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**British Standard Specification for
Carbon, low alloy and stainless steel bars
and billets for bolting material to be used
in pressure retaining applications**

Barres et billettes en acier au carbone, en acier faiblement allié et en acier inoxydable utilisées pour fabriquer les éléments de boulonnerie des appareils sous pression — Spécifications

Stäbe und Knüppel aus unlegiertem, niedriglegiertem und rostfreiem Stahl für mechanische Verbindungsmittel im Druckbehälterbau

Foreword

This new edition of this British Standard has been prepared under the direction of the Iron and Steel Standards Policy Committee. It replaces BS 1506 : 1986 which is withdrawn. This edition introduces technical changes to bring the standard up-to-date but it does not reflect a full review of the standard, which will be undertaken in due course. Properties for the steels 304S11, 316S11 and 316S13 are added to table 2, and the details associated with test pieces for material not supplied in the finally heat treated condition are given in clause 7.

This edition reflects the wide range of steels and quality variants that are in demand for the manufacture of bolting for applications at various temperatures and for a range of pressure applications in particular.

Steel types now included take cognizance, as far as possible, of steels included in international standards.

BS 1506 is one of a series of publications for different steel products intended for pressure containing applications.

The other publications in the series are as follows:

- BS 1501 Steels for fired and unfired pressure vessels:
Plates
- BS 1502 Specification for steels for fired and unfired pressure vessels: sections and bars
- BS 1503 Specification for steel forgings (including semi-finished forged products) for pressure purposes
- BS 1504 Specification for steel castings for pressure purposes

A tabulation of nearest equivalent steels specified in this edition to the steels in the 1958 edition has been included as appendix A.

The appropriate British Standards for the design and construction of boilers, pressure vessels, piping systems, etc. should be consulted, together with BS 4882 for requirements relating to the application and permissible design stresses for products made to this standard.

Purchasers ordering to this standard are advised to specify in their purchasing contract that the supplier operates a quality system in compliance with BS 5750 : Part 2 to ensure to their satisfaction that products claimed to comply with this standard consistently achieve the required level of quality.

A number of commercially and contractually oriented clauses (e.g inspection, test facilities, delivery, defects revealed after delivery) have traditionally been included in British Standard product specifications such as in the 1958 edition of BS 1506. Current BSI drafting policy does not permit such clauses as requirements of a product specification and they have therefore been omitted from the requirements of this standard. However, examples of typical clauses are given in appendix B and the purchaser of bars or billets may wish to include such clauses in his order or contract.

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

Documents

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Specification

1 Scope

This British Standard specifies requirements for the following two types of product:

- (a) bars of round, square and hexagonal cross sections, in nominal diameters or width across flats as specified in tables 1 and 2 and the conditions of supply given in appendix C, intended for the manufacture of bolts, studs and nuts for pressure retaining applications at either sub-zero or elevated temperatures;
- (b) rolled billets and forged billets (i.e. semi-finished bars) in nominal diameters or width across flats as specified in tables 1 and 2, intended for further processing into bars and blanks for the products described in (a).

This standard applies to bars and billets supplied in a range of steels comprising a medium carbon steel, low alloy steels, austenitic and martensitic stainless steels and a precipitation hardenable stainless steel.

Sub-zero temperature impact properties are specified for a number of these grades and provision is made for the verification of these properties.

In addition to the definitive requirements given, this standard also requires the items detailed in clause 3 to be documented. For compliance with this standard, both the given requirements and the separately documented requirements have to be satisfied.

NOTE 1. This standard does not apply to bars and billets intended for bolting specified in BS 3692 or BS 4439.

NOTE 2. For the full range of steel grades covered by this standard, see tables 1 and 2.

NOTE 3. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Designations

The steels shall be designated by the number of this standard and the steel type in accordance with tables 1 and 2.

Materials subject to testing to verify the low temperature impact properties shall in addition be designated by adding the suffix LT followed by a number representing the test temperature in °C.

Examples:

- (a) BS 1506-630-790;

1 % chromium ¼ % molybdenum steel, having a tensile strength of 790 N/mm² to 1000 N/mm² when heat-treated in limiting ruling sections up to and including 100 mm.

- (b) BS 1506-630-860 LT 100;

1 % chromium ¼ % molybdenum steel, having a tensile strength of 860 N/mm² to 1070 N/mm² when heat-treated in limited ruling sections up to and including 63 mm and impact tested at -100 °C.

3 Information and requirements to be agreed and to be documented

3.1 Information to be supplied by the purchaser

NOTE 1. See also appendix B for examples of commercial or contractual requirements which the purchaser may wish to include in his order or contract.

