

Please be aware that this PDF has been created from the original hardcopy document, which might not be in good condition and so the PDF might reflect this.

This British Standard, having been prepared under the direction of the Pressure Vessel Standards Committee, was published under the authority of the Board of BSI and comes into effect on 1 January 1985.

© British Standards Institution, 1985

First published March 1976
First revision January 1982
Second revision January 1985

ISBN 0 580 14036 9

British Standards Institution

Incorporated by Royal Charter, BSI is the independent national body for the preparation of British Standards. It is the UK member of the International Organization for Standardization and UK sponsor of the British National Committee of the International Electrotechnical Commission.

Copyright

Users of British Standards are reminded that copyright subsists in all BSI publications. No part of this publication may be reproduced in any form without the prior permission in writing of BSI. This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols and size, type or

grade designations. Enquiries should be addressed to the Publications Manager, British Standards Institution, Linford Wood, Milton Keynes MK14 6LE. The number for telephone enquiries is 0908 320033 and for telex 825777.

Contract requirements

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.

Revision of British Standards

British Standards are revised, when necessary, by the issue either of amendments 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. Information on all BSI publications is in the *BSI Catalogue*, supplemented each month by *BSI News* which is available to subscribing members of the Institution and gives details of new publications, revisions, amendments and withdrawn standards. Any person who, when making use of a British Standard, encounters an inaccuracy or ambiguity, is requested to notify BSI without delay in order that the matter may be investigated and appropriate action taken.

The following BSI reference relates to the work on this standard: Committee reference PVE/1

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Pressure Vessel Standards Committee (PVE/—) to Technical Committee PVE/1, upon which the following bodies were represented:

Associated Offices Technical Committee
Association of Consulting Engineers
British Chemical Engineering Contractors' Association
British Compressed Gases Association
British Gas Corporation
British Steel Industry

Electricity Supply Industry in England and Wales
Energy Industries Council
Engineering Equipment and Materials Users' Association
Health and Safety Executive
Independent Engineering Insurers' Committee
Institution of Chemical Engineers
Institution of Gas Engineers
Liquefied Petroleum Gas Industry Technical Association (UK)
Process Plant Association
Water-tube Boilermakers' Association
Welding Institute

Amendments issued since publication

Amd. No.	Date of issue	Text affected

British Standards Institution · 2 Park Street London W1A 2BS · Telephone 01-629 9000 · Telex 266933

BS 5500: 1985 Unfired fusion welded pressure vessels

Enquiry Cases — Introduction

In accordance with the provisions of clause 1.2, the publication of Enquiry Cases will be notified in *BSI News* and will be made available for inclusion in the ring-binder in a separate section following the text of the specification and the appendices.

The table below is for recording cases as they are published and included in the binder, and for noting their subsequent routing.

In general, cases will be extant, as adjuncts to the standard and open to public comment, until the text of the standard is amended to incorporate the substance of particular cases. This will be done in the course of the normal updating procedure and each case so dealt with will be recorded on the final page of the relevant amendment.

When an enquiry case is superseded by amended text to the standard, it will be removed from the list in the subsequent amendment or when a new edition of the standard is published and only those remaining extant, as described above, will be referred to. Consequently, the numerical sequence of enquiry case numbers in the first column will not be continuous because of these omissions.

Enquiry Case No.	Date of publication	Subject of the Enquiry Case	Subsequent Enquiry Case routing (e.g. incorporated into BS 5500)	Date of subsequent action
5500/15	November 1979	Vessels under external pressure: permissible design stresses		
5500/17	November 1979	Split ring flanges		
5500/18	December 1979	Design stresses for ASTM A106B tubes (equivalent to BS 3602-410)		
5500/19	December 1979	Maximum stress at a cylinder/nozzle junction due to application of internal pressure		
5500/20	December 1979	Pressure vessels designed for low pressure but having excess in-built thickness		
5500/24	May 1980	Compensation for openings in vessels subject to external pressure		
5500/25	May 1980	Specification of hot properties for steel		
5500/29	December 1980	Derivation of design strength values from actual, rather than specified, material properties		
5500/31	May 1981	Interpretation of the term 'significant general yielding'		
5500/33	August 1981	Verification of shape of vessels subject to external pressure		Page 4 reissued April 1983
5500/34	September 1981	Longitudinal compressive stress limit for pressure vessels		

BS 5500: 1985
Issue 1, January 1985

Enquiry Case No.	Date of publication	Subject of the Enquiry Case	Subsequent Enquiry Case routing (e.g. incorporated into BS 5500)	Date of subsequent action
5500/36	September 1981	Loose flanges split across a diameter and keyed into the back of a component		
5500/38	June 1982	The use of austenitic stainless steel tube to ASTM A312		
5500/39	June 1982	Jacketed construction: blocking ring/jacket attachment using fillet welds		
5500/40	June 1982	Reduction of area in all weld tensile test		
5500/41	June 1982	Vessels fabricated in Ni-Fe-Cr-Mo-Cu alloy NA16		
5500/42	December 1982	Recommended values for design stresses for BS 3692 grade 8.8 bolting material		
5500/44	December 1982	Limits of applicability of 3.5.4.2 to openings in vessel ends		
5500/45	May 1983	Design of reverse flange/flat cover combinations under internal pressure		Page 3 reissued April 1984
5500/46	May 1983	Set-in branches with added compensation rings		
5500/47	May 1983	Construction categories		
5500/49	September 1983	Integrity of construction categories		
5500/52	April 1984	Vessels under external pressure: simplified calculations		
5500/53	April 1984	Supports and mounting for horizontal vessels		
5500/54	May 1984	Bolted flat end plates		
5500/55	May 1984	Design stresses for ASTM A182, A240 and A312 materials		
5500/56	May 1984	Table 5.7 (1) Minimum through-thickness dimension		
5500/57	May 1984	ASTM A333 Gr 6 steels with restricted maximum carbon content		
5500/58	May 1984	Bolted flanges complying with ANSI B16.5		
5500/59	October 1984	Non-destructive testing requirements in the cases of assembled components and following the repair of a defect		
5500/60	October 1984	Value of stress f_t to be used to calculate test pressure where time-dependent design strengths are applicable		



Documents

Document Sharing Hub

ti A7

2155 1434

Acknowledgements

The following figures are reproduced by courtesy of the American Welding Research Council.

Figure G.2(29) was originally published as Fig. 2 on page 21 of WRC Bulletin 90 September 1963

Figure G.2(30) was originally published as Fig. 3 on page 21 of WRC Bulletin 90 September 1963

Figure G.2(31) was originally published as Fig. 7 on page 24 of WRC Bulletin 90 September 1963

Figure G.2(32) was originally published as Fig. 8 on page 24 of WRC Bulletin 90 September 1963

Figure G.2(33) was originally published as Fig. 9 on page 25 of WRC Bulletin 90 September 1963

Figure G.2(34) was originally published as Fig. 10 on page 25 of WRC Bulletin 90 September 1963

Figure G.2(35) was originally published as Fig. 11 on page 26 of WRC Bulletin 90 September 1963

Figure G.2(36) was originally published as Fig. 12 on page 26 of WRC Bulletin 90 September 1963

Figures G.2(37), G.2(38), G.2(39), G.2(40), G.2(41), G.2(42), G.2(43) and G.2(44) are reproduced by courtesy of the *Institute Journal of Solids and Structures*, 1967.

BS 5500: 1985

Issue 1, January 1985

Summary of pages

	No. of sheets	
Preliminary pages:	8	(title page, Enquiry Cases — Introduction, acknowledgements, summary of pages, pages i to ix)
Section one:	3	(pages 1/1 to 1/5)
Section two:	17	(pages 2/1 to 2/33)
Section three:	51	(pages 3/1 to 3/102)
Section four:	7	(pages 4/1 to 4/13)
Section five:	11	(pages 5/1 to 5/22)
Appendix A:	4	(pages A/1 to A/7)
Appendix B:	3	(pages B/1 to B/5)
Appendix C:	4	(pages C/1 to C/7)
Appendix D:	7	(pages D/1 to D/14)
Appendix E:	28	(pages E/1 to E/55)
Appendix F:	1	(pages F/1 to F/2)
Appendix G:	35	(pages G/1 to G/69)
Appendix H:	1	(page H/1)
Appendix J:	2	(pages J/1 to J/4)
Appendix K:	1	(pages K/1 to K/2)
Appendix L:	1	(pages L/1 to L/2)
Appendix M:	1	(page M/1)
Appendix N:	2	(pages N/1 to N/3)
Appendix P:	1	(page P/1)
Appendix Q:	1	(pages Q/1 to Q/2)
Appendix R:	1	(page R/1)
Appendix S:	1	(page S/1)
Concluding pages:	1	(reference standards)

Contents

	Page		Page
Cooperating organizations	Inside front cover	3.7	Supports, attachments and internal structures
Foreword	ix	3.7.1	General
		3.7.2	Supports
Specification		3.8	Bolted flanged connections
Section one. General		3.8.1	General
1.1 Scope	1/1	3.8.2	Notation
1.2 Interpretation	1/1	3.8.3	Narrow faced flanges
1.3 References	1/1	3.8.4	Full faced flanges with soft ring type gaskets
1.4 Definitions	1/1	3.9	Flat heat exchanger tubesheets
1.4.1 Purchaser	1/1	3.9.1	Notation
1.4.2 Manufacturer	1/2	3.9.2	Characteristics of perforated plates
1.4.3 Inspecting Authority	1/2	3.9.3	Tubesheets of exchangers with confined floating heads or U-tubes
1.4.4 Regulating Authority	1/2	3.9.4	Tubesheets of exchangers with unconfined heads
1.5 Responsibilities	1/2	3.9.5	Allowable shell and tube longitudinal stresses
1.5.1 Responsibilities of the purchaser	1/2	3.9.6	Allowable tube joint end load
1.5.2 Responsibilities of the manufacturer	1/2	3.10	Design of welds
1.5.3 Responsibilities of the Inspecting Authority	1/3	3.10.1	General
1.5.4 Certification	1/3	3.10.2	Weld joints for principal seams
		3.10.3	Welded joints for other than principal seams
Section two. Materials		3.10.4	Welded joints in time dependent applications
2.1 General	2/1	3.11	Jacket construction
2.2 Selection of materials	2/1	3.11.1	General
2.3 Nominal design strength	2/1	3.11.2	Jacketed cylindrical shells
2.4 Carbon, carbon manganese and alloy steels	2/1	3.11.3	Welded jacket connections
2.5 Aluminium	2/2	3.11.4	Outlet branches
		3.11.5	Compensation
Section three. Design		3.12	Manholes and inspection openings
3.1 Purpose	3/1	Section four. Manufacture and workmanship: steel	
3.2 Application	3/1	4.1	General aspects of construction
3.3 Corrosion, erosion and protection	3/2	4.1.1	Fully dimensioned drawing
3.3.1 General	3/2	4.1.2	Material identification
3.3.2 Additional thickness to allow for corrosion	3/2	4.1.3	Order of completion of weld seams
3.3.3 Linings and coatings	3/2	4.1.4	Junction of more than two weld seams
3.3.4 Wear plates	3/2	4.2	Cutting, forming and tolerances
3.4 Construction categories and design stresses	3/2	4.2.1	Cutting of material
3.4.1 Construction categories	3/2	4.2.2	Forming of shell sections and plates
3.4.2 Design stresses	3/2	4.2.3	Assembly tolerances
3.5 Vessels under internal pressure	3/4	4.2.4	Tolerances for vessels subject to internal pressure
3.5.1 Cylindrical and spherical shells	3/4	4.2.5	Tolerances for vessels subject to external pressure
3.5.2 Domed ends	3/4	4.3	Welded joints
3.5.3 Conical ends and truncated cones	3/5	4.3.1	General
3.5.4 Openings and branch connections	3/16	4.3.2	Welding consumables
3.5.5 Flat ends and flat plates	3/31	4.3.3	Preparation of plate edges and openings
3.5.6 Spherically domed and bolted ends conforming to figure 3.5.6	3/37	4.3.4	Assembly for welding
3.6 Vessels under external pressure	3/38	4.3.5	Attachments and the removal of temporary attachments
3.6.1 General	3/38	4.3.6	Butt joints
3.6.2 Cylindrical shells	3/38	4.3.7	Welding: general requirements
3.6.3 Conical shells	3/40	4.4	Heat treatment
3.6.4 Spherical shells	3/41	4.4.1	Preheat requirements
3.6.5 Hemispherical ends	3/42		
3.6.6 Torispherical ends	3/42		
3.6.7 Ellipsoidal ends	3/42		
3.6.8 Procedure by which the departure from the mean circle may be obtained	3/42		

