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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 It replaces BS 1506 : 1986 which is withdrawn.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.

Contents

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/mm^2 to 1000 N/mm^2 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/mm^2 to 1070 N/mm^2 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					
	C		Si		Mn		P	S		Cr		Mo		Ni		Va		Others		Limiting ruling section (4)	Tensile strength R_m		Yield strength R_e	Elongation A (5) (based on a gauge length of $5.65\sqrt{S_o}$)	Izod im strengt of 3 val
	min.	max.	min.	max.	min.	max.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.		min.	max.	min.		
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	mm	N/mm²	N/mm²	N/mm²	% min.	ft·lb
162	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	–	–	0.20	0.30	–	–	–	–	Al (met.)(3) 0.015	–	22	–	–	–	–	–
509–650	–	0.10	0.15	0.35	0.30	0.80	0.025	–	0.020	–	0.25	–	0.10	8.5	10.0	–	–	Al (met.)(3) 0.015	–	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	–	–	Al (met.)(3) 0.015	–	100	690	850	580	18	–
630–790	0.37	0.49	0.15	0.35	0.65	1.10	0.035	–	0.040	0.75	1.20	0.15	0.25	–	–	–	–	Al (met.)(3) 0.015	–	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
630–690(2)	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
																				63	850	1000	695	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	–	–	0.25	0.35	–	–	100	860	1000	725	16	35
671–850	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
																				100	850	1000	665	14	35
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	Ti 0.07 B 0.001 – – –	Ti 0.15 B 0.010 As 0.020 Sn 0.020 Cu 0.20 Al(tot.) 0.08	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	–
410S21–720	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	–
410S21–750	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
416S29	0.14	0.20	–	1.00	–	1.50	0.060	0.15	0.350	11.5	13.5	–	0.60	–	1.00	–	–	–	–	63	–	–	–	–	–

(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					
	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 $Rp0.2$	Elongatio (based o gauge le of $5.65\sqrt{S}$
	min.	max.	max.	max.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.		min.	max.	min.		
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	mm	N/mm^2	N/mm^2	N/mm^2	N/mm^2	%
286S31(1)	–	0.08	1.00	2.00	0.045	–	0.030	13.50	16.00	1.00	1.50	24.00	27.00	0.10	0.50	Ti 1.90 Al 0.10 B 0.0030	Ti 2.30 Al 0.35 B 0.010 Pb 0.005	200	900	–	–	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	N 0.22	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	N 0.22	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	N 0.22	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	N 0.22	160	580	–	–	280	35
316S65	–	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	N 0.22	160	580	–	–	280	35
316S67	–	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	N 0.22	160	580	–	–	280	35
321S31	–	0.08	1.00	2.00	0.045	–	0.030	17.00	19.00	–	–	9.00	12.00(4)	–	–	Ti 5xC	Ti 0.80	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	Ti 0.80	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	Ti 0.80	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	Nb 1.0	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 10xC	Nb 1.2	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 1957.

(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.

Table 3. Permitted variations of product analysis from the specified cast analysis for carbon steels and alloy (excluding stainless) steels

Element	Range in which maximum of specified element falls	Variation on specified range	
		Over max.	Under min.
	%	%	%
Carbon	⩽ 0.25	0.02	0.02
	> 0.25 ⩽ 0.50	0.03	0.03
	> 0.50	0.04	0.04
Silicon	⩽ 0.35	0.03	0.03
Manganese	⩽ 0.70	0.03	0.03
	> 0.70 ⩽ 1.0	0.04	0.04
	> 1.0 ⩽ 1.5	0.05	0.05
Chromium	⩽ 0.60	0.03	0.03
	> 0.60 ⩽ 1.25	0.04	0.04
	> 1.25	0.05	0.05
Molybdenum	⩽ 0.50	0.02	0.02
	> 0.50	0.03	0.03
Nickel	⩽ 1.0	0.03	0.03
	> 8.5 max. ⩽ 10.0	0.10	0.10
Vanadium	⩽ 0.30	0.03	0.03
	> 0.30	0.04	0.04
Boron	⩽ 0.010	0.0005	0.0005
Titanium	⩽ 0.20	0.01	0.01
Phosphorus	⩽ 0.030	0.003	–
	> 0.030 ⩽ 0.040	0.004	–
	> 0.040 ⩽ 0.060	0.008	–
Sulphur	⩽ 0.030	0.003	–
	> 0.030 ⩽ 0.040	0.004	–
	> 0.040	0.005	–
	when specified range is:		
	0.15 to 0.35	0.02	0.02
Aluminium	⩽ 0.080	0.005	0.005

Table 4. Permitted variations of product analysis from the specified cast analysis for martensitic and austenitic stainless steels and a precipitation hardenable stainless steel

