BRITISH STANDARD 970 : Part 4 : 1970
UDC 669.14–4+669.14.018.8

SPECIFICATION FOR

WROUGHT STEELS

(BLOOMS, BILLETS, BARS AND FORGINGS)

Part 4. Stainless, heat resisting and valve steels

BRITISH STANDARDS INSTITUTION
Gr 8

SPECIFICATION FOR

WROUGHT STEELS

IN THE FORM OF BLOOMS, BILLETS, BARS AND FORGINGS

Part 4. Stainless, heat resisting and valve steels

BS 970 : Part 4 : 1970

Incorporating amendment issued November 1971 (AMD 829)

BRITISH STANDARDS INSTITUTION

Incorporated by Royal Charter

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This British Standard, having been approved by the Iron and Steel Industry Standards Committee, was published under the authority of the Executive Board on 12th February, 1970.

First published, July, 1941
First revision, October, 1942
Second revision, March, 1947
Third revision, January, 1955
Fourth revision (Part 4), February, 1970

SBN: 580 05856 5

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

This standard makes reference to the following British Standards:

BS 18. Methods for tensile testing of metals.
BS 131. Methods for notched bar tests. Part 1. The Izod impact test on metals.
BS 240. Method for Brinell hardness test.
BS 427. Method for Vickers hardness test.
BS 891. Method for Rockwell hardness test.
BS 1837. Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys.
BS 4114. Dimensional and quantity tolerances for steel drop and press forgings and for upset forgings made on horizontal forging machines.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following BSI references relate to the work on this standard:
Committee references ISE/31, ISE/31/2, ISE/31/2/3
Draft for comment 67/29354

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CO-OPERATING ORGANIZATIONS

The Iron and Steel Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

*Board Of Trade
British Cast Iron Research Association
British Constructional Steelwork Association
*British Electrical and Allied Manufacturers' Association
British Ironfounders' Association
British Mechanical Engineering Federation
*British Railways Board
British Steel Castings Research Association
*British Steel Industry
Council of Iron Producers
Council of Ironfoundry Associations
Crown Agents for Oversea Governments and Administrations
Department of Employment and Productivity (H.M. Factory Inspectorate)
Engineering Equipment Users' Association
Federation of Civil Engineering Contractors
Institute of British Foundrymen
Institute of Iron and Steel Wire Manufacturers
*Institute of Marine Engineers
Institution of Civil Engineers
Institution of Mechanical Engineers (Automobile Division)
Institution of Production Engineers
Institution of Structural Engineers
Joint Iron Council
Lloyd's Register of Shipping
*Ministry of Defence, Army Department
*Ministry of Defence, Navy Department
*National Association of Drop Forgers and Stampers
National Physical Laboratory (Ministry of Technology)
Oil Companies Materials Association
Royal Institute of British Architects
Shipbuilders and Repairers National Federation
Society of British Aerospace Companies
*Society of Motor Manufacturers and Traders Ltd.
*Stainless Steel Development Association

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

Association of British Railway Carriage & Wagon Manufacturers
British Bolt, Nut, Screw & Rivet Federation
Ministry of Technology
National Coal Board
Spring Research Association
Stainless Steels Fabricators' Association of Great Britain
Individual Companies

BRITISH STANDARD SPECIFICATION FOR

WROUGHT STEELS IN THE FORM OF BLOOMS, BILLETS, BARS AND FORGINGS

Part 4. Stainless, heat resisting and valve steels

FOREWORD

This British Standard has been prepared under the authority of the Iron and Steel Industry Standards Committee and forms Part 4 of the revision of BS 970 which is to be published in five parts as follows:

Part 1. Carbon steels.
Part 2. Direct hardening alloy steels.
Part 3. Case hardening steels.
Part 4. Stainless, heat resisting and valve steels.
Part 5. Spring steels.

This Part of the standard is presented in three sections, Section 1, ' General requirements', Section 2, 'Specific requirements for stainless and heat resisting steels' and Section 3, 'Specific requirements for valve steels'. Elevated temperature data are being collected for the valve steels and it is intended that these will be published as soon as this information is available.

In preparing the revision of BS 970, it has been found necessary to abandon the 'En' designation system used in previous editions since it did not possess sufficient flexibility to permit the inclusion of the new steels proposed for the revised standard, nor did it permit the separation of the revised standard into parts. A new six digit designation system, for which information regarding stainless steels is given in PD 6290, 'New designation system for stainless steels,' has therefore been introduced. For the steels specified in this Part of the standard the series 300–449 has been allocated for the first three digits. Within this series allocation according to alloy type is arbitrary but it will be noted that there is correspondence to the A.I.S.I. stainless steel designation where this is possible. The letter S at the fourth digit is used to denote that the steel falls within the broad classification of 'stainless steel'. Each basic steel composition has been allocated the fifth and sixth digits '01' and specific alloys are arbitrarily designated within the range '11' to '99'.

The opportunity has been taken to align the compositions of the steels more closely with those demanded in practice, to introduce steels not covered by the previous edition of BS 970 and also to introduce permissible variations on product analysis.

This standard is written in terms of imperial units, it being intended that the metric version of the standard will be published as soon as possible.

NOTE. When metric equivalents are stated, the figures in imperial units are to be regarded as the standard. Metric conversions should be based on the tables in BS 350, ' Conversion factors and tables '.

SPECIFICATION

1. GENERAL REQUIREMENTS

1.1 SCOPE

This Part of BS 970 applies to wrought stainless and heat resisting steels and valve steels for use in the form of blooms, billets, bars and forgings. Unless otherwise specified, the mechanical properties apply to ruling sections up to 6 in.

The mechanical properties for ruling sections over 6 in shall, if required, be agreed between the manufacturer and the purchaser.

1.2 GENERAL

The steel shall be supplied in accordance with the general requirements specified in this section and the specific requirements given in Sections 2 or 3.

1.3 INFORMATION TO BE SUPPLIED BY THE PURCHASER

The following information shall be stated on the enquiry and order; a drawing of the part to be made or information regarding manipulation or service conditions to which the material will be subjected may be useful in appropriate cases.

(1) The material specification in Sections 2 or 3.

(2) The condition in which the material is to be supplied if different from 1.9.

(3) Whether mechanical tests are required and if so the condition in which the material is to be tested.

(4) If a 0·2 % proof stress is to be determined.

(5) If relevant, whether the intercrystalline corrosion test is required (see 1.12.2 and 1.13.4).

(6) Any special requirements, for example descaling and/or surface condition not specified in this British Standard (see 1.9.4.2). It is particularly advisable to indicate if the material is to be electro-polished.

(7) If a statement giving the cast analysis and/or result of mechanical or other tests is required, see 1.17.

(8) If special identification of the steel is required, see 1.18.

(9) If the material is to be inspected at the manufacturer's works and tested in the presence of the purchaser or his representative, see 1.15.

1.4 STEELMAKING PROCESS

The steel shall be made by an electric process.

1.5 CHEMICAL COMPOSITION

1.5.1 Composition ranges. The specific ranges of chemical composition are based on cast analysis which shall comply with the relevant specification.

1.5.2 Residual elements. Elements not quoted in the relevant specification shall not be added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall be taken to prevent the addition of such elements during manufacture.

The percentages of elements up to the contents given below shall be considered as incidental.

Elements	Non-austenitic steels	Austenitic steels	
		Without specified molybdenum	With specified molybdenum
	%	%	%
Titanium	—	0·10	0·10
Niobium	—	0·20	0·20
Molybdenum	0·30	0·70	—
Copper	0·30	0·50	0·70

For special applications the purchaser may specify by agreement with the supplier a different limit to the content of one or more of these, or other residual elements, or combination of them in the steel and may require the amount of such elements to be stated.

1.6 PRODUCT ANALYSIS AND PERMITTED VARIATIONS

1.6.1 Analysis of the product may vary from the cast analysis due to heterogeneity arising during the casting and solidification of the ingot. Table 1 shows the deviations permitted in product analysis in relation to cross sections not greater than 100 in².

The variations may occur in the individual elements either above or below the specified range but shall not be applied both above and below the range for any one element in any one cast of steel.

1.6.2 Any billet, bar or forging which on chemical analysis falls outside the limits of permissible deviation from the specified composition range for a significant element shall be deemed not to comply with this British Standard.

TABLE 1. PERMITTED VARIATIONS ON PRODUCT ANALYSIS FROM SPECIFIED RANGE

Element	Range in which maximum of specified element falls, %	Variation on specified range	
		Over maximum, %	Under minimum, %
Carbon	Up to and including 0·03	0·005	—
	Over 0·03 up to and including 0·25	0·01	0·01
	Over 0·25 up to and including 0·50	0·02	0·02
	Over 0·50	0·03	0·03
Silicon	Up to and including 1·0	0·05	0·05
	Over 1·0 up to and including 2·0	0·07	0·07
	Over 2·0 up to and including 4·0	0·10	0·10
Manganese	Up to and including 1·0	0·03	0·03
	Over 1·0 up to and including 2·0	0·04	0·04
	Over 2·0 up to and including 5·0	0·05	0·05
	Over 5·0 up to and including 10·0	0·06	0·06
Nickel	Up to and including 1·0	0·03	0·03
	Over 1·0 up to and including 3·0	0·05	0·05
	Over 3·0 up to and including 5·0	0·07	0·07
	Over 5·0 up to and including 10·0	0·10	0·10
	Over 10·0 up to and including 20·0	0·15	0·15
	Over 20·0	0·20	0·20
Chromium	Up to and including 10·0	0·10	0·10
	Over 10·0 up to and including 15·0	0·15	0·15
	Over 15·0 up to and including 20·0	0·20	0·20
	Over 20·0	0·25	0·25
Molybdenum	Up to and including 1·0	0·03	0·03
	Over 1·0 up to and including 2·0	0·05	0·05
	Over 2·0 up to and including 3·0	0·08	0·08
	Over 3·0	0·10	0·10
Tungsten	Up to and including 3·0	0·08	0·08
Titanium	All ranges	0·05	0·05
Niobium	All ranges	0·05	0·05
Aluminium	Up to and including 0·3	0·05	0·05
Nitrogen	Up to and including 0·25	0·01	0·01
	Over 0·25	0·03	0·03
Sulphur	Up to and including 0·030	0·003	—
	Over 0·030 up to and including 0·080	0·005	—
	Specified range 0·15/0·30	0·02	0·02
Phosphorus	Up to and including 0·030	0·003	—
	Over 0·030 up to and including 0·045	0·004	—
Selenium	All ranges	0·03	0·03

1.6.3 In the event of a single sample falling outside the permitted deviations on the product analysis further samples shall be selected for check analysis from the remainder of the consignment, as follows:

At least two samples from the same cast for delivered weights up to 5 tons, at least five samples from the same cast for delivered weights up to 20 tons, and at least eight samples from the same cast for delivered weights over 20 tons.

