BS 1501 : Part 1 : 1980

UDC 669.14-41 : 621.642 : 66.023 : 669.15-194

(Reprinted, incorporating Amendments No. 1 to No. 3 inclusive)

Steels for fired and unfired pressure vessels : plates

Part 1. Specification for carbon and carbon manganese steels

Les aciers utilisés pour les récipients sous pression chauffés et non chauffés: Tôles
Partie 1. Spécification pour les aciers au carbone et carbone manganèse

Stähle für beheizte und unbeheizte Druckbehälter: Bleche
Teil 1. Spezifikation für Kohlenstoff- und Kohlenstoffmanganstähle

British Standards Institution

BSI

Amendment No. 4
published and effective from 31 July 1990
to BS 1501 : Part 1 : 1980

Steels for fired and unfired pressure vessels : plates
Part 1. Specification for carbon and carbon manganese steels

Revised text

AMD 6259
July 1990

Foreword

After paragraph 6 insert the following new paragraph.

'Recognition has been given to the advances in steelmaking processes since the previous edition was published in 1964. Users will note, for example, the opportunity has been taken to reflect that with modern techniques it is possible to produce cleaner steels. Where applications, such as sour gas/oil service, require tighter controls on the chemical composition and steelmaking processes, the standard allows for discussion between the manufacturer and purchaser to decide the best combination for the specific applications. For the fabricator who wishes to specify lower limits on sulphur and phosphorus, suitable purchaser options are available.'

In the final paragraph delete the asterisk before 'BS 1506'.

At the foot of page 1 delete '* Contained in BS 1501-6'.

AMD 6259
July 1990

Clause 3. Designation

After paragraph 6 insert the following new paragraph 7.

'The suffix 'L' shall be added to the designation of steels 223, 224 and 225 immediately following the steel type number when they are specified with a nickel content of 0.3 % maximum.'

AMD 6259
July 1990

Clause 4.2.1 General options

After item (m) insert the following.

'(n) The manufacturer shall assume that steels with a maximum sulphur content of 0.015 %, 0.010 % or 0.005 % (ladle analysis) are not required.

(o) The manufacturer shall assume that steels with a maximum phosphorus content of 0.025 % or 0.020 % (ladle analysis) are not required.'

AMD 6259
July 1990

Tables 12, 14, 16, 18, 20, 23, 26 and 29

Insert the following as a note at the foot of the tables.

'NOTE. In addition to the elements listed in the table, and to reduce the risk of hot shortness, the sum of the copper content (%) plus ten times the tin content (%) shall not exceed 0.4 %. The tin content shall be reported.'

Additionally, in tables 23, 26 and 29 (as previously amended) in footnote ‡, after 'shall be 0.70 % maximum' insert 'and the suffix L shall be added to the designation of the steel (see clause 3).'

AMD 6259
July 1990

Clauses 27.4.1, 28.4.1, 29.4.1, 30.4.1, 31.4.1, 32.4.1, 33.4.1, 34.4.1

Insert the following note at the end of the texts.

'NOTE. The purchaser may specify lower sulphur and phosphorus contents (see **4.2.1** (n) and **4.2.1** (o) respectively.'

AMD 6259
July 1990

Standards publications referred to

Delete the existing title for BS 18 and substitute

'Method for tensile testing of metals (including aerospace materials)'.

Delete 'BS 1501-6* Steels for use in the chemical, petroleum and allied industries'.

Insert the following new entry.

'BS 1506* Specification for carbon, low alloy and stainless steel bars and billets for bolting material to be used in pressure retaining applications'

Table 33. Permitted deviations in product analysis from specified ladle analysis

Delete the existing table and substitute the following.

Deviations from specified ladle analysis														
C	Si	Mn	P	S			Nb	Cr	Cu	Mo	Ni		Al	N
				% ⩽ 0.005 ladle analysis	% > 0.005 ⩽ 0.010 ladle analysis	% > 0.010 ⩽ 0.050 ladle analysis					⩽ 0.30 ladle analysis	> 0.30 ladle analysis		
% 0.03	% +0.05 -0	% 0.10	% 0.005	% 0.001	% 0.002	% 0.005	% +0.01 -0	% 0.05	% 0.05	% 0.03	% 0.05	% 0.10	% +0.005 -0.002	% 0.005

Contents

Foreword

This edition of BS 1501 : Part 1, prepared under the direction of the Iron and Steel Standards Committee, has been extensively technically revised and metricated.

It replaces the previous edition of BS 1501 : Part 1, published in 1964, which will therefore be withdrawn.

All the essential features of the previous edition have been retained although the format has to some extent been changed to conform to the now normal style of British Standards publications. However following representations from industry to meet its particular needs a 'data sheet' presentation for each individual type of steel has been retained.

Requirements for carbon and carbon manganese steel plates for pressure purposes are specified. Requirements for plates in other steel types are specified in separate Parts of BS 1501 as follows.

BS 1501 : Part 2. Alloy steels
BS 1501 : Part 3. Corrosion and heat resisting steel

Extensive technical amendments have been made to the 1964 edition and many of these reflect significant changes in manufacturing procedures for plate and particularly continuous casting. Steel types and grades that have been agreed within the International Organization for Standardization (ISO) have been included as far as possible. However some additional types for which a need has been expressed by industry have also been included, and those that have not yet been standardized internationally have been recognized by the inclusion of additional grades and types. In all instances, the elevated temperature proof stress values have been derived by a statistical procedure incorporated in BS 3920.

A significant feature is that for some steel types and grades the tensile strength value used for the derivation of elevated temperature proof stress values by the above procedure is higher than the minimum value specified for acceptance purposes. Where an acceptance tensile test result is less than the strength value used for the derivation procedure, mandatory elevated temperature tensile tests are specified.

In preparing this revision particular account has been taken of the views expressed by the BSI Technical Committee dealing with pressure vessels.

The appropriate British Standards for the design and construction of boilers, pressure vessels etc. should be consulted for requirements relating to the application and permissible design stresses for products made to this standard.

Nearest equivalents for steels in the previous edition of BS 1501 : Part 1 are given in appendix A. Although in some instances a near equivalent cannot be given it is considered that the standard contains a sufficient variety of steels to cover the range and scope of past and current application standards for pressure purposes.

The Parts of BS 1501 are of a set of publications for different steel product forms. These comprise the following:

BS 1501 for plates;
BS 1502 for sections and bars (other than bolting material);
BS 1503 for forgings and semi-finished forged products;
BS 1504 for castings;
*BS 1506 for bars for bolting purposes.

BS 1505 has not been allocated to a specific steel product.

*Contained in BS 1501–6.

British Standard

Steels for fired and unfired pressure vessels : plates

Part 1. Specification for carbon and carbon manganese steels

Section one. General requirements

1. Scope

This British Standard specifies requirements for carbon and carbon manganese steel plates for fired and unfired pressure vessels.

Section one specifies the general requirements for these steels. Section two specifies specific requirements for testing.

Provision has been made in section three for specific requirements for eight steel types most of which have a series of grades with minimum tensile strengths ranging from 360 N/mm^2 to 490 N/mm^2 and with minimum yield strengths up to 345 N/mm^2.

Elevated temperature proof stress and stress rupture values are given in appendices C and D. For certain steel types, low temperature impact properties down to -50 °C are also specified.

2. References

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

3. Designation

The steel shall be designated by the number of this standard and the steel type number, e.g. BS 1501–151, followed by a number (the grade) representing the minimum tensile strength. (See table 1.)

The suffix 'A' shall be added to the designation when steel with specified minimum room temperature tensile properties only are required by the purchaser.

The suffix 'B' shall be added to the designation when steels with specified room temperature tensile properties and with characteristic elevated temperature properties are required by the purchaser.

The suffix 'LT' followed by a number representing the temperature in degrees centigrade below zero, at which tests are to be made shall be added to indicate the required impact properties.

If impact tests are to be made at 0 °C, the suffix 'LTO' shall be added.

The suffix 'RT' shall be added if impact tests are to be made at room temperature.

The property options for the various types and grades of steel provided by this standard are shown in table 1.

Examples

(a) BS 1501–161 grade 430A designates fully killed carbon steel plate of type 161 and grade 430 having the tensile properties at room temperature specified in table 19.

(b) BS 1501–164 grade 400B designates fully killed, aluminium treated, carbon steel plates of type 164 and grade 400 having the tensile properties at room temperature specified in table 21, and characteristic elevated temperature properties as specified in appendix C.

(c) BS 1501–224 grade 460B, LT20 designates fully killed, aluminium treated carbon manganese steel

Table 1. Property options available for the steel types and grades

Steel type	Grades	Available options		
		Specified room temperature tensile properties only	Specified room temperature tensile properties and with characteristic elevated temperature yield strength or proof stress values	Impact properties
141	360	A	Not available	Not available
154	360, 400, 430	A	Not available	Not available
151	360, 400, 430	A	B	Not available
161	360, 400, 430	A	B	Not available
164	360, 400	A	B	RT, LT0, LT20
223	460, 490	A	B	RT, LT0, LT15, LT30
224	400, 430, 460, 490	A	B	RT, LT0, LT20, LT30, LT40, LT50
225	460	A	B	LT20, LT30, LT50, LT60
225	490	A	B	LT20, LT30, LT50

plates of type 224 and grade 460 having the tensile properties at room temperature specified in table 27, characteristic elevated temperature properties as specified in appendix C, and Charpy V-notch impact properties at -20 °C as specified in table 28.

4. Information to be supplied by the purchaser

4.1 General. The following information shall be stated on the enquiry and order.

(a) The type and grade of steel required and its designation (see clause 3).

(b) Dimensions of plates required (see clause 18).

4.2 Options. There are a number of options incorporated in this British Standard. 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 (except for 4.2.1 (g)), the manufacturer shall implement the options as stated in 4.2.1, 4.2.2 and 4.2.3.

4.2.1 *General options*

(a) The manufacturer shall make the steel by the open hearth, electric or one of the basic oxygen processes (see clause 6).

(b) The manufacturer shall assume that product analysis is not required (see 7.2).

(c) The manufacturer shall assume plates to a specified carbon equivalent value are not required (see 7.4).

(d) The manufacturer shall assume there are no special requirements and supply the plates in the condition specified in clause 8.

(e) The manufacturer shall not apply controlled temperatures during and after rolling without agreement with the purchaser (see 8.1).

(f) The manufacturer shall assume there are no special requirements in respect of surface quality (see 9.1).

(g) Where weld repairs have been agreed, the manufacturer shall assume that a sketch showing positions and dimensions of weld repair is not required (see 9.3).

(h) The manufacturer shall mark the plate by stamping (see 10.2).

(i) The manufacturer shall mark bundled or boxed plates in accordance with 10.3.

(j) The manufacturer shall assume that the purchaser or his representative does not wish to visually inspect the plates, select test samples or witness tests (see clauses 14 and 19).

(k) The manufacturer shall assume that the supply of plates to restricted width and length tolerances is not required (see 18.2.2).

