	7	7	7	7	8	8	9	—
	2000	13	13	14	15	16	18	20	—
10 to less than 20	1000	7	7	7	7	7	8	8	9
	2000	12	12	12	13	14	15	17	19
20 up to and including 150	1000	7	7	7	7	7	8	8	9
	2000	11	11	12	12	12	13	14	16

15 Tolerances for wide flats

15.1 Length tolerances for wide flats

The length tolerances on ordered length for wide flats shall be $-0, +50$ mm.

The length of a wide flat shall be taken as the length of the largest rectangle contained within the wide flat.

See also option **B.16**.

15.2 Width tolerance for wide flats

The width tolerance on ordered width for wide flats shall be $\pm 2\%$ of the ordered width but shall not exceed ± 5 mm.

Width shall be measured at a distance not less than 150 mm from the end of the wide flat.

15.3 Thickness tolerances for wide flats

15.3.1 The thickness tolerances on ordered thickness for wide flats shall be as given in table 6.

Thickness shall be measured at a distance of not less than 15 mm from the longitudinal edges and not less than 100 mm from the ends of the wide flat.

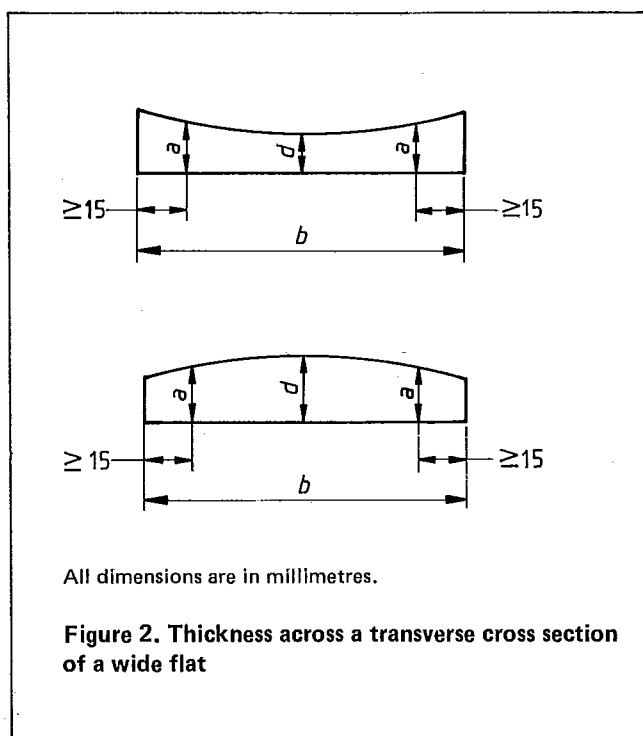
The difference in thickness across the width of one transverse cross section shall be measured on a line running at right angles to the longitudinal edges.

See also options **B.17**, **B.18** and **B.19**.

15.3.2 Additionally, the difference in thickness between dimensions a and d (see figure 2) in a transverse cross section shall not exceed the values given in table 7.

Ordered thickness	Tolerances
mm	mm
4 to less than 10	± 0.5
10 to less than 20	± 0.6
20 to less than 25	± 0.7
25 to less than 30	± 0.8
30 to less than 40	± 0.9
40 to less than 50	± 1.0
50 to less than 60	± 1.1
60 to less than 80	± 1.3
80 and over	± 2.0

Ordered width	Maximum difference in thickness between a and d
mm	mm
Over 150 up to and including 500	0.5
Over 500 up to and including 1 000	0.6
Over 1 000 up to and including 1 250	0.7



15.4 Edge camber tolerances for wide flats

The edge camber tolerances for wide flats shall be a normal straightness edge camber not exceeding 0.25 % of the length of the wide flat.

The edge camber value, C , shall be taken as the maximum deviation between one longitudinal edge and the straight line joining the two ends of this edge. It shall be measured on the concave edges of the wide flat (see figure 3).

The measuring points shall be at least 50 mm from the ends of the wide flat.

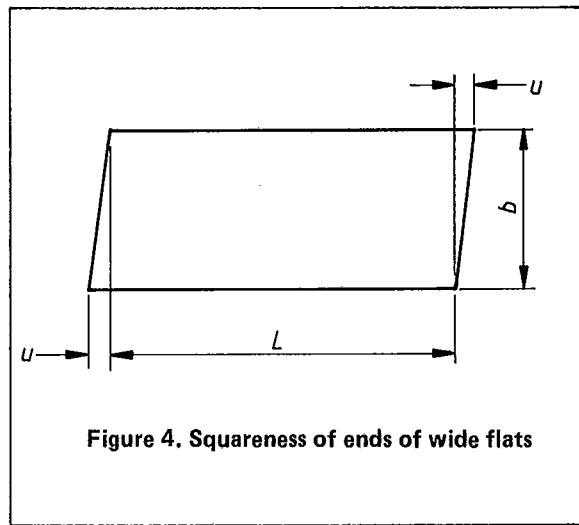
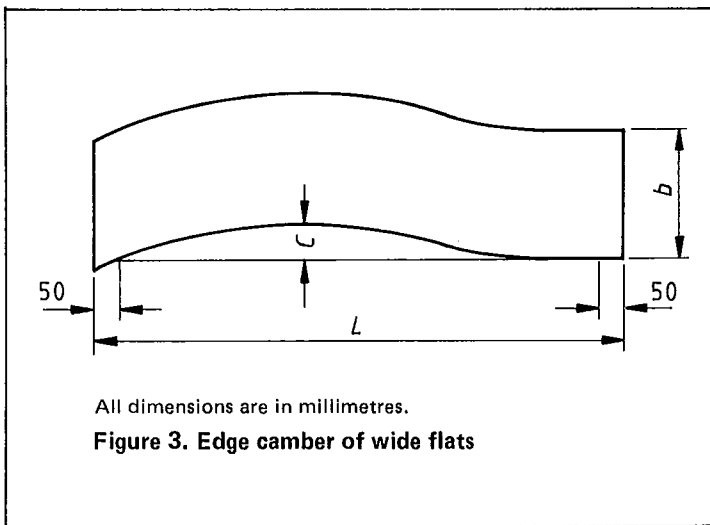
See also option **B.20**.

15.5 Squareness of ends of wide flats

The out-of-square value, u , shall be equal to or less than 1 % of the actual width of the wide flat, but shall not exceed 5 mm.

The value of u shall be taken as the orthogonal projection of one transverse edge over one longitudinal edge (see figure 4).

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15.6 Angular accuracy tolerances for wide flats

The deviation for angular accuracy, w , (see figure 5) shall not exceed the value given in table 8.

Ordered thickness	Tolerances
mm	mm
Up to and including 13	2.0
Over 13 up to and including 18	3.0
Over 18	3.5

15.7 Flatness tolerances for wide flats

Wide flats shall be supplied to a normal flatness tolerance.

The deviation in the transverse direction shall not exceed 0.3 % of the width of the wide flat.

The deviation in the longitudinal direction referred to a straightedge length of 1000 mm shall not exceed 7 mm.

In the case of a shorter measuring length of 500 mm up to but not including 1000 mm, the deviation shall not exceed 1 % of the measuring length.

To measure flatness, the wide flat, resting under its own weight, shall be placed on a flat horizontal surface. Deviations with respect to flatness shall be determined by measuring the distance between the wide flat and a straightedge which may be placed in the longitudinal or transverse directions. Only the portion situated between two points of contact shall be taken into consideration. Deviations shall be measured at a point a minimum of 200 mm from the ends.

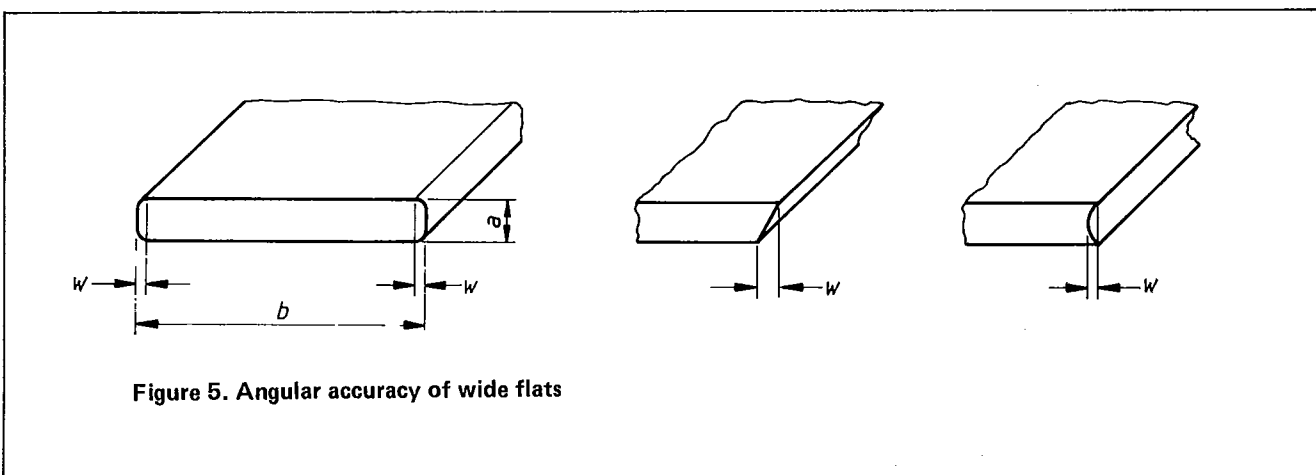
See also option B.20.

16 Tolerances for flats

16.1 Length tolerances for flats

The length tolerances on ordered length for flats shall be $-0, +300$ mm.

See also options B.16 and B.21.



16.2 Width tolerances for flats

The width tolerances on ordered width for flats shall be as given in table 9.

Table 9. Width tolerances for flats	
Ordered width	Tolerances
mm	mm
Up to and including 35	±0.5
Over 35 up to and including 75	±0.8
Over 75 up to and including 100	±1.0
Over 100 up to and including 125	±1.3
Over 125 up to and including 150	±1.5

16.3 Thickness tolerances for flats

The thickness tolerances on ordered thickness for flats shall be as given in table 10.

See also options B.22 and B.23.

Table 10. Thickness tolerances for flats	
Ordered thickness	Tolerances
mm	mm
Up to and including 10	±0.4
Over 10 up to and including 20	±0.5
Over 20 up to and including 40	±0.6
Over 40 up to and including 60	±0.8
Over 60	±1.0

17 Tolerances for round and square bars**17.1 Size tolerances for round and square bars**

17.1.1 The size (diameter in the case of round bars and width across flats in the case of square bars) tolerances on ordered size shall be as given in table 11.

Diameter or width across flats shall be measured at a distance not less than 150 mm from the end of the bars when delivery is made in lengths and at any point when delivery is made with restricted length tolerances in accordance with options B.16 and B.21.