Element	Range in which maximum of specified element falls	Variation on specified range	
		Over max.	Under min.
	%	%	%
Carbon	⩽ 0.03	0.005	0.005
	> 0.03 ⩽ 0.25	0.01	0.01
Silicon	⩽ 1.0	0.05	0.05
Manganese	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 2.0	0.04	0.04
Chromium	> 10.0 ⩽ 15.0	0.15	0.15
	> 15.0 ⩽ 20.0	0.20	0.20
Molybdenum	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 2.0	0.05	0.05
	> 2.0 ⩽ 3.0	0.08	0.08
Nickel	⩽ 1.0	0.03	0.03
	> 10.0 ⩽ 20.0	0.15	0.15
	> 20.0	0.20	0.20
Vanadium	All ranges	0.04	0.04
Titanium	⩽ 0.80	0.05	0.05
	when specified range is:		
	1.90 to 2.30	0.10	0.10
Niobium	all ranges	0.05	0.05
Phosphorus	⩽ 0.030	0.003	–
	> 0.030 ⩽ 0.045	0.004	–
	> 0.045	0.005	–
Sulphur	⩽ 0.030	0.003	
	when specified range is:		
	0.15 to 0.35	0.02	0.02
Boron	⩽ 0.010	0.0005	0.0005
Nitrogen	⩽ 0.22	0.01	0.01
Lead	⩽ 0.0050	0.0005	0.0005
Aluminium	> 0.10 ⩽ 0.35	0.01	0.01

7 Mechanical properties

7.1 General

7.1.1 *Tensile, Izod and hardness properties.* The following types of bars the tensile, Izod and hardness properties shall be as given in tables 1 and 2 (see note to **11.2.1.3**):

(a) carbon steel and low alloy steel black bars supplied in the finally heat treated condition;

(b) carbon steel and low alloy steel bars supplied in the cold drawn condition with or without stress relieving;

(c) martensitic stainless steel bars and bright bars;

(d) austenitic stainless steel bars supplied in other than the cold drawn condition; and

(e) precipitation hardened stainless steel bars.

For austenitic stainless steel bars supplied in the cold drawn condition, the mechanical properties shall be as given in table 5.

7.1.2 *Material not supplied in the finally heat treated condition.* Where the ruling section of the material does not differ appreciably from that of the finished bar to be produced, test samples may be taken directly from the material and heat treated in the original size.

When it is considered that the results of heat treating in the original size would not be representative of the properties that would be obtained on the bars to be produced, test samples shall be formed and/or machined to a diameter or equivalent diameter corresponding to the ruling section of the bars at the time of final heat treatment.

Test bars shall be given the heat treatment specified for the grade in tables 1 and 2 prior to preparation of the test pieces in accordance with **11.2.1.2, 11.2.1.3** and **11.2.1.4.**

One tensile test and, where relevant, one Izod test comprising three notches, or three Charpy V-notch impact tests shall be taken from any batch of material of similar ruling section from the same cast. For the purpose of subsequent orders these tests shall be taken as representing all sizes of material from the same cast where the ruling section of the finished bar does not exceed the ruling section of the test bar already tested.

Test pieces shall be taken from the positions given in table 11 for all steels except austenitic stainless steels in the cold drawn condition.

7.2 Charpy sub-zero impact tests

Bars and billets in steel type 509 shall be supplied with verified Charpy V-notch impact values (see note to **11.2.1.3**).

Bars and billets in other steel types with specified Charpy V-notch impact values at sub-zero temperatures (see table 1 and 2) shall be supplied either:

(a) with verification of Charpy impact properties; or

(b) without verification of Charpy impact properties.

Table 5. Mechanical properties at room temperature for austenitic stainless steel bars in the solution treated and cold-drawn condition (applicable to steel types 303S22, 304S11, 304S31, 316S11, 316S13, 316S31, 316S33, 321S31 and 347S31)

Diameter of bar	Mechanical properties			
	Tensile strength R_m (min.)	0.2 % proof stress $R_{p0.2}$ (min.)	Elongation A (min.)	Hardness HB* (max.)
	N/mm²	N/mm²	%	
Up to and including 19 mm	860	695	12	320
Over 19 mm up to and including 25 mm	790	555	15	320
Over 25 mm up to and including 32 mm	730	450	20	320
Over 32 mm up to and including 38 mm	690	345	28	320
Over 38 mm up to and including 44 mm	650	310	28	320

*As measured on a ground flat in accordance with **11.2.1.4.**

8 Dimensional tolerances

8.1 Diameter or width across flats and 'out-of-section'

8.1.1 *Hot rolled round and square bars and rough turned rounds, including bars and rounds heat treated after rolling.* The diameters or widths across flats shall not deviate from the ordered nominal sizes by more than the tolerances given in table 6.

The 'out-of-section' dimension shall not exceed the maximum given in table 6.

Table 6. Tolerances for hot rolled round and square bars and peeled or rough turned rounds

Ordered nominal size (diameter or width across flats)	Tolerance (see note 1)			
	Primary-rolled round material		Re-rolled material	
	Diameter	Maximum 'out-of-section' (see note 2)	Diameter or width across flats	Maximum 'out-of-section' (see note 2)
mm	± mm	mm	± mm	mm
⩽ 16	–	–	0.2	0.3
> 16 ⩽ 26	–	–	0.3	0.5
> 26 ⩽ 38	–	–	0.4	0.6
> 38 ⩽ 51	–	–	0.5	0.8
> 51 ⩽ 64	–	–	0.6	0.9
> 64 ⩽ 76	–	–	0.7	1.1
> 76 ⩽ 90	1.3	2.0	0.7	1.1
> 90 ⩽ 120	1.5	2.3	0.8	1.2
> 120 ⩽ 160	2.0	3.0	–	–
> 160 ⩽ 200	2.5	3.8	–	–
> 200	3.0	4.5	–	–

NOTE 1. By agreement between purchaser and supplier, the tolerances may be all plus or all minus, e.g. the tolerance on the diameter for round bars up to and including 16 mm diameter may be either plus 0.4 mm or minus 0.4 mm.

