BRITISH STANDARD

BS 1502:1982

Incorporating Amendment Nos. 1 and 2

Specification for

Steels for fired and unfired pressure vessels: sections and bars

UDC 669.14 – 422 – 423:621.772.4

Cooperating organizations

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

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

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

Associated Offices Technical Committee
British Electrical and Allied Manufacturers' Association (BEAMA)
British Gas Corporation
British Industrial Fasteners Federation
British Shipbuilders
British Valve Manufacturers' Association Ltd.
Department of Trade (Marine Division)
Institution of Metallurgists
Ministry of Defence
National Association of Steel Stockholders
Welding Institute
Coopted members

This British Standard, having been prepared under the direction of the Iron and Steel Standards Committee, was published under the authority of the Board of BSI and comes into effect on 30 September 1982

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Contents

Foreword

This edition of BS 1502, prepared under the direction of the Iron and Steel Standards Committee, has been extensively technically revised and metricated. The previous edition published in 1968 has now been withdrawn.

Major technical changes now included are:

the addition of low and medium alloy, and austenitic steels;

the addition of elevated temperature properties;

the inclusion of impact properties.

Requirements for bars used in the manufacture of rivets have now been excluded.

Requirements are specified for carbon, carbon-manganese, low and medium alloy, and austenitic steels in the form of sections and bars for general structural purposes in the manufacture of boilers and pressure vessels. The requirements for bars for forging are included in BS 1503, and those for bars for the manufacture of bolts in BS 1506.

Characteristic minimum elevated temperature yield or proof stress values derived from data or considered appropriate by the responsible BSI committee are specified. However, it is expected that verification by testing will not normally be required although the option to request this is included.

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

In preparing this revision, particular account has been taken of the views expressed by the Technical Committees of the Pressure Vessel Standards Committee.

BS 1502 is one of a set of publications for different steel product forms used for pressure purposes. Others in the series are as follows.

BS 1501, *Steels for fired and unfired pressure vessels Plates.*
BS 1503, *Steel forgings (including semi-finished forged products) for pressure purposes.*
BS 1504, *Steel castings for pressure purposes.*

Not all section forms are necessarily available without restriction and the intending purchaser should make appropriate enquiries of the manufacturer.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 20, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Section 1. General requirements

1 Scope

This British Standard specifies requirements for carbon, carbon-manganese, low and medium alloy, and austenitic steel sections and bars, for fired and unfired pressure vessels.

Section 1 covers the general requirements for these steels and section 2 specifies testing requirements.

Elevated temperature yield or proof stress and stress rupture values are given in Appendix A and Appendix B. For most steel types appropriate impact properties are also specified.

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

2 Designations

The steel shall be designated by the number of this standard [see note to **9.1** a)] and the steel type number/letters, followed when appropriate by the number (the grade) representing the minimum tensile strength, e.g. BS 1502-620–440.

In addition, except for steel type 509 for which impact tests at – 196 °C are mandatory, if impact tests are to be made at temperatures below 0 °C, the suffix LT followed by a number representing the temperature below zero, in °C, at which tests are to be made shall be added to indicate the required impact properties. If impact tests are to be made at 0 °C the suffix LT0 shall be added. If impact tests are to be made at room temperature the suffix RT shall be added.

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

Examples

a) BS 1502-224–430 LT30 designates fully killed, aluminium treated, carbon-manganese steel of type 224 and grade 430, having the tensile properties at room temperature specified in Table 3 and the Charpy V-notch impact properties at – 30 °C specified in Table 6.

b) BS 1502–620–540 designates 1 % chromium, 0.5 % molybdenum steel having the tensile properties at room temperature specified in Table 4.

3 Information to be supplied by the purchaser

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

a) the full material designation (see clause **2**);

b) the dimensions of the bar or section;

c) quantity required;

d) optional requirements (see **3.2**).

Table 1 — Property options

Steel	Specified room temperature tensile tests	Options (see note 1)		
		Elevated temperature tensile tests	Impact tests	Others
151	M	X	—	—
161	M	X	—	—
211	M	X	X	—
221	M	X	X	—
224 (grades 430, 490)	M	X	X	—
271	M	X	X	X (see note 2)
509 (grades 650, 690)	M	—	M	—
620 (grades 440, 470 and 540)	M	X	X	X (see note 2)
622	M	X	X	X (see note 2)
625 (grades 590, 640)	M	X	X	X (see note 2)
629	M	X	X	X (see note 2)
Austenitic steels	M	X	X	X (see note 3)

NOTE 1 — indicates that the option is not available.
X indicates that an option is available.
M indicates that the test is always carried out.
NOTE 2 An option to specify hardness and associated tensile tests is available (see **15.3.3**).
NOTE 3 An option to specify intercrystalline corrosion tests is available, for all austenitic steels except 304S51, 316S51 and 316S53.

3.2 Options. If the purchaser wishes to take up any of the optional requirements 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 be permitted to assume the following:

a) *General*

1) The steel may be made by the open hearth, electric or one of the basic oxygen processes (see **4.1**).

2) Product analysis is not required (see **5.2**).

3) The purchaser or his representative does not wish to visually inspect the products, select test samples or witness tests (see clause **12**).

4) The normal dimensional tolerances apply (see clause **13**).

b) *Testing*

1) Brinell hardness tests and associated tensile tests are not required for low and medium alloy steels (see **15.3.3.2**).

2) Intercrystalline corrosion tests on austenitic steels are not required (see **16.4**).

3) Elevated temperature tensile tests are not required (see **17.2**).

c) *Specific steels*

1) For steels 151 and 211, semi-killed steel is not specifically required (see Table 3 and its associated note 5).

2) For steels 271, 620–440, 620–470, 622 and 625–590, supply in either normalized and tempered or quenched and tempered conditions are permitted (see Table 4).

4 Manufacture of the steel

4.1 Steelmaking process. The steelmaking process shall be at the option of the steelmaker unless a particular process is specified by the purchaser, agreed with the steelmaker and stated on the order. Air and air-oxygen bottom blown basic converter processes shall not be used.

4.2 Deoxidation. The deoxidation practice for carbon and carbon-manganese steels shall be as specified in Table 3, for the relevant steel type. All alloy and stainless steels shall be fully killed.

5 Chemical composition

5.1 Ladle analysis. The chemical composition of the steel shall be determined by ladle analysis and shall comply with the requirements for the relevant material specification given in Table 3, Table 4 or Table 5.

5.2 Product analysis. If specified by the purchaser in his enquiry and order, analysis of the finished material shall be carried out on either the test sample used for verification of the mechanical properties or, at the option of the manufacturer, on material taken from the same location as that used for samples for mechanical testing. The number of samples to be taken for analysis and the elements to be determined shall be as agreed at the time of the enquiry and order, and shall be detailed on the order.

The permitted deviations for product analysis specified in Table 7 to Table 9 shall be applicable to the specified chemical composition limits given for the relevant material in Table 3, Table 4 or Table 5.

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

6 Condition of supply

The material shall be supplied in the relevant condition given in Table 3, Table 4 or Table 5. Where alternative conditions are available, the choice shall be at the option of the manufacturer unless otherwise agreed.

Austenitic stainless steels shall be delivered in the solution treated and quenched condition.

7 Freedom from defects

7.1 Bars

The bars shall be reasonable straight, and shall be sound and free from such segregation, cracks, laminations, or surface flaws as might preclude their use for the purpose intended.