(l) The manufacturer shall assume that supply of plates to the 0.2 % limit of camber is not required (see 18.3.2).

(m) The manufacturer shall supply plates to the flatness tolerance requirements in the mill finish (hot levelled) condition (see 18.4.1).

4.2.2 *Testing options*

(a) The manufacturer shall assume that simulated post weld heat treatment of samples is not required (see 19.4.3).

(b) The manufacturer shall assume that no alternative heat treatment of samples is required (see 19.4.4).

(c) The manufacturer shall assume that elevated temperature tests at specific temperatures are not required (see 22.2).

(d) The manufacturer shall assume that ultrasonic testing is not required (see clause 24).

(e) The manufacturer shall assume that no special tests are required (see clause 25).

(f) The manufacturer shall assume that a report of the full heat treatment history in the case of re-heat treatment is not required (see 26.4).

4.2.3 *Options for specific steels.* The manufacturer shall assume that a report on the test certificate of the nitrogen content is not required (see 27.4.2, 28.4.2, 29.4.2, 30.4.2, 31.4.2, 32.4.2, 33.4.2 and 34.4.2).

5. General and specific requirements

The plates shall comply only with the general requirements specified in section one, and with the appropriate specific requirements given in sections two and three, in the absence of information from the purchaser in respect of special requirements (see clauses 24 and 25).

6. Manufacture of the steel

6.1 Steelmaking process. The steel shall be produced by the open hearth, electric or one of the basic oxygen processes. Other processes may be used by agreement between the purchaser and the manufacturer. If requested, the manufacturer shall inform the purchaser of the steelmaking process used.

6.2 Deoxidation. Deoxidation practice shall be as defined for the relevant steel grade in section three for the relevant steel type.

7. Chemical composition

7.1 Ladle analysis. The chemical composition of the steel shall be determined by ladle analysis and shall comply with the specific requirements for the relevant material given in section three.

7.2 Product analysis. The purchaser may, if stated on the order, require analysis of the finished material. The product analysis shall be determined on the test sample used for verification of the mechanical properties, or at the option of the manufacturer, on material taken from the same location as that used for samples for mechanical testing. The number of samples to be taken for analysis and the elements to be determined shall be as agreed at the time of the enquiry and order and shall be detailed on the order.

The permitted deviations for product analysis are specified in appendix B and shall be applicable to the specified chemical composition limits given for the relevant material in section three.

7.3 Cases of dispute. In cases of dispute the methods for chemical analysis shall be in accordance with British Standard Handbook No. 19.

7.4 Maximum carbon equivalent value for weldability

7.4.1 If specified on the order and agreed between the manufacturer and the purchaser, plates shall be supplied with a specific maximum carbon equivalent value. These maximum values which are based upon ladle analysis are given in table 2.

7.4.2 For all steels except types 223 and 225, the carbon equivalent values are applicable to plates up to and including 63 mm thick. For steel types 223 and 225,

the values given in table 2 apply to plates up to and including 40 mm thick.

7.4.3 The carbon equivalent value shall be calculated using the formula:

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

7.4.4 The values given in table 2 refer to plates for which the test samples are not subject to a simulated post weld heat treatment. If a simulated post weld heat treatment is specified, the values for carbon equivalent shall be agreed between the purchaser and the manufacturer at the time of the enquiry and order.

Table 2. Maximum values of carbon equivalent

Steel type	Grade	Maximum carbon equivalent value
		%
151	360	0.39
	400	0.42
	430	0.45
161	360	0.35
	400	0.39
	430	0.41
164	360	0.39
	400	0.41
223	460	0.45
	490	0.47
224	400	0.41
	430	0.43
	460	0.47
	490	0.47
225	460	0.45
	490	0.47

8. Condition of supply of plates

8.1 Plates shall be supplied and tested in the condition specified for the relevant steel in section three except in the following circumstances.

(a) It is agreed at the time of the enquiry and order that the application of controlled temperatures during and after rolling may take the place of a normalizing heat treatment.

(b) The purchaser intends to hot form and/or normalize the plates after delivery and it is agreed at the time of the enquiry and order that plates which would otherwise be supplied normalized shall be supplied in the hot finished condition (see **19.4** regarding heat treatment of test samples). This provision is not applicable to steels 223 and 225 which are always supplied normalized, but see **8.1.1.**

(c) A specific supply condition for plates of steel types 151 and 161 up to 40 mm thick has been agreed between the purchaser and the manufacturer (see **29.3** and **30.3**).

8.1.1 Steel types 223 and 225 shall be supplied in the normalized condition or, if agreed between the purchaser and the manufacturer, in a controlled rolled condition (see **8.1**(a)).

NOTE. Hot forming at or above normalizing temperatures may adversely affect the properties of plates supplied in the controlled rolled condition and thus this supply condition is not normally appropriate when hot forming is envisaged.

9. Surface condition and soundness

9.1 Freedom from defects. The plates shall be supplied sound and free from such segregation, cracks, laminations, or surface flaws as might preclude their use for the purpose for which they are intended. Where appropriate the purchaser shall agree with the manufacturer at the time of the enquiry and order the standard of surface quality required and any other special tests (see clauses **24** and **25**).

9.2 Removal of surface imperfections

9.2.1 Operations having the object of obscuring surface imperfections shall not be used.

9.2.2 Slight surface imperfections may be removed by mechanical means provided that after such treatments the plates comply with the requirements of **18.5.**

9.2.3 Surface imperfections which cannot be rectified in accordance with **9.2.2** may, by agreement between the manufacturer and the purchaser or his representative, be rectified by grinding or chipping followed by welding, subject to the following conditions.

(a) The total area to be repaired shall not exceed 2 % of the surface area of that face of the plate.

(b) The thickness shall not be reduced to less than 80 % of the nominal thickness after the complete removal of the defect and before welding.

(c) The welding shall be carried out to a documented procedure approved by the purchaser or his representative, and by approved operatives using approved electrodes.

The welds shall be sound and free from defects or discontinuities and shall be filled to an excess thickness of at least 1.5 mm and then levelled by chiselling and/or grinding to give the repaired plate a smooth and uniform surface.

(d) The area repaired and the adjacent plate area shall be examined by a procedure and at a stage of processing agreed between the manufacturer and the purchaser to ensure that it is free from defects.

(e) The repaired plates shall be given a suitable heat treatment to minimize the effects of welding without adversely affecting mechanical properties. Plates in the normalized condition shall be re-normalized after weld repair unless otherwise agreed between the purchaser and the manufacturer.

Normalizing of controlled rolled plates after weld repair is not permitted, unless a retest is carried out which indicates that the appropriate minimum property requirements as specified in section three are maintained. Any post weld heat treatment of such plates shall be as agreed between the manufacturer and the purchaser.

9.3 Position of repairs. The position and extent of weld repaired areas shall be marked on the plate. These marks shall be referred to on the manufacturer's certificate (see **11.1**(g)). If agreed between the manufacturer and the purchaser, a sketch showing the positions and dimensions of weld repairs shall be supplied by the manufacturer.

10. Marking

10.1 Each plate as delivered shall be legibly marked with the following.

(a) Manufacturer's name or trade mark.

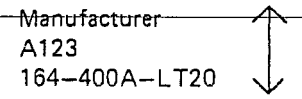
(b) A reference number by which the plate and the manufacturer's certificate can be related.

(c) The steel type number and grade number as given in table 1, (e.g. '164 400A LT20').

10.2 Marking shall be by stamping or, if specified by the purchaser, by painting (see 10.4). If paint is used, it shall be commercially free from lead, copper, zinc and tin.

If stamped on the plate, the above particulars shall be encircled with a paint mark.

Unless the provisions of 10.3 or 10.4 are valid, the information given in 10.1(a), (b) and (c) shall be stamped on each plate in such a manner that it can be read in the principal direction of rolling as indicated in the following diagram.



10.3 Alternatively, unless otherwise agreed, for plates which are bundled or boxed, the information given in 10.1 shall be marked on the box or on a tag securely attached to the bundle or box.

10.4 If painting is required in preference to stamping, the orientation of the marking in relation to the direction of rolling shall be agreed between the purchaser and the manufacturer at the time of the enquiry and order.

11. Manufacturer's certificate

11.1 **To be supplied by the manufacturer.** The manufacturer of the plates shall supply a certificate stating the following.

(a) The number of this British Standard.

NOTE. Marking BS 1501 on or in relation to a product is a claim by the manufacturer that the product has been manufactured in accordance with the requirements of the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility.

(b) The steel grade and type numbers, the suffix A or B, and where appropriate, the suffix indicating the impact tests carried out (see clause 3).

(c) The ladle analysis in respect of all specified elements (see 7.1).

(d) The product analysis if required (see 7.2).

(e) Carbon equivalent values calculated from ladle analysis if requested (see 7.4).

(f) The heat treatment, if any, given to the plates (see clause 8) and if agreed, previous heat treatments (see 26.4).

(g) If the plate contains any welded areas as indicated by surface markings on the plate (see 9.3).

(h) The plate reference number and its cast number (see 10.1).

(i) If the plate contains any thinned areas as indicated by surface markings on the plate (see 18.5.2).

(j) The heat treatment, if any, given to the test samples (see 19.4).

(k) For plates having specified impact properties, the temperature at which the impact tests were made, and the results obtained (see clause 23).

(l) The results of the room temperature mechanical tests (see clause 21).

(m) If elevated temperature tests were made in accordance with clause 22, the temperature at which the tests were made and the yield or proof strength values obtained.

(n) The results of any specified ultrasonic examination (see clause 24).

(o) The results of any special tests (see clause 25).

11.1.1 The test certificate shall be signed by an appointed representative of the manufacturer.

11.2 **To be supplied by the merchant.** If any steel is supplied from a merchant's stock, the merchant shall satisfy the purchaser that the numbers and identification marks on the steel combined with a manufacturer's certificate, confirm that the steel has been tested and complies with all the tests and requirements of this standard applicable to the material specified.

12. Delivery

No material shall be despatched from the manufacturer's works until it has been tested and has complied with all the tests and requirements of this standard as applicable to the material ordered and any additional requirements specified in the order.

13. Defects revealed after delivery

In the event of any material proving defective during subsequent fabrication, such material shall be deemed not to comply with the requirements of this British Standard notwithstanding any previous certificates of satisfactory testing. The manufacturer shall not be responsible for any failure to comply with this British Standard caused by improper treatment after delivery.

14. Inspection

The purchaser or his representative shall have access at all reasonable times to those parts of the works engaged on the order, and shall be allowed to inspect the manufacturing process at any stage.

If stated on the enquiry and order, the purchaser shall be allowed to visually inspect the items produced for his order, and also to select the test samples in accordance with clause 19 and to witness the tests.

15. Testing facilities

The manufacturer shall supply the material for testing and shall furnish and prepare the necessary test pieces and supply labour and appliances for such testing as may be carried out on his premises in accordance with this British Standard. Failing facilities at his own works, the manufacturer shall arrange for the tests to be carried out elsewhere.