See also options B.24 and B.25.

17.1.2 The out-of-section tolerances shall be as given in table 11.

Out-of-section shall be measured as the difference between the maximum and minimum diameters on the same cross section, for round bars, and the difference of the distance between parallel faces on the same cross section, for square bars.

17.2 Length tolerances for round and square bars

The length tolerance on ordered length for round and square bars shall be -0, +600 mm.

See also options B.16 and B.21.

18 Tolerances for sections

The dimensional and mass tolerances for sections shall comply with the following.

- (a) Sections (other than hollow sections): BS 4 : Part 1; BS 4848 : Parts 4 and 5.
- (b) Hollow sections: BS 4848 : Part 2.

Table 11. Size tolerances for round and square bars		
Ordered size	Tolerances on diameter or width	Tolerances on out-of-section
mm	mm	mm
Up to and including 15	±0.2	0.3
Over 15 up to and including 25	±0.3	0.5
Over 25 up to and including 35	±0.4	0.6
Over 35 up to and including 50	±0.5	0.8
Over 50 up to and including 65	±0.6	0.9
Over 65 up to and including 80	±0.7	1.1
Over 80 up to and including 100	±0.9	1.4
Over 100 up to and including 120	±1.1	1.7
Over 120 up to and including 160	±2.0	3.0
Over 160 up to and including 200	±2.5	3.8
Over 200	±3.0	4.5

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Section three

Section three. Specific requirements for testing

19 Selection and identification of test samples

NOTE. Ultrasonic testing and through-thickness testing of plates (other than continuous mill products) and wide flats may be incorporated in the specification (see options B.26 and B.27).

19.1 Selection of samples

The manufacturer shall randomly select and identify test samples in accordance with clauses 20, 21, 24 and 25.

See also options B.28, B.29, B.30 and B.31.

19.2 Condition of samples

The test samples shall be in the heat treatment condition specified in clause 6.

20 Number of tensile tests

20.1 Plates, strip (coil), wide flats, flats, sections and bars

One tensile test shall be made on the finished steel for each 40 t or part thereof of the same product form (e.g. plates or types of sections), of the same thickness or diameter range (see tables 13, 15, 17, 19, 21 and 23) from the same cast, and showing a thickness or diameter variation of not more than 5 mm above and below the thickness or diameter of the product sampled (or not more than 25 mm in the case of plates above 75 mm thick).

20.2 Hollow sections

One tensile test shall be made on the finished section for each 40 t or part thereof from the same cast, except for hollow sections made by a continuous process, for which two tensile tests shall be made for each 40 t or less of any section.

See also option B.32.

21 Direction and position of tensile test samples

21.1 Direction of samples

21.1.1 *Plates and strip (coil)*. Tensile test samples shall be cut in the transverse direction.

21.1.2 *Wide flats*. Tensile test samples shall be cut in the longitudinal direction for widths up to 400 mm and longitudinal or transverse for widths over 400 mm, at the manufacturer's discretion.

21.1.3 *Flats, sections (other than hollow sections) and bars*. Tensile test samples shall be cut in the longitudinal direction.

21.1.4 *Hollow sections*. Tensile test samples shall be cut in the longitudinal direction.

21.2 Position of samples

21.2.1 *Plates, wide flats and flats*. Samples shall be taken from one end midway between the centre and one edge. (See appendices C and D.)

21.2.2 *Strip (coil)*. Samples shall be taken at an adequate distance from the outer end midway between the centre and one edge for wide strip and at one-third of the width for narrow strip (less than 600 mm wide).

21.2.3 *Sections*. Samples shall be taken from the relevant flange positions shown in appendix C. In the case of sections with tapered flanges, it is permissible for the test samples to be taken from the web or flange, at the manufacturer's discretion, as shown in appendix C.

21.2.4 *Hollow sections*. It is permissible to test small hollow sections in full section. Where this is not done, samples from rectangular (including square) hollow sections shall be taken from any side midway between and excluding the corners as shown in appendix C.

Samples shall be cut clear of any welds.

21.2.5 *Round and square bars*. It is permissible to test small bars in full section. Where this is not done, samples shall be taken from the positions shown in appendix D.

22 Tensile test pieces

22.1 Preparation of test pieces

Tensile test pieces shall be prepared in accordance with BS 18, as appropriate, from the test samples obtained in accordance with clause 21, so that, wherever practicable, the rolled surface of the steel is retained on two opposite sides of the test piece. Where this is not practicable, round or rectangular test pieces having a thickness or diameter of not less than 12.5 mm shall be taken from the relevant positions shown in appendix D.

22.2 Straightening of test pieces

Any straightening of test pieces which is required shall be done cold. Test pieces cut from circular hollow sections shall be tested in the curved condition, but it is permissible for the ends to be flattened cold for gripping.

23 Tensile test

23.1 General

The tensile test shall be carried out in accordance with BS 18, as appropriate. The tensile strength, R_m , the yield strength, R_e , and the elongation, A , shall be determined, and the results obtained shall comply with the values given in tables 13, 15, 17, 19, 21 and 23 for the appropriate grade. For the yield strength, it is permissible for the manufacturer to determine either the upper yield stress, R_{eH} , or the 0.5 % proof stress (total extension), $R_{t0.5}$.

23.2 Dispute

If the result is in doubt or dispute, the yield strength shall be deemed not to be reached until the total extension under load as determined by the extensometer or dividers, is observed to be 0.5 % of the gauge length ($R_{t0.5}$).

23.3 Elongation

The specified elongation values relate to an 80 mm or 200 mm gauge length or a proportional gauge length of $5.65\sqrt{S_0}$ where S_0 is the original cross-sectional area of the test piece as shown in tables 13, 15, 17, 19, 21 and 23 and if other gauge lengths are used, the corresponding elongation on gauge length of 80 mm or 200 mm or $5.65\sqrt{S_0}$ shall be obtained as described in BS 3894 : Part 1.

24 Number of impact tests

24.1 Plates and strip

24.1.1 For steel sub-grades EE and F, three adjacent Charpy V-notch test pieces shall be taken from each parent plate or strip (coil).

24.1.2 For other sub-grades, three adjacent test pieces shall be taken from one of the thickest plates or strips (coils) of each 40 t or part thereof of the same thickness range (see tables 13 and 21) from the same cast.

24.2 Wide flats, flats, sections, hollow sections and bars

24.2.1 For steel sub-grades DD, E, EE and F, where applicable (see tables 13, 15, 17 and 19), three adjacent Charpy V-notch test pieces shall be taken from one of the thickest products for every 5 t or from each parent product if its mass exceeds 5 t.

24.2.2 For other sub-grades, three adjacent test pieces shall be taken from one of the thickest products of each 40 t or

part thereof of the same thickness range (see tables 13, 15, 17, 19, 21 and 23) from the same cast.

25 Position of impact test samples

The impact test samples shall be taken from the positions shown in appendix E. Impact test samples taken from welded hollow sections shall be cut clear of the weld. For other sections, the impact test samples shall be taken from within 25 mm of the centres of the position shown in appendix E.

26 Impact test pieces

NOTE 1. Impact tests for material less than 6 mm thick are not normally carried out but may be agreed between the purchaser and the manufacturer at the time of the enquiry and order.

NOTE 2. Test piece size is dependent on the actual thickness of the test sample and for circular products allowance also needs to be made for the radius of curvature of the surface.

26.1 General

The test pieces shall be cut parallel to the principal direction of rolling and the axis of the notch shall be perpendicular to the rolled surface of the product (see figure 6). The test pieces shall be prepared in accordance with BS 131 : Part 2 and 26.2 to 26.4.

26.2 Thick material

For thicknesses of 20 mm and over, standard 10 mm x 10 mm test pieces shall be so machined that they do not include material nearer to the surface than 3 mm.

26.3 Thin material

For material equal to or greater than 12 mm up to but excluding 20 mm thick, standard 10 mm x 10 mm test pieces shall be so machined that they do not include material nearer to the surface than 1 mm.

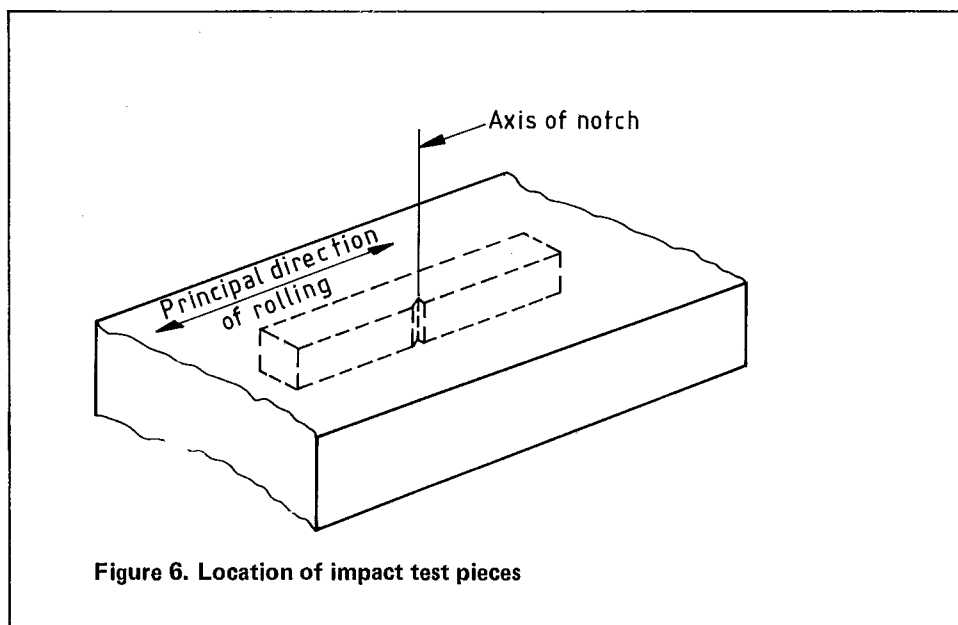


Figure 6. Location of impact test pieces

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26.4 Material less than 12 mm thick

For material equal to or greater than 6 mm thick up to but not including 12 mm thick, one of the following sizes of test pieces shall be prepared using the full thickness where necessary:

- standard test piece 10 mm × 10 mm;
- subsidiary standard test piece 10 mm × 7.5 mm;
- subsidiary standard test piece 10 mm × 5 mm.

27 Impact tests

NOTE 1. The specified impact properties are for quality control purposes during the manufacture of the steel and the fact that low temperatures are used for these tests does not necessarily imply that the steels are completely satisfactory for use at these temperatures.

NOTE 2. The steels specified in this standard may be used in many applications for which design and construction codes may differ in requirements in respect of impact testing, e.g. orientation of test samples, frequency of testing or minimum energy values. The purchaser is advised to consult the manufacturer when this is the case. For information, appendix F gives indicative energy values for products other than round and square bars at temperatures other than those specified in this standard.