Removal of surface imperfections shall be by mechanical means. After such treatment the bars shall comply with the requirements of clause **13**.

7.2 Sections

7.2.1 *Surface condition.* The surface condition of sections shall comply with the requirements of BS EN 10163-3.

7.2.2 *Internal soundness.* The sections shall be reasonably straight, and shall be sound and free from such internal defects as might preclude their use for the purpose intended.

8 Marking

8.1 Except as stated in **8.3**, each section or bar shall be legibly marked with the following:

a) manufacturer's name or trade mark;

b) a reference number by which the section or bar and the manufacturer's certificate can be related;

c) the designation for the steel type (see Table 3 to Table 5) and the suffix designating impact tests (see clause **2**), e.g. "224-430-LT50".

8.2 Marking of items b) and c) shall be by stamping, painting or by the use of durable adhesive labels at the option of the manufacturer unless one of these is agreed at the time of the enquiry and order. If paint is used it shall be commercially free from lead, copper, zinc and tin. The manufacturer's name or trade mark shall be marked by one of the above methods or by rolling in relief on the surface of sections.

8.3 Unless otherwise agreed, for bars or sections that are bundled or boxed, the information given in **8.1** shall be marked on the box or on a tag securely attached to the bundle or box.

9 Manufacturer's certificate

9.1 Supply by manufacturer. The manufacturer of the sections or bars shall supply a certificate stating:

a) the number of this British Standard;

NOTE Marking BS 1502 on or in relation to a product is a claim by the manufacturer that the product has been manufactured and supplied in accordance with the requirements and provisions specified in the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility.

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

c) the ladle analysis in respect of all specified elements (see **5.1** and Table 3 to Table 5 as appropriate);

d) the product analysis if required (see **5.2**);

e) the heat treatment, if any, given to the sections or bars (see clause **6**);

f) the reference number of each batch of sections or bars and its cast number (see **8.1**);

g) for sections or bars having specified impact properties, the temperature at which the impact tests were made and the results obtained (see **17.3**);

h) the results of the room temperature mechanical tests (see **17.1**);

i) if elevated temperature tests were made, the temperature of the test and the yield or proof stress value obtained (see **17.2**);

j) the results of any special tests;

k) whether the product contains any thinned areas as indicated by surface markings (see **13.2**).

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

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

10 Delivery

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

11 Defects revealed after delivery

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

12 Inspection

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

If stated on the enquiry and order, the purchaser shall be allowed to inspect visually the items produced for his order, to select the test samples in accordance with clause **15** and to witness the tests, or any of these.

13 Dimensional tolerances

13.1 The dimensional tolerances of all sections shall comply with the requirements of BS 4360.

The dimensional tolerances of bars shall comply with the requirements of BS 4360 in the case of carbon and carbon-manganese steels, and BS 970-2 and BS 970-4 in the case of alloy and austenitic steels respectively.

13.2 Should any product be reduced locally below the specified thickness during rolling or dressing, the position of the thinned areas shall be carefully marked and indicated to the purchaser, and the marks shall be referred to in the test certificate.

NOTE Such product may be accepted as complying with the requirements of this standard provided that in all other respects it is satisfactory and that the purchaser and inspecting authority are satisfied that though locally reduced in thickness it would, by virtue of its actual mechanical properties and any design factors, fully meet the strength requirements of the application standard.

Section 2. Testing requirements

14 Testing facilities

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

15 Selection, number, position, heat treatment and preparation of test pieces

15.1 General. The tests required, as indicated by the designation or otherwise specified (see clause **3** and Table 1), shall be carried out according to the requirements of this section.

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

15.3 Number of test samples

15.3.1 *Carbon and carbon-manganese steels supplied in the specified as-rolled condition.* For each 10 tonnes (or part thereof) of section or bar of each size rolled from each cast, one test sample shall be selected. If a 10 tonne batch comprises more than 20 lengths, two test samples taken from different lengths shall be selected from that batch.

15.3.2 *Carbon and carbon-manganese steels supplied in a specified finally heat treated condition.* For each 10 tonnes (or part thereof) of section or bar of the same cross section, rolled from each cast, and heat treated together, one test sample shall be selected.

15.3.3 ***Low and medium alloy steel***

15.3.3.1 For each batch of sections or bars of the same cross section, rolled from each cast, and heat treated together, one test sample shall be selected.

15.3.3.2 In addition, if specified on the order, Brinell hardness tests shall be made on 10 % of the sections and bars within a batch. It may further be specified at the time of order that tensile and impact tests shall be made on those sections and bars found to be either the hardest or the softest. Brinell hardness tests shall be carried out according to the requirements of BS 240-1.

15.3.4 *Austenitic steels.* For each batch of sections or bars of the same cross section, rolled from the same cast, and heat treated together, one test sample shall be selected.

15.4 Position of samples for sections and flat bars

15.4.1 *Tensile test samples.* The samples shall be taken from the positions indicated in Figure 1. In the case of universal beams, columns and bearing piles, and joists the samples may be taken from the web or flange at the manufacturer's option.

15.4.2 *Impact test samples.* The samples shall be taken from the positions indicated in Figure 2.

15.5 Heat treatment of test samples

15.5.1 Samples shall be cut from the sections or bars, after final heat treatment where specified, and shall not be heat treated further.

15.5.2 When alloy or austenitic stainless steel is ordered and supplied in a condition other than the final heat treated condition, one sample shall be taken at random for cast approval and reduced by forging or machining to the largest ruling section at the final heat treatment stage. This test bar shall be given the appropriate heat treatment for the grade as detailed in Table 4 and Table 5. For the purpose of subsequent orders this test shall be taken as representing all sizes of material from the same cast where the ruling section of the final parts does not exceed the ruling section of the test bar already tested.

15.6 Preparation of test pieces

15.6.1 *General.* All test pieces shall be cut with their longitudinal axes parallel to the direction of rolling. Any straightening of test pieces that may be required shall be done cold.

15.6.2 *Room temperature tensile test pieces*

15.6.2.1 *Preparation.* From each sample a tensile test piece shall be prepared in accordance with the requirements of BS EN 10002-1.

15.6.2.2 *Sections, and carbon and carbon-manganese steel flat bars.* Whenever practicable, the rolled surfaces of the steel shall be retained on two opposite sides of the test piece. Where this is impracticable, round or rectangular test pieces shall be used.

15.6.2.3 *Bars, other than carbon and carbon-manganese steel flat bars.* For sizes up to and including 25 mm between flats or diameter, the test piece shall be machined coaxially from the test sample.

For sizes over 25 mm, the longitudinal axis of the test piece shall be 12.5 mm from the surface of the bar.

15.6.3 *Elevated temperature tensile test pieces.* When required (see **17.2**), the test pieces shall be prepared in accordance with the requirements of BS 3688-1.

For each product and size and from each cast used for the order, a test piece shall be cut from one length of the section or the bar used for a room temperature tensile test, except that in the case of austenitic steels a test piece shall be cut from the largest section of each cast used for the order.

The test piece position shall be as specified for room temperature tensile test pieces.

15.6.4 *Impact test pieces.* When required, three impact test pieces shall be prepared from each test sample in accordance with the requirements of BS EN 10045-1. The axis of the notch shall be perpendicular to the rolled surface of the product.

In the case of sections and flat bars, the impact test pieces shall not include material nearer to the surface than 3 mm for thicknesses of 20 mm or greater, or 1 mm for thicknesses of less than 20 mm.