16. Weldability

All types and grades of steel referred to in this British Standard are reasonably weldable. Welding requires care however and should be carried out in accordance with guidance given in the appropriate British Standards for welding, e.g. BS 5135.

17. Forming operations

Hot or cold forming operations may affect the properties of the plates. Consultation with the steel manufacturer is recommended when it is considered that any resultant property changes may be unacceptable.

Normalizing temperatures vary with the chemical composition. Guidance may be obtained from the ladle analysis results reported on the test certificate or from the steel manufacturer.

18. Dimensional tolerances

18.1 General. The tolerances on dimensions apply to plates produced on non-continuous mills. The tolerances for continuous mill products are given in BS 1449 : Part 1.

18.2 Length and width tolerances for plates

18.2.1 Unless subject to the provisions of **18.2.2**, the length and width of plates shall comply with the tolerances specified for appropriate thicknesses of plate given in tables 3, 4 and 5.

Table 3. Length tolerances for plates up to and including 50 mm thick

Specified length	Length tolerance
	mm
Up to and including 3000 mm	-0 +13
Over 3000 mm up to and including 6000 mm	-0 +25
Over 6000 mm	-0 +32

Table 4. Width tolerances for plates up to and including 50 mm thick

Specified width	Width tolerances	
	Up to and including 20 mm thick	Over 20 mm up to and including 50 mm thick
	mm	mm
Up to and including 1800 mm	-0 +10	-0 +13
Over 1800 mm	-0 +13	-0 +20

Table 5. Length and width tolerances for plates over 50 mm thick

Specified thickness	Length and width tolerance
	mm
Over 50 mm up to and including 100 mm	-0 +22
Over 100 mm up to and including 150 mm	-0 +25

18.2.2 If agreed between the purchaser and the manufacturer at the time of ordering, plates may be supplied thermally cut by machine or re-sheared to the restricted length and width tolerances given in table 6.

Table 6. Restricted length and width tolerances for plates up to 150 mm thick

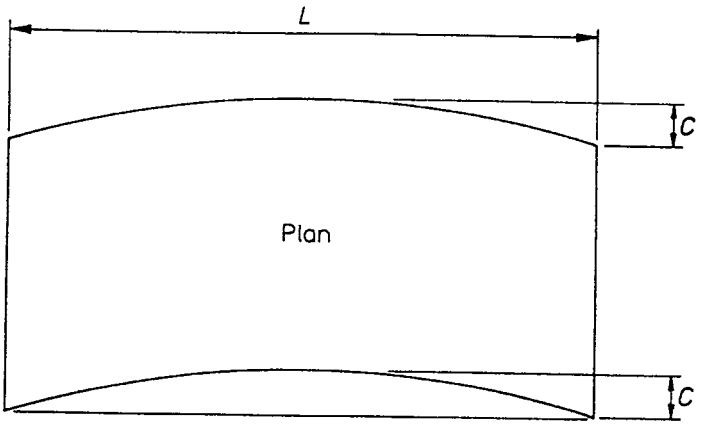
Specified thickness	Length and width tolerance
	mm
Up to and including 40 mm	-0 +6 or -6 +0 or -3 +3*
Over 40 mm up to and including 100 mm	-0 +10
Over 100 mm up to and including 150 mm	-0 +13

*One of these choices shall be selected.

18.3 Edger camber tolerances for plates

18.3.1 Camber on a plate shall be limited so that it shall be possible to inscribe the dimensions of the ordered plate within the delivered size.

18.3.2 Additionally, if agreed at the time of the enquiry and order, the camber *C*, shall be limited to 0.2 % of the actual length *L* of the plate (see figure 1).



L is the length of plate
C is the edge camber

Figure 1. Edge camber of plates

18.4 Flatness tolerances for plates

18.4.1 Plates are normally supplied in a mill finished (hot levelled) flatness condition but if agreed between the purchaser and the manufacturer at the time of the enquiry and order, plates up to 85 mm thick may be supplied cold levelled.

18.4.2 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 straight edge resting on the plate. The straight edge may be placed in any direction. Only the portion situated between two points of contact shall be taken into consideration. Deviations shall be measured at a point a minimum distance of 20 mm from the longitudinal edges and a minimum of 100 mm, for hot levelled plates or 50 mm for cold levelled plates, from the transverse edges.

18.4.3 The permissible deviations of flatness for plates shall not exceed the values given in table 7 or table 8 for the straight edge length selected. When distances between points of contact are between 500 mm and 1000 mm, the permissible deviation shall be obtained by taking the distance between the points of contact and calculating proportionally from the deviation given for a 1000 mm straight edge in table 7 or table 8.

18.5 Thickness tolerances for plates

18.5.1 Except as specified in 18.5.2 and 18.5.3 no plate shall be under the specified thickness at any point nor shall it exceed the specified thickness by more than the appropriate thickness tolerance shown in columns 2 and 3 of table 9.

Additionally, and within the tolerance limits specified in columns 2 and 3 of table 9, the difference in thickness between any two points in an individual plate shall not exceed the appropriate tolerances shown in columns 4 to 8 of table 9 except as specified in 18.5.2 and 18.5.3.

18.5.2 Should any plate be reduced locally below the specified thickness during rolling or dressing, such plate may be accepted as complying with the requirements of this British Standard provided that in all other respects it is satisfactory and that the purchaser and inspecting authority are satisfied that though locally reduced in thickness it would, by virtue of its actual mechanical properties and any design factors, fully meet the strength requirements of the application standard. The position of the thinned areas shall be carefully marked and indicated to the purchaser, and the marks referred to in the test certificate.

18.5.3 Thickness and thickness difference shall be measured at any point more than 15 mm from the edges of the plate except as specified in 18.5.2.

18.6 Squareness of plates. The out of square value *U* is the orthogonal projection of one transverse edge over one longitudinal edge (see figure 2). The value of *U* shall not exceed 1 % of the actual width of the plate.

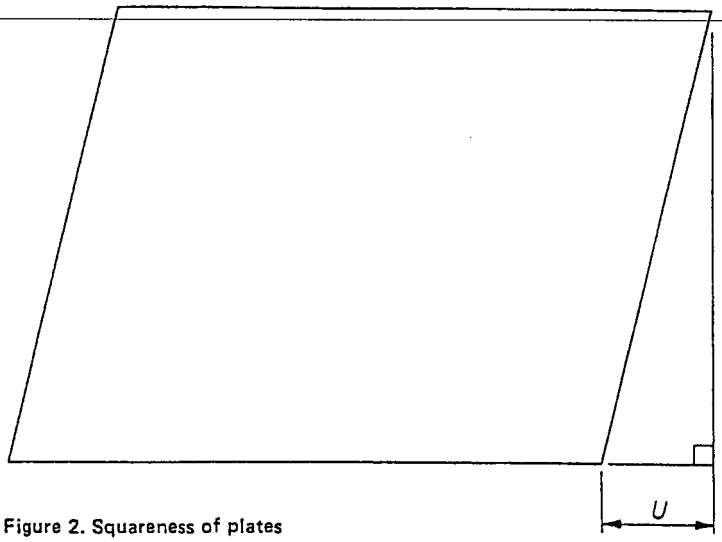


Figure 2. Squareness of plates

Table 7. Flatness tolerances for plates: mill finish (hot levelled)

Specified thickness	Straight edge length	Permissible deviations (mm) for specified widths (mm)							
		Up to and including 1500	Over 1500 up to and including 2000	Over 2000 up to and including 2500	Over 2500 up to and including 2750	Over 2750 up to and including 3000	Over 3000 up to and including 3250	Over 3250 up to and including 3500	Over 3500 up to and including 4000
	mm	mm	mm	mm	mm	mm	mm	mm	mm
3 mm up to but not including 4 mm	1000	7	8	10	–	–	–	–	–
	2000	14	18	22	–	–	–	–	–
4 mm up to but not including 6 mm	1000	7	7	8	10	–	–	–	–
	2000	14	16	21	25	–	–	–	–
6 mm up to but not including 8 mm	1000	7	7	8	8	8	–	–	–
	2000	14	14	16	17	20	–	–	–
8 mm up to but not including 10 mm	1000	7	7	7	7	8	8	9	–
	2000	13	13	14	15	16	18	20	–
10 mm up to but not including 20 mm	1000	7	7	7	7	7	8	8	9
	2000	12	12	12	13	14	15	17	19
20 mm up to and including 150 mm	1000	7	7	7	7	7	8	8	9
	2000	11	11	12	12	12	13	14	16

Table 8. Flatness tolerances for plates: cold levelled

Specified thickness	Straight edge length	Permissible deviations (mm) for specified widths (mm)							
		Up to and including 1500	Over 1500 up to and including 2000	Over 2000 up to and including 2500	Over 2500 up to and including 2750	Over 2750 up to and including 3000	Over 3000 up to and including 3250	Over 3250 up to and including 3500	Over 3500 up to and including 4000
	mm	mm	mm	mm	mm	mm	mm	mm	mm
3 mm up to but not including 4 mm	1000	3	4	5	–	–	–	–	–
	2000	8	11	15	–	–	–	–	–
4 mm up to but not including 6 mm	1000	3	4	4	5	–	–	–	–
	2000	7	11	15	18	–	–	–	–
6 mm up to but not including 8 mm	1000	3	4	4	4	5	–	–	–
	2000	7	9	11	12	14	–	–	–
8 mm up to but not including 10 mm	1000	3	3	3	3	4	4	4	–
	2000	6	7	8	9	10	12	16	–
10 mm up to but not including 20 mm	1000	3	3	3	3	3	4	4	4
	2000	6	6	7	9	9	10	10	12
20 mm up to and including 85 mm	1000	3	3	3	3	3	3	3	4
	2000	6	6	6	6	6	7	7	8

Table 9. Thickness tolerances for plates

Specified thickness	Tolerance on specified thickness		Maximum difference in thickness in any individual plate between any two points measured on the plate (mm) (except as required by 18.5.2 and 18.5.3)				
	Minus	Plus	Plate width				
			Up to but not including 2000	2000 up to but not including 2500	2500 up to but not including 3000	3000 up to but not including 3500	3500 up to and including 4000
	mm	mm	mm	mm	mm	mm	mm
Up to but not including 5 mm	0	1.20	0.80	0.90	0.90	–	–
5 mm up to but not including 8 mm	0	1.50	0.90	0.90	1.00	1.00	–
8 mm up to but not including 15 mm	0	1.70	0.90	1.00	1.00	1.10	1.10
15 mm up to but not including 25 mm	0	1.90	1.00	1.10	1.20	1.20	1.30
25 mm up to but not including 40 mm	0	2.20	1.10	1.20	1.20	1.30	1.30
40 mm up to but not including 80 mm	0	2.80	1.20	1.30	1.40	1.40	1.50
80 mm up to and including 150 mm	0	3.20	1.30	1.40	1.50	1.50	1.60

Section two. Specific requirements for testing

19. Testing requirements, selection, number, position and heat treatment of test samples and preparation of test pieces

19.1 Testing requirements. Tests shall be carried out in accordance with the requirements of this section depending upon the designation as follows.