The following information to be supplied by the purchaser shall be fully documented.

Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified:

- (a) the full designation of the material (see clause 2);
 - (b) the dimensions of the bar(s) or billet(s);
 - (c) the quantity required;
 - (d) the condition in which the bars or billets are to be supplied (see appendix C). When bars in the softened condition are specified, the purchaser shall state the maximum hardness required in the bars as delivered and whether a specific heat treatment is required;
- NOTE 2. If billets are required, details of the purchaser's subsequent processing should be given.
- (e) in the case of precision ground bars, the tolerances required (see table 10 and 8.2).

3.2 Options

If the purchaser wishes to take up any of the optional requirements for bars and billets covered by this standard, he shall specify his requirements at the time of the enquiry and order. In the absence of such information the manufacturer shall assume the following:

(a) General

- (1) that the purchaser does not require a particular steelmaking process (see clause 5);
- (2) that product analysis is not required (see 6.2).

(b) Testing

- (1) that verification of Charpy impact properties is not required (see 7.2);
- (2) that non-destructive testing is not required (see clause 9);
- (3) that intercrystalline corrosion tests on austenitic stainless steels are not required (see clause 10);
- (4) that mechanical properties are not to be determined for billets (see 4.2);

NOTE. If this option is required by the purchaser details should be agreed between the purchaser and the supplier. For the taking of test samples and the preparation of test pieces see 11.1 and 11.2.

- (5) that there are no other special requirements for billets or bars.

Table 1. Chemical composition, heat treatment and mechanical properties at room temperature and Charpy impact values at sub-zero temperatures for bars of carbon, low alloy and martens

Steel type	Chemical composition (cast analysis (1))										Mechanical properties at room temperature										Izod impact strength (3 values)			
	C		Si		Mn		P		S		Cr		Mo		Ni		V _e		Limiting ruling section (4)	Tensile strength R _m		Yield strength R _e	Elongation A (5) (based on a gauge length of 5.65 S ₀)	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.						
162	%		%		%		%		%		%		%		%		%		mm	N/mm ²	N/mm ²	N/mm ²	% min.	ft-lb
	0.40	0.60	0.15	0.35	0.60	1.00	0.040	0.050	—	—	—	—	—	—	—	—	—	—	63	—	—	—	—	—
253	0.40	0.50	0.15	0.35	0.40	0.80	0.035	0.040	—	—	—	—	—	—	—	—	—	—	22	—	—	—	—	—
	—	0.10	0.15	0.35	0.30	0.80	0.025	0.020	—	0.25	—	0.10	8.5	10.0	—	—	—	—	75	650	850	480	18	—
509—690	—	0.10	0.15	0.35	0.30	0.80	0.025	0.020	—	0.25	—	0.10	8.5	10.0	—	—	—	—	100	690	850	580	18	—
	0.37	0.49	0.15	0.35	0.65	1.10	0.035	0.040	0.75	1.20	0.15	0.25	—	—	—	—	—	100	790	1000	655	14	40	
630—860	0.37	0.49	0.15	0.35	0.65	1.10	0.035	0.040	0.75	1.20	0.15	0.25	—	—	—	—	—	63	860	1070	725	14	40	
	0.37	0.49	0.15	0.35	0.65	1.10	0.035	0.040	0.75	1.20	0.15	0.25	—	—	—	—	—	63	690	800	550	16	40	
631—850	0.35	0.45	0.10	0.35	0.40	0.70	0.035	0.040	1.00	1.50	0.50	0.70	—	0.40	—	—	—	200	850	1000	635	14	20	
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	100	850	1000	665	14	40	
670—860	0.36	0.44	0.15	0.35	0.45	0.70	0.035	0.040	0.80	1.15	0.50	0.65	—	—	—	—	—	100	860	1000	725	16	35	
	0.30	0.45	0.10	0.35	0.40	0.70	0.040	0.040	1.00	1.50	0.50	0.70	—	0.20	0.30	—	—	200	850	1000	635	14	20	
681—820	0.17	0.23	0.10	0.35	0.35	0.75	0.020	0.020	0.90	1.20	0.90	1.10	—	0.20	0.60	0.80	—	100	850	1000	665	14	35	
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	250	820	1000	660	15	20	
410S21—690	0.09	0.15	—	1.00	—	1.00	0.040	0.030	11.5	13.5	—	—	—	1.00	—	—	—	200	690	840	540	15	—	
	0.09	0.15	—	1.00	—	1.00	0.040	0.030	11.5	13.5	—	—	—	1.00	—	—	—	100	720	870	570	15	25	
410S21—760	0.09	0.15	—	1.00	—	1.00	0.040	0.030	11.5	13.5	—	—	—	1.00	—	—	—	100	760	910	585	15	—	
	0.09	0.15	—	1.00	—	1.00	0.040	0.030	11.5	13.5	—	—	—	1.00	—	—	—	63	750	900	580	14	20	
410S21—770	0.09	0.15	—	1.00	—	1.00	0.040	0.030	11.5	13.5	—	—	—	1.00	—	—	—	29	770	930	590	12	20	
	0.14	0.20	—	1.00	—	1.50	0.060	0.15	0.350	11.5	13.5	—	0.60	—	—	—	—	63	—	—	—	—	—	
416S29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	