27.1 Method of testing

The impact test shall be carried out in accordance with BS 131 : Part 2 at the temperature given in tables 13, 15, 17, 19, 21 and 23 for the grade ordered.

27.2 Values for standard test pieces

The average impact value obtained from the three standard 10 mm × 10 mm test pieces shall be not less than the appropriate value given in tables 13, 15, 17, 19, 21 and 23 (see 27.4) for the grade ordered.

27.3 Values for subsidiary standard test pieces

The average impact values obtained from three subsidiary standard test pieces shall be not less than 22 J for 10 mm × 7.5 mm test pieces or 19 J for 10 mm × 5 mm test pieces (see 27.4).

27.4 Individual value

For standard and subsidiary standard test pieces, it is permissible for one individual value to be below the average value specified, but it shall not be less than 70 % of that value.

28 Flattening test

A flattening test shall be carried out for hollow sections manufactured by a welding process. A test specimen shall be selected for each 40 t or part thereof of the same size of section which is presented for inspection. The test shall be carried out on circular hollow sections and, where practicable, on rectangular hollow sections in the round form before shaping.

A ring not less than 40 mm in length cut from one end of each selected section shall be flattened cold between two parallel flat surfaces. Burrs shall be removed before testing and the weld shall be placed at 90° to the direction of flattening. No opening of the weld shall take place until the distance between platens is less than 85 % of the original outside diameter of the section. The test shall then be continued until the weld opens and the weld shall show no signs of incomplete fusion.

No cracks or breaks in the metal, elsewhere than in the weld, shall occur until the distance between the platens is less than two-thirds of the original outside diameter of the section.

29 Bend tests

Bend tests shall not be carried out.

See also option B.33.

30 Retests

30.1 Tensile and flattening tests

Should a test result not comply with clause 23 or 28, two further test pieces shall be made on samples taken from the product from which the original test piece was prepared.

In the case of sections with tapered flanges, it is permissible for the retests to be made on test pieces taken from the flange, at the manufacturer's discretion.

Provided the results of both these further tests comply with clauses 23 or 28, all the material represented shall be deemed to comply with this standard.

If the results of either of these additional tests does not comply with clauses 23 or 28, the product from which the samples were cut shall be deemed not to comply with this standard, but the remaining material represented shall be deemed to comply with this standard provided that test pieces from two of the remaining products selected and prepared in accordance with clauses 20, 21 and 22 or 28 are tested and comply with clause 23 or 28.

30.2 Impact tests

30.2.1 General. If the average value of the three impact tests is less than the minimum average specified in clause 27 or if one individual value is less than 70 % of the specified minimum, three additional test pieces from the same sample shall be tested and the results added to those previously obtained and a new average calculated. The new average value shall be not less than the specified minimum average. Not more than two of the individual values shall be less than the specified value. Not more than one individual value shall be less than 70 % of the specified value.

30.2.2 Products tested on a thickness range basis (see 24.1.2 and 24.2.2). For products tested on a thickness range basis, if the average impact test value of the selected test from the

thickest product fails to comply with 30.2.1, the product from which the samples were cut shall be deemed not to comply with this standard but the remaining material represented shall be deemed to comply with this standard provided test pieces from two of the remaining products selected and prepared in accordance with clauses 24, 25 and 26 are tested and comply with clause 27 and, where applicable, 30.2.

30.3 Re-heat treatment

Notwithstanding the requirements of 30.1 and 30.2, the manufacturer shall have the right to heat treat or re-heat treat any material, including material already found not to comply with clauses 23, 27 and 28, and re-submit it for testing.

Section four. Specific requirements for weldable structural steel plates, strip and wide flats

The requirements for the chemical and mechanical properties of weldable structural steel plates, strip and wide flats shall be as given in tables 12 and 13.

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Section four**Table 12. Chemical composition (ladle analysis) for plates, strip and wide flats**

Figures in parentheses refer to the notes following this table.

Grade	Chemical composition							
	C max.	Si	Mn max.	P max.	S	Nb	V	Normal supply condition (1) (2)
40EE	% 0.16	% 0.10/0.50	% 1.50	% 0.040	% 0.030	% —	% —	Normalized
43EE	0.16	0.10/0.50	1.50	0.040	0.030	—	—	Normalized
50EE (3) 50F (3)	0.18 (4) (5) 0.16	0.10/0.50 0.10/0.50	1.50 (4) 1.50	0.040 0.025	0.030 0.025	0.003/0.10 0.003/0.08	0.003/0.10 0.003/0.10	Normalized Quenched and tempered (6)
55C (3)	0.22	0.60 max.	1.60	0.040	0.040	0.003/0.10	0.003/0.20	Under 16 mm as rolled. 16 mm and over normalized
55EE (3) 55F (3) (8)	0.22 0.16	0.10/0.50 0.10/0.50	1.60 1.50	0.040 0.025	0.030 0.025	0.003/0.10 0.003/0.08	0.003/0.20 0.03/0.10	Normalized (6) (7) Quenched and tempered (6)

(1) For continuous mill products and wide flats, the normal supply condition is as rolled.

(2) For alternative supply conditions see clause 6.

(3) It is permissible for the steels to be supplied with no niobium or vanadium. If no grain refining elements, or if grain refining elements other than aluminium, niobium or vanadium are used, the manufacturer shall inform the purchaser at the time of enquiry and order.

If niobium and vanadium are used in combination, the combined total shall be less than 0.13 % in the case of grades 50F and 55F, or less than 0.15 % in the case of grades 50EE, 55C and 55EE.

(4) It is permissible to vary the carbon and manganese contents (ladle analysis) for grade 50EE on the basis of an increase of 0.06 % manganese content for each decrease of 0.01 % carbon or vice versa up to a maximum manganese content of 1.60 % and a maximum carbon content of 0.20 %.

(5) For grade 50EE over 16 mm thick, a maximum carbon content of 0.20 % for ladle is permitted.

(6) Not available as continuous mill products or wide flats.

(7) It is permissible for the manufacturer to supply grade 55EE in the quenched and tempered condition when the material is supplied to a maximum carbon equivalent value (CEV).

(8) For grade 55F, an addition of molybdenum up to 0.20 % maximum is permitted, at the manufacturer's discretion.

See also options B.4, B.5, B.6, B.7, B.34 and B.35.

Table 13. Mechanical properties for plates, strip and wide flats												
Figures in parentheses refer to the notes following this table.												
Tensile strength, R_m (1)	Minimum yield strength, R_e , for thicknesses (in mm) (2)					Minimum elongation, A , on a gauge length of (1)			Minimum Charpy V-notch impact test value			Grade
	Up to and including 16	Over 16 up to and including 40	Over 40 up to and including 63	Over 63 up to and including 100	Over 100 up to and including 150	80 mm (3)	200 mm (4)	$5.65 \sqrt{S_0}$	Temp.	Energy min. value	Thickness (5)	
N/mm^2 (6)	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	%	%	%	°C	J	mm	
340/500	260	245	240	225	205	25	22	25	-50	27	75	40EE
430/580 (7)	275	265	255	245	225	23	20	22	-50	27	75	43EE
490/640 (8) (9)	355	345	340	325	305	20	18	20	-50	27	75 (10)	50EE
490/640	390	390	—	—	—	20	18	20	-60	27	40	50F
	Up to and including 16	Over 16 up to and including 25	Over 25 up to and including 40	Over 40 up to and including 63								
550/700	450	430	—	—		19	17	19	0	27	25	55C
550/700	450	430	415	400		19	17	19	-50	27	63	55EE
550/700	450	430	415	—		19	17	19	-60	27	40	55F

(1) The specified tensile strength and elongation values apply up to the maximum thickness for which minimum yield strength values are specified.

(2) For wide flats up to and including 63 mm thick and for continuous mill products up to and including 16 mm thick.

(3) Up to and including 9 mm thick, 17 % for grades 40EE and 43EE and 16 % for grade 50EE.

(4) Up to and including 9 mm thick, 16 % for grades 40EE and 43EE and 15 % for grades 50EE, 50F, 55C, 55EE and 55F.

(5) For wide flats up to and including 50 mm thick.

(6) $1 N/mm^2 = 1 MPa$.

(7) Minimum tensile strength $410 N/mm^2$ for material over 100 mm thick.

(8) Minimum tensile strength $460 N/mm^2$ for material over 100 mm thick.

(9) Minimum tensile strength $480 N/mm^2$ for material over 16 mm thick up to and including 100 mm thick.

(10) For wide flats up to and including 30 mm thick.

Section five.
**Specific requirements for weldable structural
steel sections (other than hollow sections)**

The specific requirements for the chemical and mechanical properties of weldable structural steel sections (other than hollow sections) shall be as given in tables 14 and 15.

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Section five

Table 14. Chemical composition (ladle analysis) for sections (other than hollow sections)

Figures in parentheses refer to the notes following this table.

Grade	Chemical composition						Normal supply condition (1)
	C max.	Si	Mn max.	P max.	Nb	V	
40DD	% 0.16	% 0.10/0.50	% 1.50	% 0.040	% —	% —	As rolled or normalized
43DD	0.16	0.10/0.50	1.50	0.040	—	—	As rolled or normalized
50E (2) (3)	0.18 (4)	0.10/0.50	1.50	0.040	0.003/0.10	0.003/0.10	As rolled or normalized
55C (2)	0.22	0.60 max.	1.60	0.040	0.003/0.10	0.003/0.20	As rolled

(1) For alternative supply conditions see clause 6.

(2) It is permissible for the steels to be supplied with no niobium or vanadium. If no grain refining elements, or if grain refining elements other than aluminium, niobium or vanadium are used, the manufacturer shall inform the purchaser at the time of enquiry and order. If niobium and vanadium are used in combination, the combined total shall be less than 0.15 % in the case of grades 50E and 55C.

(3) It is permissible to vary the carbon and manganese contents (ladle analysis) on the basis of an increase of 0.06 % manganese for each decrease of 0.01 % carbon or vice versa up to a maximum manganese content of 1.60 % and a maximum carbon content of 0.20 % for grade 50E.

(4) For grade 50E over 16 mm thick, a maximum carbon content of 0.20 % for ladle is permitted.

See also options B.5, B.6, B.7, B.9, B.37 and B.38.

Table 15. Mechanical properties for section (other than hollow sections)

Figures in parentheses refer to the notes following this table.