These samples shall fall within the permitted deviations. If any of these further samples are proved to be outside the permitted deviations for any significant element the consignment shall be deemed not to comply with this British Standard.

1.6.4 Samples for product analysis shall be taken in accordance with BS 1837*.

1.7 FREEDOM FROM DEFECTS

1.7.1 Internal soundness. The steel shall be free from piping, harmful segregation and other internal defects.

1.7.2 Surface defects

1.7.2.1 Blooms, billets, slabs and bars shall be rough machined, chipped, ground or otherwise prepared to remove surface defects which might produce defects in the finished product.

1.7.2.2 Forgings and drop forgings shall be finished in a workmanlike manner and shall be free from flaws and harmful defects.

1.7.3 Special testing and inspection arrangements may, if required, be agreed between the purchaser and the supplier

1.8 STANDARD SIZES AND TOLERANCES

1.8.1 Bright bars shall be supplied in accordance with Tables 5A, 5B and 6 given in Appendix A, unless otherwise agreed between the manufacturer and the purchaser.

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1.8.2 Drop and press forgings and upset forgings made on horizontal forging machines shall conform to the requirements of BS 4114 unless otherwise agreed between the purchaser and the supplier.

1.8.3 Bars for machining shall be commercially straight.

1.9 CONDITION OF MATERIAL ON DELIVERY

1.9.1 The steel shall be delivered in accordance with 1.9.2, 1.9.3, 1.9.4 or 1.9.5 whichever is appropriate, unless the order states otherwise.

1.9.2 Ferritic steels. All items in these steels shall be delivered in the softened condition. In the case of bright bars the softening heat treatment may be given before or after any cold sizing, at the option of the manufacturer.

* BS 1837, ' Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys '.

1.9.3 Martensitic steels

1.9.3.1 Blooms, billets, slabs and bars for subsequent hot working shall be supplied in the softened condition.

1.9.3.2 Forgings, drop forgings and bars for machining shall be delivered in the hardened and tempered condition.

1.9.3.3 Bright bars shall be delivered in the hardened and tempered condition, heat treatment being given either before or after any cold sizing, at the option of the manufacturer.

1.9.4 Austenitic steels

1.9.4.1 Blooms, billets, slabs and bars for subsequent hot working shall be delivered in the as forged or as rolled condition.

1.9.4.2 Forgings, drop forgings and bars for machining shall be delivered in the softened condition and, if required, subsequently descaled.

1.9.4.3 Bright bars shall be delivered in the softened condition, this heat treatment being given before grinding or cold sizing.

1.9.4.4 Cold drawn bars shall be delivered softened and subsequently cold drawn.

1.9.5 Valve steels. Valve steels shall be delivered in the condition given in the individual specifications in Section 3.

1.10 PROVISION OF MATERIAL FOR MECHANICAL TESTING

1.10.1 Definitions. For the purposes of this Part of this British Standard the following definitions apply:

(1) *Test sample.* A test sample is that portion of the material selected for testing.

(2) *Test bar.* A test bar is the test sample after preparation for heat treatment.

(3) *Test piece.* A test piece is the test sample or test bar as finally prepared for testing.

1.10.2 Selection of test samples and preparation of test bars, for tensile and Izod test

1.10.2.1 *Bars supplied in the finally heat-treated or cold drawn condition.* The samples shall be cut from the heat-treated or cold drawn bars and shall not be further heat-treated or mechanically worked after their removal.

Unless otherwise agreed, one tensile test and, if specified, one Izod impact test shall be made on any batch of bars of the same size from the same cast and heat-treated together.

1.10.2.2 *Forgings, drop forgings and machined parts.* For forgings and drop forgings with a ruling section equivalent to a diameter greater than 1⅛ in, integral test samples may be provided by agreement between the purchaser and supplier when a prolongation shall be provided on an agreed proportion of forgings or drop forgings. Unless otherwise agreed, the prolongation shall have a diameter approximately equal to the ruling section of the forging or drop forging at the time of heat treatment, and it shall not be finally severed until after heat treatment.

Where integral test samples are not practicable or are not required and for small forgings and drop forgings with ruling sections equivalent to a diameter of 1⅛ in or less, also for parts machined from bars not finally heat-treated, separate test samples shall be provided. These shall be provided from the bars or billets from which the forgings, drop forgings or parts are made or may be additional forgings, drop forgings or parts. The test samples shall be forged and/or machined to test bars of a diameter equivalent to a ruling section of the forgings, drop forgings or parts and shall be heat treated with the material they represent. The number of tests shall be agreed between the purchaser and the supplier.

1.10.2.3 *Martensitic steel not supplied in the finally heat treated condition.* Where the ruling section of the material does not differ appreciably from that of the forging or parts to be produced, test samples may be taken directly from the material and heat treated in the original size. Alternatively when it is considered either by the purchaser or the supplier that the results of heat treating in the original size would not be representative of the properties that would be obtained on the forgings or parts to be produced, test samples shall be forged and/or machined to test bars of a diameter equivalent to the ruling section of the forgings or parts at the time of heat treatment. Test bars shall be given the representative heat treatment for the parts concerned.

Unless otherwise agreed, one tensile test and, if specified, one Izod impact test, 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 forgings or parts does not exceed the ruling section of the test bar already tested.

NOTE. Tests are not normally carried out for austenitic or ferritic steels intended for further hot work.

1.11 LOCATION OF TENSILE AND IZOD TEST PIECES

1.11.1 Unless otherwise agreed, longitudinal test pieces for material other than cold drawn bars shall be prepared in accordance with 1.11.2 or 1.11.3 and longitudinal test pieces for cold drawn bars in accordance with 1.11.4.

Where transverse tests are required the location of the test pieces and values for mechanical properties shall be agreed between the purchaser and the supplier.

1.11.2 For ruling sections up to and including 1⅛ in (29 mm) the test piece shall be machined coaxially from the test bars.

1.11.3 For ruling sections over 1⅛ in (29 mm) the longitudinal axes of the test pieces shall be ½ in (12·5 mm) from the surface of the test bars.

1.11.4 Cold drawn bars shall be tested in full section for ruling sections up to and including ¾ in (19 mm). For ruling sections over ¾ in (19 mm) the test pieces shall be machined coaxially from the test bars.

1.12 FREQUENCY OF OTHER TESTS

1.12.1 Number of hardness tests. The manufacturer shall carry out sufficient tests in accordance with the relevant clauses of this standard in order to ensure that the material complies with the specified hardness.

1.12.2 Number of intercrystalline corrosion tests. This shall be the subject of agreement between the purchaser and the supplier (see 1.3(5)).

1.13 TEST METHODS

1.13.1 Tensile test

1.13.1.1 The tensile test shall be carried out in accordance with the requirements of BS 18*.

1.13.1.2 Except as provided in 1.13.1.3 tensile test pieces shall be machined from blooms, billets, slabs, bars, forgings and drop forgings to the dimensions of the 0·564 in (14 mm) diameter test piece or if the test bar is too small, to the dimensions of the largest recommended round test piece that can be obtained having a gauge length equal to 5·65 times the square root of the area of the cross section.

1.13.1.3 When agreed between the purchaser and the supplier, or for material not greater than ⅝ in diameter or width across flats, unmachined test pieces having a gauge length equal to 5·65 times the square root of the area of the cross section may be used.

1.13.2 Izod impact test. The Izod impact test comprising three notches shall be carried out in accordance with the requirements of BS 131: Part 1†.

1.13.3 Hardness test. The Brinell hardness test shall be carried out in accordance with BS 240‡ using, where possible, a 10 mm diameter ball and a load of 3000 kg. Alternatively Vickers and Rockwell methods of hardness testing in accordance with BS 427§ and BS 891¶ may be used. Considerable caution should be exer-

* BS 18, ' Method for tensile testing of metals '.
† BS 131, ' Methods for notched bar tests ', Part 1, ' The Izod impact test on metals '.
‡ BS 240, ' Method for Brinell hardness test '.
§ BS 427, ' Method for Vickers hardness test '.
¶ BS 891, ' Method for Rockwell hardness test '.

cised when converting from one hardness scale to another, and in cases of dispute the Brinell hardness test shall be used.

NOTE. When hardness testing, attention should be paid to the possible effect of surface work hardening caused by cold finishing processes.

1.13.4 Intercrystalline corrosion bend test. The bend test pieces shall not be larger than ½ in diameter or thickness. When a test is required by the purchaser the test piece shall be sensitized by heating to a temperature of 650°C for the period stated in the relevant material specification, followed by cooling in air. All test pieces shall be immersed for 72 hours in a boiling solution having the following composition:

111 g copper sulphate, $CuSO_4.5H_2O$, 98 g sulphuric acid, relative density (d) 1·84, made up to 1 litre with distilled water.

Precautions shall be taken during the boiling to prevent concentration of the solution due to evaporation.

After this preparation each test piece shall be bent through 90° round a radius equal to three times the diameter or thickness of the test piece, and shall withstand this treatment without cracking on the outer convex surface.

1.14 RETESTS

1.14.1 Tensile and Izod tests

1.14.1.1 Should any of the original test pieces fail, twice the original number of test samples shall be selected for retesting, one of which shall be taken from the bar, billet, forging or drop forging from which the original test sample was taken, unless that item has been withdrawn by the manufacturer.

1.14.1.2 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 material represented shall be deemed not to comply with this British Standard.