Designation suffix A. Room temperature tensile tests only.

Designation suffix B. Room temperature tensile tests and, additionally, elevated temperature tensile tests if required in accordance with the requirements of clause 22.

Designation suffix LT*x*. Impact tests at the designated temperature *x*.

Designation suffix RT. Impact tests at room temperature.

19.2 Selection of test samples. If stated on the enquiry and order, all test samples shall be selected by the purchaser or his representative. In the absence of any such statement the manufacturer shall select the test samples.

19.3 Number and position of test samples

19.3.1 For as-produced plates* up to and including 5000 kg mass and not exceeding 15 m in length, a sample shall be taken from one end only of each plate. For as-produced plates of mass over 5000 kg or exceeding 15 m in length, one sample shall be taken from each end of each plate.

19.3.2 The samples shall be taken from excess material at the ends of the plates, midway between the centre and one edge, and shall be sufficient to provide the specified number of test pieces.

19.3.3 For non heat treated plates produced and coiled on a continuous mill, samples shall be taken from each end of the coil.

NOTE. A summary of the number of test samples and test pieces required is given in table 10.

19.4 Heat treatment of test samples

19.4.1 The test samples shall be cut from the plate after the final heat treatment except in the case of heat treatment after repair by welding (see 9.2.3(e)) or re-heat treatment (see 26.4). When the plate is already cut to size, the samples may be heat treated after separation from, but together with the plate.

19.4.2 If the purchaser intends subsequently to normalize material supplied in the hot finished condition (e.g. after fabrication) this shall be stated on the enquiry and order and the manufacturer shall give the representative test samples (or the test blanks cut from them) a heat treatment which, to the satisfaction of the purchaser, simulates the normalizing of a full size plate.

19.4.3 Except for steels 141 and 154, if required in special cases, and when agreed at the time of the enquiry and order, test samples or the test pieces shall be subjected to a simulated post weld heat treatment at 600 ± 10 °C for 3 h followed by cooling in still air. Where this applies the composition limits for some grades of steel are subject to modification as detailed in the relevant specific requirements for the steel as specified in section three.

19.4.4 If heat treatments different from or additional to the normal heat treatments for the steel as specified in section three are to be carried out after the delivery of the plates† the purchaser may require, at the time of the enquiry and order, additional mechanical tests on additional samples which have been given different heat treatments. In this case the number and heat treatment of the test samples shall be agreed at the time of the enquiry and order. The mechanical property values obtained may be for information purposes only or may be required to satisfy specific requirements which shall also be agreed at the time of the enquiry and order.

19.5 Preparation of test pieces. From each test sample the test pieces detailed in **19.5.1**, **19.5.2** and **19.5.3** shall be prepared, with their axes at right angles to the principal direction of rolling unless otherwise stated.

19.5.1 *Room temperature tensile test.* For the room temperature tensile test a rectangular test piece with 200 mm gauge length as described in BS 18 : Part 2 shall be used. Alternatively for plates over 40 mm in thickness, a proportional round test piece as described in BS 18 : Part 2 may be used. In that case the axis of the test piece shall be located one quarter of the plate thickness from the plate surface.

19.5.2 *Elevated temperature tensile test.* For elevated temperature tests the test piece shall be prepared in accordance with BS 3688 : Part 1. The test sample shall

Table 10. Summary of number of test samples and test pieces to be taken (see clause 19)

Mass of plate as-produced	Number and position of test samples	Number of test pieces		Impact tests (if required)
		Room temperature tensile test	Elevated temperature tensile tests (if required)	
Up to and including 5000 kg (and under 15 m in length as-produced)	One test sample from one end of each plate	One test piece per sample	See clause 22	One test sample per plate (three test pieces)
Over 5000 kg (or exceeding 15 m in length as-produced)	Two test samples, one from each end of the plate	One test piece per sample	See clause 22	One test sample per plate (three test pieces)

*The term 'as-produced plate' refers to the unit plate rolled from a slab, or rolled directly from an ingot, except when the unit plate is divided prior to normalizing when it refers to each separately normalized fraction of the original plate.

†This circumstance might arise, for example, in the case of thick plates

be cut from a position on the sample adjacent to the room temperature tensile test piece. For plates more than 30 mm thick, the axis of the test piece shall be located one quarter of the plate thickness from the plate surface.

19.5.3 *Impact tests.* For impact tests one sample from which three Charpy V-notch test pieces shall be taken in accordance with BS 131 : Part 2 to represent each plate.

The test piece shall have the longitudinal axis in the principal direction of rolling. The notch shall be cut in the direction perpendicular to the original surface of the plate. (See figure 3.)

Impact test pieces shall be taken from a position close to one of the rolled surfaces. For plates over 40 mm thick the axis of the test piece shall be one quarter of the plate thickness from one of the rolled surfaces. Test pieces shall not be closer than 25 mm to any flame-cut or sheared edge.

For plates between 11 mm and 6 mm thick the largest possible subsidiary standard test piece specified in BS 131 : Part 2 shall be used. Impact tests are not normally required for plates less than 6 mm thick.

20. Mechanical test methods

20.1 Tensile tests at room temperature. Tensile tests at room temperature shall be carried out in accordance with BS 18 : Part 2. The tensile strength R_m, the yield strength R_e, and the elongation A shall be determined.

For the yield strength R_e, either the upper yield stress (R_{eH}) or the 0.5 % proof stress (total elongation) ($R_{t0.5}$) may be determined. However, in cases of dispute $R_{t0.5}$ shall be measured.

Elongation values shall be reported on a gauge length of $5.65\sqrt{S_o}$ * using conversion tables in BS 3894 : Part 1 where necessary. In cases of dispute elongation shall be measured on a gauge length of $5.65\sqrt{S_o}$.

20.2 Tensile tests at elevated temperatures. Tensile tests at elevated temperatures shall be carried out in accordance with BS 3688 : Part 1.

Although certain steels exhibit a well-defined stress at room temperature this becomes less defined with increase of test temperature. At any particular temperature the greater of the lower yield stress R_{eL} or of the 0.2 % proof stress $R_{p0.2}$ shall be taken as the criterion of acceptance.

20.3 Impact tests. The impact tests shall be carried out in accordance with BS 131 : Part 2 as required by the material specification or order.

21. Mechanical properties at room temperature

The room temperature tensile test results shall comply with the requirements of the relevant material specification in section three.

22. Mechanical properties at elevated temperatures

22.1 Elevated temperature yield strength or proof stress values. Minimum elevated temperature yield strength or proof stress values derived in accordance with the procedure described in appendix C are given in appendices D, E and F. These values are not subject to verification except in cases where the room temperature tensile test on types 164, 223, 224 (except grade 490) and 225 (except grade 460), and when designated with the suffix B, gives a tensile strength value lower than that specified for the relevant steel in table 34.

In such cases the manufacturer shall have either of the following two options.

(a) To carry out two further room temperature tensile tests on test pieces from the same sample location. If the tensile strength of either or both of these tests also falls below the value selected for derivation, an elevated temperature test shall be carried out in accordance with the procedure described in **22.1**(b).

(b) To carry out an elevated temperature test on a test piece taken from a position adjacent to the room temperature tensile test piece. This test shall be carried out at 350 °C unless elevated temperature testing at a different temperature has been specifically requested by the purchaser in accordance with the requirements of **22.2** when tests shall be at the agreed temperature. If the yield strength or proof stress value obtained from the test is equal to or above the minimum value specified in appendix C for the steel type and grade, the plate shall be deemed to comply with this British Standard and the specified elevated temperature yield strength or proof stress values for all temperatures shall be considered to be valid within normally acceptable confidence limits.

22.2 Exceptional cases. In other cases, verification of the elevated temperature yield strength or proof stress properties of material designated with the suffix B shall only be done at the specific request of the purchaser when the frequency and temperature of testing shall be agreed at the time of order. For all grades, the minimum acceptance levels for such tests should correspond to those specified in appendix C (values for tests at intermediate temperatures being obtained by linear interpolation) and be stated on the enquiry and order.

22.3 Stress rupture values. Estimated average stress rupture values are given for information in appendix G.

23. Impact properties

The average value obtained from the three tests from each sample shall be not less than the value specified for the relevant material at the appropriate test temperature. The test temperature shall be selected from those given for minimum impact values that are specified in section three for the relevant type of steel.

One individual value may be below the specified value provided it is not less than 70 % of that value.

In the case of subsidiary standard test pieces, the value to be obtained shall be as given in table 11 for the relevant type of steel.

For impact values greater than 41 J for 10 mm x 10 mm test pieces, the values for subsidiary standard test pieces shall be agreed between the manufacturer and the purchaser.

24. Ultrasonic testing

Ultrasonic testing shall be applied if specified and agreed at the time of enquiry and order. Tests shall be made in accordance with BS 5996 unless otherwise agreed.

*S_o is the original cross-sectional area of the gauge length.

Table 11. Impact test values for subsidiary standard test pieces

Average value for standard test pieces	Equivalent average value for subsidiary standard test pieces	
10 mm X 10 mm	10 mm X 7.5 mm	10 mm X 5 mm
J	J	J
27	22	19
31	25	22
41	33	29

25. Special tests

Specific surface quality requirements, or special tests, e.g. through-thickness tensile testing, may be agreed at the time of enquiry and order. In such cases the technique to be used and the results to be obtained shall be agreed between the manufacturer and the purchaser at the time of the enquiry and order.

26. Retests

26.1 Room temperature tensile tests. If a room temperature tensile test piece does not meet the test requirements, two further tests shall be made on test pieces taken from samples from the plate represented. If both of these additional tests comply with the relevant requirements specified for the material, the plate represented shall be deemed to comply with the requirements of this British Standard.

26.2 Elevated temperature tensile tests. If an elevated temperature tensile test result does not comply with test requirements, two further tests shall be made on samples taken from the same plate. If both of these additional tests comply with the relevant requirements specified for the material, the plate represented shall be deemed to comply with the requirements of this British Standard.

26.3 Impact tests. If the average of the three impact tests fails to comply with the specified minimum average value, or one of the samples has a value less than 70 % of the specified minimum value, three additional test pieces from the same sample shall be tested and the results added to those previously obtained and a new average calculated. This new average shall comply with the specified requirement for the relevant steel given in section three. Not more than two of the individual values shall be lower than the specified value and not more than one shall be lower than 70 % of that value.

26.4 Re-heat treatment. The manufacturer may heat treat or re-heat treat any plate, including any plate found not to fulfil the test requirements, and re-submit it for testing. If agreed at the time of the enquiry and order, the details of these treatments, including previous treatments, shall be reported to the purchaser.