4.4.2	Normalizing: ferritic steels	4/6
4.4.3	Post-weld heat treatment	4/6
4.4.4	Methods of heat treatment	4/6
4.4.5	Post-weld heat treatment procedure	4/6
4.5	Surface finish	4/8

Section four A. Manufacture and workmanship: aluminium

4A.1	General aspects of construction	4/9
4A.1.1	Fully dimensioned drawing	4/9
4A.1.2	Material identification	4/9
4A.1.3	Forgings	4/9
4A.1.4	Order of completion of weld seams	4/9
4A.1.5	Not applicable	4/9
4A.2	Cutting, forming and tolerances	4/9
4A.2.1	Cutting of material	4/9
4A.2.2	Forming of shell sections and end plates	4/9
4A.2.3	Assembly tolerances	4/10
4A.2.4	Tolerances for vessels subject to internal pressure	4/10
4A.2.5	Tolerances for vessels subject to external pressure	4/11
4A.3	Welded joints	4/11
4A.3.1	General	4/11
4A.3.2	Welding consumables	4/11
4A.3.3	Preparation of plate edges and openings	4/11
4A.3.4	Assembly for welding	4/12
4A.3.5	Attachments and the removal of temporary attachments	4/12
4A.3.6	Butt joints	4/12
4A.3.7	Welding: general requirements	4/12
4A.4	Heat treatment	4/12
4A.4.1	Preheat requirements	4/12
4A.4.2	Not applicable	4/13
4A.4.3	Post-weld heat treatment	4/13
4A.4.4	Not applicable	4/13
4A.4.5	Not applicable	4/13
4A.5	Surface finish	4/13

Section five. Inspection and testing: steel

5.1	General	5/1
5.2	Approval testing of fusion welding procedures	5/1
5.3	Welder and operator approval	5/1
5.4	Production control test plates	5/1
5.6	Non-destructive testing	5/1
5.6.1	General	5/1
5.6.2	Parent materials	5/2
5.6.3	Components prepared for welding	5/2
5.6.4	Non-destructive testing of welded joints	5/2
5.6.5	Choice of non-destructive test methods for welds	5/3
5.6.6	Non-destructive testing techniques for welds	5/3
5.7	Acceptance criteria for weld defects revealed by visual examination and non-destructive testing	5/4
5.7.1	General	5/4
5.7.2	Assessment of defects	5/4
5.7.3	Repair of welds	5/7

5.8	Pressure tests	5/7
5.8.1	General	5/7
5.8.2	Basic requirements	5/7
5.8.3	Hydraulic testing	5/8
5.8.4	Pneumatic tests	5/8
5.8.5	Standard test pressure	5/9
5.8.6	Proof hydraulic test	5/10
5.8.7	Combined hydraulic/pneumatic tests	5/11
5.8.8	Leak testing	5/11
5.8.9	Stamping	5/11
5.8.10	Final inspection	5/11

Section five A. Inspection and testing: aluminium

5A.1	General	5/13
5A.2	Approval testing of fusion welding procedures	5/13
5A.3	Welder and operator approval	5/13
5A.4	Production control test plates	5/13
5A.5	Details of destructive tests for procedure, welder and production control testing	5/14
5A.5.1	Test requirements	5/14
5A.5.2	Test temperatures	5/14
5A.5.3	Transverse tensile test	5/14
5A.5.4	Not applicable	5/14
5A.5.5	Side bend test	5/14
5A.5.6	Macro- and micro-examination	5/14
5A.5.7	Not applicable	5/14
5A.5.8	Retests	5/14
5A.6	Non-destructive testing	5/14
5A.6.1	General	5/14
5A.6.2	Parent materials	5/15
5A.6.3	Components prepared for welding	5/15
5A.6.4	Non-destructive testing of welded joints	5/15
5A.6.5	Choice of non-destructive test methods for welds	5/15
5A.6.6	Non-destructive testing techniques for welds	5/16
5A.7	Acceptance criteria for weld defects revealed by visual examination and non-destructive testing	5/17
5A.7.1	General	5/17
5A.7.2	Quality control level of acceptance	5/17
5A.7.3	Assessment of defects	5/17
5A.7.4	Repair of welds	5/17
5A.8	Pressure tests	5/17
5A.8.1	General	5/17
5A.8.2	Basic requirements	5/17
5A.8.3	Hydraulic testing	5/19
5A.8.4	Pneumatic tests	5/19
5A.8.5	Standard test pressure	5/19
5A.8.6	Proof hydraulic test	5/20
5A.8.7	Combined hydraulic/pneumatic tests	5/20
5A.8.8	Leak testing	5/20
5A.8.9	Stamping	5/20
5A.8.10	Final inspection	5/20

Appendices

A.	Design requirements for loadings and components not covered by section three	A/1
B.	Cylindrical, spherical and conical shells under combined loadings, including wind and earthquakes	

	Page		Page
C. Recommended practice for assessment of vessels subject to fatigue	C/1	3.8.1.4	Recommended design stress values for flange bolting materials 3/58
D. Recommended practice for carbon and carbon manganese steel vessels required to operate at low temperature	D/1	3.8.3(1)	Moment arms for flange loads under operating conditions 3/62
E. Recommended welded connections for pressure vessels	E/1	3.8.3(2)	Gasket materials and contact facings: gasket factors (m) for operating conditions and minimum design seating stress (y) 3/66
F. Recommended alternative design method of compensation using area replacement	F/1	3.8.3(3)	Effective gasket width 3/68
G. Stresses from local loads, thermal gradients, etc: recommended methods of calculation	G/1	3.8.3(4)	Values of T , Z , Y and U (factors involving K) 3/70
H. General recommendations for post-weld heat treatment of dissimilar ferritic steel joints	H/1	3.9	Values of ΔC as a function of F_s and R for all tubesheets, and C_0 for U-tube-sheets only 3/85
J. Pressure relief protective devices	J/1	3.9.6	Values of F_r for typical tube joints 3/86
K. Derivation of material nominal design strengths for construction category 1 and 2 vessels	K/1	4.2.4.1.1	Circumference 4/3
L. Basis of the design charts for openings and branches	L/1	4.2.4.1.4	Tolerance on depth of domed ends 4/3
M. Safe external working pressure for cylindrical sections outside the circularity limits specified in 3.6	M/1	4.4.1.1	Preheating recommendations for welding 4/5
N. Check list of matters on which, if relevant, agreement is required	N/1	4.4.3.1	Requirements for post-weld heat treatment of ferritic steel vessels 4/7
P. Stainless steel components with higher design stresses	P/1	4A.2.4.1.1	Circumference 4/10
Q. Recommendations for preparation and testing of production control test plates	Q/1	4A.2.4.1.4	Tolerance on depth of domed ends 4/11
R. Supporting information for 3.5.5: flat ends and flat plates	R/1	5.6.4.1.1	Thickness limits for examination of internal flaws 5/2
S. Optional documentation for supply with vessel	S/1	5.7(1)	Acceptance levels 5/5
		5.7(2)	Acceptance levels (re-assessment of category 2 construction) 5/6
		5.8.10	Principal stages of inspection 5/11
		5A.4	Number of test specimens for weld procedure approval and production control tests 5/14
		5A.5	Mechanical test requirements for butt weld procedure and welder approval 5/14
		5A.7	Acceptance levels 5/18
		5A.8.10	Principal stages of inspection 5/21
		A.3	Classification of stresses for some typical cases A/4
		D.3.2.1	Impact requirements at the reference temperature of carbon and carbon manganese steel plates, tubes and forgings D/3
		G.2.2.2	Values of K_1 and K_2 G/9
		G.3.3.2.3	Design factors K_1 and K_2 G/53
		G.3.3.2.4	Design factors, K_3 and K_4 and allowable tangential shearing stresses G/54
		G.3.3.2.5.1	Design factor K_6 G/55
		G.3.3.2.5.2	Values of constants C_4 , C_5 , K_5 , K_7 and K_8 G/56
		G.3.3.3	Values of K_{10} and K_{11} G/57
		G.4(1)	Hoop stress factor C_1 G/66
		G.4(2)	Bending stress factor C_2 G/66
		G.4(3)	Meridional stress factor C_3 G/67
		G.4(4)	Branch bending stress factor C_4 G/67
		H.1	Classification of materials H/1
		J.7.1	Coefficients of discharge J/2
		P.1	Design strength values P/1
Tables			
2.3 Design strength values: index of steels	2/2		
2A.3 Design strength values: aluminium and aluminium alloys	2/33		
2.4 Additional materials that may be used for category 3 construction	2/33		
3.4 Construction categories	3/3		
3.5.2.3 Values of $e/D \times 10^3$ for unpierced domed ends in terms of h_e/D and p/f	3/9		
3.5.3 Junction at the large base of the cone with knuckle: values of C_1 as a function of ψ and r/D_e	3/14		
3.5.4(1) Thickness of branches	3/19		
3.5.4(2) Design values of t_r/T_r	3/24		
3.6(1) Derivation of L_e	3/42		
3.6(2) Values for G and N which may be assumed	3/43		
3.6(3) E values for ferritic and austenitic steels and aluminium alloys (Young's Modulus)	3/51		
3.6(4) Values of $(\sigma_e/E)(d/e_w)^2$ for internal flat bar stiffeners	3/54		
3.6(5) Values of $(\sigma_e/E)(d/e_w)^2$ for external flat bar stiffeners	3/55		