In the case of other bars, the test pieces shall be machined coaxially from the bar for diameters or thicknesses up to and including 25 mm. For larger bar sizes the longitudinal axes of the test pieces shall be 12.5 mm from the bar surface.

For material that is too thin to permit standard test pieces to be cut, the largest feasible subsidiary standard test piece specified in BS EN 10045-1 shall be used.

NOTE Impact tests are not required for material less than 6 mm thick, nor for round bars that are too small in diameter for standard impact test pieces to be cut.

16 Test methods

16.1 Tensile tests at room temperature. Tensile tests at room temperature shall be carried out in accordance with the requirements of BS EN 10002-1.

The tensile strength R_m, the yield strength R_e and elongation A shall be determined.

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

Austenitic steels. For the yield strength R_e, either the 1.0 % proof stress ($R_{p1.0}$) or the 1.0 % total elongation proof stress ($R_{t1.0}$) shall be determined. However, in cases of dispute $R_{p1.0}$ shall be measured.

Elongation values shall be reported on a gauge length of $5.65\sqrt{S_o}$[1)], using conversion tables in BS 3894-1 where necessary except that in the case of steels not covered by BS 3894-1, the conversion method shall be agreed between the manufacturer and the purchaser. In cases of dispute, elongation shall be measured on a gauge length of $5.65\sqrt{S_o}$.

16.2 Tensile test at elevated temperature. If in special circumstances (see **17.2**) tensile tests at elevated temperatures are required by the purchaser, these shall be carried out as specified in BS 3688-1 at a temperature selected from Appendix A, and stated on the order, or at an agreed intermediate temperature (see **17.2**).

At any particular temperature the greater of the lower yield stress R_{eL} or of the 0.2 % proof stress $R_{p0.2}$ shall be taken as the criterion of acceptance. For austenitic steels the criterion of acceptance shall be the 1.0 % proof stress $R_{p1.0}$.

16.3 Impact tests. Impact tests shall be carried out in accordance with the requirements of BS EN 10045-1 as required by the material specification or order. The test temperature shall be selected from those for which minimum impact values are specified in Table 6 for the relevant type of steel.

16.4 Intercrystalline corrosion test. If specified and agreed at the time of enquiry and order, an intercrystalline corrosion test shall be carried out on austenitic steels. One test per cast and per heat treatment batch shall be made on the bar having the largest equivalent diameter in the batch.

A test piece shall be prepared in accordance with BS 5903 and sensitized by heating at a temperature of 650 °C for the time specified in Table 5, followed by cooling rapidly in air. The test piece shall then be tested in accordance with BS 5903.

17 Test results

17.1 Mechanical properties at room temperature. The room temperature tensile test results shall comply with the requirements of the relevant material specification in Table 3, Table 4 or Table 5.

[1)] S_o is the original cross-sectional area of the gauge length.

17.2 Mechanical properties at elevated temperature. The elevated temperature yield or proof stress values are not normally subject to verification by testing but if in special cases verification by testing is required, this shall be agreed at the time of the enquiry and order, and the results obtained shall comply with the requirements for the relevant material given in Appendix A. In the case of tests carried out at temperatures intermediate to those given in Appendix A, the value to be obtained shall be determined by linear interpolation.

NOTE Estimated average stress rupture values are given for information in Appendix B.

17.3 Impact properties

17.3.1 *Standard test pieces.* The average value obtained from the three tests from each sample shall be not less than the value specified for the relevant material at the appropriate test temperature (see Table 6). One individual value may be below the specified value but no individual value shall be less than 70 % of that value.

17.3.2 *Subsidiary standard test pieces.* In the case of subsidiary standard test pieces the values to be obtained, equivalent to impact values for standard test pieces, shall be as given in Table 2.

Table 2 — Impact test values for subsidiary standard test pieces

Specified average value for standard test pieces	Equivalent average value for subsidiary standard test pieces	
10 mm × 10 mm	10 mm × 7.5 mm	10 mm × 5 mm
J	J	J
27	22	19
31	25	22
34	27	24
41	33	29

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

18 Retests

18.1 Room temperature and elevated temperature tensile tests. Should a test piece not fulfil any of the test requirements, two further tests shall be made on samples taken from the section or bar from which the original test piece was prepared.

Provided the results of both these further tests fulfil the test requirements, all the material represented shall be deemed to comply with this standard.

If the results of either of these additional tests do not fulfil the test requirements, the section or bar from which the test pieces were cut shall be deemed not to comply with this standard, but the remaining material represented may be deemed to comply, provided that two of the remaining sections or bars are tested in accordance with this standard and meet its requirements.

In the case of cast approval testing when the test samples only are heat treated (see **15.5.2**), should the original test piece fail due to incorrect heat treatment, a further sample or samples shall be prepared and heat treated within the limits detailed in Table 4 or Table 5.

18.2 Impact tests

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

18.2.2 If tests taken as described in **18.2.1** fail to meet the specified requirements, this shall not prejudice the acceptance of other material in the batch provided that impact tests are made on each rolled length, or separately heat treated fraction of each rolled length in the case of heat treated material. Each length so tested shall be deemed to be acceptable if the test results meet the requirements of this standard.

18.3 Reheat treatment. Where a material is supplied in the heat treated condition, the manufacturer shall be permitted to reheat treat the material, including that already found not to fulfil the test requirements, and resubmit for testing in accordance with the requirements of clauses **15** and **16**. Where a material is normally supplied and tested as-rolled the manufacturer shall be permitted to normalize and resubmit the material for testing, as above.

Table 3 — Chemical composition (ladle analysis), deoxidation, mechanical properties at room temperature and supply condition for carbon and carbon-manganese steels

Steel type		Chemical composition (see note 1)									Deoxidation	Mechanical properties						Supply condition (see notes 2 and 3)
Description	Designation	C		Si		Mn		P max.	S max.	Al (metallic) min.		Nominal thickness (see note 4)		R_e min.	R_m		A	
		min.	max.	min.	max.	min.	max.					Over	Up to and including		min.	max.		
		%	%	%	%	%	%	%	%	%		mm	mm	N/mm^2	N/mm^2	N/mm^2	%	
Carbon	151	—	0.25	—	0.35	0.60	1.40	0.040	0.040		Semi-killed or fully killed (see note 5)		25(16)	250	430	550	22	AR or N
												25(16)	63(40)	240	430	550	22	
Carbon	161	—	0.25	0.10	0.35	0.60	1.40	0.040	0.040		Fully killed	63(40)	100(63)	230	430	550	21	AR or N
Carbon-manganese	211	—	0.19	—	0.35	0.90	1.50	0.040	0.040		Semi-killed or fully killed (see note 5)	100(63)	160(100)	220	430	550	20	AR or N
Carbon-manganese	221	—	0.19	0.10	0.35	0.90	1.50	0.040	0.040		Fully killed							AR or N
Carbon-manganese (Al treated)	224–430	—	0.17	0.10	0.40	0.90	1.50	0.040	0.040	0.015 (see note 6)	Fully killed		25(16)	275	430	550	22	N
												25(16)	63(40)	265	430	550	22	
												63(40)	100(63)	245	430	550	21	
												100(63)	160(100)	240	430	550	20	
Carbon-manganese (Al treated)	224–490	—	0.22	0.10	0.40	0.90	1.50	0.040	0.040	0.015 (see note 6)	Fully killed		25(16)	325	490	610	22	N
												25(16)	63(40)	315	490	610	22	
												63(40)	100(63)	305	490	610	21	
												100(63)	160(100)	300	490	610	20	

NOTE 1 The maximum permitted levels of the following residual elements are:

chromium	0.25 %	Total 0.70 % max.
copper	0.30 %	
molybdenum	0.10 %	
nickel	0.30 %	

NOTE 2 AR = As rolled; N = Normalized.