Tensile strength, R_m	Minimum yield strength, R_e , for thicknesses (in mm)				Minimum elongation, A , on a gauge length of		Minimum Charpy V-notch impact test value		Grade
	Up to and including 16	Over 16 up to and including 40	Over 40 up to and including 63	Over 63 up to and including 100	200 mm (1)	$5.65 \sqrt{S_0}$	Temp.	Energy min. value	
N/mm ² (2) 340/500	N/mm ² 260	N/mm ² 245	N/mm ² 240	N/mm ² 225	% 22	% 25	°C -30	J 27	40DD
430/580	275	265	255	245	20	22	-30	27	43DD
490/640 (3)	355	345	340	325	18	20	-40	27	50E
	Up to and including 16	Over 16 up to and including 25	Over 25 up to and including 40						
550/700	450	430	415	—	17	19	0	27 (4)	55C

(1) Up to and including 9 mm thick, 16 % for grades 40 and 43 and 15 % for grades 50 and 55.

(2) 1 N/mm² = 1 MPa.

(3) Minimum tensile strength 480 N/mm² for material over 16 mm thick up to and including 100 mm thick.

(4) To a maximum thickness of 19 mm.

Section six.
**Specific requirements for weldable structural
steel flats and round and square bars**

The specific requirements for the chemical and mechanical properties of weldable structural steel flats and round and square bars shall be as given in tables 16 and 17.

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Section six**Table 16. Chemical composition (ladle analysis) for flats and round and square bars**

Figures in parentheses refer to the notes following this table.

Grade	Chemical composition							
	C max.	Si	Mn max.	P	S	Nb	V	Normal supply condition (1)
40E	% 0.16	% 0.10/0.50	% 1.50	% 0.040	% 0.040	% —	% —	% As rolled or normalized
43E	0.16	0.10/0.50	1.50	0.040	0.040	—	—	As rolled or normalized
50E (2)	0.20	0.10/0.50	1.50	0.040	0.040	0.003/0.10	0.003/0.10	Normalized
55C (2)	0.22	0.60 max.	1.60	0.040	0.040	0.003/0.10	0.003/0.20	As rolled Normalized or quenched and tempered
55EE (2)	0.22	0.10/0.60	1.60	0.040	0.040	0.003/0.20	0.003/0.20	

(1) For alternative supply conditions see clause 6.

(2) It is permissible for the steels to be supplied with no niobium or vanadium. If no refining elements other than aluminium, niobium or vanadium are used, the manufacturer shall inform the purchaser at the time of enquiry and order. If niobium and vanadium are used in combination, the combined total shall be less than 0.10 % in the case of grade 50E and less than 0.20 % in the case of grades 55C and 55EE.

See also options B.4, B.5, B.6, B.7, B.34 and B.35.

Table 17. Mechanical properties for flats and round and square bars

Figures in parentheses refer to the notes following this table.

Tensile strength, R_m	Minimum yield strength, R_e , for thicknesses (in mm)				Minimum elongation, A , length of $5.65 \sqrt{S_0}$	Minimum Charpy V-notch impact test value		Grade
	Up to and including 16	Over 16 up to and including 40	Over 40 up to and including 63	Over 63 up to and including 100		Temp.	Energy min. value	
N/mm ² (2)	N/mm ²	N/mm ²	N/mm ²	N/mm ²	%	°C	J	
340/500	260	245	240	225	25	-40	27 (2)	40E
430/580	275	265	255	245	22	-40	27 (2)	43E
490/640 (3)	355	345	340	325	20	-40	27 (2)	50E
	Up to and including 16	Over 16 up to and including 25	Over 25 up to and including 40	Over 40 up to and including 63				
550/700	450	430	415	—	19	0	27 (4)	55C
550/700	450	430	415	400	19	-50	27	55EE

(1) 1 N/mm² = 1 MPa.

(2) To a maximum thickness of 75 mm.

(3) Minimum tensile strength 480 N/mm² for material over 16 mm thick up to and including 100 mm thick.

(4) To a maximum thickness of 19 mm.

Section seven.
**Specific requirements for weldable structural
steel hollow sections**

The specific requirements for the chemical and mechanical properties of weldable structural steel hollow sections shall be as given in tables 18 and 19.

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Section seven

Table 18. Chemical composition (ladle analysis) for hollow sections

Figures in parentheses refer to the notes following this table.

Grade	Chemical composition							Normal supply condition (1)
	C max.	Si max.	Mn max.	P max.	S max.	Nb	V	
43C	0.21	0.50	1.30	0.050	0.050	—	—	Hot finished
43D	0.20	0.50	1.30	0.040	0.045	—	—	Hot finished
43EE	0.18	0.50	1.30	0.040	0.045	—	—	Hot finished or normalized
50C (2)(3)	0.20	0.50	1.50	0.045	0.045	0.003/0.10	0.003/0.15	Hot finished
50D (2)(3)	0.20	0.50	1.50	0.040	0.040	0.003/0.10	0.003/0.15	Hot finished
50EE (2)(3)	0.20	0.50	1.50	0.040	0.040	0.003/0.10	0.003/0.15	Hot finished
55C (3)	0.25	0.50	1.60	0.040	0.040	0.003/0.10	0.003/0.20	Hot finished
55EE (3)	0.25	0.50	1.60	0.040	0.040	0.003/0.10	0.003/0.20	Normalized
55F (3)	0.16	0.50	1.50	0.025	0.025	0.003/0.10	0.003/0.10	Quenched and tempered

(1) For alternative supply conditions see clause 6.

(2) For each reduction of 0.01 % of carbon below the specified value an increase of 0.06 % manganese above the specified value is permitted up to a maximum of 1.60 %.

(3) It is permissible for the steels to be supplied with no niobium or vanadium. If no grain refining elements or if grain refining elements other than aluminium, niobium or vanadium are used, the manufacturer shall inform the purchaser at the time of enquiry and order. If niobium and vanadium are used in combination, the combined total shall be less than 0.13 % for grades 50C, 50D, 50EE, 55F, or less than 0.15 % in the case of 55C and 55EE.

See also options B.4, B.5, B.6, B.7, B.34 and B.35.

Table 19. Mechanical properties for hollow sections (1)							
Figures in parentheses refer to the notes following this table.							
Tensile strength, R_m	Minimum yield strength, R_e , for thicknesses (in mm)		Minimum elongation, A , on gauge length of $5.65 \sqrt{S_0}$	Minimum Charpy V-notch impact test value			Grade
	Up to and including 16	Over 16 up to and including 40 (2)		Temp.	Energy min. value	Thickness max.	
N/mm ² (3)	N/mm ²	N/mm ²	%	°C	J	mm	
430/580	275	265	22	0 (4)	27	40	43C
430/580	275	265	22	-20	27	40	43D
430/580	275	265	22	-50	27	40	43EE
490/640	355	345	21	0	27	40	50C
490/640	355	345	21	-20	27	40	50D
490/640	355	345	21	-50	27	40	50EE
	Up to and including 16	Over 16 up to and including 25 (2)					
550/700	450	430	19	0	27	25	55C
550/700	450	430	19	-50	27	25	55EE
550/700	450	430	19	-60	27	25	55F

(1) For details of flattening test see clause 28.

(2) Only circular hollow sections are available in thicknesses over 16 mm.

(3) 1 N/mm² = 1 MPa.

(4) Verification of the specified impact value to be carried out only when option B.36 is invoked by the purchaser.

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Section eight. Specific requirements for weather resistant weldable structural steels

The specific requirements for the chemical and mechanical properties of weather resistant weldable structural steels shall be as given in tables 20 to 23.

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Table 20. Chemical composition (ladle analysis) for plates, strip, wide flats, flats, sections (other than hollow sections) and round and square bars: weather resistant grades

Figures in parentheses refer to the notes following this table.

Grade	Chemical composition										Normal supply condition (1)
	C max.	Si	Mn	P	S max.	Cr	Ni max.	Cu	Al (sol.) (2)	V	
WR50A	% 0.12	% 0.25/ 0.75	% 0.30/ 0.50	% 0.070/ 0.15	% 0.050	% 0.50/ 1.25	% 0.65	% 0.25/ 0.55	% —	% —	As rolled
WR50B	0.19	0.15/ 0.65	0.90/ 1.25	0.040 max.	0.050	0.50/ 0.65	—	0.25/ 0.40	0.01/ 0.06	0.02/ 0.10	As rolled or normalized
WR50C	0.22	0.15/ 0.65	0.90/ 1.45	0.040 max.	0.050	0.50/ 0.65	—	0.25/ 0.40	0.01/ 0.06	0.02/ 0.10	As rolled or normalized

(1) For alternative supply conditions see clause 6.

(2) A total aluminium content of 0.010 % to 0.065 % shall be considered to be in compliance with this requirement.

See also options B.4, B.5, B.6 and B.7.

Table 21. Mechanical properties for plates, strip, wide flats, flats, sections (other than hollow sections) and round and square bars: weather resistant grades

Figures in parentheses refer to the notes following this table.

Minimum tensile strength, R_m	Minimum yield strength, R_e , for thicknesses (in mm)				Minimum elongation, A , on gauge length of		Minimum Charpy V-notch impact test value			Grade
	Up to and including 12	Over 12 up to and including 25	Over 25 up to and including 40	Over 40 up to and including 50	200 mm (1)	$5.65 \sqrt{S_0}$	Temp.	Energy min. value	Thickness max.	
N/mm ² (2) 480	N/mm ² 345	N/mm ² 325	N/mm ² 325	N/mm ² —	% 19	% 21	°C 0	J 27	mm 12 (3)	WR50A
480	345	345	345	340	19	21	0	27	50	WR50B
480	345	345	345	340 (4)	19	21	-15	27	50	WR50C

(1) Minimum elongation of 17 % for material under 9 mm.

(2) 1 N/mm² = 1 MPa.

(3) For round and square bars, maximum thickness is 25 mm.

(4) Up to and including 63 mm.

Table 22. Chemical composition (ladle analysis) for hollow sections: weather resistant grades

Figures in parentheses refer to the notes following this table.

Grade	Chemical composition										Normal supply condition (1)
	C max.	Si	Mn	P	S	Cr	Ni max.	Cu	Al (sol.) (2)	V	
WR50A	% 0.12	% 0.25/ 0.75	% 0.60 max.	% 0.070/ 0.15	% 0.050	% 0.30/ 1.25	% 0.65	% 0.25/ 0.55	% —	% —	Hot finished
WR50B	0.19	0.15/ 0.50	0.90/ 1.25	0.040 max.	0.050	0.40/ 0.70	—	0.25/ 0.40	0.01/ 0.06	0.02/ 0.10	Hot finished or normalized
WR50C	0.22	0.15/ 0.50	0.90/ 1.45	0.040 max.	0.050	0.40/ 0.70	—	0.25/ 0.40	0.01/ 0.06	0.02/ 0.10	Hot finished or normalized

(1) For alternative supply conditions see clause 6.

(2) A total aluminium content of 0.010 % to 0.65 % shall be considered to be in compliance with this requirement.

See also options B.4, B.5, B.6 and B.7.