(1) The results obtained from cast analysis are rounded to the last place of figures specified as limits by the application of the rounding rule in accordance with BS 1957.

(2) It is recommended that in the case of components which will be exposed to wet hydrogen sulphide atmospheres the final heat treatment, which can be the tempering operation, should be performed after any machining or thread rolling has been completed.

(3) Metallic aluminium content. Where a minimum Al (met.) is specified, determination of the total aluminium content is deemed to meet this requirement provided that the total aluminium content obtained is not less than 0.018 %. In cases of dispute, the metallic aluminium content is determined.

(4) Limiting ruling section is the diameter of the largest cylindrical bar for which the specified mechanical properties are applicable. For other shapes the equivalent cylinder is calculated using the rules given in BS 5046.

(5) The specified elongation values for steels 162 to 410S21 inclusive, cold-drawn bars supplied in the heat-treated and finally cold-drawn condition are 75 % of the quoted values. All other values are as specified in the table.

(6) If specified.

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Table 2. Chemical composition, heat treatment and mechanical properties at room temperature and Charpy impact values at sub-zero temperatures and sensitization times, for bars of austenitic stainless steels and a precipitation hardenable stainless steel. (The mechanical properties for austenitic steels in the cold-drawn condition are given in table 5)

Steel type	Chemical composition (cast analysis (1))										Mechanical properties at room temperature										Elongation (based on gauge length of 5.65%)	
	C		Si	Mn	P	S	Cr		Mo		Ni		V		Others		Limiting ruling section (6)	Tensile strength R_m		Yield strength R_e		0.2 % proof stress $R_{p0.2}$
	min.	max.	max.	max.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.		max.	min.			
286S31(1)	-	0.08	1.00	2.00	0.045	-	0.030	13.50	16.00	1.00	1.50	24.00	0.10	0.50	-	Ti 2.30 Al 0.35 B 0.010 Pb 0.005	200	900	N/mm ²	-	590	12
304S11	-	0.030	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	9.00	12.00	-	-	-	160	480	680	-	180	40
304S31	-	0.07(2)	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	8.00	11.00(3)	-	-	-	160	520	-	-	205	40
304S51	0.04	0.10	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	8.00	11.00	-	-	-	160	520	-	-	205	40
304S61	-	0.030	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	8.50	11.50	-	-	N 0.12	160	550	-	-	270	35
304S71	-	0.07(2)	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	8.00	11.00	-	-	N 0.12	160	550	-	-	270	35
303S22	-	0.12	1.00	2.00	0.060	0.15	0.35	17.00	19.00	-	0.70	8.00	10.00	-	-	-	160	510	-	-	190	40
316S11	-	0.030	1.00	2.00	0.045	-	0.030	16.50	18.50	2.00	2.50	11.00	14.00	-	-	-	160	490	690	-	190	40
316S13	-	0.030	1.00	2.00	0.045	-	0.030	16.50	18.50	2.50	3.00	11.50	14.50	-	-	-	160	490	690	-	190	40
316S31	-	0.07(2)	1.00	2.00	0.045	-	0.030	16.50	18.50	2.00	2.50	10.50	13.50	-	-	-	160	520	-	-	205	40
316S33	-	0.07(2)	1.00	2.00	0.045	-	0.030	16.50	18.50	2.50	3.00	11.00	14.00	-	-	-	160	520	-	-	205	40
316S51	0.04	0.10	1.00	2.00	0.045	-	0.030	16.50	18.50	2.00	2.50	10.50	13.50	-	-	-	160	520	-	-	205	40
316S53	0.04	0.10	1.00	2.00	0.045	-	0.030	16.50	18.50	2.50	3.00	11.00	14.00	-	-	-	160	520	-	-	205	40
316S61	-	0.030	1.00	2.00	0.045	-	0.030	16.50	18.50	2.00	2.50	10.50	13.50	-	-	N 0.12	160	580	-	-	280	35
316S63	-	0.030	1.00	2.00	0.045	-	0.030	16.50	18.50	2.50	3.00	11.50	14.50	-	-	N 0.12	160	580	-	-	280	35
316S71	-	0.07(2)	1.00	2.00	0.045	-	0.030	16.50	18.50	2.00	2.50	10.00	13.00	-	-	N 0.12	160	580	-	-	280	35
316S73	-	0.07(2)	1.00	2.00	0.045	-	0.030	16.50	18.50	2.50	3.00	10.50	13.50	-	-	N 0.12	160	580	-	-	280	35
321S11	-	0.08	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	9.00	12.00(4)	-	-	Ti 5xC	160	520	-	-	205	35
321S51-490	0.04	0.10	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	9.00	12.00	-	-	Ti 5xC	160	490	-	-	155	35
321S51-520	0.04	0.10	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	9.00	12.00	-	-	Ti 5xC	160	520	-	-	205	35
347S31	-	0.08	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	9.00	12.00(4)	-	-	Nb 10xC	160	520	-	-	205	30
347S51	0.04	0.10	1.00	2.00	0.045	-	0.030	17.00	19.00	-	-	9.00	12.00	-	-	Nb 12	160	520	-	-	205	30