Figures	Page		Page
3.5.2.1	Domed ends	3/5	
3.5.2.3	Design curves for unpierced domed ends	3/7	
3.5.3(1)	Cone/cone and cone/cylinder junctions	3/11	
3.5.3(2)	Maximum angle ψ for large base of cone	3/12	
3.5.3(3)	Value of coefficient M for a junction at the large base of the cone without knuckle	3/13	
3.5.3(4)	Design curves: determination of C_1	3/14	
3.5.3(5)	Maximum angle ψ for small base of cone	3/15	
3.5.3(6)	Value of coefficient M for a junction at the small base of the cone without knuckle	3/15	
3.5.4(0)	Positions of openings or nozzles in dished ends	3/18	
3.5.4(1)	Design curves for protruding nozzles	3/20	
3.5.4(2)	Design curves for flush nozzles in spherical shells ($d/D < 0.5$) and for flush nozzles in conical shells ($d/D < 0.3$)	3/21	
3.5.4(3)	Design curves for flush nozzles in cylindrical shells ($0 < d/D < 0.3$)	3/22	
3.5.4(4)	Design curves for flush nozzles in cylindrical shells ($0.2 < d/D \leq 1.0$)	3/23	
3.5.4(5)	Nozzle in a conical shell	3/26	
3.5.4(6)	Notation applicable to spheres	3/26	
3.5.4(7)			
3.5.4(8)			
3.5.4(9)			
3.5.4(10)	Notation applicable to cylinders	3/27	
3.5.4(11)			
3.5.4(12)			
3.5.4(13)			
3.5.4(14)	Protruding rim	3/27	
3.5.4(15)	Flush rim	3/27	
3.5.4(16)	Arrangement factor g	3/28	
3.5.4(17)	Branch compensation	3/28	
3.5.4(18)	Notation applicable to spheres and cylinders	3/29	
3.5.4(19)			
3.5.4(20)			
3.5.4(21)	Modified flush branch compensation	3/30	
3.5.4(22)	Modified protruding branch compensation	3/30	
3.5.5(1)	Typical welded flat ends and covers	3/32	
3.5.5(2)	Typical non-welded flat ends and covers	3/33	
3.5.5(3)	Flat unstayed heads: design curves	3/34	
3.5.5(4)	Value of coefficient Z for non-circular flat heads	3/35	
3.5.5(5)	Typical stays: areas supported by stays	3/36	
3.5.6	Spherically domed and bolted end	3/37	
3.6(0)	Stiffening rings for cylindrical vessels subject to external pressure	3/44	
	3.6(1)	Design curves: calculation of minimum cylindrical shell thickness (values of n for which K is a minimum)	3/44
	3.6(2)	Values of e for use with equation 2	3/45
	3.6(3)	Curves for evaluation of allowable pressure p	3/46
	3.6(4)	Schematic representation of stiffeners	3/48
	3.6(5)	Design of stiffeners	3/51
	3.6(6)	Values of β for use with equation 3	3/52
	3.6(7)	Conical sections: typical stiffeners	3/53
	3.8.3(1)	Classification of flanges for calculation purposes	3/62
	3.8.3(2)	Location of gasket load reaction	3/69
	3.8.3(3)	Values of T , U , Y and Z	3/74
	3.8.3(4)	Values of F (integral-type flange factors)	3/75
	3.8.3(5)	Values of V (integral-type flange factors)	3/75
	3.8.3(6)	Values of F_L (loose hub flange factors)	3/76
	3.8.3(7)	Values of V_L (loose hub flange factors)	3/76
	3.8.3(8)	Values of f (hub stress correction factors)	3/76
	3.8.4	Full faced flange with soft ring type gasket	3/81
	3.9(1)	F versus wall thickness/i.d. ratio for integral vessel	3/84
	3.9(2)	Design curves: determination of C	3/87
	3.9(3)	Design curves: determination of F_0	3/88 3/89
	3.9(4)		
	3.9(5)	Design curves: determination of F_i	3/90 3/91
	3.9(6)		
	3.9(7)		
	3.9(8)	Typical clamped and simply supported configurations	3/92
	3.9(9)	Characteristics for perforated thin plates, $e < 2P$	3/93
	3.9(10)	Characteristics for perforated thick plates, $e \geq 2P$	3/94
		Determination of the buckling length L_k	3/95
	3.10(1)	Butt welds in plates of unequal thickness	3/99
	3.10(2)	Butt welds with offset of median lines	3/100
	3.11(1)	Some acceptable types of jacketed vessels	3/102
	3.11(2)	Typical blocking ring and sealer ring construction	3/102
	5.7	Partial non-destructive testing (NDT) category 2 constructions	5/7
	A.3	Stress categories and limits of stress intensity	A/6
	B.3(1)	Stresses in a cylindrical shell under combined loading	B/3
	B.3(2)	Stresses in a spherical shell under combined loading	B/4
	B.3(3)	Stresses in a conical shell under combined loading	B/5

	Page		Page	
C.2.1		E.1(6)	Typical full penetration joint preparations for one-sided welding only: aluminium and its alloys	E/8
	C/5	E.1(7)	Typical full penetration joint preparations for two-sided welding only: aluminium and its alloys	E/9
C.3.1		E.1(8)	Typical full penetration joint preparations for one-sided welding with temporary backing or permanent backing: aluminium and its alloys	E/10
	C/6			
C.4.3	C/7	E.2(1)	Standard weld details	E/14
D.2(1)		E.2(2)	Transverse and longitudinal sections of branch connections	E/15
		E.2(3)	Weld details for set-in branches	E/16
		E.2(4)		
	D/7	E.2(5)		
D.2(2)		E.2(6)	Set-on branches	E/17—E/23
		E.2(7)		
		E.2(8)		
		E.2(9)		
		E.2(10)		
	D/8	E.2(11)	Set-in branches: fillet welded connections	E/24
D.2(3)		E.2(12)	Set-in branches: partial penetration butt welded connections	E/25
	D/9	E.2(13)	Set-in branches: full penetration connections	E.26, E.27
D.2(4)	D/10	E.2(14)	Set in branches: full penetration connections with asymmetrical butt joints	E/28
		E.2(15)	Set-in branches: full penetration connections welded from one side only	E/29
D.3(1)			Forged branch connections	E/30, E/31
	D/11	E.2(16)	Set-on branches with added compensation rings	E/32
D.3(2)			Set-in branches with added compensation rings	E/33—E/36
	D/11	E.2(17)		
		E.2(18)	Studded connections	E/37
D.3(3)	D/11	E.2(19)	Socket welded and screwed connections	E/38
			Flanges	E/39—E/41
D.3.2.1	D/12	E.2(20)	Jacketed vessels: typical vessel/blocking ring attachments	E/42
		E.2(21)	Jacketed vessels: typical blocking ring/jacket attachments	E/43
D.4(1)	D/13	E.2(22)	Jacketed vessels: typical sealer rings	E/44
		E.2(23)	Jacketed vessels: typical through connections	E/45
D.4(2)		E.2(24)	Flat ends and covers	E/45
	D/13	E.2(25)	Tube to tubeplate connections	E/47—E/49
D.5	D/14	E.2(26)	Tubeplate to shell connections: accessible for welding on both sides of the shell	E/50
		E.2(27)		
		E.2(28)		
E.1(1)	E/2	E.2(29)		
E.1(2)		E.2(30)		
	E/3	E.2(31)		
E.1(3)		E.2(33)		
	E/5	E.2(34)		
E.1(4)		E.2(35)		
	E/6	E.2(36)		
		E.2(37)		
		E.2(38)		
E.1(5)	E/7	E.2(39)		

BS 5500: 1985

Issue 1, January 1985

	Page		Page
E.2(40)	Tubeplate to shell connections: accessible for welding from <i>outside</i> of shell only	E/51	G.2(20) Circumferential moment
E.2(41)	Tubeplate to shell connections: accessible for welding on <i>both</i> sides of shell	E/52	G.2(21) Longitudinal moment
E.2(42)	Tubeplate to shell connections	E/53—E/55	G.2(22) Chart for finding s and u
E.2(43)			G.2(23) Spherical shell subjected to a radial load
E.2(44)			G.2(24) Deflections of a spherical shell subjected to a radial load W
F.2	Compensation of welded branch or standpipe or opening	F/2	G.2(25) Moments and membrane forces in a spherical shell subjected to a radial load W
G.2(0)	Restriction on vessel/attachment geometry	G/2	G.2(26) Spherical shell subjected to an external moment
G.2(1)	Vessel with central radial load	G/3	G.2(27) Deflections of a spherical shell subjected to an external moment M
G.2(2)	Vessel with radial load out of centre	G/3	G.2(28) Moments and membrane forces in a spherical shell subjected to an external moment M
G.2(3)	Graph for finding equivalent length L_e	G/4	G.2(29) Maximum stress in sphere for internal pressure (flush nozzles)
G.2(4)	Chart for finding $64 \frac{r}{t} \left(\frac{C_x}{r} \right)^2$	G/4	G.2(30) Maximum stress in sphere for internal pressure (protruding nozzles)
G.2(5)	Cylindrical shells with radial load: circumferential moment per millimetre width	G/5	G.2(31) Maximum stress for thrust loading (flush nozzles)
G.2(6)	Cylindrical shells with radial load: longitudinal moment per millimetre width	G/6	G.2(32) Maximum stress in sphere for thrust loading (protruding nozzles)
G.2(7)	Cylindrical shells with radial load: circumferential membrane force per millimetre width	G/7	G.2(33) Maximum stress in sphere for moment loading (flush nozzles)
G.2(8)	Cylindrical shells with radial load: longitudinal membrane force per millimetre width	G/8	G.2(34) Maximum stress in sphere for moment loading (protruding nozzles)
G.2(9)	Hoop bending moment due to a radial line load variation round circumference	G/10	G.2(35) Maximum stress in sphere for shear loading (flush nozzles)
G.2(10)	Longitudinal moment from radial line load variation round circumference	G/11	G.2(36) Maximum stress in sphere for shear loading (protruding nozzles)
G.2(11)	Circumferential membrane stress from radial line load variation round circumference	G/12	G.2(37) Shakedown values for pressure loading (flush nozzle)
G.2(12)	Longitudinal membrane forces from radial line load variation round circumference	G/13	G.2(38) Shakedown values for pressure loading (protruding nozzle)
G.2(13)	Hoop bending moment due to a radial line load variation along cylinder	G/15	G.2(39) Shakedown values for thrust and moment loadings (flush nozzle)
G.2(14)	Longitudinal moment due to a radial line load variation along cylinder	G/16	G.2(40) Shakedown values for thrust and moment loadings (protruding nozzle)
G.2(15)	Hoop membrane forces due to a radial line load variation along cylinder	G/17	G.2(41) Shakedown values for thrust and moment loadings (flush nozzle)
G.2(16)	Longitudinal membrane forces due to a radial line load variation along cylinder	G/18	G.2(42) Shakedown values for thrust and moment loadings (protruding nozzle)
G.2(17)	Maximum radial deflection of a cylindrical shell subjected to a radial load W uniformly distributed over a square $2C \times 2C$	G/20	G.3(1) Typical brackets
G.2(18)		G/21	G.3(2) Reinforcing plate on cylindrical shell
G.2(19)	Graphs for finding the square $2C_1 \times 2C_1$ equivalent to a rectangular loading area $2C_x \times 2C_\phi$	G/22	G.3(4) Typical ring support
			G.3(5) Typical steelwork under ring support
			G.3(6) Leg supports for vertical vessels
			G.3(7) Typical ring girder
			G.3(8) Typical supports for horizontal vessels