NOTE 3 Normalized sections can be supplied by agreement only.

NOTE 4 Thicknesses in parentheses apply to sections and flat bars.

NOTE 5 May be semi-killed or fully killed at the manufacturer's option except when semi-killed steel is specifically required and the supply is agreed at the time of the enquiry and order.

NOTE 6 Determination of the total aluminium is deemed to meet this requirement provided the value obtained is not less than 0.018 %.

Table 4 — Chemical composition (ladle analysis), mechanical properties at room temperature and heat treatment and supply condition for alloy steels (see note 1)

Steel type		Chemical composition															Limiting ruling section	Mechanical properties				Heat treatment (see note 2)		
Description	Designation	C		Si		Mn		P max.	S max.	Cr		Mo		Ni		Others		R_e min.	R_m		A	Austenitizing temperature	Temper temperature	Supply condition
		min.	max.	min.	max.	min.	max.			min.	max.	min.	max.	min.	max.				min.	max.				
		%	%	%	%	%	%	%	%	%	%	%	%	%	%		mm	N/mm^2	N/mm^2	N/mm^2	%	°C	°C	
Manganese-chromium Molybdenum-vanadium	271	—	0.17	0.15	0.40	1.00	1.50	0.040	0.040	0.50	1.00	0.20	0.35	0.30	0.70	Vanadium 0.05–0.10 Al (met.) 0.020 max. (see note 3)	160	370	560	710	17	900–950	625–675	N + T or Q + T
1 % Chromium 0.5 % Molybdenum	620–440	0.10	0.18	0.15	0.40	0.40	0.70	0.040	0.040	0.80	1.20	0.45	0.65	—	—	Al (met.) 0.020 max. (see note 3)	160	265	440	590	19	900–960	630–720	N + T or Q + T
	620–470	0.10	0.18	0.15	0.40	0.40	0.70	0.040	0.040	0.80	1.20	0.45	0.65	—	—	Al (met.) 0.020 max. (see note 3)	160	300	470	620	18	900–960	630–720	N + T or Q + T
	620–540	0.10	0.18	0.15	0.40	0.40	0.70	0.040	0.040	0.80	1.20	0.45	0.65			0.020 max. (see note 3)	160	375	540	690	18	900–960	620–720	Q + T
2.25 % Chromium 1% Molybdenum	622	0.08	0.15	0.15	0.50	0.40	0.70	0.040	0.040	2.00	2.50	0.90	1.20	—	—	Al (met.) 0.020 max. (see note 3)	160	275	490	640	18	900–960	650–750	N + T or Q + T
5 % Chromium- 0.5 % Molybdenum	625–590	0.10	0.18	0.15	0.50	0.30	0.60	0.030	0.030	4.00	6.00	0.45	0.65	—	—	Al (met.) 0.020 max. (see note 3)	160	450	590	740	17	925–975	650–750	N + T or Q + T
	625–640	0.10	0.18	0.15	0.50	0.30	0.60	0.030	0.030	4.00	6.00	0.45	0.65	—	—	0.020 max. (see note 3)		500	640	790	15	925–975	650–750	Q + T
9 % Chromium- 1 % Molybdenum	629–590	0.08	0.15	0.25	1.00	0.30	0.60	0.030	0.030	8.0	10.0	0.90	1.10	—	—	Al (met.) 0.020 max. (see note 3)	160	400	590	740	16	900–1 000	700–800	N + T
9 % Nickel	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.) 0.015 min. (see note 4)	75	490	650	850	18	880–930 770–820	540–600	N + N + T
	509–690	—	0.10	0.15	0.35	0.30	0.80	0.025	0.020		0.25		0.10	8.5	10.0	0.015 min. (see note 4)	100	580	690	850	17	770–820	540–600	Q + T

NOTE 1 The supply of sections, for which production facilities are very limited, is by special agreement only.
NOTE 2 N = Normalized; Q = Quenched; T = Tempered.
NOTE 3 Determination of total aluminium is deemed to meet this requirement provided the value obtained does not exceed 0.020 %.
NOTE 4 Determination of total aluminium is deemed to meet this requirement provided the value obtained is not less than 0.018 %.

Table 5 — Chemical composition (ladle analysis), mechanical properties at room temperature, heat treatment and sensitization times for austenitic stainless steels (see note 1)

Steel type		Chemical composition													Limiting ruling section	Mechanical properties			Heat treatment		
Description	Designation	C		Si	Mn	P	S	Cr		Mo		Ni		Others		R_e	R_m	A	Condition (see note 2)	Solution temperature (see note 3)	Sensitization
		min.	max.	max.	max.	max.	max.	min.	max.	min.	max.	min.	max.			min.	min.	min.			
		%	%	%	%	%	%	%	%	%	%	%	%	%	mm	N/mm^2	N/mm^2	%		°C	min
18 % chromium 10 % nickel	304S11	—	0.03	1.0	2.0	0.045	0.030	17.0	19.0			9.0	12.0		160	215	480	40	q	1 000–1 100	30
	304S31	—	0.07	1.0	2.0	0.045	0.030	17.0	19.0			8.0	11.0		160	230	490	40	q	1 000–1 100	15
	304S51	0.04	0.10	1.0	2.0	0.045	0.030	17.0	19.0			8.0	11.0		160	230	490	40	q	1 000–1 125	N/A (see note 4)
	304S61	—	0.03	1.0	2.0	0.045	0.030	17.0	19.0			8.5	11.5	N 0.12–0.22	160	305	550	35	q	1 000–1 100	30
	304S71	—	0.07	1.0	2.0	0.045	0.030	17.0	19.0			8.0	11.0	N 0.12–0.22	160	305	550	35	q	1 000–1 100	15
18 % chromium 12 % nickel molybdenum	316S11	—	0.03	1.0	2.0	0.045	0.030	16.5	18.5	2.00	2.50	11.0	14.0		160	225	490	40	q	1 000–1 100	30
	316S13	—	0.03	1.0	2.0	0.045	0.030	16.5	18.5	2.50	3.00	11.5	14.5		160	225	490	40	q	1 000–1 100	30
	316S31	—	0.07	1.0	2.0	0.045	0.030	16.5	18.5	2.00	2.50	10.5	13.5		160	240	510	40	q	1 000–1 100	15
	316S33	—	0.07	1.0	2.0	0.045	0.030	16.5	18.5	2.50	3.00	11.0	14.0		160	240	510	40	q	1 000–1 100	15
	316S51	0.04	0.10	1.0	2.0	0.045	0.030	16.5	18.5	2.00	2.50	10.5	13.5		160	240	510	40	q	1 000–1 100	N/A (see note 4)
	316S53	0.04	0.10	1.0	2.0	0.045	0.030	16.5	18.5	2.50	3.00	11.0	14.0		160	240	510	40	q	1 000–1 100	N/A (see note 4)
18 % chromium 12 % nickel molybdenum (nitrogen containing)	316S61	—	0.03	1.0	2.0	0.045	0.030	16.5	18.5	2.00	2.50	10.5	13.5	N 0.12–0.22	160	315	580	35	q	1 000–1 100	30
	316S63	—	0.03	1.0	2.0	0.045	0.030	16.5	18.5	2.50	3.00	11.5	14.5	N 0.12–0.22	160	315	580	35	q	1 000–1 100	30
	316S65	—	0.07	1.0	2.0	0.045	0.030	16.5	18.5	2.00	2.50	10.0	13.0	N 0.12–0.22	160	315	580	35	q	1 000–1 100	15
	316S67	—	0.07	1.0	2.0	0.045	0.030	16.5	18.5	2.50	3.00	10.5	13.5	N 0.12–0.22	160	315	580	35	q	1 000–1 100	15
18 % chromium 10 % nickel titanium	321S31	—	0.08	1.0	2.0	0.045	0.030	17.0	19.0			9.0	12.0	Ti 5 × C – 0.08	160	235	510	35	q	1 000–1 100	30
	321S51–490	0.04	0.10	1.0	2.0	0.045	0.030	17.0	19.0			9.0	12.0	Ti 5 × C – 0.08	160	190	490	35	q	1 070–1 140	30
	321S51–510	0.04	0.10	1.0	2.0	0.045	0.030	17.0	19.0			9.0	12.0	Ti 5 × C – 0.08	160	235	510	35	q	950–1 070	30
18 % chromium 10 % nickel niobium	347S31	—	0.08	1.0	2.0	0.045	0.030	17.0	19.0			9.0	12.0	Nb 10 × C – 1.0	160	240	510	30	q	1 000–1 100	30
	347S51	0.04	0.10	1.0	2.0	0.045	0.030	17.0	19.0			9.0	12.0	Nb 10 × C – 1.2	160	240	510	30	q	1 050–1 125	30