(1) The results obtained from cast analysis are rounded to the last place of figures specified as limits by the application of the rounding rule in accordance with BS 1557.

(2) These steels should not be expected to pass the intercrystalline corrosion test unless the carbon content is restricted to 0.05 % maximum.

(3) For steel 304S31 intended for sub-zero applications, nickel contents up to 12.0 % are permitted.

(4) For steel 321S31 and 347S31 intended for sub-zero applications, nickel contents up to 12.5 % are permitted.

(5) The extent of reduction during cold sizing of solution treated material will influence properties from the subsequent precipitation treatment and is not covered by this standard.

(6) Limiting ruling section is the diameter of the largest cylindrical bar for which the specified mechanical properties are applicable. For other shapes the equivalent cylinder is calculated using the rules given in BS 5046.

(7) The specified elongation values for cold drawn bars supplied in the heat-treated and finally cold-drawn condition are 75 % of the quoted value. All other values are as specified in the table.

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4 General requirements

4.1 Bars

Bars shall comply with the requirements specified in clauses 5 to 10.

For verification purposes, test samples shall be taken and test pieces shall be prepared in accordance with clause 11 and shall be tested in accordance with clause 12.

NOTE. For the intercrystalline corrosion test on austenitic stainless steels, the sampling and testing requirements are included for convenience in clause 10.

Retests shall be permitted in accordance with clause 13.

Bars shall be identified by marking in accordance with clause 14.

A manufacturer's certificate shall be provided in accordance with clause 15.

4.2 Billets

Billets as supplied shall comply with clauses 5 (steelmaking process), 6 (chemical composition) and 9 (freedom from defects) and shall be capable, after further appropriate processing by the purchaser, of complying with clauses 7 (mechanical properties) and 10 (intercrystalline corrosion test).

Billets shall be supplied either:

- (a) with mechanical property verification tests; or
- (b) without mechanical property verification tests.

If verification is required, the tests shall be carried out in accordance with the appropriate requirements of clauses 10 to 13 and a certificate of compliance shall be provided in accordance with clause 15.

Billets shall be identified by marking in accordance with clause 14.

5 Steelmaking process

The steels, irrespective of type, from which the bars and billets are manufactured shall be fully killed.

All types of stainless steels shall be made by an electric steelmaking process.

For the medium carbon steel and the low alloy steels any steelmaking process shall be permitted with the exception of the air and the mixed air/oxygen bottom blown basic converter processes.

NOTE. Subject to the requirements specified above, in normal commercial practice the steelmaking process is the option of the manufacturer unless the purchaser has requested a specific process within the provisions specified above.

6 Chemical composition

6.1 Cast analysis

The chemical composition of the steel, determined by cast analysis, shall be as given in tables 1 and 2 for the steel type ordered.

6.2 Product check analysis

Bars and billets shall be supplied either:

- (a) with a verification of product analysis; or
- (b) without a verification of product analysis.

When a product analysis is required, samples shall be taken in accordance with BS 1837 and, in the event of a dispute, shall be analysed in accordance with the appropriate methods of BS Handbook No. 19 or BS 6200 : Part 3.

If an analysis on the product is carried out, the deviations given in tables 3 and 4 shall apply to the specified cast analysis.

Such variations shall apply either above or below the individual element ranges but shall not apply both above and below the specified range of any one element in any one cast of steel.