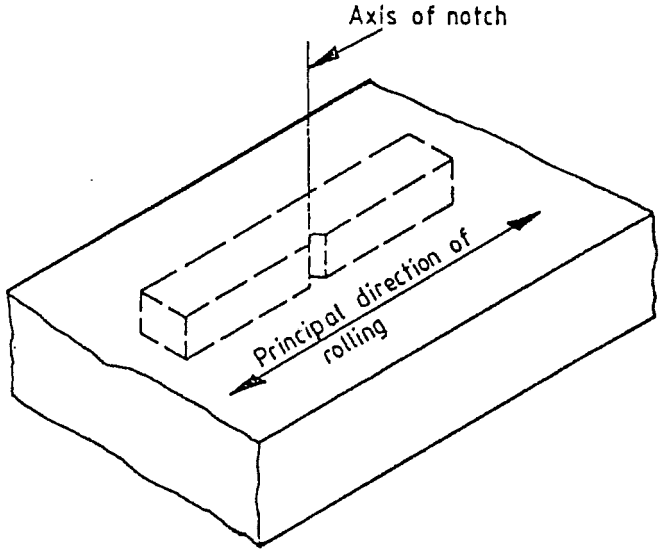


Figure 3. Location of impact test piece

Section three. Specific requirements for steel types

27. BS 1501–141 Rimmed carbon steel (for hard glass enamelled vessels)

27.1 General. The requirements are specified for rimmed carbon steel plates up to and including 19 mm thick in one grade.

This steel is intended only for hard glass enamelled pressure vessels.

One grade of this steel is available as follows.

Grade 360: tensile strength 360 N/mm^2 to 480 N/mm^2. Only suffix A is applicable to this steel (see clause 3).

27.2 Deoxidation. This steel shall be rimmed.

27.3 Heat treatment condition. The steel shall be supplied in the hot finished condition.

27.4 Chemical composition

27.4.1 *Ladle analysis.* The ladle analysis shall comply with the requirements given in table 12.

Table 12. Chemical composition (ladle analysis) of steel 141

Element	Grade 360	
	%	
Carbon	max. 0.16	
Manganese	max. 0.50	
Phosphorus	max. 0.050	
Sulphur	max. 0.050	
Chromium	max. 0.25	Total 0.70 % max.
Copper	max. 0.30	
Molybdenum	max. 0.10	
Nickel	max. 0.30	

27.4.2 *Nitrogen content.* The nitrogen content shall not exceed 0.009 %. It shall be determined but shall be reported on the test certificate only if agreed between the purchaser and the manufacturer at the time of the enquiry and order.

27.4.3 *Product analysis.* Product analysis is not applicable to this steel.

27.5 Mechanical properties at room temperature. The mechanical properties at room temperature obtained from test pieces selected, prepared and tested in accordance with clauses **19**, **20** and **21** shall comply with the properties given in table 13.

Table 13. Mechanical properties at room temperature of steel 141

Nominal plate thickness		Tensile strength R_m		Yield strength R_e	Elongation A
Over	Up to and including	min.	max.	min.	min.
mm	mm	N/mm^2	N/mm^2	N/mm^2	%
3	16	360	480	205	25
16	19	360	480	195	25

27.6 Elevated temperature proof stress and stress rupture values. Elevated temperature properties are not specified for this steel.

27.7 Charpy V-notch impact properties. Impact properties are not specified for this steel.

28. BS 1501–154 Aluminium semi-killed carbon steel

28.1 **General.** The requirements are specified for aluminium semi-killed carbon steel plates up to 9.5 mm thick in three grades.

The steel is primarily intended for use at ambient temperature and for pressure vessels where design is based on minimum tensile or room temperature yield strength only.

The purchaser shall state which of the following grades of this steel type is required.

Grade 360: tensile strength 360 N/mm^2 to 480 N/mm^2
Grade 400: tensile strength 400 N/mm^2 to 520 N/mm^2
Grade 430: tensile strength 430 N/mm^2 to 550 N/mm^2

Only suffix A is applicable to this steel (see clause 3).

28.2 **Deoxidation.** This steel shall be semi-killed with aluminium only.

28.3 **Heat treatment condition.** The steel shall be supplied in the hot finished condition.

28.4 **Chemical composition**

28.4.1 *Ladle analysis.* The ladle analysis shall comply with the appropriate requirements given in table 14.

Table 14. Chemical composition (ladle analysis) of steel 154

Element		Grade 360	Grade 400	Grade 430	
		%	%	%	
Carbon	max.	0.20	0.24	0.25	
Manganese	min.	0.30	0.40	0.40	
	max.	1.20	1.20	1.20	
Phosphorus	max.	0.050	0.050	0.050	
Sulphur	max.	0.050	0.050	0.050	
Chromium	max.	0.25	0.25	0.25	*Total 0.70 % max.
Copper	max.	0.30	0.30	0.30	
Molybdenum	max.	0.10	0.10	0.10	
Nickel	max.	0.30	0.30	0.30	

*Applies to all grades.

28.4.2 *Nitrogen content.* The nitrogen content shall not exceed 0.012 %. It shall be determined but shall be reported on the test certificate only if agreed between the purchaser and the manufacturer at the time of the enquiry and order.

28.4.3 *Product analysis.* If product analysis is required, the requirements of clause 7 shall apply. The permitted deviations in product analysis from the specified ladle analysis shall be as specified in appendix B.

28.5 **Mechanical properties at room temperature.** The mechanical properties obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 21 shall comply with the appropriate properties given in table 15.

28.6 **Elevated temperature proof stress and stress rupture values.** Elevated temperature properties are not specified for this steel.

28.7 **Charpy V-notch impact properties.** Impact properties are not specified for this steel.

Table 15. Mechanical properties at room temperature of steel 154

Grade	Nominal plate thickness up to and including	Tensile strength R_m		Yield strength R_e	Elongation A
		min.	max.	min.	min.
	mm	N/mm^2	N/mm^2	N/mm^2	%
360	9.5	360	480	205	23
400	9.5	400	520	235	23
430	9.5	430	550	250	22

29. BS 1501—151 Semi-killed or fully killed carbon steel

29.1 General. The requirements are specified for semi-killed or fully killed carbon steel plates up to and including 100 mm thick in three grades. The plates may be supplied having specified elevated temperature properties.

The purchaser shall state which of the following grades of this steel type are required and whether the suffix A or B is applicable (see clause 3).

Grade 360: tensile strength 360 N/mm^2 to 480 N/mm^2
Grade 400: tensile strength 400 N/mm^2 to 520 N/mm^2
Grade 430: tensile strength 430 N/mm^2 to 550 N/mm^2

29.2 Deoxidation. At the manufacturer's option the steel may be supplied semi-killed or fully killed unless the supply of semi-killed steel is specifically required and agreed at the time of the enquiry and order. When the steel is fully killed the silicon content shall be as specified in table 16. Aluminium may be used in addition to silicon for deoxidation.

29.3 Heat treatment condition

29.3.1 The plates shall be supplied in the normalized condition, except that, at the manufacturer's option, the normalizing treatment for plates up to and including 40 mm thick may be omitted providing all specified property requirements are met when the steel is in the hot finished condition (see clause 8).

29.3.2 If requested by the purchaser and agreed at the time of the enquiry and order, plates of this steel up to 40 mm thick shall be supplied in the normalized condition. Alternatively, if agreed, normalizing of the plates shall be omitted and the test samples shall be normalized (see **8.1** and **19.4.2**).

29.4 Chemical composition

29.4.1 *Ladle analysis.* The ladle analysis shall comply with the appropriate requirements given in table 16.

Table 16. Chemical composition (ladle analysis) of steel 151

Element		Grade 360	Grade 400	Grade 430	
		%	%	%	
Carbon	max.	0.17	0.20	0.25	
Silicon	max.	0.35	0.35	0.35	
Manganese	min.	0.40	0.50	0.60	
	max.	1.20	1.30	1.40	
Phosphorus	max.	0.030	0.030	0.030	
Sulphur	max.	0.045	0.045	0.045	
Chromium	max.	0.25	0.25	0.25	*Total 0.70 % max.
Copper	max.	0.30	0.30	0.30	
Molybdenum	max.	0.10	0.10	0.10	
Nickel	max.	0.30	0.30	0.30	

*Applies to all grades.

29.4.2 *Nitrogen content.* The nitrogen content shall not exceed 0.012 %. It shall be determined but shall be reported on the test certificate only if agreed between the purchaser and the manufacturer at the time of the enquiry and order.

29.4.3 *Product analysis.* If product analysis is required, the requirements of clause 7 shall apply. The permitted deviations in product analysis from the specified ladle analysis shall be as specified in appendix B.

29.5 Mechanical properties at room temperature. The mechanical properties obtained from test pieces selected, prepared and tested in accordance with clauses **19**, **20** and **21** shall comply with the appropriate properties given in table 17.

Table 17. Mechanical properties at room temperature of steel 151

Grade	Nominal plate thickness		Tensile strength R_m		Yield strength R_e	Elongation A
	Over	Up to and including	min.	max.	min.	min.
	mm	mm	N/mm^2	N/mm^2	N/mm^2	%
360	3	16	360	480	205	26
	16	40			195	26
	40	63			185	25
	63	100			175	24
400	3	16	400	520	225	24
	16	40			215	24
	40	63			205	23
	63	100			200	22
430	3	16	430	550	250	23
	16	40			240	23
	40	63			230	22
	63	100			220	21

29.6 Elevated temperature proof stress and stress rupture values. Characteristic elevated temperature proof stress values are specified in appendix D and stress rupture values in appendix G.

29.7 Charpy V-notch impact properties. Impact properties are not specified for this steel.

30. BS 1501—161 Fully killed carbon steel

30.1 General. The requirements are specified for fully killed carbon steel plates up to and including 150 mm thick in three grades. The plates may be supplied having specified elevated temperature properties.

The purchaser shall state which of the following grades of this steel type are required and whether the suffix A or B is applicable (see clause 3).

Grade 360: tensile strength 360 N/mm² to 480 N/mm²
Grade 400: tensile strength 400 N/mm² to 520 N/mm²
Grade 430: tensile strength 430 N/mm² to 550 N/mm²

30.2 Deoxidation. This steel shall be fully killed. The silicon content shall be as specified in table 18. Aluminium may be used in addition to silicon for deoxidation.

30.3 Heat treatment condition. The plates shall be supplied in the normalized condition, except that at the manufacturer's option the normalizing treatment for plates up to and including 40 mm thick may be omitted provided all specified property requirements are met when the steel is in the hot finished condition (see clause 8).

30.3.1 If requested by the purchaser and agreed at the time of the enquiry and order, plates of steel type 161 up to 40 mm thick shall be supplied in the normalized condition, or alternatively, if agreed, normalizing of the plates shall be omitted and the test samples normalized (see 8.1 and 19.4.2).

30.4 Chemical composition

30.4.1 *Ladle analysis.* The ladle analysis shall comply with the appropriate requirements given in table 18.