NOTE 1 The supply of sections, for which production facilities are very limited, is by special agreement only.

NOTE 2 Cooled in oil, water or air (rapidly).

NOTE 3 Provided free cooling of the product from hot working does not lead to the formation of carbide precipitates, sigma or other detrimental phases, and the requirements for the mechanical and intercrystalline corrosion tests are satisfied, the specified solution treatment may be omitted.

NOTE 4 N/A = intercrystalline corrosion test not applicable.

Table 6 — Charpy V-notch impact properties

Steel	Maximum thickness		Minimum average value at a test temperature in °C of							Notes
	Bars excluding flat bars	Sections and flat bars	RT	0	– 20	– 30	– 40	– 50	– 196	
	mm	mm	J	J	J	J	J	J	J	
151			Not specified							—
161			Not specified							—
211	80	50	41	27	—	—	—	—	—	see note 1
221	80	50	41	27	—	—	—	—	—	see note 1
224	80	50	55	55	47	41	31	27	—	see note 1
271	160	160	41	—	—	—	—	—	—	see note 1
620–440 N + T	160	160	27	—	—	—	—	—	—	see note 1
620–440 Q + T	160	160	41	—	—	—	—	—	—	see note 1
620–470 N + T	160	160	27	—	—	—	—	—	—	see note 1
620–470 Q + T	160	160	41	—	—	—	—	—	—	see note 1
620–540	160	160	41	—	—	—	—	—	—	see note 1
622	160	160	41	—	—	—	—	—	—	see note 1
625–590	160	160	41	—	—	—	—	—	—	see note 1
629	160	160	27	—	—	—	—	—	—	see note 1
509 N + N + T	75	75	—	—	—	—	—	—	42	see note 1
509 Q + T	100	100	—	—	—	—	—	—	27	see note 1
Austenitic stainless (see note 3)	160	160	—	—	—	—	—	—	70	see notes 1 and 3
Nitrogen bearing austenitic stainless (see note 4)	160	160	—	—	—	—	—	—	60	see notes 1 and 4

NOTE 1 The values are applicable only when the purchaser specifies that tests are to be carried out (see clause **2**).
NOTE 2 Impact tests are always carried out (see Table 1).
NOTE 3 Excluding the nitrogen bearing steels 304S61, 304S71, 316S61, 316S63, 316S65 and 316S67.
NOTE 4 Applies to steels 304S61, 304S71, 316S61, 316S63, 316S65 and 316S67.

Table 7 — Permitted deviation from the specified composition: carbon and carbon-manganese steels

Element	Specified range	Permissible deviation from the specified range
	%	%
Carbon	Up to and including 0.25	0.03
Silicon	Up to and including 0.40	– 0.05 + 0.05
Manganese	Up to and including 1.50	0.10
Phosphorus	Up to and including 0.030	0.005
Sulphur	Up to and including 0.050	0.005

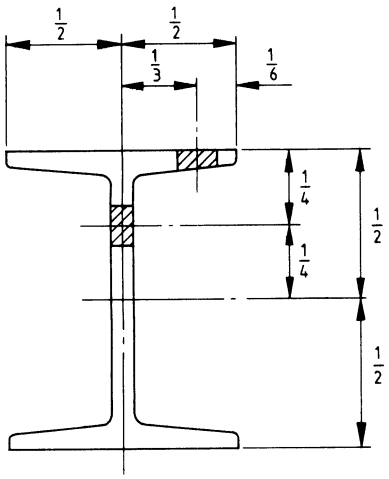
NOTE These deviations, other than when maxima only are specified, apply either above or below the specified limits of the range but not both above and below for the same element from different sample products from the same cast.

Table 8 — Permitted deviation from the specified composition: low and medium alloy steels (see note to Table 7)

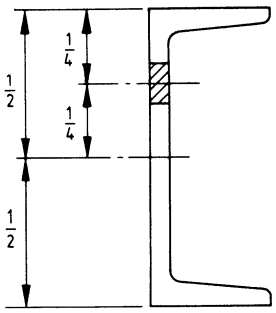
Element	Specified range	Permissible deviation from the specified range
	%	%
Carbon	Up to and including 0.18	0.01
Silicon	Up to and including 0.50 Over 0.50 up to and including 1.0	0.04 0.05
Manganese	Up to and including 1.00 Over 1.00 up to and including 1.50	0.04 0.08
Phosphorus	Up to and including 0.040	0.004
Sulphur	Up to and including 0.040	0.004
Chromium	Up to and including 1.25 Over 1.25 up to and including 2.50 Over 2.50 up to and including 10.0	0.04 0.05 0.10
Molybdenum	Up to and including 0.65 Over 0.65 up to and including 1.20	0.03 0.05
Nickel	Up to and including 1.0 Range 8.5 to 10.0	0.03 0.10
Vanadium	0.05 to 0.10 inclusive	0.02

Table 9 — Permitted deviation from the specified composition: austenitic stainless steels (see note to Table 7)

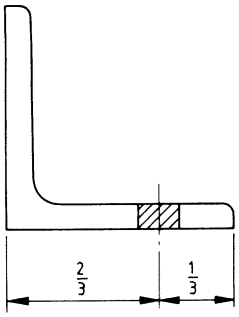
Element	Specified range	Permissible deviation from the specified range
	%	%
Carbon	Up to and including 0.03 Over 0.03 up to and including 0.10	0.005 0.01
Silicon	Up to and including 1.0	0.05
Manganese	Up to and including 2.0	0.04
Phosphorus	Up to and including 0.045	0.004
Sulphur	Up to and including 0.030	0.003
Chromium	Up to and including 19.0	0.20
Molybdenum	Up to and including 3.0	0.08
Nickel	Up to and including 14.5	0.15
Titanium	All ranges	0.05
Niobium	All ranges	0.05
Nitrogen	All ranges	0.01