1.14.1.3 In the case of material supplied in the heat-treated condition the manufacturer shall have the right to re-heat-treat the material and re-submit it for testing.

1.14.2 Hardness tests

1.14.2.1 If any item does not meet the specified requirements, one or both of the following procedures shall be adopted at the discretion of the manufacturer.

1.14.2.2 All the items in the batch shall be hardness tested and only those items which comply with the specified hardness requirement shall be regarded as acceptable.

1.14.2.3 Items of incorrect hardness or the complete batch shall be re-heat-treated and re-submitted for testing.

1.14.3 Intercrystalline corrosion test. Should the interpretation of the result be in doubt, then this shall be subject to negotiation between the purchaser and supplier.

1.15 INSPECTION

The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on the order. He shall be at liberty to inspect the manufacture at any stage and to witness the required tests. When the material is to be inspected and tested in the presence of the purchaser's representative, it shall be so stated on the enquiry and order (see 1.3 (9)).

1.16 TEST FACILITIES

The manufacturer shall supply the material required 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 and in accordance with this British Standard. Failing facilities at his own works for making the prescribed tests, the manufacturer shall arrange for the tests to be carried out elsewhere.

1.17 MANUFACTURER'S STATEMENT

If required by the order, the manufacturer shall supply the ladle analysis of the material or the results of the mechanical or other tests or combinations of these (see 1.3(7)).

1.18 IDENTIFICATION

If the purchaser requires special identification to be applied to the material then the manner of identification shall be the subject of negotiation between the purchaser and the supplier and that this identification is required shall be stated on the enquiry or order (see 1.3(8)).

1.19 SYMBOLS

1.19.1 Symbols for tensile ranges of hardened and tempered material. The varying tensile ranges specified for those steels used in the hardened and tempered condition have been designated with the letters P, R. S and T so that the same letters always represent the same lower limit of the tensile range as follows:

Symbol	Tensile strength range (tonf/in²)	(kgf/mm²)	Symbol	Tensile strength range (tonf/in²)	(kgf/mm²)
P	35/45	55/71	S	50/60	79/94
R	45/55	71/87	T	55/65	87/102

NOTE. Other mechanical properties associated with these tensile ranges are detailed in Section 2.

1.19.2 Symbols for mechanical properties. The symbols for mechanical properties used in this standard are those described in BS 18*. These are as follows:

R_m denotes tensile strength.
R_e denotes yield stress.
A denotes percentage elongation.
$R_{p0.2}$ denotes 0·2 % proof stress.

* BS 18, ' Methods for tensile testing of metals '.

TABLE 2. NUMERICAL LIST OF STEELS CONTAINED IN SECTIONS 2 AND 3 SHOWING PAGE REFERENCES, THE En STEELS REPLACED AND NEAREST A.I.S.I. STEELS

Grade	Page reference	En steel replaced	Nearest A.I.S.I. steel	Type *	
302S25	42	58A	302	A	Cr Ni 18/9, C 0·12
303S21	52	58M	303	A	Cr Ni 18/9, S bearing, free machining
303S41	52	58M	303 Se	A	Cr Ni 18/9, Se bearing, free machining
304S12	42		304 L	A	Cr Ni 18/10, C 0·03
304S15	42	58E	304	A	Cr Ni 18/9, C 0·06
310S24	54		310	A	Cr Ni 25/20
315S16	46	58H	—	A	Cr Ni Mo 17/10/1½, C 0·07
316S12	48		316 L	A	Cr Ni Mo 17/12/2½, C 0·03
316S16	48	58J	316	A	Cr Ni Mo 17/11/2½, C 0·07
317S12	50		—	A	Cr Ni Mo 18/15/3½, C 0·03
317S16	50		317	A	Cr Ni Mo 18/13/3½, C 0·06
320S17	48	58J	—	A	Cr Ni Mo 17/12/2½ + Ti, C 0·08
321S12	44	58B & 58C	321	A	Cr Ni 18/9/Ti, C 0·08
321S20	44	58B & 58C	321	A	Cr Ni 18/9/Ti, C 0·12
325S21	52	58M	—	A	Cr Ni 18/9/Ti, S bearing, free machining
326S36	52		—	A	Cr Ni Mo 17/11/2½ Se bearing, free machining
331S40	59	54	—	V	Ni Cr W 14/14/2½
331S42	59	54A	—	V	Ni Cr W 14/14/2½ + Mo
347S17	44	58F & 58G	347	A	Cr Ni 18/9/Nb, C 0·08
349S52	60		—	V	Cr Mn Ni, 21/4 N
349S54	60		—	V	Cr Mn Ni, 21/4 N, S bearing
352S52	61		—	V	Cr Mn Ni, 21/4 N + Nb
352S54	61		—	V	Cr Mn Ni, 21/4 N + Nb, S bearing
381S34	62		—	V	Cr Ni, 21/11 + N
401S45	57	52	—	V	Si Cr, 3/8
403S17	20		403	F	13 Cr, C 0·08 max.
410S21	24	56A	410	M	13 Cr, C 0·12
416S21	32	56AM	416	M	13 Cr, C 0·12, S bearing, free machining
416S29	34	56BM	—	M	13 Cr, C 0·17, S bearing, free machining
416S37	36	56CM	—	M	13 Cr, C 0·24, S bearing, free machining
416S41	32	56AM	416 Se	M	13 Cr, C 0·12, Se bearing, free machining
420S29	26	56B	—	M	13 Cr, C 0·17
420S37	28	56C	420	M	13 Cr, C 0·24
420S45	30	56D	—	M	13 Cr, C 0·32
430S15	22	60	430	F	17 Cr, C 0·10
431S29	38	57	431	M	17 Cr, 2½ Ni, C 0·15
441S29	40		—	M	17 Cr, 2½ Ni, C 0·15, S bearing, free machining
441S49	40		—	M	17 Cr, 2½ Ni, C 0·15, Se bearing, free machining
443S65	58	59	—	V	Cr Ni Si, 20/1½/2

As altered Nov. 1971

* F Denotes ferritic steel. M Denotes martensitic steel. A Denotes austenitic steel. V Denotes valve steel.

2. SPECIFIC REQUIREMENTS FOR STAINLESS AND HEAT RESISTING STEELS

TABLE 3. TABLE OF PAGE REFERENCES, THE En STEELS REPLACED AND NEAREST A.I.S.I. STEELS FOR STAINLESS AND HEAT RESISTING STEELS INCLUDED IN SECTION 2

Grade	Page reference	En steel replaced	Nearest A.I.S.I. steel	Type
			Ferritic steels	
403S17	20		403	13 Cr, C 0·08 max.
430S15	22	60	430	17 Cr, C 0·10
			Martensitic steels	
410S21	24	56A	410	13 Cr, C 0·12
420S29	26	56B	—	13 Cr, C 0·17
420S37	28	56C	420	13 Cr, C 0·24
420S45	30	56D	—	13 Cr, C 0·32
416S21	32	56AM	416	13 Cr, C 0·12, S bearing, free machining
416S41	32	56AM	416 Se	13 Cr, C 0·12, Se bearing, free machining
416S29	34	56BM	—	13 Cr, C 0·17, S bearing, free machining
416S37	36	56CM	—	13 Cr, C 0·24, S bearing, free machining
431S29	38	57	431	17 Cr, 2½ Ni, C 0·15
441S29	40		—	17 Cr, 2½ Ni, C 0·15, S bearing, free machining
441S49	40		—	17 Cr, 2½ Ni, C 0·15, Se bearing, free machining
			Austenitic steels	
304S12	42		304 L	Cr Ni 18/10, C 0·03
304S15	42	58E	304	Cr Ni 18/9, C 0·06
302S25	42	58A	302	Cr Ni 18/9, C 0·12
321S12	44	58B & 58C	321	Cr Ni 18/9/Ti, C 0·08
321S20	44	58B & 58C	321	Cr Ni 18/9/Ti, C 0·12
347S17	44	58F & 58G	347	Cr Ni 18/9/Nb, C 0·08
315S16	46	58H	—	Cr Ni Mo 17/10/1½, C 0·07
316S12	48		316 L	Cr Ni Mo 17/12/2½, C 0·03
316S16	48	58J	316	Cr Ni Mo 17/11/2½, C 0·07
320S17	48	58J	—	Cr Ni Mo 17/12/2½ + Ti, C 0·08
317S12	50		—	Cr Ni Mo 18/15/3½ C 0·03
317S16	50		317	Cr Ni Mo 18/13/3½ C 0·06
303S21	52	58M	303	Cr Ni 18/9, S bearing, free machining
303S41	52	58M	303 Se	Cr Ni 18/9, Se bearing, free machining
325S21	52	58M	—	Cr Ni 18/9/Ti, S bearing, free machining
326S36	52		—	Cr Ni Mo 17/11/2½ Se bearing, free machining
310S24	54		310	Cr Ni 25/20

As altered Nov. 1971

The data for these steels are summarized in Tables 7, 8, 9, 10 and 11, of Appendix B, on pages 66, 68, 70, 72 and 73.

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FERRITIC 13 % CHROMIUM STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	—	0·08
Silicon	—	0·80
Manganese	—	1·00
Nickel	—	0·50
Chromium	12·0	14·0
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. See 1.9.2.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the softened condition shall be as follows:

Soften by air cooling or furnace cooling from a temperature of 700–780 °C.

Mechanical properties. The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Tensile strength, R_m	
tonf/in² min.	27
kgf/mm² min.	43
Yield stress, R_e	
tonf/in², min.	18
kgf/mm², min.	28
Elongation, A	
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	20
Hardness	
HB max.	170
When specifically ordered, **0·2 % Proof stress $R_{p0{\cdot}2}$**	
tonf/in², min.	16
kgf/mm², min.	25

FERRITIC 17 % CHROMIUM STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	—	0·10
Silicon	—	0·80
Manganese	—	1·00
Nickel	—	0·50
Chromium	16·0	18·0
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. See 1.9.2.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the softened condition shall be as follows:

Soften by cooling freely in air from a temperature of 750–820 °C.