Table 18. Chemical composition (ladle analysis) of steel 161

Element		Grade 360	Grade 400	Grade 430	
		%	%	%	
Carbon	max.	0.17	0.20	0.25	
Silicon	min.	0.10	0.10	0.10	
	max.	0.35	0.35	0.35	
Manganese	min.	0.40	0.50	0.60	
	max.	1.20	1.30	1.40	
Phosphorus	max.	0.030	0.030	0.030	
Sulphur	max.	0.030	0.030	0.030	
Chromium	max.	0.25	0.25	0.25	*Total 0.70 % max.
Copper	max.	0.30	0.30	0.30	
Molybdenum	max.	0.10	0.10	0.10	
Nickel	max.	0.30	0.30	0.30	

*Applies to all grades.

30.4.2 *Nitrogen content.* The nitrogen content shall not exceed 0.012 %. It shall be determined but shall be reported on the test certificate only if agreed between the purchaser and the manufacturer at the time of the enquiry and order.

30.4.3 *Product analysis.* If product analysis is required, the requirements of clause 7 shall apply. The permitted deviations in product analysis from the specified ladle analysis shall be as specified in appendix B.

30.5 Mechanical properties at room temperature. The mechanical properties obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 21 shall comply with the appropriate properties given in table 19.

30.6 Elevated temperature proof stress and stress rupture values. Characteristic elevated temperature proof stress values are specified in appendix D and stress rupture values in appendix G.

30.7 Charpy V-notch impact properties. Impact properties are not specified for this steel.

Table 19. Mechanical properties at room temperature of steel 161

Grade	Nominal plate thickness		Tensile strength R_m		Yield strength R_e	Elongation A
	Over	Up to and including	min.	max.	min.	min.
	mm	mm	N/mm²	N/mm²	N/mm²	%
360	3	16	360	480	205	26
	16	40			195	26
	40	63			185	25
	63	100			175	24
	100	150			170	24
400	3	16	400	520	225	24
	16	40			215	24
	40	63			205	23
	63	100			200	22
	100	150			195	22
430	3	16	430	550	250	23
	16	40			240	23
	40	63			230	22
	63	100			220	21
	100	150			210	21

31. BS 1501–164 Fully killed aluminium treated carbon steel

31.1 General. The requirements are specified for fully killed aluminium treated carbon steel plates up to and including 150 mm thick in two grades. The plates may be supplied having specified elevated temperature properties and low temperature properties.

The purchaser shall state which of the following grades of this steel type are required and whether the suffix A or B and any other designation is applicable (see clause 3).

Grade 360: tensile strength 360 N/mm^2 to 480 N/mm^2
Grade 400: tensile strength 400 N/mm^2 to 520 N/mm^2

31.2 Deoxidation. The steel shall be fully killed and aluminium treated.

31.3 Heat treatment condition. The steel shall be supplied in the normalized condition, unless an alternative condition of supply is agreed between the purchaser and the manufacturer (see clause 8).

31.4 Chemical composition

31.4.1 *Ladle analysis.* The ladle analysis shall comply with the appropriate requirements given in table 20.

31.4.2 *Nitrogen content.* The nitrogen content shall not exceed 0.012 %. It shall be determined but shall be reported on the test certificate only if agreed between the purchaser and the manufacturer at the time of enquiry and order.

31.4.3 *Product analysis.* If product analysis is required, the requirements of clause 7 shall apply. The permitted deviations in product analysis from the specified ladle analysis shall be as specified in appendix B.

31.5 Mechanical properties at room temperature. The mechanical properties obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 21 shall comply with the appropriate properties given in table 21.

31.6 Elevated temperature proof stress and stress rupture values. Characteristic elevated temperature proof stress values are specified in appendix E and stress rupture values in appendix G.

31.7 Charpy V-notch impact values

31.7.1 If specified on the enquiry and order, Charpy V-notch impact values obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 23 shall comply with the requirements given in table 22.

31.7.2 Charpy V-notch impact values for plates over 63 mm thick shall be agreed between the manufacturer and the purchaser at the time of the enquiry and order.

31.7.3 The specified Charpy V-notch impact values apply also when samples are subjected to the standard simulated post weld heat treatment specified in 19.4.3, but values for samples subjected to other treatments (see 19.4.4) shall be agreed between the manufacturer and the purchaser.

Table 20. Chemical composition (ladle analysis) of steel 164

Element		Grade 360	Grade 400	
		%	%	
Carbon*	max.	0.20	0.23	
Silicon	min.	0.10	0.10	
	max.	0.35	0.35	
Manganese	min.	0.40	0.50	
	max.	1.20	1.30	
Phosphorus	max.	0.030	0.030	
Sulphur	max.	0.030	0.030	
Aluminium (metallic)†	min.	0.015	0.015	
Chromium	max.	0.25	0.25	‡Total 0.70 % max.
Copper	max.	0.30	0.30	
Molybdenum	max.	0.10	0.10	
Nickel	max.	0.30	0.30	

*For steel plate of grade 360 over 63 mm thick the maximum carbon content shall be 0.22 %. For steel plate of grade 400 over 63 mm thick the maximum carbon content shall be 0.25 %.

†Determination of total aluminium shall be deemed to meet this requirement provided the value obtained is not less than 0.018 %.

‡Applies to all grades.

Table 21. Mechanical properties at room temperature of steel 164

Grade	Nominal plate thickness		Tensile strength R_m		Yield strength R_e	Elongation A
	Over	Up to and including	min.	max.	min.	min.
	mm	mm	N/mm^2	N/mm^2	N/mm^2	%
360	3	16	360	480	255	25
	16	40			235	25
	40	63			220	24
	63	100			*	23
	100	150			*	23
400	3	16	400	520	275	23
	16	40			265	23
	40	63			245	22
	63	100			*	21
	100	150			*	21

*The values of yield strength for plates over 63 mm thick up to and including 150 mm thick shall be the values specified for plates of thickness between 40 mm and 63 mm reduced by 1 % for each 5 mm or part thereof increase in thickness over 63 mm.

Table 22. Charpy V-notch impact values for plates of steel 164 up to and including 63 mm thick

Grade	Impact test values minimum average of three at a temperature of °C of		
	RT	0	-20
	J	J	J
360 } 400 }	41	31	27

32. BS 1501–223 Fully killed niobium treated carbon manganese steel

32.1 General. The requirements are specified for fully killed niobium treated carbon manganese steel plates up to 150 mm thick in two grades. The plates may be supplied having specified elevated temperature properties and low temperature impact properties.

The purchaser shall state which of the following grades of this steel type are required and whether the suffix A or B and any other designation is applicable (see clause 3).

Grade 460: tensile strength 460 N/mm^2 to 580 N/mm^2
Grade 490: tensile strength 490 N/mm^2 to 610 N/mm^2

32.2 Deoxidation. The steel shall be fully killed. The silicon content shall be as specified in table 23. Aluminium may be used in addition to silicon for deoxidation.

32.3 Heat treatment condition. The steel shall be supplied in the normalized condition unless an alternative condition of supply is agreed between the purchaser and the manufacturer (see clause 8).

32.4 Chemical composition

32.4.1 *Ladle analysis.* The ladle analysis shall comply with the appropriate requirements given in table 23.

32.4.2 *Nitrogen content.* The nitrogen content shall not exceed 0.012 %. It shall be determined but shall be reported on the test certificate only if agreed between the manufacturer and the purchaser at the time of the enquiry and order.

32.4.3 *Product analysis.* If product analysis is required, the requirements of clause 7 shall apply. The permitted deviations in product analysis from the specified ladle analysis shall be as specified in appendix B.

Table 23. Chemical composition (ladle analysis) of steel 223

Element		Grade 460	Grade 490	
		%	%	
Carbon	max.	0.20*	0.20*	
Silicon	min.	0.10	0.10	
	max.	0.40	0.50	
Manganese	min.	0.80	0.90	
	max.	1.60	1.60	
Phosphorus	max.	0.030	0.030	
Sulphur	max.	0.030	0.030	
Niobium	min.	0.010	0.010	
	max.	0.060	0.060	
Chromium	max.	0.25	0.25	†Total 0.50 % max.
Copper	max.	0.30	0.30	
Molybdenum	max.	0.10	0.10	
Nickel‡	max.	0.75	0.75	

*When test samples are subject to simulated post weld heat treatment, the maximum carbon content shall be 0.22 %.

†Applies to all grades.

‡The purchaser may specify a nickel content of 0.30 % maximum; in this case, the combined total for chromium, copper, molybdenum and nickel shall be 0.70 % maximum.

32.5 Mechanical properties at room temperature. The mechanical properties obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 21 shall comply with the appropriate properties given in table 24.

Table 24. Mechanical properties at room temperature of steel 223

Grade	Nominal plate thickness		Tensile strength R_m		Yield strength R_e	Elongation A
	Over	Up to and including	min.	max.	min.	min.
	mm	mm	N/mm^2	N/mm^2	N/mm^2	%
460	3	16	460	580	340	22
	16	40			330	22
	40	63			320	21
	63	100			*	20
	100	150			*	20
490	3	16	490	610	355	21
	16	40			345	21
	40	63			340	20
	63	100			*	20
	100	150			*	20

*The values of yield strength for plates of over 63 mm thickness shall be the values specified for plates of thickness between 40 mm and 63 mm reduced by 1 % for each 5 mm or part thereof increase in thickness over 63 mm.

32.6 Elevated temperature proof stress and stress rupture values. Characteristic elevated temperature proof stress values are specified in appendix E and stress rupture values in appendix G.

32.7 Charpy V-notch impact properties

32.7.1 If specified on the enquiry and order, Charpy V-notch values obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 23 shall comply with the requirements given in table 25.

32.7.2 Charpy V-notch impact values for plates over 80 mm thick shall be agreed between the manufacturer and the purchaser at the time of the enquiry and order.

Table 25. Charpy V-notch impact values for plates of steel 223 up to and including 80 mm* thick

Grade	Impact test values minimum average of three at a temperature °C of			
	RT	0	-15	-30
	J	J	J	J
460 / 490	61	55	41	27

*In the event that the purchaser specifies a nickel content of 0.30 % maximum (see footnote ‡ to table 23), then the above impact values shall only be applicable to plates up to and including 63 mm thick.

32.7.3 The specified Charpy V-notch impact values apply also when samples are subjected to the standard simulated post weld heat treatment specified in 19.4.3, but values for samples subjected to other treatments (see 19.4.4) shall be agreed between the manufacturer and the purchaser.

33. BS 1501–224 Fully killed aluminium treated carbon manganese steel

33.1 General. The requirements are specified for fully killed aluminium treated carbon manganese steel plates, up to 150 mm thick in four grades. The plates may be supplied having specified elevated temperature properties and low temperature impact properties.

The purchaser shall state which of the following grades of this steel type are required and whether the suffix A or B and any other designation is applicable (see clause 3).

Grade 400: tensile strength 400 N/mm² to 520 N/mm²
Grade 430: tensile strength 430 N/mm² to 550 N/mm²
Grade 460: tensile strength 460 N/mm² to 580 N/mm²
Grade 490: tensile strength 490 N/mm² to 610 N/mm²

33.2 Deoxidation. The steel shall be fully killed and aluminium treated.

33.3 Heat treatment condition. The steel shall be supplied in the normalized condition unless an alternative condition of supply is agreed between the purchaser and the manufacturer (see clause 8).