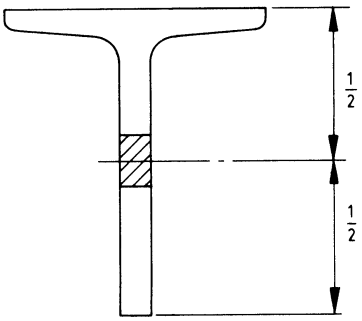
(a) Universal beams, columns, and bearing piles and joists



(b) Channels

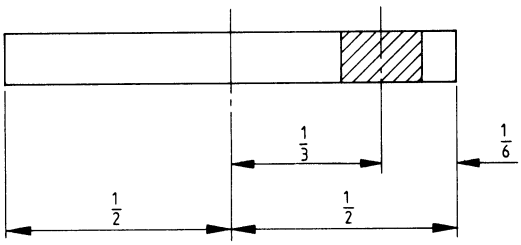


(c) Angles

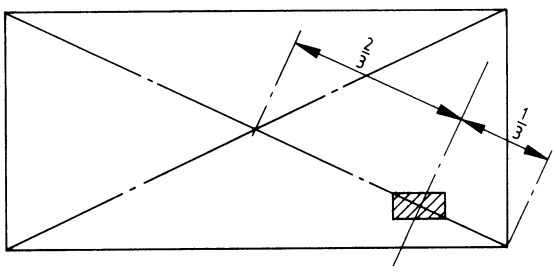


(d) T-bars

NOTE The test sample may be taken from either leg of unequal angles

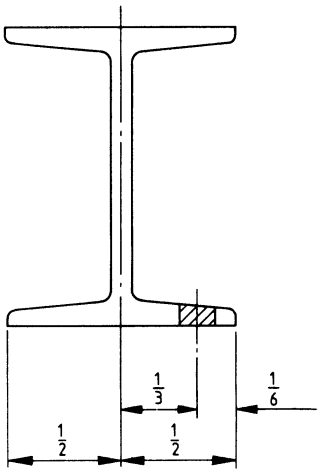


(e) Flat bars

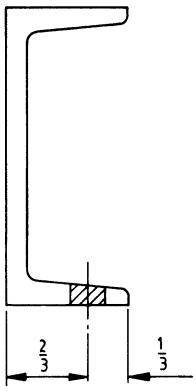


(f) Flat bars: alternative sample position

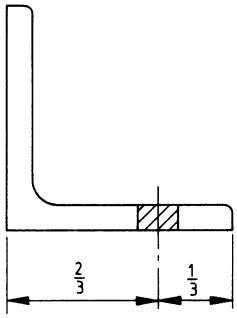
Figure 1 — Positions of test samples for tensile tests: sections and flat bars



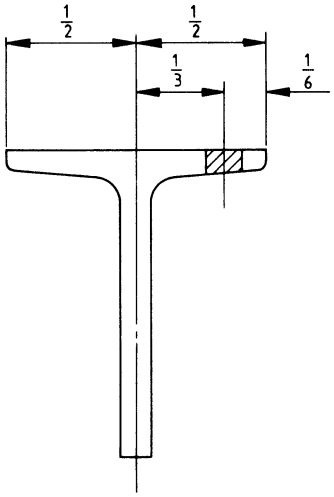
(a) Universal beams, columns, and bearing piles and joists



(b) Channels

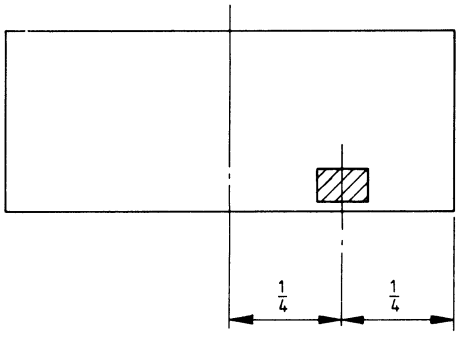


(c) Angles



(d) T-bars

NOTE The test sample may be taken from either leg of unequal angles



(e) Flat bars

Figure 2 — Positions of test samples for impact tests: sections and flat bars

Appendix A Characteristic elevated temperature yield stress or proof stress values

The values of elevated temperature yield stress or proof stress are given in Table 10 to Table 12. They are characteristic minimum values subject to accepted confidence limits.

Table 10 — Minimum lower yield stress (R_{eL}) or minimum proof stress ($R_{p0.2}$) at elevated temperatures: carbon and carbon-manganese steels

Steel	Nominal thickness (see note) R_{eL} min. or $R_{p0.2}$ min. at a temperature in °C of							
	Over	Up to and including	150	200	250	300	350	400
	mm	mm	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
151, 161, 211, 221	—	25 (16)	222	215	192	161	153	148
	25 (16)	50 (40)	210	202	181	161	153	148
	50 (40)	100 (63)	200	192	178	161	153	148
	100 (40)	160 (100)	186	181	172	161	153	148
224–430	—	25 (16)	229	205	182	162	152	143
	25 (16)	50 (40)	224	203	182	162	152	143
	50 (40)	100 (63)	217	199	182	162	152	143
	100 (63)	160 (100)	212	196	182	162	152	143
224–490	—	25 (16)	265	240	213	192	182	173
	25 (16)	50 (40)	260	237	213	192	182	173
	50 (40)	100 (63)	256	234	213	192	182	173
	100 (63)	160 (100)	251	229	213	192	182	173

NOTE Thicknesses in parentheses apply to sections and flat bars.

Table 11 — Minimum proof stress ($R_{p0.2}$) at elevated temperatures: low and medium alloy steels

Steel	Rp0.2 minimum at a temperature in °C of									
	150	200	250	300	350	400	450	500	550	600
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
271	330	322	312	306	298	288	282	269	255	221
620–440	230	220	209	183	170	164	161	156	151	146
620–470	260	249	238	216	204	200	195	189	181	174
620–540	328	315	303	294	284	279	273	265	251	240
622	253	245	236	230	224	218	205	189	167	145
625–590	402	394	389	385	374	359	333	297	—	—
625–640	450	442	436	430	415	397	367	326	—	—
629	348	334	330	326	322	316	311	290	235	—

Table 12 — Minimum proof stress ($R_{p1.0}$) at elevated temperatures: austenitic stainless steels

Steel	$R_{p1.0}$ minimum at a temperature in °C of											
	150	200	250	300	350	400	450	500	550	600	650	700
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
304S11	150	137	128	122	116	110	108	106	102	100	96	93
304S31	160	147	139	132	125	120	117	115	112	109	104	99
304S51	160	147	139	132	125	120	117	115	112	109	104	99
304S61	201	182	172	163	156	149	144	140	136	—	—	—
304S71	201	182	172	163	156	149	144	140	136	—	—	—
316S11	161	149	139	133	127	123	119	115	112	110	107	105
316S13	161	149	139	133	127	123	119	115	112	110	107	105
316S31	172	159	150	143	137	133	129	125	121	119	116	113
316S33	172	159	150	143	137	133	129	125	121	119	116	113
316S51	172	159	150	143	137	133	129	125	121	119	116	113
316S53	172	159	150	143	137	133	129	125	121	119	116	113
316S61	208	192	180	172	166	161	157	152	149	—	—	—
316S63	208	192	180	172	166	161	157	152	149	—	—	—
316S65	208	192	180	172	166	161	157	152	149	—	—	—
316S67	208	192	180	172	166	161	157	152	149	—	—	—
321S31	180	172	164	158	152	148	144	140	138	135	130	124
321S51–490	139	131	125	118	114	110	107	105	104	102	100	97
321S51–510	180	172	164	158	152	148	144	140	138	135	130	124
347S31	192	182	172	166	162	159	157	155	153	151	—	—
347S51	192	182	172	166	162	159	157	155	153	151	—	—

Appendix B Stress rupture values

The following tables provide information on stress rupture values for specific steel types.