Table 23. Mechanical properties for hollow sections: weather resistant grades (1)

Figures in parentheses refer to the notes following this table.

Tensile strength, R_m	Minimum yield strength, R_e , for thicknesses (in mm)			Minimum elongation, A , on gauge length of $5.65 \sqrt{S_0}$	Charpy V-notch impact test value			Grade
	Up to and including 12 mm	Over 12 up to and including 25 (2)	Over 25 up to and including 40		Temp.	Energy min.	Thickness max.	
N/mm ² (3) 480	N/mm ² 345	N/mm ² 325	N/mm ² 325	% 21	°C 0	J 27	mm 12	WR50A
480	345	345	345	21	0	27	40	WR50B
480	345	345	345	21	-15	27	40	WR50C

(1) For details of flattening test see clause 28.

(2) Only circular hollow sections are available in thicknesses over 16 mm.

(3) 1 N/mm² = 1 MPa.

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Appendix A

Appendices

Appendix A. Comparison between grades in this standard and BS 4360 : 1979 and equivalence with grades in Euronorms and ISO standards

Tables 24 to 29 give comparisons between grades in this standard and those in BS 4360 : 1979 for the various products. Table 30 shows the nearest equivalent grades in Euronorms and ISO standards.

This standard				BS 4360 : 1979			
Grade	Tensile strength	Minimum yield strength at 16 mm	Charpy V-notch impacts 27 J at	Grade	Tensile strength	Minimum yield strength at 16 mm	Charpy V-notch impacts 27 J at
40EE	N/mm ² 340/500	N/mm ² 260	°C -50	40E	N/mm ² 400/480	N/mm ² 260	°C -50
43EE	430/580	275	-50	43E	430/540	280	-50
50EE	490/640	355	-50	50E	490/620	355	-50
50F	490/640	390	-60	50F	490/620	390	-60
55C	550/700	450	0	55C	550/700	450	0
55EE	550/700	450	-50	55E	550/700	450	-50
55F	550/700	450	-60	55F	550/700	450	-60

This standard				BS 4360 : 1979			
Grade	Tensile strength	Minimum yield strength at 16 mm	Charpy V-notch impacts 27 J at	Grade	Tensile strength	Minimum yield strength at 16 mm	Charpy V-notch impacts 27 J at
40DD	N/mm ² 340/500	N/mm ² 260	°C -30	40E	N/mm ² 400/480	N/mm ² 255	°C -30
43DD	430/580	275	-30	43E	430/510	270	-30
50E	490/640	355	-40				
55C	550/700	450	0	55C	550/700	450	0
				55E	550/700	450	-50

This standard				BS 4360 : 1979			
Grade	Tensile strength	Minimum yield strength at 16 mm	Charpy V-notch impacts 27 J at	Grade	Tensile strength	Minimum yield strength at 16mm	Charpy V-notch impacts 27 J at
40E	N/mm ² 340/500	N/mm ² 260	°C -40	40E	N/mm ² 400/480	N/mm ² 255	°C -30
43E	430/580	275	-40	43E	430/510	270	-30
50E	490/640	355	-40				
55C	550/700	450	0	55C	550/700	450	0
55EE	550/700	450	-50	55E	550/700	450	-50

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Appendix A**Table 27. Hollow sections: comparison with BS 4360 : 1979**

Figure in parentheses refers to the note following this table.

This standard				BS 4360 : 1979			
Grade	Tensile strength	Minimum yield strength at 16 mm	Charpy V-notch impacts 27 J at	Grade	Tensile strength	Minimum yield strength at 16 mm	Charpy V-notch impacts 27 J at
43C	N/mm ² 430/580	N/mm ² 275	°C 0 (1)	43C	N/mm ² 430/540	N/mm ² 275	°C 0 (1)
43D	430/580	275	-20	43D	430/540	275	-15
43EE	430/580	275	-50	43E	430/540	275	-50
50C	490/640	355	0	50B	490/640	355	—
50D	490/640	355	-20	50C	490/640	355	0
50EE	490/640	355	-50	50D	490/640	355	-10
				50E	490/640	355	-30
55C	550/700	450	0	55C	550/700	450	0
55EE	550/700	450	-50	55E	550/700	450	-50
55F	550/700	450	-60				

(1) The specified impact values are verified by test only at the request of the purchaser.

Table 28. Plates, strip, wide flats, flats, sections (other than hollow sections) and round and square bars: weather resistant grades: comparison with BS 4360 : 1979

Figure in parentheses refers to the note following this table.

This standard				BS 4360 : 1979			
Grade	Minimum tensile strength	Minimum yield strength at 12 mm	Charpy V-notch impacts 27 J at	Grade	Minimum tensile strength	Minimum yield strength at 12 mm	Charpy V-notch impacts 27 J at
WR50A (1)	N/mm ² 480	N/mm ² 345	°C 0	WR50A1	N/mm ² 480	N/mm ² 345	°C —
				WR50A	480	345	0
WR50B	480	345	0	WR50B1	480	345	—
				WR50B	480	345	0
WR50C	480	345	-15	WR50C1	480	345	-15
				WR50C	480	345	-15

(1) WR50A incorporates the requirements of WR50A1 and WR50A, i.e. it is available with specified tensile properties up to and including 40 mm thick (WR50A1) and impact properties up to and including 12 mm thick (WR50A).

This standard				BS 4360 : 1979			
Grade	Minimum tensile strength	Minimum yield strength at 12 mm	Charpy V-notch impacts 27 J at	Grade	Tensile strength	Minimum yield strength at 12 mm	Charpy V-notch impacts 27 J at
	N/mm ²	N/mm ²	°C		N/mm ²	N/mm ²	°C
WR50A	480	345	0				
WR50B	480	345	0	WR50C	500/620	355	0
WR50C	480	345	-15	WR50D	500/620	355	-15

Table 30. Nearest equivalent grades in Euronorms and ISO standards
Figure in parentheses refers to the notes following this table.

Grade	Nearest equivalent Euronorm 113 grade	Nearest equivalent ISO 4950-1980 grade
40DD 40E 40EE	—	—
43DD 43E 43EE	Fe E 285 KT — Fe E 285 KT	—
50E 55EE 55F	Fe E 355 KT Fe E 355 KT Fe E 460 KT	E 355 E E 355 E E 460 E
	Nearest equivalent Euronorm 155-1980 grade (1)	Nearest equivalent ISO 4952-1981 grade (1)
WR50A WR50B WR50C	Fe 510 C1 KI Fe 510 C2 KI Fe 510 D2 KI	Fe 355 W1A Fe 355 W2C Fe 355 W2D
(1) Equivalence is based on tensile and impact properties; no equivalence on weathering characteristics is intended or implied.		

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Appendix B

Appendix B. Options (see 4.2)

B.1 Steelmaking process

The steelmaking process shall be specified by the purchaser (see 5.1).

B.2 Temperature controlled rolling (TCR)

TCR shall not be applied in place of normalizing (see 6.2).

B.3 Thermo-mechanical controlled rolling (TMCR): except for reversing mill plates of sub-grade EE

It is permissible for the application of TMCR to take the place of normalizing, at the supplier's discretion. In all cases the specified properties shall be obtained (see 6.2).

WARNING. TMCR material is unsuitable for subsequent normalizing or hot forming in the normalizing temperature range as a significant deterioration of mechanical properties will occur.

B.4 Ladle analysis: additional elements

Details of elements in addition to those given in tables 12, 14, 16, 18, 20 and 22 shall be supplied. The purchaser shall indicate which elements are required (see 7.1 and tables 12, 14, 16, 18, 20 and 22).

B.5 Actual carbon equivalent value (CEV)

The manufacturer shall either:

(a) state on the test certificate the actual carbon equivalent value (CEV) of the steel based on ladle analysis and calculated using the formula:

$$C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}; \text{ or}$$

(b) at his discretion, report in the details of the ladle analysis supplied (see 7.1 and tables 12, 14, 16, 18, 20 and 22) the elements in the CEV formula.

B.6 Maximum carbon equivalent value (CEV)

The grades listed in tables 31 to 34 shall be supplied with a CEV based on ladle analysis (see 7.1 and tables 12, 14, 16, 18, 20 and 22) and calculated using the following formula. The CEV shall not exceed the maximum values given in tables 31 to 34, as appropriate to the product.

$$C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

If a copper addition (see B.37 and B.38) is specified by the purchaser, 0.02 % shall be added to the specified maximum CEV.

The ladle analysis shall include details of all the elements in the CEV formula.

B.7 Product analysis

Product analysis (see 7.2 and tables 12, 14, 16, 18, 20 and 22) shall be determined by the manufacturer on a test sample used for verification of the mechanical properties or from material at the location shown in appendix C, or if this is not possible, by sampling in accordance with BS 1837. The analysis shall be carried out on the basis of one test per cast.

B.8 Repair by welding

No repair by welding shall be carried out without permission (see 9.1.1 and 9.2.4).

Table 31. Maximum CEV for plates and wide flats		
Grade	Maximum CEV	Thickness
	%	mm
40EE	0.39	Up to and including 100
43EE	0.39	Up to and including 100
50EE	0.43	Up to and including 63
50F	0.39	Up to and including 25
	0.41	Over 25 up to and including 40
55C	0.51	Up to and including 25
55EE	0.51	Up to and including 50
55F	0.41	Up to and including 40
WR50B, WR50C	0.54	Up to and including 50

Table 32. Maximum CEV for sections (other than hollow sections)		
Grade	Maximum CEV	Thickness
	%	mm
40DD	0.39	Up to and including 100
43DD	0.39	Up to and including 100
50E	0.43	Up to and including 63
55C	0.51	Up to 19
WR50B, WR50C	0.54	Up to and including 50

Table 33. Maximum CEV for flats and round and square bars	
Grade	Maximum CEV
	%
40E	0.41
43E	0.41
55C and 55EE	0.51

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Table 34. Maximum CEV for hollow sections

Grade	Maximum CEV	Thickness
	%	mm
43C	0.41	Up to and including 40
43D, 43EE	0.39	Up to and including 40
50C	0.45	Up to and including 16
	0.47	Over 16 up to and including 40
50D	0.43	Up to and including 40
50EE	0.43	Up to and including 40
55C, 55EE	0.51	Up to and including 10
	0.53	Over 10 up to and including 25
55F	0.41	Up to and including 16
	0.45	Over 16 up to and including 25
WR50B, WR50C	0.54	Up to and including 40

B.9 Repair by welding

No repair by welding shall be carried out (see 9.1.1 and 9.2.4).

B.10 Correction of minor defects: sections and flats

Removal of minor surface defects by grinding to a local reduction of thickness over 3 mm or over 4 % below the minimum otherwise allowed by BS 4 : Part 1 and BS 4848 : Parts 4 and 5 shall not be carried out (see 9.2.3).