NOTE 2. For the purposes of table 6, 'out-of-section' is defined as follows:

round bar. The difference between the maximum and the minimum diameter of the bar measured at the same cross section;

square bar. The difference between the two dimensions measured across the two pairs of opposing (parallel) sides at a common cross section of the bar.

8.1.2 *Hot re-rolled hexagonal bars, including bars treated after rolling.* The widths across flats shall not deviate from the ordered nominal sizes by more than the tolerances given in table 7.

The 'out-of-section' dimension shall not exceed the maximum given in table 7.

Table 7. Tolerances for hot rolled hexagonal bars (re-rolled material)

Nominal size (width across flats)	Tolerance (see note 1)	
	Width across flats	Maximum 'out-of-section' (see note 2)
mm	± mm	mm
⩽ 16	0.2	0.3
> 16 ⩽ 26	0.3	0.5
> 26 ⩽ 38	0.4	0.6
> 38 ⩽ 51	0.5	0.8
> 51 ⩽ 64	0.6	0.9
> 64 ⩽ 76	0.7	1.1

NOTE 1. By agreement between purchaser and supplier, the tolerances may be all plus, or all minus, e.g. the tolerance for width across flats for sections up to and including 16 mm may be either plus 0.4 mm or minus 0.4 mm.

NOTE 2. For the purposes of table 7, 'out-of-section' is defined as follows:

hexagonal bar. The difference between the least and the greatest dimensions measured across the three pairs of opposing (parallel) sides at a common cross section of the bar.

8.1.3 *Cold drawn bars.* The diameters or widths across flats shall not deviate from the ordered nominal sizes by more than the tolerances given in table 8.

Table 8. Tolerances for cold drawn bars

Section	Nominal size (diameter or width across flats)	Tolerance
	mm	mm
Round	> 6 ⩽ 18	+0, - 0.070
	> 18 ⩽ 30	+0, - 0.085
	> 30 ⩽ 50	+0, - 0.100
	> 50 ⩽ 80	+0, - 0.120
	> 80 ⩽ 100	+0, - 0.140
Square and hexagon	> 6 ⩽ 18	+0, - 0.090
	> 18 ⩽ 30	+0, - 0.110
	> 30 ⩽ 50	+0, - 0.130
	> 50 ⩽ 80	+0, - 0.160
	> 80	See note

NOTE. For nominal sizes greater than 80 mm, the tolerance should be the subject of agreement between the manufacturer and the purchaser.

For bars supplied with sawn ends, the bars shall be measured at least 10 mm from the ends.

For bars with cold sheared ends, the bars shall be measured at a distance from the ends of not less than the nominal size (diameter or width across flats).

For bars with other than sawn or cold sheared ends, the bars shall be measured at least 150 mm from the ends.

8.1.4 *Turned bars and ground bars.* The diameters or widths across flats shall not deviate from the ordered nominal size by more than the tolerances given in table 9.

Table 9. Tolerances for turned bars and ground bars (see note 1)

Nominal size (diameter or width across flats)	Tolerance (see note 2)
mm	mm
> 6 ⩽ 18	+0, -0.070
> 18 ⩽ 30	+0, -0.085
> 30 ⩽ 50	+0, -0.100
> 50 ⩽ 80	+0, -0.120
> 80 ⩽ 120	+0, -0.140
> 120 ⩽ 180	+0, -0.160
> 180 ⩽ 250	+0, -0.185

NOTE 1. This table covers bars that have been hot rolled, possibly thermally treated, and turned or ground, and that are normally going to be further processed prior to being put into service (see also note 1 to table 10).

NOTE 2. Bars may be supplied with finer tolerances, by agreement between supplier and purchaser. The tolerances may be specified all positive if required.

For bars supplied with sawn edges, the bars shall be measured at least 10 mm from the ends.

For bars with cold sheared ends, the bars shall be measured at a distance from the ends of not less than the nominal size (diameter or width across flats).

For bars with other than sawn or cold sheared ends, the bars shall be measured at least 150 mm from the ends.

8.1.5 *Precision ground round bars.* The diameters shall not deviate from the ordered nominal size by more than the tolerances given in table 10.

The 'out-of-round' dimension shall not exceed the maximum given in table 10.

The surface texture of precision ground round bars shall not exceed 0.8 μm R_a*, measured in accordance with BS 1134 : Part 1.

NOTE. Finer surface textures may be supplied by agreement between the supplier and the purchaser.