Table 13 — Stress rupture values: carbon and carbon-manganese steels

Steel	Temperature	Estimated average stress for rupture in						
		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
	°C	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
151, 161	380	213	192	183	171*	164*	159*	155*
	390	197	176	167	155*	149*	144*	140*
	400	181	161	152	141*	134*	130*	126*
	410	166	147	138	127*	121*	116*	113*
	420	151	133	125	114*	108*	104*	101*
	430	138	120	112	102*	96*	92*	89*
	440	125	107	100	90*	84*	80*	77*
	450	112	95	88	78*	73*	69*	66*
	460	100	84	77	67*	62*	58*	55*
	470	89	73	66	57*	52*	48*	45*
	480	78	63	56*	47*	41*	37*	34*
	490	67	52	46*	36*	29*	23*	—
	500	57	42	35*	—	—	—	—
211, 221, 224–430, 224–490	380	291	262	248	227	215	206*	199*
	390	266	237	223	203	190	181*	174*
	400	243	214	200	179	167	157*	150*
	410	221	192	177	157	144	135*	128*
	420	200	171	156	136	124	115*	108*
	430	180	151	136	117	105	97*	91*
	440	161	132	118	100	89	82*	77*
	450	143	115	102	85	76	70*	66*
	460	126	99	87	73	65	60*	56*
	470	110	86	75	63	56	52*	(48)*
	480	96	74	65	55	(49)	(44)*	(41)*
	490	84	65	57	(47)	(42)	(37)*	(32)*
	500	74	57	50	(41)	(34)	—	—

See footnotes to Table 15.

Table 14 — Stress rupture values: low and medium alloy steels

Steel	Temperature	Estimated average stress for rupture in						
		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
	°C	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
271	400	454	435	425	417*	402*	398*	391*
	410	445	425	414	405*	391*	385*	378*
	420	432	411	399	388*	375*	367*	359*
	430	415	392	379	367*	354*	346*	337*
	440	394	371	356	341*	328*	318*	311*
	450	371	346	330	309*	298*	287*	281*
	460	346	316	300	272*	263*	249*	245*
	470	321	284	266	235*	225*	208*	204*
	480	294	252	232	201*	188*	171*	168*
	490	265	219	198	168*	154*	141*	136*
	500	234	189	167	139*	123*	113*	108*
	510	205	157	139	113*	99*	88*	85*
	520	177	136	113	90*	78*	66*	63*
	530	150	106	90	70*	57*	50*	(45)*
	540	125	85	71	53*	(41)*	(34)*	(30)*
	550	102	68	56	(39)*	(30)*	(23)*	(18)*
	560	83	52	—	—	—	—	—
	570	69	(42)	—	—	—	—	—
620—440, 620—470, 620—540	480	304	267	239	210	194*	180*	170*
	490	273	233	207	177	161*	148*	139*
	500	239	200	177	146	132*	122*	114*
	510	209	169	149	121	108*	99*	91*
	520	179	140	124	99	87*	79*	74*
	530	154	116	101	81	71	64*	59*
	540	129	96	82	67	57	52*	48*
	550	109	79	68	54	46	42*	39*
	560	91	66	55	43	38	34*	32*
	570	76	54	45	35	(31)	(28)*	(26)*
	580	64	44	—	—	—	—	—
	590	53	36	—	—	—	—	—
	600	44	(29)	—	—	—	—	—
622	450	(309)	(276)*	(257)*	221*	209*	203*	198*
	460	(285)	(254)*	236*	204*	192*	186*	181*
	470	(263)	233	217*	186*	175*	169*	164*
	480	240	213	197*	170*	158*	152*	147*
	490	219	192	177*	153*	141*	135*	130*
	500	196	172	158*	137*	126*	119*	113*
	510	176	152	139*	122*	110*	103*	98*
	520	155	134	123*	107*	95*	89*	84*
	530	137	118	107	93	82*	77*	74*
	540	122	103	93	79	73*	68*	64*
	550	108	90	80	69	63*	58*	55*
	560	96	79	71	59	54*	50*	47*
	570	85	70	62	51	47	43*	41*
	580	76	61	54	44	40	(37)*	(35)*
	590	68	54	47	(38)	(35)	(32)*	(30)*
	600	61	48	42	(34)	(30)	(28)*	(26)*

Table 14 — Stress rupture values: low and medium alloy steels

Steel	Temperature	Estimated average stress for rupture in						
		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
	°C	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
625–590, 625–640	450	—	—	—	276*	252*	237*	226*
	460	—	273*	247*	218*	202*	192*	183*
	470	226	221*	204*	181*	167*	158*	152*
	480	220	187	172*	153*	142*	135*	129*
	490	190	160	148*	132*	122*	114*	108*
	500	164	140	129*	113*	103*	96*	90*
	510	145	123	112*	96*	86*	80*	75*
	520	129	107	96*	81*	73*	68*	64*
	530	114	92	82*	70*	62*	57*	53*
	540	100	80	71*	59*	52*	47*	44*
	550	88	70	62*	50*	44*	40*	(37)*
	560	77	61	53*	43*	(38)*	(36)*	—
	570	68	52	45*	(37)*	—	—	—
	580	60	45	39*	—	—	—	—
	590	53	39	(34)*	—	—	—	—
	600	46	(35)	—	—	—	—	—
	610	40	—	—	—	—	—	—
	620	(36)	—	—	—	—	—	—
629	420	(463)*	(428)*	(412)*	(390)*	(377)*	(368)*	(361)*
	430	(416)*	(384)*	(369)*	(349)*	(337)*	(329)*	(322)*
	440	(375)*	(345)*	(331)*	(313)*	302*	295*	289*
	450	(340)	(312)	299	282*	272*	265*	259*
	460	(308)	282	270	254*	245*	238*	233*
	470	281	256	245	229*	220*	214*	209*
	480	256	232	222	207	198*	192*	187*
	490	233	211	201	187	178*	172*	168*
	500	213	191	181	168	160*	154*	149*
	510	194	173	164	150	143*	137*	132*
	520	176	156	147	134	126*	121*	116*
	530	160	141	131	118	111*	105*	101*
	540	145	126	116	104	96*	90*	86*
	550	130	111	102	89	81*	76*	71*
	560	117	98	88	75	68*	62*	58*
	570	103	84	75	62	55*	50*	46*
	580	90	71	62	50*	44*	40*	37*
	590	78	59	50	40*	36*	33*	31*
	600	66	48	41	34*	30*	29*	27*
	610	54	39	34	29*	27*	25*	24*
	620	45	33	30	26*	24*	23*	(22)*
	630	37	29	26	23*	(22)*	(21)*	(20)*
	640	32	26	24	(22)*	(21)*	(20)*	(19)*
	650	28	24	(22)	(20)*	(19)*	—	—
	660	25	(22)*	(20)	(19)*	—	—	—
	670	23	(20)*	(19)	(18)*	—	—	—

See footnotes to Table 15.