Mechanical properties. The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Limiting ruling section, inches	2½
Tensile strength, R_m	
tonf/in², min.	28
kgf/mm², min.	44
Yield stress, R_e	
tonf/in², min.	18
kgf/mm², min.	28
Elongation, A	
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	20
Hardness	
HB max.	170
When specifically ordered, **0·2 % Proof stress $R_{p0{\cdot}2}$**	
tonf/in², min.	16
kgf/mm², min.	25

MARTENSITIC 13 % CHROMIUM STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·09	0·15
Silicon	—	0·80
Manganese	—	1·00
Nickel	—	1·00
Chromium	11·5	13·5
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. See 1.9.3.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the hardened and tempered condition shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between:

Condition	P	R
Temperature	650 °C and 750 °C	600 °C and 700 °C

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Condition	P	R
Limiting ruling section, inches	**6**	**2½**
Tensile strength, R_m tonf/in²	35–45	45–55
Yield stress, R_e tonf/in², min.	21	34
Elongation, A % min. on $5{\cdot}65\sqrt{S_o}$ gauge length	20	15
Izod impact value ft lbf, min.		
Up to and including 2½ in ruling section	40	25
Over 2½ in to 6 in ruling section	25	—
Hardness HB	152–207	201–255
When specifically ordered, **0·2 % Proof stress**, $R_{p0.2}$ tonf/in², min.	22	32

As altered Nov. 1971

(2) When supplied in the softened condition the hardness shall be 179 HB max.

MARTENSITIC 13 % CHROMIUM STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·14	0·20
Silicon	—	0·80
Manganese	—	1·00
Nickel	—	1·00
Chromium	11·5	13·5
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. See 1.9.3.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the hardened and tempered condition shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between:

Condition	R	S
Temperature	650 °C and 750 °C	600 °C and 700 °C

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Condition	R	S
Limiting ruling section, inches	**6**	**1⅛**
Tensile strength, R_m		
tonf/in²	45–55	50–60
kgf/mm²	71–87	79–94
Yield stress, R_e		
tonf/in², min.	34	38
kgf/mm², min.	54	60
Elongation, A		
% min. on $5{\cdot}65\sqrt{S_0}$ gauge length	15	13
Izod impact value ft lbf, min.		
Up to and including 1⅛ in ruling section	—	20
Up to and including 2½ in ruling section	25	—
Over 2½ in to 6 in ruling section	20	—
Hardness		
HB	201–255	223–277
When specifically ordered, **0·2 % Proof stress, $R_{p0·2}$**		
tonf/in², min.	32	36
kgf/mm², min.	50	57

(2) When supplied in the softened condition the hardness shall be 217 HB max.

MARTENSITIC 13 % CHROMIUM STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·20	0·28
Silicon	—	0·80
Manganese	—	1·00
Nickel	—	1·00
Chromium	12·0	14·0
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. See 1.9.3.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the hardened and tempered condition shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between:

Condition	R	S
Temperature	650 °C and 750 °C	600 °C and 700 °C

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Condition	R	S
Limiting ruling section, inches	6	6
Tensile strength, R_m		
tonf/in²	45–55	50–60
kgf/mm²	71–87	79–94
Yield stress, R_e		
tonf/in², min.	34	38
kgf/mm², min.	54	60
Elongation, A		
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	15	13
Izod impact value ft lbf, min.		
Up to and including 2½ in ruling section	25	20
Over 2½ in to 6 in ruling section	20	10
Hardness		
HB	201–255	223–277
When specifically ordered, **0·2 % Proof stress, $R_{p0·2}$**		
tonf/in², min.	32	36
kgf/mm², min.	50	57

(2) When supplied in the softened condition the hardness shall be 229 HB max.

MARTENSITIC 13 % CHROMIUM STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·28	0·36
Silicon	—	0·80
Manganese	—	1·00
Nickel	—	1·00
Chromium	12·0	14·0
Sulphur	—	0·030
Phosphorus	—	0·040

As altered Nov. 1971

Condition of supply. See 1.9.3.

Heat treatment

(1) The heat treatment to be given to test bars and to material supplied in the hardened and tempered conditions R and S shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between:

Condition	R	S
Temperature	650 °C and 750 °C	600 °C and 700 °C

(2) This steel is normally used when maximum hardness is required when the heat treatment shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between 150 °C and 250 °C.

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Condition	R	S
Limiting ruling section, inches	6	6
Tensile strength, R_m		
tonf/in²	45–55	50–60
kgf/mm²	71–87	79–94
Yield stress, R_e		
tonf/in², min.	34	38
kgf/mm², min.	54	60
Elongation, A		
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	15	13
Izod impact value ft lbf, min.		
Up to and including 2½ in ruling section	25	20
Over 2½ in to 6 in ruling section	20	10
Hardness		
HB	201–255	223–277
When specifically ordered, **0·2 % Proof stress, $R_{p0·2}$**		
tonf/in², min.	32	36
kgf/mm², min.	50	57

(2) After hardening and tempering at 150–250 °C the hardness in ruling sections up to 1⅛ in shall be 540 HV min.

(3) When supplied in the softened condition the hardness shall be 241 HB max.

MARTENSITIC 13 % CHROMIUM STEELS—FREE MACHINING

Chemical composition. The steels shall contain:

Element	Grade 416S21		Grade 416S41	
	% min.	% max.	% min.	% max.
Carbon	0·09	0·15	0·09	0·15
Silicon	—	1·00	—	1·00
Manganese	—	1·50	—	1·50
Nickel	—	1·00	—	1·00
Chromium	11·5	13·5	11·5	13·5
Molybdenum	—	0·60	—	0·60
Sulphur	0·15	0·30	—	0·060
Phosphorus	—	0·040	—	0·040
Selenium	—	—	0·15	0·30

As altered Nov. 1971

Condition of supply. See 1.9.3.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the hardened and tempered condition shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between:

Condition	P	R
Temperature	650 °C and 750 °C	600 °C and 700 °C

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1 shall be as follows:

Condition	P	R
Limiting ruling section, inches	6	2½
Tensile strength, R_m tonf/in²	35–45	45–55
Yield stress, R_e tonf/in², min.	24	34
Elongation, A % min. on $5{\cdot}65\sqrt{S_0}$ gauge length	15	11
Izod impact value ft lbf, min.	25	20
Hardness HB	152–207	201–255
When specifically ordered, **0·2 % Proof stress $R_{p0.2}$** tonf/in², min.	22	32

As altered Nov. 1971

(2) When supplied in the softened condition the hardness shall be 179 HB max.

MARTENSITIC 13 % CHROMIUM STEEL—FREE MACHINING

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·14	0·20
Silicon	—	1·00
Manganese	—	1·50
Nickel	—	1·00
Chromium	11·5	13·5
Molybdenum	—	0·60
Sulphur	0·15	0·30
Phosphorus	—	0·040

Condition of supply. See 1.9.3.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the hardened and tempered condition shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between:

Condition	R	S
Temperature	650 °C and 750 °C	600 °C and 700 °C

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Condition	R	S
Limiting ruling section, inches	**6**	**1⅛**
Tensile strength, R_m		
tonf/in²	45–55	50–60
kgf/mm²	71–87	79–94
Yield stress, R_e		
tonf/in², min.	34	38
kgf/mm², min.	52	60
Elongation, A		
% min. on $5{\cdot}65\sqrt{S_0}$ gauge length	11	10
Izod impact value		
ft lbf, min.	20	10
Hardness		
HB	201–255	223–277
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**		
tonf/in², min.	32	36
kgf/mm², min.	50	57

(2) When supplied in the softened condition the hardness shall be 217 HB max.

MARTENSITIC 13 % CHROMIUM STEEL—FREE MACHINING

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·20	0·28
Silicon	—	1·00
Manganese	—	1·50
Nickel	—	1·00
Chromium	12·0	14·0
Molybdenum	—	0·60
Sulphur	0·15	0·30
Phosphorus	—	0·040

Condition of supply. See 1.9.3.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the hardered and tempered condition shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between:

Condition	R	S
Temperature	650 °C and 750 °C	600 °C and 700 °C

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Condition	R	S
Limiting ruling section, inches	**6**	**6**
Tensile strength, R_m		
tonf/in²	45–55	50–60
kgf/mm²	71–87	79–94
Yield stress, R_e		
tonf/in², min.	34	38
kgf/mm², min.	54	60
Elongation, A		
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	11	10
Izod impact value		
ft lbf, min.	20	10
Hardness		
HB	201–255	223–277
When specifically ordered, **0·2 % Proof stress, $R_{p0·2}$**		
tonf/in², min.	32	36
kgf/mm², min.	50	57

(2) When supplied in the softened condition the hardness shall be 229 HB max.

MARTENSITIC CHROMIUM NICKEL STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·12	0·20
Silicon	—	0·80
Manganese	—	1·00
Nickel	2·00	3·00
Chromium	15·0	18·0
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. See 1.9.3.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the hardened and tempered condition shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between 550 °C and 650 °C*.

* When 0·2 % proof stress is specified it is recommended that a double tempering treatment be used, the first tempering temperature being 640–680 °C and, after cooling, the second being 590–610 °C.

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Condition	T
Limiting ruling section, inches	6
Tensile strength, R_m	
tonf/in²	55–65
kgf/mm²	87–102
Yield stress R_e	
tonf/in², min.	44
kgf/mm², min.	69
Elongation A	
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	11
Izod impact value ft lbf, min.	
Up to and including 2½ in ruling section	25
Over 2½ in to 6 in ruling section	15
Hardness	
HB	248–302
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**	
tonf/in², min.	41
kgf/mm², min.	65

(2) When supplied in the softened condition the hardness shall be 277 HB max.

MARTENSITIC CHROMIUM NICKEL STEELS—FREE MACHINING

Chemical composition. The steels shall contain:

Element	Grade 441S29		Grade 441S49	
	% min.	% max.	% min.	% max.
Carbon	0·12	0·20	0·12	0·20
Silicon	—	1·00	—	1·00
Manganese	—	1·50	—	1·50
Nickel	2·00	3·00	2·00	3·00
Chromium	15·0	18·0	15·0	18·0
Molybdenum	—	0·60	—	0·60
Sulphur	0·15	0·30	—	0·060
Phosphorus	—	0·040	—	0·040
Selenium	—	—	0·15	0·30

As altered Nov. 1971

Condition of supply. See 1.9.3.