B.11 Marking

Each wide flat, flat and section of grades 40, 43, 50, 55 and WR grades shall be marked with a continuous paint line not less than 12.5 mm wide throughout its length. (This option is not applicable to material supplied in bundles). As an alternative at the supplier's discretion, structural hollow sections shall be supplied painted over the entire external surface.

For grades 40 and 43 the colour shall be red.
For grades 50 the colour shall be blue.
For grades 55 the colour shall be green.
For grades WR the colour shall be white.
(See clause 11).

B.12 Length and width tolerances for plates

Plates shall be supplied machine gas cut or re-sheared to the length and width tolerances given in table 35 (see 14.2 and 14.3).

Table 35. Restricted length and width tolerances for plates

Ordered thickness	Tolerances
mm	mm
Up to and including 40	-0 +6
Over 40 up to and including 100	-0 +10
Over 100 up to and including 150	-0 +13

B.13 Thickness tolerances for plates: all over

Plates shall be supplied to the thickness tolerances given in table 36 (see 14.4).

B.14 Thickness tolerances for plates: all under

Plates shall be supplied to the thickness tolerances given in table 37 (see 14.4).

Ordered thickness	Width of plate (in mm)				
	Up to and including 2000	Over 2000 up to and including 2500	Over 2500 up to and including 3000	Over 3000 up to and including 3500	Over 3500 up to and including 4000
mm Less than 5	mm -0 +0.80	mm -0 +1.00	mm -0 +1.00	mm -	mm -
5 to less than 8	-0 +0.90	-0 +1.20	-0 +1.60	-0 +1.60	-
8 to less than 25	-0 +1.10	-0 +1.30	-0 +1.60	-0 +1.70	-0 +1.90
25 to less than 40	-0 +1.10	-0 +1.40	-0 +1.60	-0 +1.70	-0 +1.90
40 to less than 80	-0 +1.20	-0 +1.60	-0 +1.70	-0 +1.90	-0 +2.10
80 up to and including 150	-0 +2.20	-0 +2.30	-0 +2.40	-0 +2.50	-0 +2.50

Ordered thickness	Width of plate (in mm)				
	Up to and including 2000	Over 2000 up to and including 2500	Over 2500 up to and including 3000	Over 3000 up to and including 3500	Over 3500 up to and including 4000
mm Under 5	mm -0.80 +0	mm -1.00 +0	mm -1.00 +0	mm -	mm -
5 to less than 8	-0.90 +0	-1.20 +0	-1.60 +0	-1.60 +0	-
8 to less than 25	-1.10 +0	-1.30 +0	-1.60 +0	-1.70 +0	-1.90 +0
25 to less than 40	-1.10 +0	-1.40 +0	-1.60 +0	-1.70 +0	-1.90 +0
40 to less than 80	-1.20 +0	-1.60 +0	-1.70 +0	-1.90 +0	-2.10 +0
80 up to and including 150	-2.20 +0	-2.30 +0	-2.40 +0	-2.50 +0	-2.50 +0

B.15 Special flatness tolerances for plates

Plates shall be supplied to the tolerances given in table 38 (see 14.6).

For steel grades with a specified minimum yield strength exceeding 360 N/mm^2 , the flatness tolerance given in table 38 shall be increased by 50 %.

Deviations shall be measured at a point a minimum of 20 mm from the longitudinal edges and a minimum of 50 mm for the transverse edge.

When distances between points of contact are between 500 mm and 1000 mm, the deviation shall be obtained by taking the distance between points of contact and calculating proportionally from the deviation given for a 1000 mm straightedge in table 38.

B.16 Length tolerances for wide flats, flats and round and square bars

Wide flats, flats and round and square bars shall be supplied to a tolerance of $-0, +6 \text{ mm}$ (see 15.1, 16.1 and 17.2).

B.17 Thickness tolerances for wide flats: Euronorm 91-1981 Class 1

Wide flats shall be supplied to the thickness tolerances given in table 39 (see 15.3.1).

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Table 38. Special flatness tolerances for plates

Ordered thickness	Straight-edge length selected	Permitted deviations for ordered widths (in mm)							
		Less than 1500	1500 to less than 2000	2000 to less than 2500	2500 to less than 2750	2750 to less than 3000	3000 to less than 3250	3250 to less than 3500	3500 to 4000
mm 3 to less than 4	mm 1000	3	4	5	—	—	—	—	—
	2000	8	11	15	—	—	—	—	—
4 to less than 6	1000	3	4	4	5	—	—	—	—
	2000	7	11	15	18	—	—	—	—
6 to less than 8	1000	3	4	4	4	5	—	—	—
	2000	7	9	11	12	14	—	—	—
8 to less than 10	1000	3	3	3	3	4	4	4	—
	2000	6	7	8	9	10	12	16	—
10 to less than 20	1000	3	3	3	3	3	4	4	4
	2000	6	6	7	9	9	10	10	12
20 up to and including 150	1000	3	3	3	3	3	3	3	4
	2000	6	6	6	6	6	7	7	8

Table 39. Thickness tolerances for wide flats: Euronorm 91-1981 Class I

Ordered thickness	Tolerances: class I
mm	mm
4 to less than 10	-0.4 +0.6
10 to less than 20	-0.4 +0.8
20 to less than 25	-0.5 +0.9
25 to less than 30	-0.6 +1.0
30 to less than 40	-0.7 +1.1
40 to less than 50	-0.9 +1.1
50 to less than 60	-1.0 +1.2
60 to less than 80	-1.0 +1.6
80 and over	-1.0 +3.0

Table 40. Thickness tolerances for wide flats: all over

Ordered thickness	Tolerances
mm	mm
4 to less than 10	-0 +1.0
10 to less than 20	-0 +1.2
20 to less than 25	-0 +1.4
25 to less than 30	-0 +1.6
30 to less than 40	-0 +1.8
40 to less than 50	-0 +2.0
50 to less than 60	-0 +2.2
60 to less than 80	-0 +2.6
80 and over	-0 +4.0

B.18 Thickness tolerances for wide flats: all over

Wide flats shall be supplied with the thickness tolerances given in table 40 (see 15.3.1).

B.19 Thickness tolerances for wide flats: all under

Wide flats shall be supplied with the thickness tolerances given in table 41 (see 15.3.1).

Ordered thickness	Tolerances
mm	mm
4 to less than 10	-1.0 +0
10 to less than 20	-1.2 +0
20 to less than 25	-1.4 +0
25 to less than 30	-1.6 +0
30 to less than 40	-1.8 +0
40 to less than 50	-2.0 +0
50 to less than 60	-2.2 +0
60 to less than 80	-2.6 +0
80 and over	-4.0 +0

B.20 Special edge camber and flatness tolerances for wide flats

Wide flats shall be supplied in the special straightness condition (see 15.4 and 15.7).

The edge camber tolerances shall be 0.125 % of the length of the wide flat.

The deviation in flatness in the transverse direction shall not exceed 0.3 % of the width of the wide flat.

The maximum deviation in flatness in the longitudinal direction referred to a straightedge length of 1000 mm shall not exceed 3 mm. In the case of a shorter measuring length of 500 mm up to but not including 1000 mm, the maximum deviation shall not exceed 0.5 % of the measuring length.

B.21 Length tolerances for flats and round and square bars

Flats and round and square bars shall be supplied to a tolerance of -0, +50 mm (see 16.1 and 17.2).

B.22 Thickness tolerances for flats: all over

Flats shall be supplied to the thickness tolerances given in table 42 (see 16.3).

Table 42. Thickness tolerances for flats: all over

Ordered thickness	Tolerances
mm	mm
Up to and including 10	-0 +0.8
Over 10 up to and including 20	-0 +1.0
Over 20 up to and including 40	-0 +1.2
Over 40 up to and including 60	-0 +1.6
Over 60	-0 +2.0

B.23 Thickness tolerances for flats: all under

Flats shall be supplied to the thickness tolerances given in table 43 (see 16.3).

Table 43. Thickness tolerances for flats: all under

Ordered thickness	Tolerances
mm	mm
Up to and including 10	-0.8 +0
Over 10 up to and including 20	-1.0 +0
Over 20 up to and including 40	-1.2 +0
Over 40 up to and including 60	-1.6 +0
Over 60	-2.0 +0

B.24 Size tolerances for round and square bars: all over

Round and square bars shall be supplied with tolerances on diameter (in the case of round bars) or width across the flats (in the case of square bars) as given in table 44 (see 17.1.1).

B.25 Size tolerances for round and square bars: all under

Round and square bars shall be supplied with tolerances on diameter (in the case of round bars) or width across the flats (in the case of square bars) as given in table 45 (see 17.1.1).

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Table 44. Size tolerances for round and square bars: all over

Size	Tolerances on diameter or width	Tolerances on out-of-section
mm	mm	mm
Up to and including 15	-0 +0.4	0.3
Over 15 up to and including 25	-0 +0.6	0.5
Over 25 up to and including 35	-0 +0.8	0.6
Over 35 up to and including 50	-0 +1.0	0.8
Over 50 up to and including 65	-0 +1.2	0.9
Over 65 up to and including 80	-0 +1.4	1.1
Over 80 up to and including 100	-0 +1.8	1.4
Over 100 up to and including 120	-0 +2.2	1.7
Over 120 up to and including 160	-0 +4.0	3.0
Over 160 up to and including 200	-0 +5.0	3.8
Over 200	-0 +6.0	4.5

Table 45. Size tolerances for round and square bars: all under

Size	Tolerances on diameter or width	Tolerances on out-of-section
mm	mm	mm
Up to and including 15	-0.4 +0	0.3
Over 15 up to and including 25	-0.6 +0	0.5
Over 25 up to and including 35	-0.8 +0	0.6
Over 35 up to and including 50	-1.0 +0	0.8
Over 50 up to and including 65	-1.2 +0	0.9
Over 65 up to and including 80	-1.4 +0	1.1
Over 80 up to and including 100	-1.8 +0	1.4
Over 100 up to and including 120	-2.2 +0	1.7
Over 120 up to and including 160	-4.0 +0	3.0
Over 160 up to and including 200	-5.0 +0	3.8
Over 200	-6.0 +0	4.5

B.26 Ultrasonic testing

Plates (other than continuous mill products) and wide flats shall be subjected to ultrasonic testing in accordance with BS 5996 (see note to section three).

At the time of enquiry and order the purchaser shall specify:

- (a) the quality grade(s) from BS 5996 which shall apply to his order;
- (b) if he intends to witness the ultrasonic testing and, if so, the frequency of witnessing (all products or random).

B.27 Through thickness testing

Plates (other than continuous mill products) and wide flats shall be through thickness tested in accordance with BS 6780 to the quality level from BS 6780 specified by the purchaser. The suffix Z followed by 15, 25 or 35, as appropriate, shall be added to the steel designation (see note to section three).