Table 15 — Stress rupture values: austenitic stainless steels

Steel	Temperature	Estimated average stress for rupture in						
		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
	°C	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
304S51	550	176	147*	134*	115*	108*	102*	97*
	560	164	135*	123*	105*	99*	93*	88*
	570	152	126*	113*	98*	89*	84*	79*
	580	142	115*	103*	89*	81*	76*	73*
	590	131	105*	94*	81*	74*	69*	66*
	600	122	96*	85*	74*	67*	62*	59*
	610	113	88*	78*	68*	60*	56*	53*
	620	104	80*	72*	61*	54*	50*	47*
	630	95	74	65*	55*	49*	45*	42*
	640	87	67	58*	50*	43*	(40)*	(37)*
	650	79	61	52*	45*	(39)*	(35)*	(33)*
	660	73	55	47*	(40)*	(34)*	(31)*	(29)*
	670	67	50	41*	(35)*	(30)*	(27)*	(25)*
	680	61	44*	(36)*	(30)*	(26)*	(24)*	(22)*
	690	55	(40)*	(32)*	(26)*	(23)*	(21)*	—
	700	48	(35)*	(27)*	(23)*	(20)*	—	—
316S51, 316S52	550	260	243	226	196*	187*	181*	176*
	560	245	224	208	180*	171*	165*	159*
	570	228	204	192	160*	152*	146*	140*
	580	211	187	175	147	139	133	127*
	590	195	171	158	132	124	116	110*
	600	179	155	142	118	110	103	97*
	610	164	139	128	106	97	91	86*
	620	149	125	115	96	86	80	76*
	630	136	112	103	86	76	71	67*
	640	123	100	91	76	68	63	59*
	650	111	89	80	69	60	56	52*
	660	99	79	72	60	53	49	46*
	670	89	72	63	53	47	43	40*
	680	80	64	56	46	41*	38*	35*
	690	74	57	50	41	36*	33*	31*
	700	65	51	45	37	32*	29*	28*
	710	59	46	40	33	28*	(26)*	(25)*
	720	53	41	36	30	(25)*	(24)*	(23)*
	730	48	37*	32*	27*	(24)*	(22)*	(21)*
	740	44	33*	29*	(25)*	(21)*	(20)*	(19)*
	750	39	30*	(26)*	(23)*	—	—	—
321S51, 490	570	197	167*	154*	137*	130*	125*	120*
	580	182	154	142*	126*	119*	113*	109*
	590	170	142	130*	116*	109*	103*	99*
	600	157	130	120*	106*	99*	93*	89*
	610	145	120	110*	97*	89*	84*	80*
	620	134	109	100*	88*	80*	76*	72*
	630	124	99	91*	78*	73*	(68)*	(64)*
	640	114	90	82*	71*	(65)*	(60)*	(57)*
	650	104	82	75*	(64)*	(57)*	(53)*	(50)*
	660	95	75	(67)*	(57)*	(50)*	(46)*	(43)*
	670	86	(67)	(60)*	(50)*	(44)*	(40)*	(37)*
	680	77	(60)*	(54)*	(44)*	(38)*	(35)*	(32)*
	690	(70)	(53)*	(47)*	(39)*	(33)*	(30)*	—
	700	(63)	(47)*	(42)*	(34)*	—	—	—

Table 15 — Stress rupture values: austenitic stainless steels

Steel	Temperature	Estimated average stress for rupture in						
		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
	°C	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
321S51,	570	185	154*	139*	123*	112*	106*	101*
510	580	170	141	127*	112*	102*	96*	92*
	590	156	128	117*	102*	93*	86*	81*
	600	142	118	107*	92*	83*	76*	72*
	610	130	107	97*	82*	73*	67*	62*
	620	120	98	87*	74*	64*	58*	54*
	630	110	88	77*	64*	(55)*	(50)*	(46)*
	640	101	79	69*	(55)*	(47)*	(43)*	(40)*
	650	92	71	60*	(47)*	(41)*	(37)*	(34)*
	660	82	61	(52)*	(40)*	(35)*	(32)*	(29)*
	670	74	(53)*	(44)*	(36)*	(30)*	(27)*	—
	680	65	(46)*	(37)*	(31)*	—	—	—
	690	(57)*	(40)*	(32)*	(27)*	—	—	—
	700	(48)*	(34)*	(27)*	(23)*	—	—	—
347S51	540	243	210*	198*	181*	171*	164*	159*
	550	228	197	185*	168*	158*	151*	146*
	560	215	184	172*	154*	145*	138*	133*
	570	200	172	159*	142*	132*	127*	122*
	580	186	159	146	129	121	114*	110*
	590	173	146	133	118	109	103*	99*
	600	159	133	123	106	98	93*	88*
	610	146	123	111	96	88	83*	79*
	620	134	112	101	86	79	75*	71*
	630	124	102	91	77	71*	66*	63*
	640	114	92	82	69	63*	58*	55*
	650	104	83	74	61	55*	51*	48*
	660	95	74	66	53	48*	44*	41*
	670	86	66	58	46	42*	38*	36*
	680	77	58	51	40*	36*	(33)*	(31)*
	690	69	51	44	35*	(32)*	(29)*	(27)*
	700	61	44	39	(30)*	(28)*	(25)*	(25)*
	710	54	38	(33)	(25)*	(24)*	(22)*	—
	720	46	(33)	(28)	(22)*	—	—	—

NOTE 1 *indicates values that have involved extended time extrapolation.
() indicates values that have involved extended stress extrapolation.

NOTE 2 The confidence that can be placed upon values obtained by extrapolation is related to the extent of extrapolation. For the purposes of this standard, extrapolations exceeding approximately three times the minimum allowable duration times are described as extended time extrapolations.

Values obtained by extending the parametric master curves to stresses beyond the range for which tests have been carried out are described as extended stress extrapolations. The values are subject to greater uncertainty than other values.

Publications referred to

BS 240, *Method for Brinell hardness testing.*

BS 240-1, *Testing of metals.*

BS 970, *Wrought steels in the form of blooms, billets, bars and forgings.*

BS 970-2, *Direct hardening alloy steels, including alloy steels capable of surface hardening by nitriding.*

BS 970-4, *Stainless, heat resisting and valve steels.*

BS 1501, *Steels for fired and unfired pressure vessels. Plates*[2)].

BS 1503, *Specification for steel forgings (including semi-finished forged products) for pressure purposes*[2)].

BS 1504, *Specification for steel castings for pressure purposes*[2)].

BS 1506, *Carbon and alloy steel bars for bolting material*[2)].

BS 3688, *Methods for mechanical testing of metals at elevated temperatures.*

BS 3688-1, *Tensile testing.*

BS 3894, *Method for converting elongation values for steel.*

BS 3894-1, *Carbon and low alloy steels.*

BS 4360, *Specification for weldable structural steels.*

BS 5903, *Method for determination of resistance to intergranular corrosion of austenitic stainless steels: copper sulphate — sulphuric acid method (Moneypenny Strauss test).*

BS EN 10002, *Tensile testing of metallic materials.*

BS EN 10002-1, *Method of test at ambient temperature.*

BS EN 10045, *Charpy impact test on metallic materials.*

BS EN 10045-1, *Test method (V- and U-notches).*

BS EN 10163, *Specification for delivery requirements for surface condition of hot rolled steel plates, wide flats and sections.*

BS EN 10163-3, *Sections.*

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

[2)] Referred to in foreword only.

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