Heat treatment. The heat treatment to be given to test bars and to material supplied in the hardened and tempered condition shall be as follows:

Harden in oil or air from a temperature of 950–1020 °C.

Temper at a suitable temperature between 550 °C and 650 °C*.

* When a 0·2 % proof stress is specified it is recommended that a double tempering treatment be used, the first tempering temperature being 640–680 °C and, after cooling, the second being 590–610 °C.

Mechanical properties

(1) The mechanical properties obtained from test pieces, selected, prepared and tested in accordance with the appropriate requirements of Section 1, shall be as follows:

Condition	T
Limiting ruling section, inches	2½
Tensile strength, R_m	
tonf/in²	55–65
kgf/mm²	87–102
Yield stress, R_e	
tonf/in², min.	44
kgf/mm², min.	69
Elongation, A	
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	8
Izod impact value	
ft lbf, min.	15
Hardness	
HB	248–302
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**	
tonf/in², min.	40
kgf/mm², min.	63

(2) When supplied in the softened condition the hardness shall be 277 HB max.

UNSTABILIZED AUSTENITIC CHROMIUM NICKEL STEELS

Chemical composition. The steels shall contain:

Element	Grade 304S12		Grade 304S15		Grade 302S25	
	% min.	% max.	% min.	% max.	% min.	% max.
Carbon	—	0·03	—	0·06	—	0·12
Silicon	0·20	1·00	0·20	1·00	0·20	1·00
Manganese	0·50	2·00	0·50	2·00	0·50	2·00
Nickel	9·0	12·0	8·0	11·0	8·0	11·0
Chromium	17·5	19·0	17·5	19·0	17·0	19·0
Titanium	—	—	—	—	—	—
Sulphur	—	0·030	—	0·030	—	0·030
Phosphorus	—	0·045	—	0·045	—	0·045

Condition of supply. See 1.9.4.

Softening treatment. Soften by water quenching, oil quenching or cooling rapidly in air from a temperature of 1000–1120 °C.

Intercrystalline corrosion test. When required by the purchaser softened material shall pass the test specified in 1.13.4 (see also 1.12.2). The test piece shall be sensitized for the period specified below.

Steel grade	Period of sensitizing
304S12	30 min
304S15 up to a ruling section of 2½ in	15 min
302S25	None

Mechanical properties in the softened condition. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared, and tested in accordance with the appropriate requirements of Section 1 shall be as specified in the table below.

If properties other than those specified below are required, they shall be agreed between the manufacturer and the purchaser.

Grade	304S12 304S15	302S25
Tensile strength, R_m		
tonf/in², min.	30	33
kgf/mm², min.	47	52
Elongation, A		
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	40	40
Hardness		
HB max.	183	183
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**		
tonf/in², min.	11	13·5
kgf/mm², min.	17	21

NOTE. If bars are straightened by reeling or cold rectification the surface becomes work-hardened and the specified maximum Brinell hardness to be obtained on such bars shall be agreed between the manufacturer and the purchaser.

Grades 304S15 and 302S25—mechanical properties of cold drawn bars. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 (see 1.11.4) shall be as follows:

Properties	Up to and including ¾ in	Over ¾ in, up to and including 1 in	Over 1 in, up to and including 1¼ in	Over 1¼ in, up to and including 1½ in	Over 1½ in, up to and including 1¾ in
Tensile strength, R_m					
tonf/in², min.	56	51	47	45	42
kgf/mm², min.	88	80	74	71	66
Elongation, A					
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	12	15	20	28	28
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**					
tonf/in², min.	45	36	29	22	20
kgf/mm², min.	71	57	46	35	31

STABILIZED AUSTENITIC CHROMIUM NICKEL STEELS

Chemical composition. The steels shall contain:

Element	Grade 321S12		Grade 321S20		Grade 347S17	
	% min.	% max.	% min.	% max.	% min.	% max.
Carbon	—	0·08	—	0·12	—	0·08
Silicon	0·20	1·00	0·20	1·00	0·20	1·00
Manganese	0·50	2·00	0·50	2·00	0·50	2·00
Nickel	9·0	12·0	8·0	11·0	9·0	12·0
Chromium	17·0	19·0	17·0	19·0	17·0	19·0
Titanium	5C	0·70	5C	0·90	—	—
Niobium	—	—	—	—	10C	1·00
Sulphur	—	0·030	—	0·030	—	0·030
Phosphorus	—	0·045	—	0·045	—	0·045

Condition of supply. See 1.9.4.

Softening treatment. Soften by water quenching, oil quenching or cooling rapidly in air from a temperature of 1000–1120°C.

Intercrystalline corrosion test. When required by the purchaser softened material shall pass the test specified in 1.13.4 (see also 1.12.2). The test piece shall be sensitized for a period of 30 minutes.

Mechanical properties in the softened condition. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 shall be as specified in the table below.

If properties other than those specified below are required, they shall be agreed between the manufacturer and the purchaser.

Grade	321S12	321S20 347S17
Tensile strength, R_m		
tonf/in², min.	32	33
kgf/mm², min.	50	52
Elongation, A		
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	40	40
Hardness		
HB max.	183	183
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**		
tonf/in², min.	12·5	13·5
kgf/mm², min.	20	21

NOTE. If bars are straightened by reeling or cold rectification the surface becomes work-hardened and the specified maximum Brinell hardness to be obtained on such bars shall be agreed between the manufacturer and the purchaser.

Grades 321S12 and 321S20—mechanical properties of cold drawn bars. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 (see 1.11.4), shall be as follows:

Properties	Up to and including ¾ in	Over ¾ in, up to and including 1 in	Over 1 in, up to and including 1¼ in	Over 1¼ in, up to and including 1½ in	Over 1½ in, up to and including 1 ¾ in
Tensile strength, R_m					
tonf/in², min.	56	51	47	45	42
kgf/mm², min.	88	80	74	71	66
Elongation, A					
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	12	15	20	28	28
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**					
tonf/in², min.	45	36	29	22	20
kgf/mm², min.	71	57	46	35	31

AUSTENITIC CHROMIUM NICKEL MOLYBDENUM STEEL
(1½ % Molybdenum)

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	—	0·07
Silicon	0·20	1·00
Manganese	0·50	2·00
Nickel	9·0	11·0
Chromium	16·5	18·5
Molybdenum	1·25	1·75
Sulphur	—	0·030
Phosphorus	—	0·045

Condition of supply. See 1.9.4.

Softening treatment. Soften by water quenching, oil quenching or cooling rapidly in air from a temperature of 1000–1120 °C.

Intercrystalline corrosion test. When required by the purchaser, softened material shall pass the test specified in 1.13.4 (see also 1.12.2). The test piece shall be sensitized for a period of 15 minutes.

Mechanical properties in the softened condition. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 shall be as specified in the table below.

If properties other than those specified below are required, they shall be agreed between the manufacturer and the purchaser.

Tensile strength, R_m	
tonf/in², min.	30
kgf/mm², min.	47
Elongation, A	
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	40
Hardness	
HB max.	183
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**	
tonf/in², min.	11
kgf/mm², min.	17

NOTE. If bars are straightened by reeling or cold rectification the surface becomes work hardened and the specified maximum Brinell hardness to be obtained on such bars shall be agreed between the manufacturer and the purchaser.

AUSTENITIC CHROMIUM NICKEL MOLYBDENUM STEELS
(2½ % Molybdenum)

Chemical composition. The steels shall contain:

Element	Grade 316S12		Grade 316S16		Grade 320S17	
	% min.	% max.	% min.	% max.	% min.	% max.
Carbon	—	0·03	—	0·07	—	0·08
Silicon	0·20	1·00	0·20	1·00	0·20	1·00
Manganese	0·50	2·00	0·50	2·00	0·50	2·00
Nickel	11·0	14·0	10·0	13·0	11·0	14·0
Chromium	16·5	18·5	16·5	18·5	16·5	18·5
Molybdenum	2·25	3·0	2 25	3·0	2·25	3·0
Titanium	—	—	—	—	4C	0·60
Sulphur	—	0·030	—	0·030	—	0·030
Phosphorus	—	0·045	—	0·045	—	0·045

Condition of supply. See 1.9.4.

Softening treatment. Soften by water quenching, oil quenching or cooling rapidly in air from a temperature of 1000–1120 °C.

Intercrystalline corrosion test. When required by the purchaser softened material shall pass the test specified in 1.13.4 (See also 1.12.2). The test piece shall be sensitized for the period specified below.

Steel grade	Period of sensitizing
316S12	30 min
316S16	15 min
320S17	30 min

Mechanical properties in the softened condition. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 shall be as specified in the table below.

If properties other than those specified below are required, they shall be agreed between the manufacturer and the purchaser.

Grade	316S12 and 316S16	320S17
Tensile strength, R_m		
tonf/in² min.	30	32
kgf/mm² min.	47	50
Elongation, A		
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	40	40
Hardness		
HB max.	183	183
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**		
tonf/in² min.	11	12·5
kgf/mm² min.	17	20

NOTE. If bars are straightened by reeling or cold rectification the surface becomes work-hardened and the specified maximum Brinell hardness to be obtained on such bars shall be agreed between the manufacturer and the purchaser.

Grade 316S16—mechanical properties of cold drawn bars. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1, (see 1.11.4) shall be as follows:

Properties	Up to and including ¾ in	Over ¾ in, up to and including 1 in	Over 1 in, up to and including 1¼ in	Over 1¼ in, up to and including 1½ in	Over 1½ in, up to and including 1¾ in
Tensile strength, R_m					
tonf/in² min.	56	51	47	45	42
kgf/mm² min.	88	80	74	71	66
Elongation, A					
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	12	15	20	28	28
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**					
tonf/in² min.	45	36	29	22	20
kgf/mm² min.	71	57	46	35	31

AUSTENITIC CHROMIUM NICKEL MOLYBDENUM STEELS

(3½ % Molybdenum)

Chemical composition. The steels shall contain:

Element	Grade 317S12		Grade 317S16	
	% min.	% max.	% min.	% max.
Carbon	—	0·03	—	0·06
Silicon	0·20	1·00	0·20	1·00
Manganese	0·50	2·00	0·50	2·00
Nickel	14·0	17·0	12·0	15·0
Chromium	17·5	19·5	17·5	19·5
Molybdenum	3·0	4·0	3·0	4·0
Sulphur	—	0·030	—	0·030
Phosphorus	—	0·045	—	0·045

Condition of supply. See 1.9.4.