	Page		Page
G.3(9) Cylindrical shell acting as beam over supports	G/50	G.3(16) Typical ring stiffeners	G/57
G.3(10) Factor for bending moment at mid-span	G/51	G.4(1) Nozzle geometry	G/62
G.3(11) Factors for bending moment at supports	G/52	G.4(2) Transient fluid and metal temperatures	G/62
G.3(12) Portion of shell ineffective against longitudinal bending	G/53	G.4(3) Inner surface thermal stress factors K_1 and k_1	G/63
G.3(13) Circumferential bending moment diagrams	G/54	G.4(4) Outer surface thermal stress factors K_2 and k_2	G/64
G.3(15) Saddle supports	G/56	G.4(5) Mean temperature factors K_b and K_s	G/65

Foreword

This British Standard has been prepared under the direction of the Pressure Vessel Standards Committee. It is a new edition of the 1982 version and incorporates all technical changes up to and including Amendment No. 3 (April 1984) associated with that version. The proposals in ISO/DIS 2694 'Pressure vessels', drafted by Technical Committee 11 of the International Organization for Standardization (ISO), have been taken into account where considered appropriate.

NOTE. Some of the figures in this standard have been taken from ISO/DIS 2694 and employ the comma as the decimal marker; normal BSI practice is to use the full point.

BS 5500, which covers pressure vessels manufactured from carbon, ferritic alloy and austenitic steels, and from aluminium, replaced the following standards:

BS 1500 Fusion welded pressure vessels for general purposes
Part 1 Carbon and low alloy steels
Part 3 Aluminium

BS 1515 Fusion welded pressure vessels for use in the chemical, petroleum and allied industries
Part 1 Carbon and ferritic alloy steels
Part 2 Austenitic stainless steel

The previous editions stated the intention of integrating into one British Standard the requirements for design, manufacture, testing and inspection of fusion welded pressure vessels. It is still intended to keep under review the question of publishing appropriate supplements covering other types of pressure vessels, for some of which separate British Standards currently exist. In the meantime, by agreement between the parties concerned, this standard may be used where applicable in place of other British Standards. If there is sufficient demand from industry, the standard will also be extended to cover other non-ferrous materials.

The format adopted to facilitate amendments to the text and the incorporation of supplements covering other types of vessels and materials in the previous editions, has been retained.

The requirements of this standard vary considerably depending upon the thickness and type of material to be used. When this combination is such as will permit satisfactory fabrication by relatively straightforward processes, spot non-destructive testing is permitted without any penalty in design thickness; in certain cases visual inspection only is permitted with an appropriate penalty on design thickness.

The strengths that may be assumed for design purposes of materials covered by current British Standards are individually specified in table 2.3. The concept of design strength tables, as used in BS 1500, has been reintroduced because of the difficulty of specifying in any other way

appropriate design strengths for materials and product forms covered by a variety of standard specifications which have been revised to line up with relevant ISO material standards. Appropriate modifications to the tables and to appendix K are incorporated, these being concerned with the coverage of the types and ranges of material in the revised standards rather than with significant changes to the presently permitted strength levels which, except in the creep range, are generally consistent with those permitted by BS 1515.

A significant departure from pressure vessel standards prior to BS 5500 is that design strengths in the creep range are given for a range of design lifetimes that may be extended, on expiry, on the basis of periodic 'fitness-for-continued-service reviews' based on inspection and consideration of actual load-temperature history. This approach recognizes the limitations inherent in any simple design method for vessels operating in the creep range and also provides a flexible basis that may be used in cases where the design strength values which have been derived from ISO data, are significantly different from those used with success in the past.

Specific requirements for these reviews are not given in this standard because they require development and will be covered by other standards publications for the periodic inspection of pressure vessels.

Recommendations covering aspects requiring further consideration in particular cases are given in the appendices. The British Standards Institution will be pleased to receive constructive proposals based on experience or research that may lead to improvements in these appendices.

As with the previous editions, it is intended to keep this standard up to date by the issue from time to time of replacement pages, or additional pages where necessary. Each replacement or added page will carry an issue number (with date) indicating its relationship to the original standard, the pages of which are marked 'Issue 1'. For example,

Issue 1 will indicate an original page or one that has been added to the original standard and has not been amended since insertion;

Issue 2 will indicate a first revision of either an original page or an added page;

Issue 3 will indicate either an original page revised for the second time since publication or an added page revised for the second time since insertion.

Side-lining on replacement pages will indicate that changes of technical or reference significance have been made at that point.

British Standard Specification for Unfired fusion welded pressure vessels

Section one. General

1.1 Scope

This British Standard specifies requirements for the design, construction, inspection, testing and certification of unfired fusion welded pressure vessels. The materials of construction are defined in section two. The term 'pressure vessel' as used in this standard includes branches up to the point of connection to the connecting piping by bolting, screwing or welding, and supports, brackets or other attachments directly welded to the pressure containing shell.

This standard applies only to pressure vessels manufactured under the survey of a competent engineering inspection Authority or Organization. The intent of this requirement may be regarded as satisfied where inspection is carried out by competent personnel of a separate engineering inspection department maintained by the purchaser of the vessel. An inspection department maintained by the manufacturer does not satisfy this requirement except:

- (a) that specific responsibilities may be delegated at the discretion of the Inspecting Authority or Organization; or
- (b) in the case of vessels for the manufacturer's own use and not for re-sale.

The vessels covered by this standard shall be made only by the manufacturers who can satisfy the Inspecting Authority or Organization that they are competent and suitably equipped to fulfil the appropriate requirements of this standard. (See also asterisked footnote.)

This standard does not cover the following.

- (a) Storage tanks designed for the storage of liquids at near atmospheric pressures, i.e. where the pressure additional to that due to the hydrostatic head does not exceed 140 mbar† above or 6 mbar below atmospheric pressure in accordance with such standards as BS 799, BS 2594, BS 2654, BS 4741, BS 5387.

Low pressure, above ground storage tanks which have a single vertical axis of revolution designed for the storage of liquids at a pressure not exceeding 1 bar†.

- (b) Vessels in which the stresses calculated in accordance with the equations given in section three of this standard are less than 10 % of the design stress permitted by section three.

(c) Strip wound compound or other special designs of vessels which may be appropriate for very high pressures.

(d) Transport vessels, i.e. vessels used for transport of contents under pressure.

- (e) Vessels for specific applications which are covered by standards listed in the *BSI Catalogue*.

Manufacturing techniques of glassed steel vessels may require special design considerations subject to the limits imposed by the method of construction and which should have the agreement of the Inspecting Authority.

1.2 Interpretation

If any ambiguity be found or doubt arise as to the meaning or effect of any part of this standard or as to whether anything ought to be done or omitted to be done in order that this standard should be complied with in full, the question shall be referred to the Pressure Vessels Technical Committee (PVE/I) of the British Standards Institution, whose interpretation of the requirements of this standard upon the matter at issue shall be given free of charge and shall be final and conclusive. Parties adopting this standard for the purposes of any contract shall be deemed to adopt this provision unless they expressly exclude it or else import an arbitration provision in terms extending to interpretation of this standard. However, this provision is limited to questions of interpretation and does not confer upon the committee any power, duty or authority to adjudicate upon the contractual rights or duties of any person under a contract except in so far as they may necessarily be affected by the interpretation arrived at by the committee.

Findings or rulings of the committee upon all enquiries, including matters of interpretation, which are of sufficient importance that both enquiries and replies be made public as soon as possible will be published in an enquiry-reply form for inclusion in the BS 5500 ring binder as Enquiry Cases. Their availability will be notified in *BSI News*.

After taking into account any public comment thereon, Enquiry Cases may be incorporated, as appropriate, into the standard as amendments which will form part of the next convenient annual updating.

1.3 References

The titles of the publications referred to in this standard are listed on the last page.

1.4 Definitions

For the purposes of this British Standard the following definitions apply.

1.4.1 purchaser. The organization or individual who buys the finished pressure vessel for its own use or as an agent for the owner.

* A national scheme to provide assurance that vessels are manufactured in conformity with this British Standard without the necessity for a purchaser specifically to commission the competent inspection Authority is operated by the Pressure Vessels Quality Assurance Board under the aegis of the Institution of Mechanical Engineers. Manufacturers holding a valid PVQAB Certificate of Authorization relating to the manufacture of pressure vessels to the relevant construction categories defined in this standard may also be deemed to be competent and suitably equipped for this purpose.

† 1 mbar = 10^2 N/m^2 = 100 Pa.

1 bar = 10^5 N/m^2 = 0.1 N/mm^2 = 100 kPa.

1.4.2 manufacturer. The organization which designs, constructs and tests the pressure vessel in accordance with the purchaser's specification. By agreement, the design function may be carried out by the purchaser or his agent, independently from the organization which constructs and tests the vessel (see 1.5).

1.4.3 Inspecting Authority. The body or association which checks that the design, materials and construction comply with the requirements of this standard.

1.4.4 Regulating Authority. The authority in the country of installation which is legally charged with the enforcement of the requirements of the law and regulations of that country relating to pressure vessels.

1.5 Responsibilities

1.5.1 Responsibilities of the purchaser. The purchaser shall be responsible for furnishing the manufacturer with the following information:

(a) a specification of the normal working conditions of the vessel, together with details of any transient and/or adverse conditions in which the vessel is required to operate and any special regulations for in-service inspection.