Table 10. Tolerances for precision ground round bars (see note 1)

Nominal diameter	Tolerances (see notes 2 and 3)			
	Diameter		Maximum 'out-of-round'	
	Normal	Fine	Normal	Fine
mm	mm	mm	mm	mm
⩾6 ⩽75	0.050	0.025	0.025	0.0125

NOTE 1. This table covers bars that have been hot worked, possibly thermally treated, and either cold drawn to specific properties and precision ground, or turned and ground. These bars are normally put into service in the condition of supply. (See also note 1 to table 9.)

NOTE 2. The tolerances stated in the table are total tolerances and may be all +ve, all –ve, or +ve/–ve according to the customers requirements.

NOTE 3. Finer tolerances than those stated in the table may be available by agreement between the supplier and the purchaser.

For bars with cold sheared ends, the bars shall be measured at a distance from the ends of not less than the nominal diameter.

To measure the 'out-of-round' dimension, a 60 ° 3 point gauge shall be used.

8.2 Straightness

8.2.1 *Billets and bars for further machining.* Billets and bars for machining shall be straightened to within 1 mm in any 250 mm length.

8.2.2 *Billets and bars for forging.* Billets and bars for forging shall be straight to within 1/250 in any unit length.

8.2.3 *Precision ground round bars.* Precision ground round bars shall be straightened to within a maximum of 0.15 mm total indicator reading (TIR†) in any 300 mm length.

*R_a is the arithmetic mean deviation, previously known as centre line average (CLA).

†TIR is the difference between the minimum and maximum reading of a dial gauge set on the mid point of a bar which is rotated between

9 Freedom from defects

The procedures for manufacture shall ensure that bars and billets are free from piping, segregation and internal defects, such as laminations and surface flaws, that are detrimental to appropriate processing and, where specified, the end use.

Bars and billets intended for further processing shall be surface conditioned to remove surface defects detrimental to appropriate processing.

Bars and billets shall be supplied either:

(a) having been subjected to non-destructive testing; or

(b) not having been subjected to non-destructive testing.

NOTE. If non-destructive testing is required, the test methods and the acceptance criteria should be the subject of agreement between the manufacturer and the purchaser.

10 Intercrystalline corrosion test on austenitic stainless steels

(applicable to all austenitic stainless steels except grades 286S31, 303S22, 304S51, 316S51 and 316S53)

Bars and billets in all grades of austenitic stainless steel, with the exceptions of grades 286S31, 303S22, 304S51, 316S51 and 316S53, shall be supplied either:

(a) having been subjected to and having passed an intercrystalline corrosion test(s) in accordance with BS 5903; or

(b) not having been subjected to an intercrystalline corrosion test.

If intercrystalline corrosion testing is required, the test(s) shall be carried out at the rate of one test per cast per heat treatment batch. If bars of different sizes are heat treated in one batch, the sample for the test shall be taken from one of the bars of largest size in the batch.

The test sample(s) shall be sensitized at 650 °C for the time period given in table 2 and then cooled in air.

11 Selection of test samples and preparation of test pieces for verification of mechanical properties

11.1 Selection of samples

11.1.1 *General.* Take the test samples from the bars and billets in accordance with **11.1.3** from the lots specified in **11.1.2**. The test samples shall be of suitable length for the preparation of the test pieces in accordance with **11.2**.

11.1.2 *Lots.* For the purpose of sampling, a lot shall comprise each 5 tonne batch or part thereof of bars or billets made from the same cast in the same grade of steel, nominal dimensions and condition of supply. For bars supplied in the heat treated condition, all the bars in the lot shall have been heat treated together.

11.1.3 *Test samples from bars supplied in the finally heat treated condition and the cold drawn condition.* For mechanical property tests, take the following samples at random from each lot:

(a) tensile test: one sample;

(b) impact test:

(1) for the Izod impact test at room temperature: one sample;

(2) for the Charpy V-notch impact test at sub-zero temperature: one sample to provide three test pieces (see **11.2.1.1**);

(c) hardness test: a minimum of 3 % of the bars or billets in the lot, to the nearest greater whole number of bars or billets.

NOTE. Hardness tests may be carried out at a rate higher than 3 % per lot, subject to agreement between supplier and purchaser.

The test samples cut from the bars shall not be further heat treated or mechanically worked prior to testing.

11.1.4 *Test samples from bars and billets supplied in the hot rolled condition.* For tensile, impact and hardness tests, take the numbers of samples specified in **11.1.3** from each cast.

11.2 Preparation of test pieces

11.2.1 *Bars supplied in the finally heat treated condition and the cold drawn condition*

11.2.1.1 *Position of tensile and impact test pieces.* From the test samples taken in accordance with **11.1.3**, take tensile and impact test pieces as follows:

(a) for bars supplied in all steels and material conditions except austenitic stainless steels in the solution treated and cold drawn condition, take the test pieces from the positions given in table 11;

(b) for austenitic stainless steel bars supplied in the solution treated and cold drawn condition, take the test pieces from the positions given in table 12.

11.2.1.2 *Preparation of tensile test pieces.* Where machined tensile test pieces are to be used (see tables 11 and 12), prepare the test pieces in accordance with BS 18 : Part 2 using a gauge length of $5.65\sqrt{S_o}$ *.