Softening treatment. Soften by water quenching, oil quenching or cooling rapidly in air from a temperature of 1000–1120 °C.

Intercrystalline corrosion test. When required by the purchaser softened material shall pass the test specified in 1.13.4 (see also 1.12.2). The test piece shall be sensitized for the period specified below.

Steel grade	Period of sensitizing
317S12	30 min
317S16	15 min

Mechanical properties in the softened condition. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 shall be as specified in the table below.

If properties other than those specified below are required, they shall be agreed between the manufacturer and the purchaser.

Tensile strength, R_m	
tonf/in² min.	30
kgf/mm² min.	47
Elongation, A	
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	40
Hardness	
HB max.	183
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**	
tonf/in² min.	11
kgf/mm² min.	17

NOTE. If bars are straightened by reeling or cold rectification, the surface becomes work-hardened and the specified maximum Brinell hardness to be obtained on such bars shall be agreed between the manufacturer and the purchaser.

FREE MACHINING AUSTENITIC CHROMIUM NICKEL STEELS

Chemical composition. The steels shall contain:

Element	Grade 303S21		Grade 303S41		Grade 325S21		Grade 326S36	
	% min.	% max.	% min.	% max.	% min.	% max.	% min.	% max.
Carbon	—	0·12	—	0·12	—	0·12	—	0·12
Silicon	0·20	1·00	0·20	1·00	0·20	1·00	0·20	1·00
Manganese	1·00	2·00	1·00	2·00	1·00	2·00	1·00	2·00
Nickel	8·0	11·0	8·0	11·0	8·0	11·0	10·0	13·0
Chromium	17·0	19·0	17·0	19·0	17·0	19·0	16·5	18·5
Molybdenum	—	—	—	—	—	—	2·25	3·0
Titanium	—	—	—	—	5C	0·90	—	—
As altered Nov. 1971 Sulphur	0·15	0·30	—	0·060	0·15	0·30	—	0·060
Phosphorus	—	0·045	—	0·045	—	0·045	—	0·045
Selenium	—	—	0·15	0·30	—	—	0·15	0·30

Condition of supply. See 1.9.4.

Softening treatment. Soften by water quenching, oil quenching or cooling rapidly in air from a temperature of 1000–1120 °C.

Intercrystalline corrosion test. When required by the purchaser softened material shall pass the test specified in 1.13.4 (see also 1.12.2). The test piece shall be sensitized for the period specified below.

Steel grade	Period of sensitizing
303S21	None
303S41	None
325S21	30 min
326S36	None

Mechanical properties in the softened condition. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 shall be as specified in the table below.

If properties other than those specified below are required, they shall be agreed between the manufacturer and the purchaser.

Tensile strength, R_m	
tonf/in² min.	33
kgf/mm² min.	52
Elongation, A	
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	40
Hardness	
HB max.	183
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**	
tonf/in² min.	13·5
kgf/mm² min.	21

NOTE. If bars are straightened by reeling or cold rectification, the surface becomes work-hardened and the specified maximum Brinell hardness to be obtained on such bars shall be agreed between the manufacturer and the purchaser.

Grades 303S21, 303S41, 325S21 and 326S36—mechanical properties of cold drawn bars. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 (see 1.11.4) shall be as follows:

Properties	Up to and including ¾ in	Over ¾ in, up to and including 1 in	Over 1 in, up to and including 1¼ in	Over 1¼ in, up to and including 1½ in	Over 1½ in, up to and including 1¾ in
Tensile strength, R_m					
tonf/in² min.	56	51	47	45	42
kgf/mm² min.	88	80	74	71	66
Elongation, A % min. on $5{\cdot}65\sqrt{S_o}$ gauge length	12	15	20	28	28
When specifically ordered, **0·2 % Proof stress, $R_{p0{\cdot}2}$**					
tonf/in² min.	45	36	29	22	20
kgf/mm² min.	71	57	46	35	31

310S24

AUSTENITIC CHROMIUM NICKEL STEEL (25/20)

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	—	0·15
Silicon	0·20	1·00
Manganese	0·50	2·00
Nickel	19·0	22·0
Chromium	23·0	26·0
Sulphur	—	0·030
Phosphorus	—	0·045

Condition of supply. See 1.9.4.

Softening treatment. Soften by water quenching, oil quenching or cooling rapidly in air from a temperature of 1000–1120 °C.

Intercrystalline corrosion test. When required by the purchaser, softened material shall pass the test specified in 1.13.4 (see also 1.12.2). The test piece shall not be sensitized.

Mechanical properties in the softened condition. If mechanical tests are required by the order, the properties to be obtained from test pieces selected, prepared and tested in accordance with the appropriate requirements of Section 1 shall be as specified in the table below.

If properties other than those specified below are required, they shall be agreed between the manufacturer and the purchaser.

Tensile strength, R_m	
tonf/in² min.	35
kgf/mm² min.	55
Elongation, A	
% min. on $5{\cdot}65\sqrt{S_o}$ gauge length	40
Hardness	
HB max.	207
When specifically ordered,	
0·2 % Proof stress, $R_{p0{\cdot}2}$	
tonf/in² min.	14
kgf/mm² min.	22

NOTE. If bars are straightened by reeling or cold rectification the surface becomes work-hardened and the specified maximum Brinell hardness to be obtained on such bars shall be arranged between the manufacturer and the purchaser.

3. SPECIFIC REQUIREMENTS FOR VALVE STEELS

TABLE 4. TABLE OF PAGE REFERENCES AND THE En STEELS REPLACED FOR VALVE STEELS INCLUDED IN SECTION 3

Grade	Page reference	En steel replaced	Type
401S45	57	52	Si Cr, 3/8
443S65	58	59	Cr Ni Si, 20/1½/2 (XB)
331S40	59	54	Ni Cr W 14/14/2½
331S42	59	54A	Ni Cr W 14/14/2½ + Mo
349S52	60		Cr Mn Ni, 21/4 N
349S54	60		Cr Mn Ni, 21/4 N, S bearing
352S52	61		Cr Mn Ni, 21/4 N + Nb
352S54	61		Cr Mn Ni, 21/4 N + Nb, S bearing
381S34	62		Cr Ni, 21/11 + N

SILICON CHROMIUM VALVE STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·40	0·50
Silicon	3·00	3·75
Manganese	0·30	0·75
Nickel	—	0·50
Chromium	7·5	9·5
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. Rod and bar shall be supplied in the rolled or rolled and stress-relieved condition unless otherwise required by the order.

Material approval test. A test sample up to 1½ in ruling section shall be hardened by oil quenching from 1030–1060 °C and tempered between 800 °C and 850 °C after which the hardness shall be 255 HB min.

Additionally a test sample in full section but not exceeding ½ in diameter shall be capable of hardening by oil quenching from 1030–1060 °C to a hardness of 550 HV min.

Heat treatment. For valves or parts supplied in the finally heat-treated condition the purchaser may specify one of the following alternative treatments:

(1) Harden in oil from a temperature of 1030–1060 °C. Temper at a suitable temperature between 750 °C and 850 °C

(2) Stress-relieve by heating for 1–2 hours at a temperature within the range 700–850 °C followed by air cooling.

CHROMIUM NICKEL SILICON VALVE STEEL

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·75	0·85
Silicon	1·75	2·25
Manganese	0·30	0·75
Nickel	1·20	1·70
Chromium	19·0	21·0
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. Rod and bar shall be supplied in the rolled or rolled and stress-relieved condition unless otherwise required by the order.

Material approval test. A test sample up to 1½ in ruling section shall be hardened by oil quenching from 1050–1080 °C, tempered between 850 °C and 870 °C and re-tempered between 690 °C and 710 °C, after which the hardness shall be 269 HB min.

Additionally a test sample in full section but not exceeding ½ in diameter shall be capable of hardening by oil quenching from 1050–1080 °C to a hardness of 450 HV min.

Heat treatment. For valves or parts supplied in the finally heat-treated condition the purchaser may specify one of the following alternative treatments:

(1) Harden in oil from a temperature of 1050–1080 °C. Temper at a suitable temperature between 700 °C and 750 °C.

(2) Harden in oil from a temperature of 1050–1080 °C. Temper at a temperature between 850 °C and 870 °C, quench in oil, or cool in air and re-temper at a temperature between 690 °C and 710 °C.

(3) Stress-relieve by heating for 1–2 hours at a temperature within the range 700–850 °C followed by air cooling.

AUSTENITIC NICKEL CHROMIUM TUNGSTEN VALVE STEELS

Chemical composition. The steels shall contain:

Element	Grade 331S40		Grade 331S42	
	% min.	% max.	% min.	% max.
Carbon	0·35	0·50	0·37	0·47
Silicon	1·00	2·00	1·00	2·00
Manganese	0·50	1·00	0·50	1·00
Nickel	12·0	15·0	13·0	15·0
Chromium	12·0	15·0	13·0	15·0
Molybdenum	—	—	0·40	0·70
Tungsten	2·00	3·00	2·20	3·00
Sulphur	—	0·030	—	0·030
Phosphorus	—	0·040	—	0·040

Condition of supply. Rod and bar shall be supplied in the rolled or softened condition unless otherwise required by the order.

Heat treatment. For valves or parts supplied in the finally heat-treated condition the purchaser may specify one of the following alternative treatments:

(1) Solution-treat at a temperature within the range 1150–1200 °C followed by cooling in air, oil or water.

(2) Soften by heating for 1–2 hours at a temperature within the range 950–1020 °C followed by cooling in air, oil or water.