Where a purchaser elects to perform the design function for the vessel, the design specification furnished by the purchaser shall contain all the information (whether provided by the purchaser or by the manufacturer) which the manufacturer would otherwise be required by 4.1.1 to submit before commencing manufacture. The purchaser shall be responsible for the completeness of the design specification and for ensuring that all the information contained in it, or agreed modifications to it, comply with the requirements of this standard. The purchaser shall also be responsible for the accuracy of all design calculations associated with the preparation of the design specification:

(b) the name of the Inspecting Authority to be commissioned by the purchaser (see asterisked footnote to 1.1);

(c) any additional requirements not given in this standard;

(d) any special statutory or other regulations with which the finished vessel is required to comply;

(e) the name of the Regulating Authority (if any).

Where the Inspecting Authority is nominated by the purchaser, the purchaser shall be responsible for ensuring that any information which the manufacturer is required to supply, as specified in this standard, is made available to the Inspecting Authority.

Where necessary, it shall be the responsibility of the purchaser to ensure that the Inspecting Authority is acceptable to the Regulating Authority. This should be done at the time of the order.

1.5.2 Responsibilities of the manufacturer. The manufacturer shall be responsible for the completeness and accuracy of all design calculations and for compliance with all applicable requirements of this standard for the whole vessel. During fabrication, unexpected factors may arise which justify deviations from the specified requirements but which do not affect the safety as intended by this standard. Such deviations shall be submitted to the purchaser for approval and shall be recorded in accordance with item (f).

Where a purchaser elects to perform the design function for the vessel, the manufacturer shall be responsible for ensuring that all design information he requires to construct and test

the vessel is included in the design specification and for ensuring that all construction and testing is carried out in compliance with the requirements of this standard. The manufacturer shall also be responsible for the accuracy of any information he provides to the purchaser for inclusion in the design specification.

The manufacturer may subcontract specific activities to other organizations provided it satisfies the Inspecting Authority under the general provisions of 1.1 that it is competent to ensure by appropriate control or surveillance of its subcontractors that all relevant requirements of the standard are met.

The organization which discharges the manufacturer's responsibilities for construction and testing shall assume overall responsibility for compliance with the requirements of this standard during all related activities including part manufacture and subsequent fabrication to completion at works and/or site.

Examinations carried out by the Inspecting Authority do not absolve the manufacturer from his responsibility for compliance with the applicable requirements of this standard.

The manufacturer shall furnish to the purchaser any information which, as specified by the standard, requires the approval of the purchaser.

The manufacturer shall supply to the purchaser for record purposes a copy of the following documentation, as finally approved, for each vessel or batch of nominally identical vessels.

(a) A fully dimensioned drawing of the vessel, as built, together with any relevant supporting information as specified in 4.1.1 and which is not covered by items (b) to (h) below.

(b) A list of materials (including welding consumables) used in the construction of the vessel with details of any special heat treatments carried out by the material supplier.

NOTE. For materials specified to a British Standard the date of the standard will be given. Where other materials are used (see 2.2.3) the full specification is to be supplied.

(c) The non-destructive testing specification for the vessel in accordance with the requirements of 5.6.1.

(d) The welding procedures used during vessel manufacture (see 5.2.2).

(e) The procedures used for radiography, ultrasonic inspection and/or crack detection of welds (see 5.6.6.1, 5.6.6.2, 5.6.6.3 and 5.6.6.4).

(f) Records of authorized deviations or concessions as permitted in the first paragraph of this clause. The manufacturer shall add the suffix 'XX' to the serial number of each vessel for which any deviations or concessions have been authorized.

(g) A Certificate of Compliance for each vessel (see 1.5.4).

(h) A facsimile of stamping as required by 5.8.9.

The duration for which a manufacturer will retain all records he is required to generate during the design and construction of a vessel is influenced by a number of considerations which are outside the scope of this standard. If a purchaser wishes to retain permanent copies of any such records other than those listed above, e.g. design calculations, material certificates, subsequent heat treatment and manufacturing procedures, inspection and test reports

he should define his requirements in the purchase specification. To facilitate the identification of any such requirement a check list of optional documentation is given in appendix S.

1.5.3 Responsibilities of the Inspecting Authority. The Inspecting Authority shall be responsible for checking that the design of the vessel complies with the requirements of this standard and that all inspections and tests required during the manufacture of the vessel are carried out.

1.5.4 Certification. On completion of the vessel the manufacturer shall issue Form X to certify that the vessel has been designed, constructed and tested in every respect in accordance with the requirements of this standard. Form X shall be countersigned by the Inspecting Authority as required.

Where some of the activities covered by this standard are performed under the surveillance of a second Inspecting Authority, each Inspecting Authority shall attach a statement to Form X confirming which part of the total work has been carried out under its surveillance and that to the best of its knowledge and belief all aspects of this work have been in accordance with the requirements of BS 5500. The countersigned certificate and its attachments (if any) shall be furnished to the purchaser with a copy to the Regulating Authority if required.

Where the purchaser elects to perform the design function for the vessel, the purchaser shall complete the section of Form X which certifies that the design of the vessel complies with this standard.

Issue 1, January 1985

Vessel description

Year of manufacture Relevant BS 5500 issue
Purchaser Purchaser's serial no.
PVOAB serial no. (if any).

Name of manufacturer

Manufacturer's serial number (see note 1)

Name of Design Organization (if not above manufacturer).

.

Name of Inspecting Authority.

Design conditions of principal components (see notes 2 and 3)	Design pressure	Design temp.	Construction category	Corrosion allowance
	bar	°C		mm

Other factors affecting design (e.g. weight, nature of contents, environment)
(see notes 3 and 4)

Component	Temperature °C	Holding time h
-----------	-------------------	-------------------

Location (see note 5)	Test pressure bar	Test medium and temperature	Date
--------------------------	----------------------	--------------------------------	------

Certificate of Compliance (design)

We hereby certify that the design of this vessel complies with BS 5500

For manufacturer (see note 6):

Date:

Position:

Name of company:

We hereby confirm that we have checked the design of the above vessel and that this complies with the requirements of BS 5500.

For Inspecting Authority:

Date:

Position:

Name of company:

Certificate of Compliance (construction and testing)

We hereby certify that this vessel has been constructed and tested in compliance with the requirements of BS 5500.

For Manufacturer:

Date:

Position:

Name of company:

We hereby confirm that the construction and testing of the above vessel has been carried out under our surveillance and that to the best of our knowledge and belief all aspects of this work have been in accordance with the requirements of BS 5500.

For Inspecting Authority:

Date:

Position:

Name of company:

Where some of the construction and testing activities are performed under the surveillance of a second Inspecting Authority, see 1.5.4.

NOTE 1. The suffix 'XX' is to be added to the serial number of each vessel for which any deviations or concessions have been authorized (see 1.5.2 (f)).

NOTE 2. The design conditions associated with the operational duties specified by the purchaser should be given.

If a purchaser wishes to change the operational duty of a vessel, revised design conditions, consistent with the vessel scantlings, will be established separately, as appropriate.

NOTE 3. Where the design covers operation below 0 °C the pressure and temperature characteristic and associated working stress level over the entire operating temperature range should be stated.

NOTE 4. Where appropriate, cross reference to drawings or specifications will suffice.

NOTE 5. Where a vessel is tested in a different orientation to that in which it will normally operate, this should be stated.

NOTE 6. This part of the Certificate to be signed by the purchaser in cases where the purchaser elects to perform the design function (see 1.5.4).

Section two. Materials

2.1 General

This section covers the material selection and nominal design strengths for pressure vessels constructed in accordance with this standard.

2.2 Selection of materials

2.2.1 The selection of the materials of construction for pressure containing parts and their integral attachments shall take into account the suitability of the material with regard to fabrication* and to the conditions under which they will eventually operate. Special consideration should be given to the selection of materials for vessels designed to operate below 0 °C (see appendix D). Austenitic stainless steels (including the high nitrogen and warm worked varieties) and aluminium alloys are not susceptible to low stress brittle fracture and no special requirements are necessary for their use at temperatures down to -196 °C. Any special limits, for example with respect to composition, heat treatment, etc., which the materials or pressure vessel user may require in relation to the particular end use of material, shall be the subject of agreement between the purchaser and the manufacturer at the time of enquiry and order.

2.2.2 All the materials used in the manufacture of pressure parts shall comply with the requirements of the appropriate British Standard referred to in 2.4 or 2.5 except as otherwise permitted by this section.

Welding material shall satisfy the requirements of sections four and five of this standard.

The use of castings for pressure parts shall be subject to agreement between the purchaser and the manufacturer. An appropriate 'quality specification' for such castings should be agreed between the manufacturer and the material supplier at the time of enquiry, specifying the standards of inspection to be applied and of acceptance for defects. As a minimum, all acceptable fillets and changes of section, etc., shall be subject to magnetic particle or penetrant inspection. Bolts and nuts shall be in accordance with the material specifications listed in tables 3 and 4 of BS 4882: 1973 or table 3 of BS 1473: 1972.

2.2.3 Other materials may be used for pressure parts by express agreement between the purchaser and the manufacturer provided that:

- (a) they comply with the general requirements of 2.4 or 2.5 as appropriate and are covered by a written specification at least as comprehensive as the British Standards listed in table 2.3 for the nearest equivalent material;
- (b) the design strengths are determined in accordance with 2.3.2.

2.2.4 Materials for supporting lugs, skirts, baffles and similar non-pressure parts welded to vessels shall be of established identity and shall be compatible with the material to which they are attached.

2.3 Nominal design strength

2.3.1 Nominal design strength values for materials covered by British Standards are given in table 2.3.

These values are for design purposes as specified in the relevant sections of this standard only and are not intended

to be a basis for acceptance or rejection of material. Their derivation is described in appendix K.

NOTE. Values between those given in the various columns of the table may be linearly interpolated.

2.3.2 The nominal design strength of materials used in accordance with 2.2.3 shall be derived in a manner consistent with appendix K: details of the procedure used shall be agreed between the purchaser and the manufacturer and recorded.

2.4 Carbon, carbon manganese and alloy steels

2.4.1 Permissible materials covered by British Standards are listed together with their appropriate nominal design strengths in table 2.3. Non-destructive testing requirements are covered in 5.6.2. Where relevant, the restrictions in 2.4.2.2 apply.

Additionally, materials complying with the requirements of the standards listed in table 2.4 may be used for the construction of category 3 vessels provided the qualifying requirements indicated in table 2.4 are satisfied.

2.4.2 For other materials covered by this subsection the following general requirements shall apply.

2.4.2.1 The material specification (see 2.2.3) shall specify steelmaking process, compositional limits for all constituents, deoxidation practice, heat treatment and appropriate mechanical properties for acceptance and other purposes.

2.4.2.2 For ferritic steels intended for welding, the upper limit of the carbon range (in the ladle analysis) should not exceed 0.25 %. Steels with a higher carbon content which are intended for welding may be used subject to special agreement on welding procedures between the parties concerned. The maximum allowable phosphorus and sulphur content should not exceed 0.05 % each in the ladle analysis.