Where unmachined tensile test pieces are to be used (see tables 11 and 12) the gauge length shall be $5.65\sqrt{S_o}$ *.

11.2.1.3 *Preparation of Izod and Charpy V-notch impact test pieces*

NOTE. Verification of impact properties is not required for bar sizes which are too small to permit preparation of the standard 10 mm × 10 mm square section Charpy test piece or the circular section Izod test piece.

For Izod impact test pieces (for room temperature tests), prepare circular section test pieces with three notches in accordance with BS 131 : Part 1.

For Charpy V-notch test pieces (for sub-zero temperature tests), prepare the three test pieces of 10 mm × 10 mm square section in accordance with BS 131 : Part 2.

*S_o is the original cross-sectional area in the case of unmachined bars determined from the diameter or width across flats of the

Table 11. Positions of tensile and impact test pieces to be taken longitudinally from bars supplied in all steels and material conditions except austenitic stainless steels in the solution treated and cold drawn condition

Nominal bar size (diameter or width across flats)	Position of test pieces
mm $\leqslant$ 25	either: (a) unmachined full cross section of the bar (see note); or (b) machined with the longitudinal axis co-axial with that of the bar
$>$ 25 $\leqslant$ 100	machined with the longitudinal axis 12.5 mm below the surface of the bar
$>$ 100	machined with the longitudinal axis 25 mm below the surface of the bar

NOTE. The option to use unmachined bars does not apply for impact test pieces.

Table 12. Positions of tensile and impact test pieces to be taken longitudinally from bars supplied in austenitic stainless steels in the solution treated and cold drawn condition

Nominal bar size (diameter or width across flats)	Position of test pieces
mm $\leqslant$ 19	either: (a) unmachined full cross section of bar (see note); or (b) machined with the longitudinal axis co-axial with that of the bar
$>$ 19	machined with the longitudinal axis co-axial with that of the bar

NOTE. The option to use unmachined bars does not apply for impact test pieces.

11.2.1.4 *Preparation of test pieces for hardness testing.* Grind a flat on the surface of the bar or billet, the surface finish of the flat and the width of the flat being such as to permit accurate measurement of the diameter of indentation.

NOTE. Precautions should be taken to ensure that the surface tested is representative and that its hardness is not affected by any unsuitable machining, grinding or polishing process applied to it.

12 Tensile, impact and hardness testing

12.1 Tensile testing

12.1.1 *General.* Tensile testing at room temperature shall be carried out in accordance with BS 18 : Part 2.

12.1.2 *Carbon, low alloy, precipitation hardening stainless and martensitic stainless steels.* The tensile strength R_m, the yield strength R_e and the elongation A shall be determined.

For the specified yield strength R_e, the properties given in (a) and (b) below shall be determined.

(a) *Hardened and tempered steels.* The upper yield stress R_{eH} or the 0.5 % proof stress (total elongation) $R_{t0.5}$ or the 0.2 % proof stress (non-proportional elongation) $R_{p0.2}$ shall be determined and the material specification shall be complied with in this respect if the particular value satisfies the value of the yield strength R_e. In cases of dispute $R_{p0.2}$ shall be determined.

(b) *Cold worked steels.* The upper yield stress R_{eH} or the 0.5 % proof stress (non-proportional elongation) $R_{p0.5}$ or the 0.2 % proof stress (non-proportional elongation) $R_{p0.2}$ shall be determined and the material specification shall be complied with in this respect if the particular value satisfies the value of the yield strength R_e. In cases of dispute $R_{p0.2}$ shall be determined.

12.1.3 *Austenitic stainless steels.* The tensile strength R_m, the 0.2 % proof stress (non-proportional elongation) $R_{p0.2}$ and the elongation A shall be determined.

12.2 Impact testing

12.2.1 *Izod impact testing at room temperature.* Testing shall be carried out in accordance with BS 131 : Part 1.

12.2.2 *Charpy V-notch impact testing at sub-zero temperature.* Testing shall be carried out in accordance with BS 131 : Part 2.

12.3 Hardness testing

Hardness testing shall be carried out using one of the following methods:

(a) the Brinell hardness test in accordance with BS 240 using the largest diameter ball consistent with the size of bar being tested; or

(b) the Vickers hardness test in accordance with BS 427; or

(c) the Rockwell hardness test in accordance with BS 891.

In cases of dispute, the Brinell hardness test shall be the reference method used.

NOTE 1. Considerable caution should be used when converting from one hardness scale to another. Attention is drawn to BS 860.

NOTE 2. Attention is drawn to the possible effects of surface work hardening, caused by finishing processes, on the results of hardness tests on austenitic stainless steels.

13 Retests

13.1 General

Retests shall be permitted in accordance with 13.2 to 13.5. However, if any test sample or test piece fails to comply with the requirements of clause 7 as a result of incorrect test procedure or faulty equipment, the test results shall be discarded and a further test sample(s) shall be retested in accordance with clause 12.