33.4 Chemical composition

33.4.1 *Ladle analysis.* The ladle analysis shall comply with the appropriate requirements given in table 26.

33.4.2 *Nitrogen content.* The nitrogen content shall not exceed 0.012 %. It shall be determined but shall be reported on the test certificate only if agreed between the manufacturer and the purchaser at the time of the enquiry and order.

33.4.3 *Product analysis.* If product analysis is required, the requirements of clause 7 shall apply. The permitted deviations in product analysis from the specified ladle analysis shall be as specified in appendix B.

33.5 Mechanical properties at room temperature. The mechanical properties obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 21 shall comply with the appropriate properties given in table 27.

Table 26. Chemical composition (ladle analysis) of steel 224

Element		Grade 400	Grade 430	Grade 460	Grade 490	
		%	%	%	%	
Carbon	max.	0.18	0.20	0.22	0.22	
Silicon	min.	0.10	0.10	0.10	0.10	
	max.	0.35	0.40	0.40	0.40	
Manganese	min.	0.90	0.90	0.90	0.90	
	max.	1.50	1.50	1.60	1.60	
Phosphorus	max.	0.030	0.030	0.030	0.030	
Sulphur	max.	0.030	0.030	0.030	0.030	
Aluminium* (metallic)	min.	0.015	0.015	0.015	0.015	
Chromium	max.	0.25	0.25	0.25	0.25	†Total 0.50 % max.
Copper	max.	0.30	0.30	0.30	0.30	
Molybdenum	max.	0.10	0.10	0.10	0.10	
Nickel‡	max.	0.75	0.75	0.75	0.75	

* Determination of total aluminium shall be deemed to meet this requirement provided the value obtained is not less than 0.018 %.

† Applies to all grades.

‡ The purchaser may specify a nickel content of 0.30 % maximum; in this case, the combined total for chromium, copper, molybdenum and nickel shall be 0.70 % maximum.

33.6 Elevated temperature proof stress and stress rupture values. Characteristic elevated temperature proof stress values are specified in appendix F and stress rupture values in appendix G.

33.7 Charpy V-notch impact properties

33.7.1 If specified on the enquiry and order, Charpy V-notch impact values obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 23 shall comply with the requirements given in table 28.

Table 27. Mechanical properties at room temperature of steel 224

Grade	Nominal plate thickness		Tensile strength R_m		Yield strength R_e	Elongation A
	Over	Up to and including	min.	max.	min.	min.
	mm	mm	N/mm²	N/mm²	N/mm²	%
400	3	16	400	520	275	23
	16	40			265	23
	40	63			245	22
	63	100			*	21
	100	150			*	21
430	3	16	430	550	305	22
	16	40			285	22
	40	63			275	21
	63	100			*	20
	100	150			*	20
460	3	16	460	580	325	21
	16	40			315	21
	40	63			305	20
	63	100			*	19
	100	150			*	19
490	3	16	490	610	325	21
	16	40			315	21
	40	63			305	20
	63	100			*	19
	100	150			*	19

*The value of yield strength for plates of over 63 mm thick up to and including 150 mm thick shall be the values specified for plates of thickness between 40 mm and 63 mm reduced by 1 % for each 5 mm or part thereof increase in thickness over 63 mm.

Table 28. Charpy V-notch impact values for plates of steel 224 up to and including 80 mm* thick

Grade	Impact test values minimum average of three at a temperature °C of					
	RT	0	-20	-30	-40	-50
	J	J	J	J	J	J
All grades	61	55	47	41	31	27

*In the event that the purchaser specifies a nickel content of 0.30 % maximum (see footnote ‡ to table 26), then the above impact values shall only be applicable to plates up to and including 63 mm thick.

33.7.2 Charpy V-notch impact values for plate over 80 mm thick shall be agreed between the manufacturer and the purchaser at the time of the enquiry and order.

33.7.3 The specified Charpy V-notch impact values apply also when samples are subjected to the standard simulated post weld heat treatment specified in 19.4.3, but values for samples subjected to other treatments (see 19.4.4) shall be agreed between the purchaser and the manufacturer.

34. BS 1501—225 Fully killed niobium and aluminium treated carbon manganese steel

34.1 General. The requirements are specified for fully killed niobium and aluminium treated carbon manganese steel plates up to 150 mm thick in two grades. The plates may be supplied having specified elevated temperature properties and low temperature impact properties.

Two grades of this type of steel are available as follows.

Grade 460: tensile strength 460 N/mm^2 to 580 N/mm^2

Grade 490: tensile strength 490 N/mm^2 to 610 N/mm^2

The purchaser shall state whether the suffix A or B and any other designation is applicable (see clause 3).

34.2 Deoxidation. The steel shall be fully killed and aluminium treated.

34.3 Heat treatment condition. The steel shall be supplied in the normalized condition unless an alternative condition of supply is agreed between the purchaser and the manufacturer (see clause 8).

34.4 Chemical composition

34.4.1 *Ladle analysis.* The ladle analysis shall comply with the appropriate requirements given in table 29.

34.4.2 *Nitrogen content.* The nitrogen content shall not exceed 0.012 %. It shall be determined but shall be reported on the test certificate only if agreed between the manufacturer and the purchaser at the time of the enquiry and order.

34.4.3 *Product analysis.* If product analysis is required, the requirements of clause 7 shall apply. The permitted deviations in product analysis from the specified ladle analysis shall be as specified in appendix B.

Table 29. Chemical composition (ladle analysis) of steel 225

Element		Grade 460	Grade 490
		%	%
Carbon*	max.	0.20	0.20
Silicon	min.	0.10	0.10
	max.	0.40	0.50
Manganese	min.	0.80	0.90
	max.	1.60	1.60
Phosphorus	max.	0.030	0.030
Sulphur	max.	0.030	0.030
Aluminium (metallic)†	min.	0.015	0.015
Niobium	min.	0.010	0.010
	max.	0.060	0.060
Chromium	max.	0.25 total	0.25 total
Copper	max.	0.30 } 0.50 %	0.30 } 0.50 %
Molybdenum	max.	0.10 max.	0.10 max.
Nickel	max.	0.75	0.75‡

* When test samples are subjected to simulated post weld heat treatment, the maximum carbon content shall be 0.22 %.

† Determination of total aluminium shall be deemed to meet this requirement, provided the value obtained is not less than 0.018 %.

‡ The purchaser may specify a nickel content of 0.30 % maximum for grade 490; in this case, the combined total for chromium, copper, molybdenum and nickel shall be 0.70 % maximum.

34.5 Mechanical properties at room temperature. The mechanical properties obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 21 shall comply with the appropriate properties given in table 30.

Table 30. Mechanical properties at room temperature of steel 225

Grade	Nominal plate thickness		Tensile strength R_m		Yield strength R_e	Elongation A
	Over	Up to and including	min.	max.	min.	min.
	mm	mm	N/mm^2	N/mm^2	N/mm^2	%
460	3	16	460	580	340	22
	16	40			330	22
	40	63			320	21
	63	100			*	20
	100	150			*	20
490	3	16	490	610	355	21
	16	40			345	21
	40	63			340	20
	63	100			*	20
	100	150			*	20

* The values of yield strength for plates of over 63 mm thickness shall be the values specified for plates of thickness between 40 mm and 63 mm, reduced by 1 % for each 5 mm or part thereof increase in thickness over 63 mm.

34.6 Elevated temperature proof stress and stress rupture values. Characteristic elevated temperature proof stress values are specified in appendix E and stress rupture values in appendix G.

34.7 Charpy V-notch impact properties

34.7.1 If specified on the enquiry and order, Charpy V-notch impact values obtained from test pieces selected, prepared and tested in accordance with clauses 19, 20 and 23 shall comply with the requirements given in table 31.

Table 31. Charpy V-notch impact values for steel 225 up to and including 80 mm thick

Grade	Impact test values minimum average of three at a temperature °C of			
	−20	−30	−50	−60
	J	J	J	J
460	61	47	27	27†
490*	61	47	27	—

* In the event that the purchaser specifies a nickel content of 0.30 % maximum for grade 490 (see note to table 29), then the above impact values shall only be applicable to plates up to and including 63 mm thick.

† Up to and including 30 mm thick.

34.7.2 Charpy V-notch impact values for plates over 80 mm thick shall be agreed between the manufacturer and the purchaser at the time of the enquiry and order.

34.7.3 The specified Charpy V-notch impact values apply also when samples are subjected to the standard simulated post weld heat treatment specified in 19.4.3, but values for samples subjected to other treatments (see 19.4.4) shall be agreed between the purchaser and the manufacturer.

Appendix A

Types and grades of steel included in BS 1501 : Part 1 : 1964 and BS 1501 : Part 1 : 1980

The comparisons in table 32 are of necessity approximations and are intended only as a guide. Reference to all the original material specifications should be made for more detailed information.

For steel types 141, 154, 151 and 161, the comparisons are direct and on an overall basis. However for steels 211, 221, 213, 223 and 224, due to the many design factors involved it is necessary to consider equivalence depending upon different property parameters.

Appendix B

Permitted deviations in product analysis from specified ladle analysis

If product analysis is required, the results of this analysis shall not vary from the specified composition by more than the permitted amounts given in table 33.

The product analysis shall be carried out on samples taken from a location corresponding to that used for the samples for mechanical testing by the manufacturer.

The number of samples to be taken shall be agreed between the manufacturer and the purchaser at the time of the enquiry and order.

The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range, but not both above and below for the same element from different samples from the same cast. When maxima only are specified, the deviations are positive only.

Table 33. Permitted deviations in product analysis from specified ladle analysis

Deviations from specified ladle analysis					
C	Si	Mn	P	S	Nb
%	%	%	%	%	%
0.03	-0 +0.05	0.10	0.005	0.005	-0 +0.01

Appendix C

Elevated temperature yield strength or proof stress values for plates designated with the suffix B

C.1 Derivation of values. BS 3920 describes a procedure for deriving minimum elevated temperature yield strength or proof stress values which uses the well established linear relationship between elevated temperature yield strength or proof stress and room temperature tensile strength data, the specified minimum elevated temperature yield strength or proof stress being derived on the basis of the specified minimum room temperature tensile strength for the steel type and grade in question.

In deriving the minimum elevated temperature yield strength or proof stress values specified in this appendix, the same principles have been applied where sufficient data exists except that in the case of steel types 164, 223, 224 (except grade 490) and 225 (except grade 460), a room temperature tensile strength, (see table 34), higher than the specified minimum has been used as a basis for the derivation. This has allowed higher minimum elevated temperature yield strength or proof stress levels to be specified than would otherwise be possible. For these cases confidence is maintained by requiring an elevated temperature yield strength or proof stress (see **22.1**) to be carried out on each plate where the actual room temperature tensile strength is shown to be less than that specified in table 34.