2.4.2.3 The deoxidation practice should be appropriate to the type of steel ordered particularly where it may influence the level of elevated or low temperature properties. Semi-killed steel may be used in accordance with this standard for plates, seamless and welded tubes in carbon and carbon manganese steels with an upper limit of the specified tensile strength range of 640 N/mm² and with a thickness not exceeding 100 mm. Rimmed steel should only be used for welded tubes in carbon and carbon manganese steel types with an upper limit of the specified tensile strength range of 490 N/mm² under service temperature conditions between 0 °C and 380 °C.

2.4.2.4 Mechanical properties at room temperature shall be specified for acceptance tests in accordance with BS 18 covering R_m , R_e (see appendix K) and minimum elongation at fracture.

The specified minimum percentage elongation at fracture referred to a gauge length of $5.65 \sqrt{S_0}$ should be appropriate to the type of steel with a lower limit of 16 % for plates, 15 % for castings and 14 % for tubes and forgings, unless the use of the steel is subject to special agreement.

Unless otherwise agreed, minimum Charpy V-notch properties related to BS 131: Part 2 shall also be specified, with the direction of testing as specified in appropriate British Standards for similar product forms.

The rate of testing and methods of acceptance testing shall generally be consistent with appropriate British Standards for similar product forms.

*See appendix G of BS 5135: 1984 for general guidance on the susceptibility of materials to lamellar tearing during fabrication.

2.4.2.5 For materials that will be used above 50 °C, a yield point or proof stress properties related to tests in accordance with BS 3688 should be specified unless otherwise agreed.

2.4.2.6 Stress rupture properties shall be specified for materials which will be used in the creep range. These shall be determined in accordance with the procedure laid down in BS 3228: Part 2. The manufacturer of the vessel shall be assured that the product supplied is capable of meeting the specified properties by a statement that the manufacturing processes have remained equivalent to those for the steel for which the test results were obtained.

2.4.2.7 Charpy V-notch impact test properties at appropriate temperatures shall be specified for materials that will be used for low temperature service, except in the case where impact testing is unnecessary (see appendix D). The properties shall be verified in accordance with BS 131: Part 2 at the rate of three tests per sample at a temperature to be agreed.

2.4.2.8 Materials shall be supplied in a heat treated condition appropriate to the nearest equivalent British Standard unless otherwise agreed between the interested parties.

Plates for hot forming may be supplied in any suitable condition as agreed between the manufacturer and the material supplier.

Carbon and carbon manganese steel plates for cold forming shall be supplied in the normalized condition except when their thickness is less than 25 mm, when the plates may be supplied as-rolled if guaranteed elevated temperature properties are not required.

Low alloy plates for cold forming should be supplied in the normalized and tempered condition but may be supplied in the normalized condition if metallurgically suitable and provided post-weld heat treatment will suffice as the tempering treatment.

Electric resistance welded or induction welded tubes may be used in the as-welded condition provided the specified upper limit of tensile strength does not exceed 540 N/mm² and they are not intended for service below a temperature of 0 °C.

2.4.2.9 The heat treatment condition to which the specified properties relate shall be clearly stated in the material specifications. These properties can be affected by reheating during fabrication and, where necessary (see 4.4), the manufacturer should discuss the application and proposed heating or reheating of the steel with the material supplier. However, the test plates should be supplied and tested in a condition corresponding to the material specification specifically requested by the manufacturer. The heat treatment to be given to the test pieces and the acceptance properties should be agreed at the time of order.

2.5 Aluminium*

2.5.1 Permissible materials covered by British Standards are listed together with their appropriate nominal design strengths in table 2A.3. Non-destructive testing requirements are covered in 5.6.2.

2.5.2 For other materials covered by this clause (see 2.2.3) the general requirements specified in 2.5.2.1 to 2.5.2.5 apply.

2.5.2.1 The material specification (see 2.2.3) shall specify the composition limits for all constituents, heat treatment and the appropriate mechanical properties for acceptance and other purposes.

2.5.2.2 Mechanical properties at room temperature shall be specified for acceptance tests in accordance with BS 18 covering:

the tensile strength range,

the minimum 0.2 % proof stress (R_p),

the specified minimum percentage elongation at fracture, referred to a gauge length of $5.65 \sqrt{S_0}$ or 50 mm, should be appropriate to the type of material with a lower limit of 5 %.

2.5.2.3 For materials that will be used at temperatures above 50 °C, tensile data should be provided from which the expected minimum tensile strength and minimum 0.2 % proof strength at the operating temperature can be established. If the operating temperature equals or exceeds 100 °C, stress rupture data shall be available for determining the design strength and design lifetime.

2.5.2.4 The design strength values given in table 2A.3 are appropriate to materials having the minimum tensile strength (R_m) and minimum 0.2 % proof stress ($R_{p0.2}$) values at room temperature shown in columns 2 and 3. Other thicknesses of the same form and other product forms may be used, the minimum tensile properties being established either by reference to the material specification or by arrangement with the material supplier. If the minimum values of $R_{p0.2}$ and R_m are less than those given in table 2A.3 for the same temper or condition, the design strengths that are not time-dependent shall be reduced proportionately.

2.5.2.5 Pressure vessels in aluminium alloys containing 3.0 % or more of magnesium for use at temperatures above 60 °C shall be constructed only from material supplied in the annealed (O) condition.

NOTE. Consideration should be given to the extent of cold forming during fabrication and the need for annealing. The purchaser is advised to discuss the proposed application with the manufacturer and material supplier.

Table 2.3 Design strength values: index of steels

	Standard	Part of table 2.3
Steel plates	BS 1501: Part 1 BS 1501: Part 2 BS 1501: Part 3	(a) (b) (c)
Steel sections and bars	BS 1502	(d)
Steel forgings	BS 1503	(e)
Steel castings	BS 1504	(f)
Steel pipes and tubes	BS 3059: Parts 1 and 2 BS 3601, BS 3602: Parts 1 and 2	(g) (h)
	BS 3603	(h)
	BS 3604	(i)
	BS 3605	(j)
	BS 3606	(k)

* In the context of this British Standard, the term 'aluminium' means either aluminium or its alloys as listed in table 2A.3.

Table 2.3(a) Design strength values (N/mm²)

Plates

Grade, type & method of manufacture	R_m	R_e	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																	Design lifetime h	Notes
	N/mm ²	N/mm ²			50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480		
Carbon steel (rimmed) to BS 1501 : Part 1																							
141, 360A	360	205 195	M 0	3 to 16* 19*	137 130	126 122	115 113	112 108	100	86	79												9, 16
Carbon steel (semi-killed with aluminium) to BS 1501 : Part 1																							
154, 360A	360	205	M 1	3 to 9.5	137	126	115	112	100	86	79												9
154, 400A	400	235	M 1	3 to 9.5	156	144	133	130	116	97	91												
154, 430A	430	250	M 1	3 to 9.5	167	157	148	143	128	107	102												
Carbon steel (semi-killed or fully-killed) to BS 1501 : Part 1																							
151, 161, 360 (A and B)	360	205	M 1	3 to 16*	137	126	115	112	100	86	81	78		77	76	69	60	52	44	36	100 000	9, 16	
		195		40*	130	119	113	108	96						74	65	56	48	40	32	150 000		
		185		63*	123	114	105	101	95						71	62	53	45	37	28	200 000		
		175		100*	117	108	99	96	91						68	59	51	42	35	26	250 000		
		170		150*	113	105	96	93	88														
151, 161, 400 (A and B)	400	225	M 1	3 to 16*	150	141	133	130	117	97	92	89	88	87	79	69	60	52	44	36	100 000	16	
		215		40*	143	135	128	123	110				88	83	74	65	56	48	40	32	150 000		
		205		63*	137	129	121	117	108				88	80	71	62	53	45	37	28	200 000		
		200		100*	133	123	113	111	105				87	78	68	59	51	42	35	26	250 000		
		195		150*	130	119	110	108	102														
151, 161, 430 (A and B)	430	250	M 1	3 to 16*	167	157	148	143	128	107	102	100	99	98	88	79	69	60	52	44	36	100 000	16
		240		40*	160	150	140	135	121				99	93	83	74	65	56	48	40	32	150 000	
		230		63*	153	143	133	128	119				99	90	80	71	62	53	45	37	28	200 000	
		220		100*	147	135	124	121	115				97	87	78	68	59	51	42	35	26	250 000	
		210		150*	140	129	118	115	110														

Table 2.3(a) Design strength values (N/mm²) (continued)

Plates

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																		Design lifetime h	Notes	
					50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480				
Carbon steel (fully-killed aluminium treated) to BS 1501 : Part 1																									
164, 360A	360	255	M 1	3 to 16*	153	138	124	110	97	86	79		73	73	72	71	69	60	52	44	36	100 000 150 000 200 000 250 000	9, 16		
		235		40*	153	137	122	109							71	65	56	48	40	32					
		220		63*	147	130	115	106							71	62	53	45	37	28					
		202		100*	135	122	110	104							68	59	51	42	35	26					
		180		150*	120	112	105	102																	
164, 360B	360	255	M 1	3 to 16*	153	145	137	122	107	95	87		83	82	81	79	69	60	52	44	36	100 000 150 000 200 000 250 000	16		
		235		40*	153	143	134	121							81	74	65	56	48	40	32				
		220		63*	147	137	127	117							80	71	62	53	45	37	28				
		202		100*	135	129	122	115							78	68	59	51	42	35	26				
		180		150*	120	118	117	112																	
164, 400A	400	275	M 1	3 to 16*	170	155	140	125	111	98	91		86	85	84	79	69	60	52	44	36	100 000 150 000 200 000 250 000	9, 16		
		265		40*	170	154	138	125							83	74	65	56	48	40	32				
		245		63*	163	147	131	122							80	71	62	53	45	37	28				
		225		100*	150	138	126	120							78	68	59	51	42	35	26				
		201		150*	134	127	121	117																	
164, 400B	400	275	M 1	3 to 16*	170	161	153	137	121	108	101		95	94	88	79	69	60	52	44	36	100 000 150 000 200 000 250 000	16		
		265		40*	170	160	149	135							93	83	74	65	56	48	40			32	
		245		63*	163	152	144	133							90	80	71	62	53	45	37			28	
		225		100*	150	143	138	130							87	78	68	59	51	42	35			26	
		201		150*	134	132	132	128																	
Carbon manganese steel (fully-killed niobium treated) to BS 1501 : Part 1																									
223, 460A	460	340	M 1	3 to 16*	195	182	169	155	143	130	124	117	115	114	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16		
		330		40*	195	182									115	111	95	81	68	58	50			43	37
		320		63*	195	182									115	104	88	75	63	54	46			40	34
		294		100*	195	182									115	98	83	70	59	51	43			37	31
		262		150*	175	172																			