13.2 Product check analysis results

In the event of the results of the analysis of a single sample falling outside the permitted variations on the product analysis given in tables 3 and 4, further samples shall be selected for analysis from the remainder of the consignment as follows:

(a) at least two samples from the same cast for delivered masses up to 5 tonnes;

(b) at least five samples from the same cast for delivered masses up to 20 tonnes;

(c) at least eight samples from the same cast for delivered masses over 20 tonnes.

The results of the analysis of these samples shall fall within the permitted variations. If the analysis of any of these further samples is outside the permitted variations for any specified elements, the consignment shall be deemed not to comply with the requirements of this standard.

13.3 Tensile test results

Should any of the original test pieces fail to meet the specified requirements for mechanical properties, twice the original number of test samples shall be selected for retesting. One of the retest pieces shall be taken from the original bar from which the original test sample was taken, unless that bar has been withdrawn by the manufacturer.

The mechanical properties obtained from the test pieces prepared from the further test samples shall comply with the specified requirements. Should any of the retests fail, the bars or billets represented shall be deemed not to comply with the requirements of this standard.

In the case of bars supplied in the heat treated condition, the manufacturer shall be permitted to reheat-treat the lot represented and resubmit for sampling in accordance with clause 11 and testing in accordance with clause 12.

13.4 Izod and Charpy V-notch impact test results

If the average of the three impact test values is less than the specified minimum value given in tables 1 and 2, or if any individual value is less than 70 % of the specified minimum value given in tables 1 and 2, one further three notch Izod test piece or three further Charpy test pieces shall be taken for retesting. The further test pieces shall be taken from the original test sample taken in accordance with clause 11.

After the retests, the bars in the lot shall be deemed not to comply with this standard if:

(a) the average of all six of the impact tests carried out (i.e. the original tests plus the retests) is less than the specified minimum value given in tables 1 and 2; or

(b) more than two of six individual impact values are less than the specified minimum value given in tables 1 and 2; or

(c) more than one of the six individual values is less than 70 % of the specified minimum value given in tables 1 and 2.

In the case of bars supplied in the heat treated condition, the manufacturer shall be permitted to reheat-treat the lot represented and resubmit for sampling in accordance with clause 11 and testing in accordance with clause 12.

13.5 Hardness test results

If any bar fails to meet the specified requirements, all the bars in the lot shall be hardness tested and those which comply with the specified hardness shall be deemed to comply with this standard.

Should any of the further bars fail to meet the specified requirements then one of the two procedures below shall be adopted.

(a) The lot represented by the original tests shall be reheat-treated and re-submitted for testing.

(b) With the exception of steels 162, 253 and 415S29, tensile test pieces shall be prepared from bars showing the widest deviations (above and/or below) from the specified hardness range. Should the tensile test results obtained from such test pieces comply with the specified tensile properties, the batch represented by these tests shall be deemed to comply with the hardness requirements specified in this standard.

Should any of the bars retested in accordance with (a) and (b) above fail to meet the specified requirements, the batch represented shall be deemed not to comply with the specified hardness requirements.

In the case of bars supplied in the heat treated condition, the manufacturer shall be permitted to reheat-treat the lot represented and resubmit for sampling in accordance with clause 11 and testing in accordance with clause 12.

13.6 Intercrystalline corrosion testing

The relevant provisions of BS 5903 shall apply.

14 Marking

For products over 75 mm in the major sectional dimension, each bar or billet shall be marked by the manufacturer with an identification mark by which the product can be traced to the cast of steel from which it was produced and, if relevant, the heat treatment batch.

For products up to and including 75 mm in the major sectional dimension, the products shall be either:

(a) individually marked, as for products over 75 mm in the major sectional dimension; or

(b) bundled and identified by marks on a tag attached to each bundle.

15 Manufacturer's certificate

15.1 Supply by manufacturer

The manufacturer of the bars or billets shall supply a certificate stating the following:

(a) the number and date of this British Standard, i.e. BS 1506 : 1990*.

(b) the material designation (see clause 2);

(c) the cast analysis in respect of all specified elements (see clause 6, and tables 1 and 2 as appropriate);

(d) the heat treatment, if any, given to the bars or billets;

(e) the reference number of each batch of bars or billets and its cast number (see clause 14);

(f) for bars or billets having verified specified impact properties, the temperature at which the impact tests were made and the results obtained (see tables 1 and 2);

(g) the results of the room temperature mechanical property tests (see tables 1, 2 and 5);

(h) the result of the intercrystalline corrosion test on austenitic stainless steels (see clause 10).

15.2 Supply by merchant

If the bars or billets are supplied from a merchant's stock, the merchant shall satisfy the purchaser by means of numbers and identification marks on the bars and billets, combined with a manufacturer's certificate, that such bars or billets have been tested and comply with the requirements of this standard applicable to the material specified.

*Marking BS 1506 : 1990 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.

Appendices

Appendix A. Comparisons between the designations for steel grades in the 1958 edition of BS 1506 and their nearest equivalents in this edition

Comparisons between the designations for steel grades in the 1958 edition of BS 1506 and their nearest equivalents. in this edition are given in table 13.

Designations for steels in the 1958 edition that have been discontinued and new designations introduced in the current edition are clearly indicated.