B.28 Purchaser's selection and identification of test samples: prior to products being cut to ordered size

The purchaser shall randomly select and identify test samples in accordance with clauses 20, 21, 24 and 25, prior to the products being cut to ordered size (see clause 19).

B.29 Purchaser's selection and identification of test samples: after products have been cut to ordered size

The purchaser shall randomly select and identify test samples in accordance with clauses 20, 21, 24 and 25, after the products have been cut to ordered size (see clause 19). In this case the purchaser shall accept the material from which the test samples have been cut provided always that the test results comply with this standard.

B.30 Purchaser's witnessing of mechanical tests

The mechanical tests (namely, tensile, impact, bend) applicable to the purchaser's order shall be carried out in the purchaser's presence (see clause 19).

B.31 Purchaser's visual inspection

With respect to surface condition (see clauses 9.1.1 and 9.2) and/or product marking (see clause 11) and/or relevant dimensional and shape tolerances (see section two), the manufacturer shall make available for the purchaser's visual inspection all, or a random selection of the items produced for his order, as specified by the purchaser (see clause 19).

B.32 Hollow sections: number of tensile tests

One additional test shall be made for each size of section ordered (see 20.2).

B.33 Bend tests for plate, strip and wide flats

For thicknesses up to and including 25 mm (13 mm for grades WR50A, WR50B and WR50C), bend tests shall be carried out in accordance with appendix G and shall comply with the requirements given in table 50 (see clause 29).

B.34 Addition of copper in the range 0.20 % to 0.35 %

Grades 50C, 55C and 55EE shall be supplied with copper in the range 0.20 % to 0.35 % (see tables 12, 14, 16 and 18).

B.35 Addition of copper in the range 0.35 % to 0.50 %

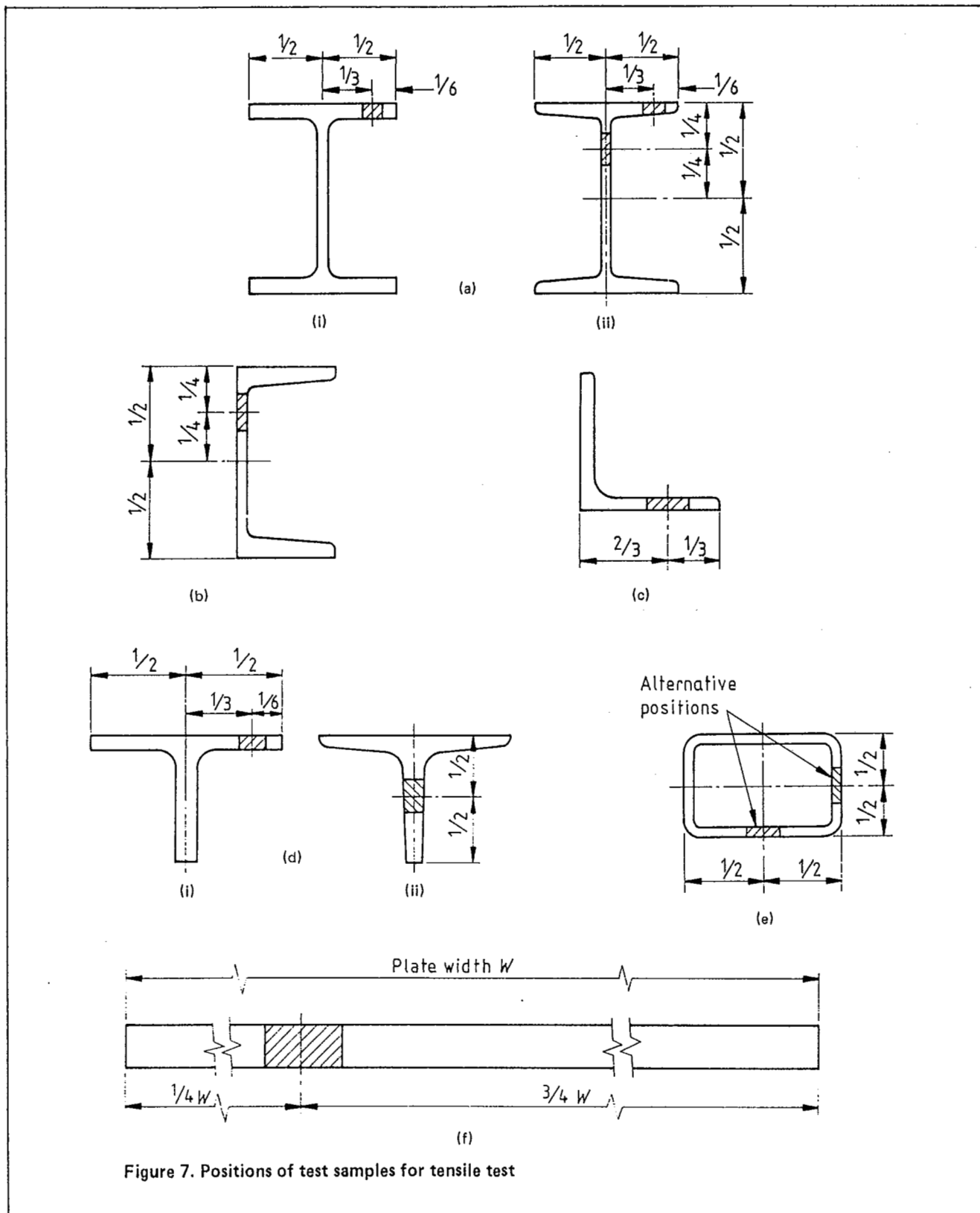
Grades 50C, 55C and 55EE shall be supplied with copper in the range 0.35 % to 0.50 % (see tables 12, 14, 16 and 18).

B.36 Impact testing: Hollow sections in grade 43C

The specified impact values for hollow sections in grade 43C shall be verified by testing (see table 19).

Appendix C. Positions of test samples for tensile test

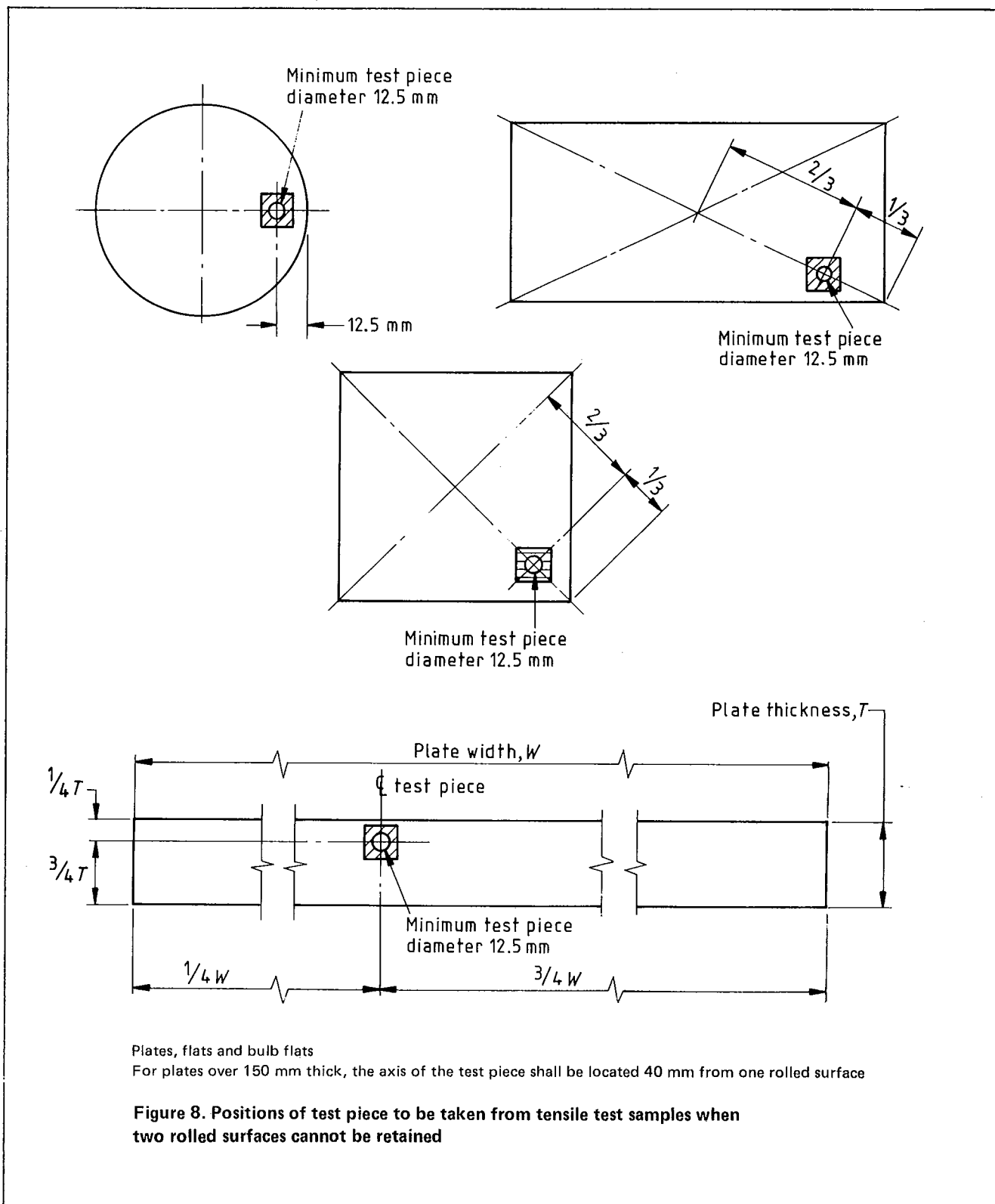
The position of test samples for tensile testing (see clause 21) shall be as shown in figure 7.