CHROMIUM MANGANESE NICKEL VALVE STEELS
Precipitation Hardening

Chemical composition. The steels shall contain:

Element	Grade 349S52		Grade 349S54	
	% min.	% max.	% min.	% max.
Carbon	0·48	0·58	0·48	0·58
Silicon	—	0·25	—	0·25
Manganese	8·0	10·0	8·0	10·0
Nickel	3·25	4·50	3·25	4·50
Chromium	20·0	22·0	20·0	22·0
Nitrogen	0·38	0·50	0·38	0·50
Sulphur	—	0·035	0·035	0·080
Phosphorus	—	0·040	—	0·040
Carbon plus nitrogen	0·90	—	0·90	—

NOTE. If required these steels may be ordered with a carbon plus nitrogen content of 0·92 % min.

Condition of supply. Rod and bar shall be supplied in the rolled or rolled and stress-relieved condition unless otherwise required by the order.

Material approval test. A test sample up to 1½ in ruling section shall be solution-treated at a temperature within the range 1160–1190 °C followed by quenching in oil or water and precipitation hardening at a temperature within the range 750–850 C for a time not exceeding 15 hours, after which the hardness shall be 321 HB min.

In the case of material ordered with 0·92 % min. carbon plus nitrogen the hardness shall be 352 HB min. after the same heat treatment.

Heat treatment. For valves or parts supplied in the finally heat-treated condition the purchaser may specify one of the following alternative treatments:

(1) Solution-treat at a temperature within the range 1160–1190 C followed by quenching in oil or water.

Precipitation-harden at a suitable temperature between 750 C and 850 °C for a time between 6 hours and 15 hours.

(2) Stress-relieve by heating for 1–2 hours at a temperature within the range 750–850 C followed by air cooling.

CHROMIUM MANGANESE NICKEL NIOBIUM VALVE STEELS
Precipitation Hardening

Chemical composition. The steels shall contain:

Element	Grade 352S52		Grade 352S54	
	% min.	% max.	% min.	% max.
Carbon	0·48	0·58	0·48	0·58
Silicon	—	0·45	—	0·45
Manganese	8·0	10·0	8·0	10·0
Nickel	3·25	4·50	3·25	4·50
Chromium	20·0	22·0	20·0	22·0
Niobium	2·00	3·00	2·00	3·00
Nitrogen	0·38	0·50	0·38	0·50
Sulphur	—	0·035	0·035	0·080
Phosphorus	—	0·040	—	0·040
Carbon plus nitrogen	0·90	—	0·90	—

Condition of supply. Rod and bar shall be supplied in the rolled or rolled and stress-relieved condition unless otherwise required by the order.

Material approval test. A test sample up to 1½ in ruling section shall be solution-treated at a temperature within the range 1170–1200 °C followed by quenching in oil or water and precipitation hardening at a temperature within the range 750–850 °C for a time not exceeding 15 hours, after which the hardness shall be 285 HB min.

Heat treatment. For valves or parts supplied in the finally heat-treated condition the purchaser may specify one of the following alternative treatments:

(1) Solution-treat at a temperature within the range 1170–1200 °C followed by quenching in oil or water.

Precipitation-harden at a suitable temperature between 750 °C and 850 °C for a time between 6 hours and 15 hours.

(2) Stress-relieve by heating for 1–2 hours at a temperature within the range 750–800 °C followed by air cooling.

AUSTENITIC CHROMIUM NICKEL VALVE STEEL (21/11 + N)

Chemical composition. The steel shall contain:

Element	% min.	% max.
Carbon	0·15	0·25
Silicon	0·75	1·25
Manganese	—	1·50
Nickel	10·5	12·5
Chromium	20·0	22·0
Nitrogen	0·15	0·30
Sulphur	—	0·030
Phosphorus	—	0·040

Condition of supply. Rod and bar shall be supplied in the rolled or rolled and stress-relieved condition unless otherwise required by the order.

Material approval test. A test sample up to 1½ in ruling section shall be solution-treated at a temperature within the range 1100–1200°C followed by cooling in air, oil or water, after which the hardness shall be 197 HB min.

Heat treatment. For valves or parts supplied in the finally heat-treated condition the purchaser may specify one of the following alternative treatments:

(1) Solution-treat at a temperature within the range 1100–1200°C followed by cooling in air, oil or water.

Precipitation-harden at a suitable temperature between 750°C and 850°C, for a time between 10 hours and 15 hours followed by cooling in air.

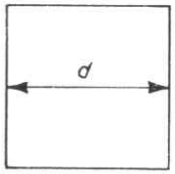
(2) Stress-relieve by heating for 1–2 hours at a temperature within the range 750–850°C followed by air cooling.

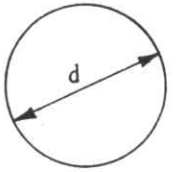
APPENDIX A

STANDARD SIZES AND TOLERANCES FOR ROUND, SQUARE AND HEXAGONAL BRIGHT STEEL BAR—INCH UNITS

A.1 Standard sizes. (For tolerances see Table 6.)

TABLE 5A. STANDARD SIZES FOR ROUND AND SQUARE BRIGHT STEEL BAR—INCH UNITS

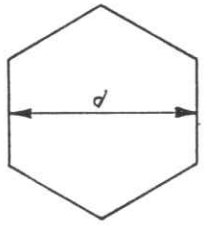




Section	Sizes	Increments at which standard sizes occur
Round	*Diameter, d*	
	½ and up to and including 1	1/32
	1 1/16 and up to and including 2	1/16
	2⅛ and up to and including 3	⅛
	3¼ and over	¼
Square	*Across flats, d*	
	½ and up to and including 1	1/16
	1⅛ and up to and including 2	⅛
	2¼ and over	¼

TABLE 5B. STANDARD SIZES FOR HEXAGONAL BRIGHT STEEL BAR—INCH UNITS

For tolerances see Table 6.



Decimal sizes		
Across flats *d*	Across flats *d*	Across flats *d*
0·525	1·390	2·760
0·600	1·480	3·018
0·710	1·575	3·150
0·820	1·670	3·340
0·920	1·860	3·560
1·010	2·050	
1·100	2·220	
1·200	2·410	
1·300	2·580	

Fractional sizes		
Across flats *d*	Across flats *d*	Across flats *d*
½	1 1/16	1 13/16
9/16	1⅛	1⅞
⅝	1¼	2
1 1/16	1 5/16	2 3/16
¾	1⅜	2¼
1 3/16	1 7/16	2⅜
⅞	1½	2½
1 5/16	1⅝	2¾
1	1¾	3
		3¼

A2. Tolerances

TABLE 6. TOLERANCES FOR ROUND, SQUARE AND HEXAGONAL BRIGHT STEEL BAR—INCH UNITS

Section	Range	Tolerance
Round	*Diameter, d*	
	½ and up to and including ⅞	− 0·003 + 0·000
	Over ⅞ up to and including 2	− 0·004 + 0·000
	Over 2 up to and including 4	− 0·005 + 0·000
	Over 4 up to and including 5	− 0·006 + 0·000
	Over 5	− 0·007 + 0·000
Square	*Across flats, d*	
	½ and up to and including ⅞	− 0·004 + 0·000
	Over ⅞ up to and including 2	− 0·005 + 0·000
	Over 2 up to and including 3	− 0·006 + 0·000
Hexagonal decimal sizes	*Across flats, d*	
	0·525 and up to and including 0·920	− 0·004 + 0·000
	Over 0·920 up to and including 2·050	− 0·005 + 0·000
	Over 2·050 up to and including 3·340	− 0·006 + 0·000
	3·560	− 0·010 + 0·000
Hexagonal fractional sizes	*Across flats, d*	
	½ and up to and including ⅞	− 0·004 + 0·000
	Over ⅞ and up to and including 2	− 0·005 + 0·000
	Over 2 and up to and including 3¼	− 0·006 + 0·000

NOTE. For any special application covered by a British Standard the tolerances given in that standard should apply. If a special application is not covered by a British Standard the tolerances may be as agreed between the manufacturer and the purchaser.

APPENDIX

SUMMARY

TABLE 7. FERRITIC AND MARTENSITIC STAINLESS

Grade	Page reference	C	Si max.	Mn max.	Ni
		%	%	%	%
403S17	20	0·08 max.	0·80	1·00	0·50 max.
430S15	22	0·10 max.	0·80	1·00	0·50 max.
410S21	24	0·09/0·15	0·80	1·00	1·00 max.
420S29	26	0·14/0·20	0·80	1·00	1·00 max.
420S37	28	0·20/0·28	0·80	1·00	1·00 max.
420S45	30	0·28/0·36	0·80	1·00	1·00 max.
416S21	32	0·09/0·15	1·00	1·50	1·00 max.
416S41	32	0·09/0·15	1·00	1·50	1·00 max.
416S29	34	0·14/0·20	1·00	1·50	1·00 max.
416S37	36	0·20/0·28	1·00	1·50	1·00 max.
431S29	38	0·12/0·20	0·80	1·00	2·00/3·00
441S29	40	0·12/0·20	1·00	1·50	2·00/3·00
441S49	40	0·12/0·20	1·00	1·50	2·00/3·00

B

TABLES

STEELS—CHEMICAL COMPOSITION

Cr	Mo max.	S	P max.	Se
%	%	%	%	%
12·0/14·0	—	0·030 max.	0·040	—
16·0/18·0	—	0·030 max.	0·040	—
11·5/13·5	—	0·030 max.	0·040	—
11·5/13·5	—	0·030 max.	0·040	—
12·0/14·0	—	0·030 max.	0·040	—
12·0/14·0	—	0·030 max.	0·040	—
11·5/13·5	0·60	0·15/0·30	0·040	—
11·5/13·5	0·60	0·030 max.	0·040	0·15/0·30
11·5/13·5	0·60	0·15/0·30	0·040	—
12·0/14·0	0·60	0·15/0·30	0·040	—
15·0/18·0	—	0·030 max.	0·040	—
15·0/18·0	0·60	0·15/0·30	0·040	—
15·0/18·0	0·60	0·030 max.	0·040	0·15/0·30