The 'nearest equivalent' steels are not necessarily identical and the user should consult the relevant standards for detailed comparison.

Appendix B. Examples of commercial or contractual clauses which the purchaser may wish to include in his order or contract

B.1 Inspection

The purchaser or his representative is to have access at all reasonable times to those parts of the manufacturer's works engaged on the order. He is at liberty to inspect the manufacture at any stage and to select and witness the required tests. When the material is to be inspected and tested in the presence of the purchaser's respresentative, it should be so stated on the order.

B.2 Test facilities

The manufacturer is to supply the materials required for testing and furnish and prepare the necessary test pieces and supply labour and appliances for such testing as may be carried out on his premises and in accordance with BS 1506. In the absence of facilities at his own works for carrying out the prescribed tests, the manufacturer is to arrange for the tests to be carried out elsewhere.

B.3 Delivery

No material is to be despatched from the manufacturer's works until it has been tested and found to comply with all the tests and requirements of BS 1506 applicable to the material ordered and any additional requirements given on the order.

B.4 Defects revealed after delivery

In the event of material proving defective during subsequent manufacturing operations, such material is to be regarded as not complying with BS 1506, notwithstanding any previous certificates of satisfactory testing, provided that the material has not been improperly treated after delivery.

Table 13. Comparison between the designations for steel published in the 1958 edition of BS 1506 and those in the current edition

Steel type	BS 1506 : 1958 grade	BS 1506 : 1989 grade	Comments
Carbon steel	111	No equivalent	Discontinued
Carbon steel	162	162	Minor restrictions to analysis, condition R discontinued
Carbon molybdenum	240	No equivalent	Discontinued. Nearest equivalent grade 253
Carbon molybdenum	No equivalent	253	New grade. Chemical analysis different from grade 240
9 % Nickel	No equivalent	509-650	New grade
9 % Nickel	No equivalent	509-690	New grade
1 % Chromium-molybdenum	621A	630	
1 % Chromium-molybdenum	621B	631	
5 % Chromium-molybdenum	625	No equivalent	Discontinued
1 % Chromium-molybdenum-vanadium	661	670	
1 % Chromium-molybdenum-vanadium	No equivalent	671	New grade, similar to grade B16 of BS 4882
1 % Chromium-molybdenum-vanadium boron titanium	No equivalent	681	New grade, similar to grade B16A of BS 4882
12 % Chromium	713	410S21	
12 % Chromium free machining	No equivalent	416S29	New grade
Precipitation hardening, austenitic stainless steel	No equivalent	286S31	New grade
Austenitic chromium-nickel	801 grade A and grade B	304S51	Special grade for higher temperatures in creep range
Austenitic chromium-nickel	801 grade C	No equivalent	
Austenitic chromium-nickel; free machining	801 grade AM	303S22	
Austenitic chromium-nickel; nitrogen bearing	No equivalent	304S61	Low carbon new grade
		304S71	Higher carbon new grade
Stabilized austenitic chromium-nickel	821 grade Ti	321S31	Standard grade, titanium stabilized
	No equivalent	321S51-490	Higher carbon range, titanium stabilized
	No equivalent	321S51-520	
Stabilized austenitic chromium-nickel	821 grade Nb	347S31	Standard grade, niobium stabilized
Stabilized austenitic chromium-nickel		347S51	Higher carbon range, niobium stabilized
Stabilized austenitic chromium-nickel, free machining	821 grade TiM	No equivalent	Discontinued
Austenitic chromium-nickel-molybdenum*	845	316S33	Nearest substitute for BS 1506-845, 2.5 % to 3 % Mo
	No equivalent	316S31	2 % to 2.5 % Mo
	No equivalent	316S51	Higher carbon, 2 % to 2.5 % Mo
	No equivalent	316S53	Higher carbon, 2.5 % to 3 % Mo
Austenitic chromium-nickel-molybdenum, nitrogen bearing	No equivalent	316S61	Low carbon, 2 % to 2.5 % Mo
		316S63	Low carbon, 2.5 % to 3 % Mo
		316S65	2.0 % to 2.5 % Mo
		316S67	2.5 % to 3 % Mo

*This type has been subdivided in the new standard to give a variety of grades suiting different applications consistent with established practice.

Appendix C. Conditions of supply for bars and billets

Bars and billets are supplied in a range of finishes and heat-treatment conditions as listed in tables 14, 15 and 16. The various conditions are coded to allow purchasers to simplify their enquiry or order (see clause 3).