<i>Key to figures</i>				
Figure	Product form	Clause reference		Notes
		Tensile test	Flattening test	
(a)(i)	Sections with parallel flanges	21.2.3		
(a)(ii)	Sections with tapered flanges	21.2.3		The test sample may be taken from the web or the flange, at the manufacturer's discretion
(b)	Channels	21.2.3		
(c)	Equal and unequal angles	21.2.3		The test sample may be taken from either leg of an unequal angle
(d)(i)	T-bars cut from sections with parallel flanges. Rolled short stalk T-bars. Rolled long stalk T-bars with parallel flanges	21.2.3		
(d)(ii)	T-bars cut from sections with tapered flanges. Rolled long and short stock T-bars with tapered flanges	21.2.3		
(e)	Hollow sections	21.2.4	28	
(f)	Plates Wide flats Flats Bulb flats	21.2.1		
Figure 7 (concluded)				

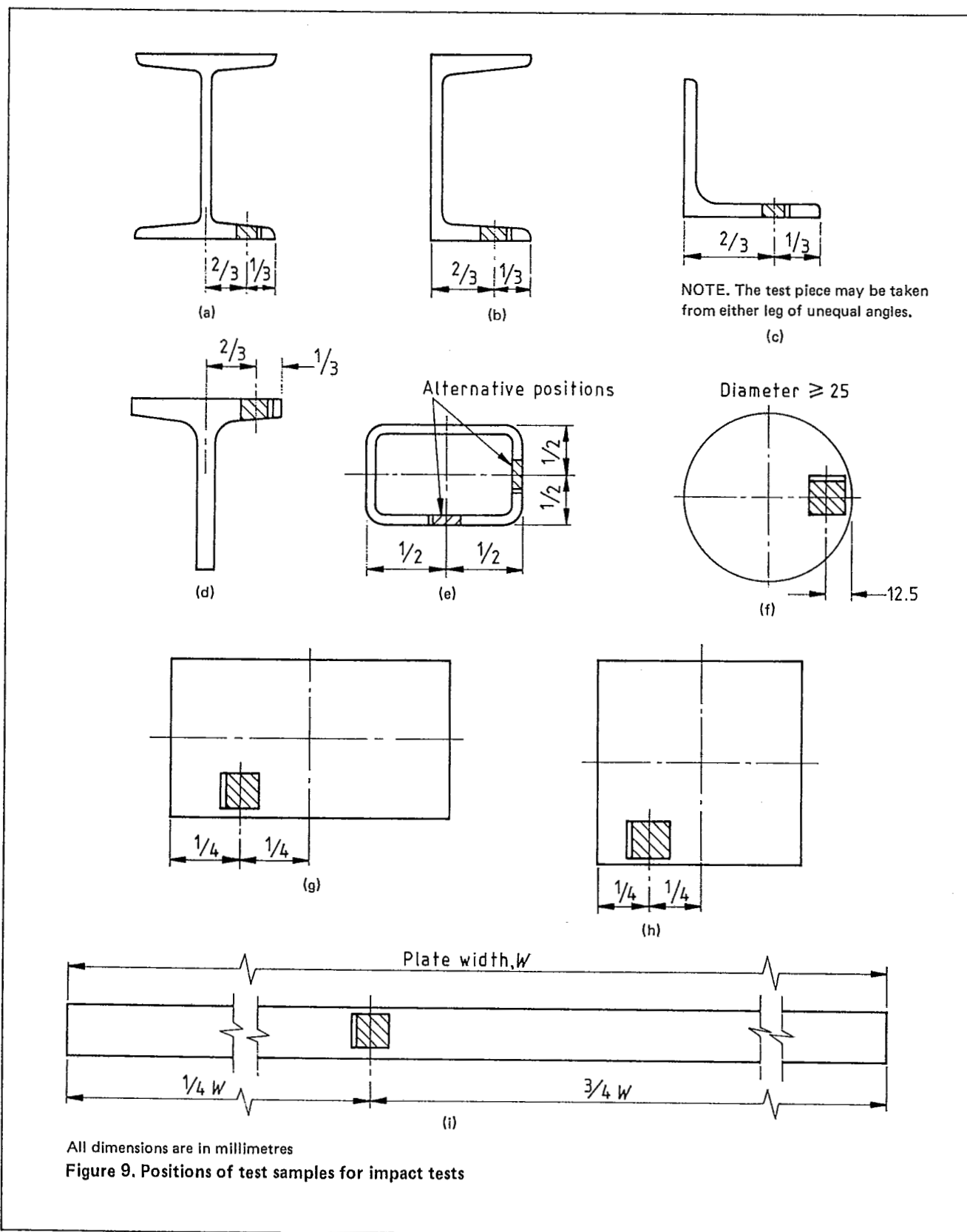
Appendix D. Positions of test piece to be taken from tensile test samples when two rolled surfaces cannot be retained

The positions of the test piece to be taken from tensile test samples when two rolled surfaces cannot be retained shall be as shown in figure 8 (see also clauses 21 and 22).



Appendix E. Positions of test samples for impact tests

The positions of test samples for impact tests shall be as shown in figure 9 (see clauses 25 and 26).



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Appendix E

<i>Key to figures</i>	
Figure	Product form
(a)	Sections
(b)	Channels
(c)	Equal and unequal angles
(d)	T-bars cut from universal beams T-bars cut from universal columns Rolled short stalk T-bars Rolled long stalk T-bars
(e)	Hollow sections
(f)	Round bars
(g), (h) and (i)	Plates Wide flats Flats Bulb flats
Figure 9 (concluded)	

Appendix F. Indicative Charpy V-notch impact values at temperatures other than those given in tables 13, 15 and 19

Tables 46, 47 and 48 give values of Charpy V-notch impact values at temperatures other than those given in tables 13, 15 and 19. These values are indicative only and are not subject to verification by test.

Table 46. Indicative Charpy V-notch impact values: plates, strip and wide flats		
Grade	Temperature	Charpy V-notch impact test value
40EE	°C	J
	-20	61
43EE	-30	47
	-20	61
50EE	-30	47
	-35	41
50F	-40	41
	-50	34
55EE	-20	61
	-30	47
55F	-40	41
	-50	34

Table 47. Indicative Charpy V-notch impact values: sections (other than hollow sections)		
Grade	Temperature	Charpy V-notch impact test value
40DD	°C	J
	-20	34
43DD	-20	34

Table 48. Indicative Charpy V-notch impact values: hollow sections		
Grade	Temperature	Charpy V-notch impact test value
43EE	°C	J
	-20	61
50C	-30	47
	+10	41
50D	-10	41
50EE	-35	41
55EE	-20	61
	-30	47
55F	-40	41
	-50	34

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Appendix G

Appendix G. Bend test for plates, strip and wide flats in thicknesses up to and including 25 mm

G.1 Number of bend tests

One bend test shall be carried out for each 40 t or part thereof from the same cast.

G.2 Direction of samples

Bend test samples shall be cut in the same direction as the tensile test samples (see 21.1.1 and 21.1.2).

G.3 Position of samples

Samples for the preparation of bend test pieces shall be taken from positions similar to those for tensile tests (see 21.2.1 and 21.2.2).

G.4 Bend test pieces

G.4.2.1 If the material dimensions permit, a rectangular test piece not less than 75 mm long and 25 mm wide shall be used for thicknesses less than 3 mm, and not less than 40 mm wide for thicknesses of 3 mm and over. For smaller sizes, the maximum width obtainable shall be used.

G.4.2.2 In all test pieces the rough edge or arris caused by cutting shall be removed and the edges slightly rounded by filing, grinding or machining.

G.5 Bend test

The test pieces shall be at room temperature and shall be bent through 180 °C, without fracture, to an internal diameter as specified for the appropriate grade in table 49 where *a* is the thickness of the test piece. The bending shall be carried out in accordance with BS 1639.

NOTE. The bend diameters given in table 49 are for specially prepared test pieces (see G.4) and conditions during fabrication may be more severe and not be simulated by those during laboratory testing.

In general, plates, strip and wide flats in thicknesses up to 25 mm can be formed to 90 ° without heating provided the following precautions are taken.

- (a) The diameter of bending should be as generous as possible and care should be taken to ensure that the steel accurately follows the shape of the tool. Knife edges should be avoided.
- (b) Bending of heavily cold worked or flame cut edges should be avoided. In particular, heavy shearing burr should not be present. Burr produced by shearing or blanking should be on the inside of the bend.
- (c) Where possible the axis of the bend should be transverse to the rolling direction of the steel. For guidance table 50 lists the recommended minimum internal forming diameters for typical cold forming practice.

Table 49. Bend test requirements for plates, strip and wide flats in thicknesses up to and including 25 mm

Figure in parentheses refers to the note following this table.

Grade	Bend max. diameter
40EE	2.5 <i>a</i>
43EE	3 <i>a</i>
50EE 50F	3 <i>a</i>
55C	4 <i>a</i>
55EE, 55F	3 <i>a</i>
WR50A WR50B WR50C	3 <i>a</i> (1)

(1) For grades WR50A, WR50B and WR50C, the bend test applies to a maximum thickness of 13 mm.

Table 50. Recommended minimum internal forming diameters for guidance only						
Grade	Material thickness (in mm)					
	Less than 4	4 to less than 6	6 to less than 9	9 to less than 13	13 to less than 19	19 up to and including 25
	Minimum internal forming diameter					
40EE	3a	4a	5a	6a	6a	6a
43EE	3a	4a	5a	6a	6a	6a
50EE	4a	4a	6a	7a	7a	8a
50F	—	6a	6a	7a	7a	8a
55C	6a	6a	6a	7a	8a	9a
55E, 55F	6a	6a	6a	7a	8a	9a
WR50A	4a	4a	6a	6a	—	—
WR50B	—	4a	6a	6a	—	—
WR50C	—	4a	6a	6a	—	—

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Publications referred to

- BS 4 Structural steel sections
Part 1 Specification for hot-rolled sections
- BS 18 Method for tensile testing of metals (including aerospace materials)
- BS 131 Methods for notched bar tests
Part 2 The Charpy V-notch impact test on metals
- BS 1449 Steel plate, sheet and strip
Part 1 Specification for carbon and carbon-manganese plate, sheet and strip
- BS 1639 Methods for bend testing of metals
- BS 1837 Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys
- BS 3894 Method for converting elongation values for steel
Part 1 Carbon and low alloy steels
- BS 4848 Specification for hot-rolled structural steel sections
Part 2 Hollow sections
Part 4 Equal and unequal angles
Part 5 Bulb flats
- BS 4870 Specification for approval testing of welding procedures
Part 1 Fusion welding of steel
- BS 4872 Specification for approval testing of welders when welding procedure approval is not required
Part 1 Fusion welding of steel
- BS 5135 Specification for arc welding of carbon and carbon manganese steels
- BS 5996 Methods for ultrasonic testing and specifying quality grades of ferritic steel plate
- BS 6512 Specification for limits and repair of surface discontinuities of hot-rolled steel plates and wide flats
- BS 6562 Terms used in the iron and steel industry
Part 2 Glossary of terms used in classifying and defining steel industry products by shape and dimensions
- BS 6780 Specification for through thickness reduction of area of steel plates and wide flats
- Handbook No. 19 Methods for the sampling and analysis of iron, steel and other ferrous metals
- ISO 630 Structural steels
- ISO 4950 High yield strength flat steel products
Part 1 General requirements
Part 2 Products supplied in the normalized or controlled rolled condition
- ISO 4952 Structural steels with improved atmospheric corrosion resistance
- Euronorm 25* General structural steels
- Euronorm 91* Hot rolled wide flats
Tolerances on dimension, shape and mass
- Euronorm 113* Special quality weldable structural steels
Grades and qualities — general provisions
- Euronorm 155* Weathering steels for structural purposes
Quality standard

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