TABLE 8. MARTENSITIC STAINLESS STEELS—MECHANICAL PROPERTIES IN THE HARDENED AND TEMPERED CONDITION RELATED TO TENSILE STRENGTH RANGE

Heat treatment condition symbol		P					R				
Tensile strength range, R_m tonf/in²		35/45					45/55				
Brinell hardness number range, HB		152/207					201/255				
Grade	Page reference	LRS*	R_e*	A*	I*	$R_{p0.2}$*	LRS*	R_e*	A*	I*	$R_{p0.2}$*
410S21	24	2½	24	20	40	22	—	—	—	—	—
		6	24	20	25	22	—	—	—	—	—
420S29	26	—	—	—	—	—	2½	34	15	25	32
		—	—	—	—	—	6	34	15	20	32
420S37	28	—	—	—	—	—	2½	34	15	25	32
		—	—	—	—	—	6	34	15	20	32
420S45†	30	—	—	—	—	—	2½	34	15	25	32
		—	—	—	—	—	6	34	15	20	32
416S21	32	6	24	15	25	22	—	—	—	—	—
416S41	32	6	24	15	25	22	—	—	—	—	—
416S29	34	—	—	—	—	—	6	34	11	20	32
416S37	36	—	—	—	—	—	6	34	11	20	32
431S29	38	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—
441S29	40	—	—	—	—	—	—	—	—	—	—
441S49	40	—	—	—	—	—	—	—	—	—	—

Heat treatment condition symbol		S					T				
Tensile strength range, R_m tonf/in²		50/60					55/65				
Brinell hardness number range, HB		223/277					248/302				
Grade	Page reference	LRS*	R_e*	A*	I*	$R_{p0.2}$*	LRS*	R_e*	A*	I*	$R_{p0.2}$*
410S21	24	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—
420S29	26	1⅛	38	13	20	36	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—
420S37	28	2½	38	13	20	36	—	—	—	—	—
		6	38	13	10	36	—	—	—	—	—
420S45†	30	2½	38	13	20	36	—	—	—	—	—
		6	38	13	10	36	—	—	—	—	—
416S21	32	—	—	—	—	—	—	—	—	—	—
416S41	32	—	—	—	—	—	—	—	—	—	—
416S29	34	1⅛	38	10	10	36	—	—	—	—	—
416S37	36	6	38	10	10	36	—	—	—	—	—
431S29	38	—	—	—	—	—	2½	44	11	25	41
		—	—	—	—	—	6	44	11	15	41
441S29	40	—	—	—	—	—	2½	44	8	15	40
441S49	40	—	—	—	—	—	2½	44	8	15	40

* LRS denotes limiting ruling section in inches.
R_e denotes minimum yield stress in tonf/in².
A denotes elongation—% min. on $5{\cdot}65\sqrt{S_o}$ gauge length.
† This steel is normally used at maximum hardness when the hardness shall be 540 HV min. for ruling sections up to 1⅛ in.
I denotes minimum Izod impact value in ft lbf.
$R_{p0.2}$ denotes minimum 0·2 % proof stress in tonf/in²—only applicable when specifically ordered.

TABLE 9. AUSTENITIC STAINLESS STEELS—CHEMICAL COMPOSITION

Grade	Page reference	C max.	Si	Mn	Ni	Cr	Mo	Ti	Nb	S	P max.	Se
		%	%	%	%	%	%	%	%	%	%	%
304S12	42	0·03	0·20/1·00	0·50/2·00	9·0/12·0	17·5/19·0	—	—	—	0·030 max.	0·045	—
304S15	42	0·06	0·20/1·00	0·50/2·00	8·0/11·0	17·5/19·0	—	—	—	0·030 max.	0·045	—
302S25	42	0·12	0·20/1·00	0·50/2·00	8·0/11·0	17·0/19·0	—	—	—	0·030 max.	0·045	—
321S12	44	0·08	0·20/1·00	0·50/2·00	9·0/12·0	17·0/19·0	—	5C/0·70	—	0·030 max.	0·045	—
321S20	44	0·12	0·20/1·00	0·50/2·00	8·0/11·0	17·0/19·0	—	5C/0·90	—	0·030 max.	0·045	—
347S17	44	0·08	0·20/1·00	0·50/2·00	9·0/12·0	17·0/19·0	—	—	10C/1·00	0·030 max.	0·045	—
315S16	46	0·07	0·20/1·00	0·50/2·00	9·0/11·0	16·5/18·5	1·25/1·75	—	—	0·030 max.	0·045	—
316S12	48	0·03	0·20/1·00	0·50/2·00	11·0/14·0	16·5/18·5	2·25/3·0	—	—	0·030 max.	0·045	—
316S16	48	0·07	0·20/1·00	0·50/2·00	10·0/13·0	16·5/18·5	2·25/3·0	—	—	0·030 max.	0·045	—
320S17	48	0·08	0·20/1·00	0·50/2·00	11·0/14·0	16·5/18·5	2·25/3·0	4C/0·60	—	0·030 max.	0·045	—
317S12	50	0·03	0·20/1·00	0·50/2·00	14·0/17·0	17·5/19·5	3·0/4·0	—	—	0·030 max.	0·045	—
317S16	50	0·06	0·20/1·00	0·50/2·00	12·0/15·0	17·5/19·5	3·0/4·0	—	—	0·030 max.	0·045	—
303S21	52	0·12	0·20/1·00	1·00/2·00	8·0/11·0	17·0/19·0	—	—	—	0·15/0·30	0·045	—
303S41	52	0·12	0·20/1·00	1·00/2·00	8·0/11·0	17·0/19·0	—	—	—	0·030 max.	0·045	0·15/0·30
325S21	52	0·12	0·20/1·00	1·00/2·00	8·0/11·0	17·0/19·0	—	5C/0·90	—	0·15/0·30	0·045	—
326S36	52	0·12	0·20/1·00	1·00/2·00	10·0/13·0	16·5/18·5	2·25/3·0	—	—	0·030 max.	0·045	0·15/0·30
310S24	54	0·15	0·20/1·00	0·50/2·00	19·0/22·0	23·0/26·0	—	—	—	0·030 max.	0·045	—

TABLE 10. AUSTENITIC STAINLESS STEELS—MECHANICAL PROPERTIES IN THE SOFTENED CONDITION

Grade	Page reference	Properties			
		R_m*	A*	HB*	$R_{p0.2}$*
304S12	42	30	40	183	11
304S15	42	30	40	183	11
302S25	42	33	40	183	13·5
321S12	44	32	40	183	12·5
321S20	44	33	40	183	13·5
347S17	44	33	40	183	13·5
315S16	46	30	40	183	11
316S12	48	30	40	183	11
316S16	48	30	40	183	11
320S17	48	32	40	183	12·5
317S12	50	30	40	183	11
317S16	50	30	40	183	11
303S21	52	33	40	183	13·5
303S41	52	33	40	183	13·5
325S21	52	33	40	183	13·5
326S36	52	33	40	183	13·5
310S24	54	35	40	207	14

NOTE. The 1·0 % proof stress will be found to be not less than 2 tonf/in² higher than the 0·2 % proof stress specified above.

* R_m denotes minimum tensile strength in tonf/in².
A denotes elongation, % min. on $5{\cdot}65\sqrt{S_O}$ gauge length.
HB denotes maximum Brinell hardness number.
$Rp_{0.2}$ denotes minimum 0·2 % proof stress in tonf/in², only applicable when specifically ordered.

TABLE 11. AUSTENITIC STAINLESS STEELS—MECHANICAL PROPERTIES IN THE COLD DRAWN CONDITION ACCORDING TO SECTION SIZE

Grade	Page reference	Section size—diameter or width across flats (in)		Properties		
		Over	Up to and including	R_m*	A*	$R_{p0.2}$*
304S15	42	—	¾	56	12	45
304S25	42					
321S12	44	¾	1	51	15	36
321S20	44					
316S16	48	1	1¼	47	20	29
303S21	52					
303S41	52	1¼	1½	45	28	22
325S21	52					
326S36	52	1½	1¾	42	28	20

* R_m denotes minimum tensile strength in tonf/in².
A denotes elongation, % min. on $5{\cdot}65\sqrt{S_o}$ gauge length.
$R_{p0.2}$ denotes minimum 0·2 % proof stress in tonf/in², only applicable when specifically ordered.

TABLE 12. VALVE STEELS—CHEMICAL COMPOSITION

Grade	Page reference	C	Si	Mn	Ni	Cr	Mo	W	Nb	N	C + N min.	S	P max.
		%	%	%	%	%	%	%	%	%	%	%	%
401S45	57	0·40/0·50	3·00/3·75	0·30/0·75	0·50 max.	7·5/9·5	—	—	—	—	—	0·030 max.	0·040
443S65	58	0·75/0·85	1·75/2·25	0·30/0·75	1·20/1·70	19·0/21·0	—	—	—	—	—	0·030 max.	0·040
331S40	59	0·35/0·50	1·00/2·00	0·50/1·00	12·0/15·0	12·0/15·0	—	2·00/3·00	—	—	—	0·030 max.	0·040
331S42	59	0·37/0·47	1·00/2·00	0·50/1·00	13·0/15·0	13·0/15·0	0·40/0·70	2·20/3·00	—	—	—	0·030 max.	0·040
349S52	60	0·48/0·58	0·25 max.	8·0/10·0	3·25/4·50	20·0/22·0	—	—	—	0·38/0·50	0·90	0·035 max.	0·040
349S54	60	0·48/0·58	0·25 max.	8·0/10·0	3·25/4·50	20·0/22·0	—	—	—	0·38/0·50	0·90	0·035/0·080	0·040
352S52	61	0·48/0·58	0·45 max.	8·0/10·0	3·25/4·50	20·0/22·0	—	—	2·00/3·00	0·38/0·50	0·90	0·035 max.	0·040
352S54	61	0·48/0·58	0·45 max.	8·0/10·0	3·25/4·50	20·0/22·0	—	—	2·00/3·00	0·38/0·50	0·90	0·035/0·080	0·040
381S34	62	0·15/0·25	0·75/1·25	1·50 max.	10·5/12·5	20·0/22·0	—	—	—	0·15/0·30	—	0·030 max.	0·040

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