Table 14. Conditions of supply for carbon steels, low alloy steels and martensitic stainless steels

Steel types

(a) Carbon; 162
(b) Carbon-molybdenum; 253
(c) 9 % Nickel; 509-650 and 509-690
(d) Chromium-molybdenum; 630-790, 630-860 and 630-690, 631-850
(e) Chromium-molybdenum-vanadium; 670-860 and 671-850
(f) Chromium-molybdenum-vanadium-boron-titanium; 681-820
(g) Martensitic stainless steels; 410S21-720, 410S21-750, 410S21-770, 416S29

Heat-treatment	Code	Surface conditioning	Code
None	10	None	a
Softened (see clause 3)	11	Descaled	b
Fully heat-treated in accordance with table 1	12	Peeled or rough turned (see table 6)	c
Fully heat-treated in accordance with table 1 in controlled atmospheres*	13	Turned	d
		Ground	e
Stress relieved after cold sizing or cold straightening	14	Turned and ground	f
		Turned and precision ground	g
Following heat-treatment in a controlled atmosphere,* stress relieved in a controlled atmosphere after cold sizing or cold straightening	15	Descaled and cold sized	h
		Descaled, cold sized and precision ground†	m

Examples of the use of codes given above

Code	Condition ordered	Purpose examples
10a	As forged or rolled, no heat-treatment or surface conditioning	Bars, billets for further hot working and heat-treatment
11a	Forged or rolled and softened	Bars for cold working or machining and heat-treatment
12g	Forged or rolled, fully heat-treated, turned and precision ground	Bars for thread rolling or final machining

* *Controlled atmosphere.* A gaseous atmosphere surrounding the material during heat treatment, the composition of the atmosphere being adjusted to preserve a bright surface and/or to prevent decarburization of the material.

† In the case of martensitic stainless steels, cold sizing can be done before hardening and tempering, at the manufacturer's option.

Table 15. Conditions of supply for austenitic stainless steels

Steel types

303, 304 series, 316 series, 321 series, 347 series

Heat-treatment/cold drawing	Code	Surface conditioning	Code
None	20	None	a
Fully heat-treated in accordance with table 2	21	Descaled	b
Fully heat-treated in accordance with table 2 in controlled atmospheres*	22	Peeled or rough turned (see table 6)	c
		Turned	d
Fully heat-treated in accordance with table 2 and cold drawn	23	Ground	e
		Turned and ground	f
		Turned and precision ground	g
		Descaled and cold sized	h
		Descaled, cold sized and precision ground	m
		Descaled and cold drawn	p
		Descaled, cold drawn and precision ground	r

Examples of the use of codes given above

Code	Condition ordered	Purpose examples
20a	As forged or rolled, no heat-treatment or surface conditioning	Bars for hot working and heat-treatment
20d	As forged or rolled, no heat-treatment but turned	As above
21f	As forged or rolled, fully heat-treated, turned and ground	Bars for cold forging or thread rolling
21m	As forged or rolled, fully heat-treated, descaled, cold sized and precision ground	As above
23a	As forged or rolled, fully heat-treated and cold drawn, no further conditioning of surface	Bars for machining (higher strength)
23r	As forged or rolled, fully heat-treated, descaled, cold drawn and precision ground	Bars for thread rolling

* *Controlled atmosphere.* A gaseous atmosphere surrounding the material during heat treatment, the composition of the atmosphere being adjusted to preserve a bright surface and/or to prevent decarburization of the material.

Table 16. Conditions of supply for a precipitation hardenable stainless steel

Steel type
286S31

Heat-treatment	Code	Surface conditioning	Code
None	30	None	a
Solution treated in accordance with table 2	31	Descaled	b
Solution treated in accordance with table 2 in controlled atmosphere*	32	Peeled or rough turned (see table 6)	c
		Turned	d
Solution treated in accordance with table 2 and precipitation hardened	33	Ground	e
		Turned and ground	f
		Turned and precision ground	g
		Descaled and cold sized	h
		Descaled, cold sized and precision ground	m

Examples of the use of codes given above

Code	Condition ordered	Purpose examples
31e	As forged or rolled, solution treated and ground	Bars for precipitation hardening after processing by purchaser
33b	As forged or rolled, solution treated and precipitation hardened, descaled	Bars for machining

* *Controlled atmosphere.* A gaseous atmosphere surrounding the material during heat treatment, the composition of the atmosphere being adjusted to preserve a bright surface and/or to prevent decarburization of the material.

Publications referred to

BS 18	Methods for tensile testing of metals (including aerospace materials)
BS 131	Methods for notched bar tests Part 1 The Izod impact test on metals Part 2 The Charpy V-notch impact test on metals
BS 240	Method for Brinell hardness test and for verification of Brinell hardness testing machines
BS 427	Method for Vickers hardness test
BS 860	Tables for comparison of hardness scales
BS 891	Method for Rockwell hardness test
BS 1134	Method for the assessment of surface texture Part 1 Method and instrumentation
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
BS 1837	Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys
BS 1957	The presentation of numerical values
BS 3692	Specification for ISO metric precision hexagon bolts, screws and nuts. Metric units
BS 4439	Specification for screwed studs for general purposes. Metric units
BS 4882	Specification for bolting for flanges and pressure containing purposes
BS 5046	Method for the estimation of equivalent diameters in the heat treatment of steel
BS 5750	Quality systems *Part 2 Specification for production and installation
BS 5903	Method for determination of resistance to intergranular corrosion of austenitic stainless steels : copper sulphate–sulphuric acid method (Moneypenny Strauss test)
BS 6200	Sampling and analysis of iron, steel and other ferrous metals Part 3 Methods of analysis

BS Handbook No. 19 Methods for the sampling and analysis of iron, steel and other ferrous metals

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