2/4

812

2155 1453

Table 2.3(a) Design strength values (N/mm²) (continued)

Plates

Grade, type & method of manufacture	R_m	R_e	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																	Design lifetime h	Notes
	N/mm ²	N/mm ²			50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480		
Carbon manganese steel (fully-killed niobium treated) to BS 1501 : Part 1																							
223, 460B	460	340	M 1	3 to 16*	195	187	179	173	158	139	131	125	124	121	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16
		330		40*	195	187	179						124	111	95	81	68	58	50	43	37		
		320		63*	195	187	179						121	104	88	75	63	54	46	40	34		
		294		100*	195	187	179						115	98	83	70	59	51	43	37	31		
		262		150*	175	175	175																
223, 490A	490	355	M 1	3 to 16*	208	193	179	173	158	139	131	123	122	121	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16
		345		40*	208	193	179						122	111	95	81	68	58	50	43	37		
		340		63*	208	193	179						121	104	88	75	63	54	46	40	34		
		313		100*	208	193	179						115	98	83	70	59	51	43	37	31		
		279		150*	186	180	175																
223, 490B	490	355	M 1	3 to 16*	208	198	189	184	168	147	137	133	132	121	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16
		345		40*	208	198	189						128	111	95	81	68	58	50	43	37		
		340		63*	208	198	189						121	104	88	75	63	54	46	40	34		
		313		100*	208	198	189						115	98	83	70	59	51	43	37	31		
		279		150*	186	186	186																
Carbon manganese steel (fully-killed aluminium treated) to BS 1501 : Part 1																							
224, 400A	400	275	M 1	3 to 16*	170	155	140	125	111	98	91	86	85	84	83	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16	
		265		40*	170	154	138	125						84	81	68	58	50	43	37			
		245		63*	163	147	131	122						84	75	63	54	46	40	34			
		225		100*	150	138	126	120						83	70	59	51	43	37	31			
		201		150*	134	127	121	117															
224, 400B	400	275	M 1	3 to 16*	170	161	153	137	121	108	101	95	94	93	90	77	65	56	48	42	100 000 150 000 200 000 250 000	16	
		265		40*	170	161	149	135						93	81	68	58	50	43	37			
		245		63*	163	154	144	133						88	75	63	54	46	40	34			
		225		100*	150	144	138	130						83	70	59	51	43	37	31			
		201		150*	134	133	132	128															

Table 2.3(a) Design strength values (N/mm²) (concluded)

Plates

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																	Design lifetime h	Notes		
					50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480				
Carbon manganese steel (fully-killed aluminium treated) to BS 1501 : Part 1																									
224, 430A	430	305	M 1	3 to 16*	183	168	153	137	121	108	101		95	94	93	90	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16		
		285		40*	183	166	149	135							93	81	68	58	50	43	37				
		275		63*	183	164	144	133							88	75	63	54	46	40	34				
		253		100*	168	153	138	130							83	70	59	51	43	37	31				
		225		150*	150	141	132	128																	
224, 430B	430	305	M 1	3 to 16*	183	174	165	149	132	117	111		105	104	103	90	77	65	56	48	42	100 000 150 000 200 000 250 000	16		
		285		40*	183	172	161	147					104	95	81	68	58	50	43	37					
		275		63*	183	170	157	145					104	88	75	63	54	46	40	34					
		253		100*	168	160	151	142					98	83	70	59	51	43	37	31					
		225		150*	150	148	144	139																	
224, 460A	460	325	M 1	3 to 16*	196	180	165	149	132	117	111		105	104	103	90	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16		
		315		40*	196	178	161	147					104	95	81	68	58	50	43	37					
		305		63*	196	176	157	145					104	88	75	63	54	46	40	34					
		281		100*	187	169	151	142					98	83	70	59	51	43	37	31					
		250		150*	167	155	144	139																	
224, 460B		325	M 1	3 to 16*	196	186	177	160	142	128	121	116	115	114	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	16		
		315		40*	196	184	173	158					115	111	95	81	68	58	50	43	37				
		305		63*	196	183	171	156					115	104	88	75	63	54	46	40	34				
		281		100*	187	176	164	153					115	98	83	70	59	51	43	37	31				
		250		150*	167	162	157	150																	
224, 490 (A and B)	490	325	M 1	3 to 16*	208	192	177	160	142	128	121	116	115	114	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	16		
		315		40*	208	190	173	158					115	111	95	81	68	58	50	43	37				
		305		63*	204	187	171	156					115	104	88	75	63	54	46	40	34				
		281		100*	187	176	164	153					115	98	83	70	59	51	43	37	31				
		250		150*	167	162	157	150																	
Carbon manganese steel (fully-killed niobium and aluminium treated)																									
225, 490A	490	355	M 1	3 to 16*	208	193	179		173	158	139	131	123	124	121	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16	
		345		40*	208	193	179								124	111	95	81	68	58	50	43			37
		340		63*	208	193	179								121	104	88	75	63	54	46	40			34
		313		100*	208	193	179								115	98	83	70	59	51	43	37			31
		279		150*	186	180	175																		
225, 490B	490	355	M 1	3 to 16*	208	198	189		184	168	147	137	133	132	121	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	9, 16	
		345		40*	208	198	189								128	111	95	81	68	58	50	43			37
		340		63*	208	198	189								121	104	88	75	63	54	46	40			34
		313		100*	208	198	189								115	98	83	70	59	51	43	37			31
		279		150*	186	186	186																		

Table 2.3(b) Design strength values (N/mm²)

Plates

Grade, type & method of manufacture	R_m	R_e	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																								Design lifetime h	Notes							
	N/mm ²	N/mm ²			50	100	150	200	250	300	350	400	440	450	460	480	490	500	510	520	530	540	550	560	570	580											
Low alloy steel to BS 1501 : Part 2																																					
240 ½MoV	450	285 275	M 2	Up to 16 16 to 63 above 63	190 167 183	167	145	138	130	121	117	114																									1a
271 MnCrMoV	586	464	M 4	Up to 25 25 to 76 above 76	249	249	249	249	249	249	242	234	231		209	155	107		69		41		30					100 000	11a								
	556	417			237	237	237	237	237	235	229	221	219														200 000										
	556	386			237	237	233	227	221	207	201	194	193		192	131	87		51		36		18					100 000									
281 NiCrMoV	566	464	M 4	Up to 25 25 to 76 above 76	249	249	249	249	249	249	242	234	201		188	168	124			55		33		24					100 000	11b							
	556	417			237	237	237	237	235	229	221															200 000											
	556	386			237	237	233	227	221	207	201	194	193		177	152	105	69		40		21		14					200 000								
282 NiCrMoV	586	480	M 4	Up to 25 25 to 76 above 76	249	249	249	249	249	249	247	242	201		188	168	124											100 000									
	586	448			249	249	249	249	249	247	237	232													150 000												
	572	417			243	243	243	243	232	217	211	206	193		177	152	105									200 000											
503 ¾Ni	448	263	M 5	Up to 38	175																																
509-510 9Ni	695	515	M 6	Up to 51	295																																
	695	586		Up to 51	295																																

2/7

BS 5500: 1985
Issue 1, January 1985

Table 2.3(b) Design strength values (N/mm²) (concluded)

Plates						Values of f for design temperatures ($^{\circ}\text{C}$) not exceeding																								Design lifetime h	Notes
Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Thickness mm	50	100	150	200	250	300	350	400	440	450	460	480	490	500	510	520	530	540	550	560	570	580					
Low alloy steel to BS 1501 : Part 2																															
620-27A 1Cr½Mo	417	286	M 7	Up to 152	177	158	139	131	115	98	93	90		89																	
620-27B 1Cr½Mo	417	286	M 7	Up to 152	177	163	149	141	124	105	100	97		95				94	94	93	76	62	51	42	33	27	100 000				
																			94	83	67	55	44	35	29	24	150 000				
																			94	76	61	49	40	32	26	22	200 000				
																			87	70	57	45	37	30	25	20	250 000				
620-621 31A 1Cr½Mo 1¼Cr½Mo	479 448	340 317	M 7	Up to 75 above 75	210 191	185 167	174 157	166 149	154 136	141 120	133 114	129 109		126 108		120 106															
620-621 31B 1Cr½Mo 1¼Cr½Mo	479 448	340 317	M 7	Up to 75 above 75	210 191	199 180	187 169	178 160	166 146	151 129	143 122	139 117		134 115		120 113	112 101	93 83	76 67	62 55	51 44	42 35	33 29	27 24		100 000					
																		113	94	76	61	49	40	32	26	22	150 000				
																		107	87	70	57	45	37	30	25	20	200 000				
																											250 000				
622-31A 2¼Cr1Mo	479	278	M 9	Up to 152	185	159	134	127	125	123	120	115		110		105															
622-31B 2¼Cr1Mo	479	278	M 9	Up to 152	185	164	144	137	134	132	129	124		117		112	109	105	94	82	72	61	53	45	39	34	100 000				
																		108	97	85	73	63	56	48	41	36	31	150 000			
																		104	91	79	68	59	52	45	38	33	28	200 000			
																		100	87	75	65	57	49	42	36	32	27	250 000			
622-45A 2¼Cr1Mo	687	556	M 9	Up to 152	292	292	292	292	292	292	292	206		145		126															
622-45B 2¼Cr1Mo	687	556	M 9	Up to 152	292	292	292	292	292	292	292	220		170	157	131	118	105	94	82	72	61	53	45	39	34	100 000				
																		161	148	121	108	97	85	73	63	56	48	41	36	31	150 000
																		156	143	117	104	91	79	68	59	52	45	38	33	28	200 000
																		152	139	113	100	87	75	65	57	49	42	36	32	27	250 000

Table 2.3(c) Design strength values (N/mm²)

Plates

Grade, type & method of manufacture	R _m N/mm ²	R _e N/mm ²	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																								Design lifetime h	Notes																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
					50	100	150	200	250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700	720	740			750																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
High alloy steel to BS 1501 : Part 3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				

Table 2.3(c) Design strength values (N/mm²) (concluded)