Table 32. Types and grades of steel included in BS 1501 : Part 1 : 1964 and BS 1501 : Part 1 : 1980

Type and grade of steel in BS 1501 : Part 1 : 1964	Nearest equivalent type and grade of steel in BS 1501 : Part 1 : 1980
141	141 grade 360
154 grade 23	154 grade 360
154 grade 26	154 grade 400
154 grade 28	154 grade 430
151 grade 23	151 grade 360
151 grade 26	151 grade 400
151 grade 28	151 grade 430
161 grade 23	161 grade 360
161 grade 26	161 grade 400
161 grade 28	161 grade 430

Type and grade of steel in BS 1501 : Part 1 : 1964	Nearest equivalent type and grade of steel in BS 1501 : Part 1 : 1980 grade based on		
	Room temperature yield strength	Room temperature tensile strength	Elevated temperature proof stress
211 & 221 grade 26	164 grade 360	164 grade 400	224 grade 400
211 & 221 grade 28	164 grade 360	224 grade 430	224 grade 430
211 & 221 grade 30	164 grade 400	224 grade 460	224 grade 460
211 & 221 grade 32	224 grade 430	224 grade 490	223 grade 460
213 & 223 grade 28	224 grade 430	224 grade 430	224 grade 430
213 & 223 grade 30	224 grade 460	223 grade 460	223 grade 460
213 & 223 grade 32	223 grade 460	223 grade 490	223 grade 490
224 grade 26	224 grade 400	224 grade 400	224 grade 400
224 grade 28	224 grade 400 or 430	224 grade 430	224 grade 400
224 grade 30	224 grade 430	224 grade 460	224 grade 430
224 grade 32	224 grade 460	224 grade 490	224 grade 460

Table 34. Tensile strength used for derivation of elevated temperature proof stress values when this is higher than the specified minimum value

Grade	Room temperature tensile strength used for derivation of elevated temperature yield or 0.2 % proof stress for steel type			
	164	223	224	225
	N/mm²	N/mm²	N/mm²	N/mm²
360	390	–	–	–
400	430	–	430	–
430	–	–	460	–
460	–	490	490	–
490	–	510	–	510

C.2 Availability of elevated temperature data. The amount of data required by BS 3920 for derivation of values does not always exist. In such cases minimum elevated temperature proof stress values which are considered to be reliable have been included, as follows.

(a) For steels 151 and 161 there is adequate evidence that the values derived by the BS 3920 procedure on normalized plates are valid also for plates in the hot finished condition up to 40 mm thick. These values are therefore specified for this condition and thickness.

(b) In all other cases where the amount of data required by BS 3920 is not available, the minimum elevated temperature proof stress values have nevertheless been obtained from the results of analyses of available data which have been made on an international basis by committees of the International Organization for Standardization.

C.3 Characteristic elevated temperature yield strength proof stress values. Characteristic values of elevated temperature lower yield strength values or proof stress values for plates designated with the suffix B are specified in appendices D, E and F.

Appendix D

Minimum yield strength (R_{eL}) or 0.2 % proof stress ($R_{p0.2}$) values at elevated temperatures for steel types 151 and 161

Steel type	Grade	Nominal plate thickness*		Minimum yield stress R_{eL} or 0.2 % proof stress $R_{p0.2}$ at temperature °C					
		Over	Up to and including	150	200	250	300	350	400
		mm	mm	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
151 and 161	360	3	16	172	168	150	124	117	115
		16	40	169	162	144	124	117	115
		40	63	158	152	141	124	117	115
		63	100	148	144	136	124	117	115
	400	3	16	200	195	174	145	137	133
		16	40	192	185	165	145	137	133
		40	63	182	175	162	145	137	133
		63	100	170	166	157	145	137	133
	430	3	16	222	215	192	161	153	148
		16	40	210	202	181	161	153	148
		40	63	200	192	178	161	153	148
		63	100	186	181	172	161	153	148

*The values for plates of steel 161 over 100 mm thickness shall be the values specified for plates of thicknesses between 63 mm and 100 mm reduced by 1 % for each 5 mm, or part thereof, increase in thickness over 100 mm.

Appendix E

Minimum yield strength (R_{eL}) or 0.2 % proof stress ($R_{p0.2}$) values at elevated temperatures for steel types 164, 223 and 225

Steel type	Grade	Nominal plate thickness*		Minimum yield strength R_{eL} or 0.2 % proof stress $R_{p0.2}$ at temperature °C						
		Over	Up to and including	150	200	250	300	350	400	450
		mm	mm	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
164	360	3	16	206	182	161	142	131	124	–
		16	40	201	181	161	142	131	124	–
		40	63	191	176	161	142	131	124	–
	400	3	16	229	205	182	162	152	143	–
		16	40	224	203	182	162	152	143	–
		40	63	217	199	182	162	152	143	–
223	460	3	16	269	245	227	208	196	184	176
		16	40	269	245	227	208	196	184	176
		40	63	269	245	227	208	196	184	176
	490	3	16	284	258	240	220	206	195	187
		16	40	284	258	240	220	206	195	187
		40	63	284	258	240	220	206	195	187
225	460	3	16	246	227	210	190	178	167	161
		16	40	246	227	210	190	178	167	161
		40	63	246	227	210	190	178	167	161
	490	3	16	284	258	240	220	206	195	187
		16	40	284	258	240	220	206	195	187
		40	63	284	258	240	220	206	195	187

*The values for plates over 63 mm thick up to and including 150 mm thick shall be the value specified for plate of thickness between 40 mm and 63 mm reduced by 1 % for each 5 mm or part thereof increase in thickness over 63 mm.

Appendix F

Minimum yield strength (R_{eL}) or 0.2 % proof stress ($R_{p0.2}$) values at elevated temperatures for steel type 224

Steel type	Grade	Nominal plate thickness*		Minimum yield stress R_{eL} or 0.2 % proof stress $R_{p0.2}$ at temperature °C					
		Over	Up to and including	150	200	250	300	350	400
		mm	mm	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
224	400	3	16	229	205	182	162	152	143
		16	40	224	203	182	162	152	143
		40	63	217	199	182	162	152	143
	430	3	16	247	223	198	177	167	158
		16	40	242	220	198	177	167	158
		40	63	236	217	198	177	167	158
	460	3	16	265	240	213	192	182	173
	and	16	40	260	237	213	192	182	173
	490	40	63	256	234	213	192	182	173

*The values for plates over 63 mm thick up to and including 150 mm thick shall be the values specified for plates of thickness between 40 mm and 63 mm reduced by 1 % for each 5 mm or part thereof increase in thickness over 63 mm.

Appendix G

Stress rupture values

Steel type	Rupture time	Estimated average strength for rupture (1) (2) at temperature °C												
		380	390	400	410	420	430	440	450	460	470	480	490	500
	h	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
151	10 000	213	197	181	166	151	138	125	112	100	89	78	67	57
161	30 000	192	176	161	147	133	120	107	95	84	73	63	52	42
164	50 000	183	167	152	138	125	112	100	88	77	66	56*	46*	35*
(all grades)	100 000	171*	155*	141*	127*	114*	102*	90*	78*	67*	57*	47*	36*	
	150 000	164*	149*	134*	121*	108*	96*	84*	73*	62*	52*	41*	29*	
	200 000	159*	144*	130*	116*	104*	92*	80*	69*	58*	48*	37*	23*	
	250 000	155*	140*	126*	113*	101*	89*	77*	66*	55*	45*	34*		
223	10 000	291	266	243	221	200	180	161	143	126	110	96	84	74
224	30 000	262	237	214	192	171	151	132	115	99	86	74	65	57
225	50 000	248	223	200	177	156	136	118	102	87	75	65	57	50
(all grades)	100 000	227	203	179	157	136	117	100	85	73	63	55	(47)	(41)
	150 000	215	190	167	144	124	105	89	76	65	56	(49)	(42)	(34)
	200 000	206*	181*	157*	135*	115*	97*	82*	70*	60*	52*	(44)*	(37)*	
	250 000	199*	174*	150*	128*	108*	91*	77*	66*	56*	(48)*	(41)*	(32)*	

NOTE 1. Asterisks indicate where values have been obtained by 'extended time' extrapolation and parentheses indicate where values have been obtained by 'extended stress' extrapolation. Such values should be used with caution.

NOTE 2. Average values are listed but it is estimated that the scatter will not exceed ± 20 %.

Standards publications referred to

BS 18	Methods for tensile testing of metals Part 2 Steel (general)
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 Carbon steel plate, sheet and strip
BS 1501–6*	Steels for use in the chemical, petroleum and allied industries
BS 1502*	Steels for fired and unfired pressure vessels. Sections and bars
BS 1503*	Steels for fired and unfired pressure vessels. Forgings
BS 1504*	Specification for steel castings for pressure purposes
BS 3688	Methods for mechanical testing of metals at elevated temperatures Part 1 Tensile testing
BS 3894	Method for converting elongation values for steel Part 1 Carbon and low alloy steels
BS 3920	Procedure for deriving and verifying the minimum elevated temperature yield or proof stress properties of steel products
BS 5135	Metal-arc welding of carbon and carbon manganese steels
BS 5996	Methods for ultrasonic testing and specifying quality grades of ferritic steel plate
Handbook No. 19	Methods for the sampling and analysis of iron, steel and other ferrous metals

This British Standard, having been prepared under the direction of the Iron and Steel Standards Committee, was published under the authority of the Executive Board and comes into effect on 28 November 1980.

First published November 1950
First revision September 1958
Second revision July 1964
Third revision November 1980

The following BSI references relate to the work on this standard:
Committee reference ISM/73 Draft for comment 78/73067 DC

Cooperating organizations

The Iron and Steel Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following:

British Cast Iron Research Association
British Constructional Steelwork Association
British Internal Combustion Engine Manufacturers' Association
British Ironfounders' Association
British Railways Board
*British Shipbuilders
*British Steel Industry
British Steel Industry (Wire Section)
Concrete Society Limited
Council of Ironfoundry Associations
Department of Industry (National Physical Laboratory)
*Electricity Supply Industry in England and Wales
*Engineering Equipment Users' Association
Federation of Civil Engineering Contractors
Greater London Council
Institute of Marine Engineers
Institute of Quality Assurance
Institution of Production Engineers
Institution of Structural Engineers
International Tin Research Institute
*Lloyd's Register of Shipping
*Ministry of Defence
National Association of Drop Forgers and Stampers
*Oil Companies Materials Association
*Process Plant Association
Royal Institute of British Architects
Society of Motor Manufacturers and Traders Limited
Steel Casting Research and Trade Association
*Water-tube Boilermakers' Association

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this British Standard:

Associated Offices Technical Committee
British Electrical and Allied Manufacturers' Association (BEAMA)
British Gas Corporation
British Industrial Fasteners Federation
British Steel Corporation
British Valve Manufacturers' Association Ltd.
Institution of Metallurgists
National Association of Steel Stockholders
Welding Institute
Individual experts

Amendments issued since publication

Amd. No.	Date of issue	Text affected
4297	July 1983	Indicated by a line in the margin
5149	July 1986	Indicated by a line in the margin
5747	November 1987	Indicated by a line in the margin