Plates

Grade, type & method of manufacture	R_m	R_e	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																								Design lifetime h	Notes		
	N/mm ²	N/mm ²			-50	100	150	200	250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700	720	740			750	
High alloy steel to BS 1501 : Part 3																																
316-S16	520	262		Up to 51	173	152	134	122	114	110	107	103	100	95	94	93	93	92	91	72	58	46	35	28	23						100 000	6
																			85	66	52	41	36	31	25	19					150 000	
																			79	61	48	37	33	29	22	18					200 000	
																			75	58	45	35	31	27	21	18					250 000	
316-S49	510	216		Up to 51	143	128	114	104	97	94	90	88	86	82	80	79	78	77	75	74	72	58	53	46	35	28	23					
																					66	52	46	41	31	25	19					150 000
																					61	48	43	37	29	22	18					200 000
																					58	45	40	35	27	21	18					250 000
316-S62, S66	620	340		Up to 32	227	189	172	154	149	143	137	132	128	124			118		80				50									
316-S82	620	340		Up to 25.4	248	248	248	248																								
320-S17	520	270		Up to 51	180	157	137	124	116	112	107	104																				
310-S24	540	270		Up to 51	180	157	137	124	116	112	107	104	101	97			73		58				40			24			13			
NA15 (Annealed)	520	240			160	144	134	129	129	129	129	124	122	122			119		84				46			24			10			
NA15 (Solution treated)	448	193			130	130	124	111	97	86	86	86	86	78			71		69				68			39			27			
NA16	590	262			173	173	169	160	154	149	149	149																				

Table 2.3(d) Design strength values (N/mm²)

Sections and bars

Grade, type & method of manufacture	R_m	R_e	BS 5500 grade	Thickness mm	Diameter mm	Values of f for design temperatures (°C) not exceeding																Design lifetime h	Note
	N/mm ²	N/mm ²				50	100	150	200	250	300	350	400	410	420	430	440	450	460	470	480		
Carbon steel (semi- or silicon-killed) to BS 1502																							
151, 161	430	250	M 0	Up to 16*	Up to 25*	167	157	148	143	128	107	102	99	98	88	79	69	60	52	44	36	100 000 150 000 200 000 250 000	16
		240		Up to 40*	Up to 50*	160	150	140	135	121			99	93	83	74	65	56	48	40	32		
		230		Up to 63*	Up to 100*	153	143	133	128	119			99	90	80	71	62	53	45	37	28		
		220		Up to 100*	Up to 160*	147	135	124	121	115			97	87	78	68	59	51	42	35	26		
Carbon manganese steel (semi- or silicon-killed) to BS 1502																							
211, 221	430	250	M 1	Up to 16*	Up to 25*	167	157	148	143	128	107	102	99	98	97	90	77	65	56	48	42	100 000 150 000 200 000 250 000	16
		240		Up to 40*	Up to 50*	160	150	140	135	121			95	81	68	58	50	43	37				
		230		Up to 63*	Up to 100*	153	143	133	128	119			88	75	63	54	46	40	34				
		220		Up to 100*	Up to 160*	147	135	124	121	115			83	70	59	51	43	37	31				
Carbon manganese steel (silicon-killed, aluminium treated) to BS 1502																							
224, 430	430	275	M 1	Up to 16*	Up to 25*	183	168	153	137	121	108	101	95	94	93	90	77	65	56	48	42	100 000 150 000 200 000 150 000	16
		265		Up to 40*	Up to 50*	176	163	149	136	93	81	68	58	50	43	37							
		245		Up to 63*	Up to 100*	163	154	144	133	88	75	63	54	46	40	34							
		240		Up to 100*	Up to 160*	160	151	141	131	83	70	59	51	43	37	31							
224, 490	490	325	M 1	Up to 16*	Up to 25*	208	193	177	160	142	128	121	115	114	104	90	77	65	56	48	42	100 000 150 000 200 000 250 000	16
		315		Up to 40*	Up to 50*	208	191	173	158	111	95	81	68	58	50	43	37						
		305		Up to 63*	Up to 100*	203	187	171	156	104	88	75	63	54	46	40	34						
		300		Up to 100*	Up to 160*	200	184	168	152	98	83	70	59	51	43	37	31						

Table 2.3(d) Design strength values (N/mm²) (continued)

Sections and bars

Grade, type & method of manufacture	R _m N/mm ²	R _e N/mm ²	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																								Design lifetime h	Notes	
					50	100	150	200	250	300	350	400	440	450	460	480	490	500	510	520	530	540	550	560	570	580					
Low alloy steel to BS 1502																															
271-560 MnCrMoV	560	370	M 4	≤ 160	238	229	220	215	208	204	199	192		188	185	155	129	107	87	69	54	41	30					100 000	15		
																														150 000	
																															200 000
																															250 000
620-440 1Cr½Mo	440	265	M 7	≤ 160	177	163	149	142	131	123	113	108		105			101	100	93	76	62	51	42	33	27		100 000	15			
																														150 000	
																															200 000
																															250 000
620-540 1Cr½Mo	540	375	M 7	≤ 160	230	224	219	210	202	196	189	186		178	175	162	136	112	93	76	62	51	42	33	27		100 000	15			
																														150 000	
																															200 000
																															250 000
622-490 2¼Cr1Mo	490	275	M 9	≤ 160	183	176	169	163	157	153	149	145		137	135	131	118	105	94	82	72	61	53	45	39	34	100 000	5.15			
																														150 000	
																															200 000
																															250 000
625-590 5Cr½Mo	590	450	M 10	≤ 160																											
625-640 5Cr½Mo	640	500		≤ 160																											
629-590 9Cr1Mo	590	400		≤ 160	251	241	232	223	220	217	215	211	208	207	195	159	144	129	115	103	91	80	68	57	48	38	100 000				
																														150 000	
																															200 000
																															250 000
509-650 9Ni	650	490		≤ 75	277																								1d.13		
509-690 9Ni	690	490	M 5	≤ 100	294																							1d.13 15			

Table 2.3(d) Design strength values (N/mm²) (concluded)

Sections and bars

Grade, type & method of manufacture	R _m N/mm ²	R _e N/mm ²	BS 5500 grade	Ruling section mm	Values of f for design temperatures (°C) not exceeding																												Design lifetime h	Notes
					50	100	150	200	250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700	720	740	750					
Austenitic stainless steel to BS 1502																																		
304-S11	480	215		160	143	127	111	101	95	90	86	81	80																					
304-S31	490	230		160	153	136	119	109	103	98	93	87	87																					
304-S51	490	230		160	153	136	119	109	103	98	93	89	87	85		84	83	81	68	57	47	38	35	31	23	18				100 000	6			
																84	83	76	62	51	41	33	30	26	20	15				150 000				
																83	78	72	58	48	38	31	27	24	18						200 000			
																81	75	68	56	45	36	28	25	22	17						250 000			
304-S61	550	305		160	203	174	149	135	127	121	116	110	107	104																				
304-S71	550	305		160	203	174	149	135	127	121	116	110	107	104																				
316-S11, S13, S53	490	225		160	150	134	119	110	103	99	94	91	88																					
316-S31, S33	510	240		160	160	143	127	118	111	106	101	99	96																					
316-S51	510	240		160	160	143	127	118	111	106	101	99	96	93		90		89	88	72	58	53	46	35	28	23				100 000	6			
																			85	66	52	46	41	31	25	19						150 000		
																			79	61	48	43	37	29	22	18						200 000		
																			75	58	45	40	35	27	21	18						250 000		
316-S61, S63 -S65, S67	580	315		160	210	180	154	142	133	127	123	119	116	113																				
321-S31	510	235		160	157	145	133	127	121	117	113	110	107																					
321-S51 (490)	490	190		160	127	115	103	97	93	87	84	81	79	78		77		76	76	68	55	49	44	34	26									
																			76	61	50	44	38	29								100 000	6	
																			72	58	46	41	35	27								150 000		
																			68	55	44	38	33	25								200 000		
																																	250 000	
321-S51 (510)	510	235		160	157	145	133	127	121	117	113	110	107	104		102	102	101	86	71	57	42	36	31									100 000	
																			102	93	78	64	49	36	32	27							150 000	
																			97	89	74	58	45	33	28	25							200 000	
																			93	85	71	55	42	31	26	22							250 000	
347-S31	510	240		160	160	151	142	135	127	123	120	118	116																					
347-S51	510	240		160	160	151	142	135	127	123	120	118	116	115		113	113	113*	99	81	66	53	47	41	31	24							100 000	7
																			113	111	93	75	61	48	41	37	28	21					150 000	
																			113*	106	88	71	58	45	39	34	25	19					200 000	
																			112	102	85	68	55	42	37	31	24	19					250 000	

BS 5500:1985
Issue 1, January 1985

Table 2.3(e) Design strength values (N/mm²)
Forgings (see Special note 1b)

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Ruling section mm (See note (d))	Values of f for design temperatures (°C) not exceeding																	Design lifetime h	Notes
					50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480		
Carbon manganese steels to BS 1503																							
164-490	490	305 280	M 1	≤ 100 > 100, ≤ 150	203 187	187 173	171 159	156 145	142 137	128 121	115	114 111 104 98	98 95 88 83	90 81 75 70	77 68 63 59	65 58 54 51	56 50 46 43	48 43 40 37	42 37 34 31	100 000 150 000 200 000 250 000	15		
221-410	410	215 205	M 1	≤ 100 > 100	143 137	134 126	125 116	121 113	112 108	100 95	92	92 92 88 83	90 81 75 70	77 68 63 59	65 58 54 51	56 50 46 43	48 43 40 37	42 37 34 31	100 000 150 000 200 000 250 000	15			
221-430	430	225 215	M 1	≤ 100 > 100	150 143	141 133	133 124	129 121	119 115	107 102	99	99 99 99 98	98 95 88 83	90 81 75 70	77 68 63 59	65 58 54 51	56 50 46 43	48 43 40 37	42 37 34 31	100 000 150 000 200 000 250 000	15		
221-460	460	245 235	M 1	≤ 100 > 100	163 157	154 146	145 135	140 131	129 125	117 112	108	108 108 104 98	104 95 88 83	90 81 75 70	77 68 63 59	65 58 54 51	56 50 46 43	48 43 40 37	42 37 34 31	100 000 150 000 200 000 250 000	15		
221-490	490	265 255	M 1	≤ 100 > 100	177 170	167 158	157 146	151 141	140 135	128 122	119	118 118 118 115	118 111 104 98	104 95 88 83	90 81 75 70	77 68 63 59	65 58 54 51	56 50 46 43	48 43 40 37	100 000 150 000 200 000 250 000	15		
221-510	510	285	M 1	100	190	177	165	159	147	135	129	125	124 124 121 115	121 111 104 98	104 95 81 70	90 81 68 59	77 68 58 51	65 58 50 43	56 50 46 37	48 43 40 31	100 000 150 000 200 000 250 000	15	
221-530	530	295	M 1	100	197	185	173	167	155	141	136											14, 15	
221-550	550	305	M 1	100	203	192	181	175	162	149	142											14, 15	

Table 2.3(e) Design strength values (N/mm²) (continued)

Forgings (see Special note 1b)

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Ruling section mm (See note (d))	Values of f for design temperatures (°C) not exceeding																	Design lifetime h	Notes
					50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480		
Carbon manganese steels to BS 1503																							
223-410	410	245 230	M 1	≤ 100 > 100	163	150	138	130	120	106	99		92		91	90	77	65	56	48	42	100 000	15
					153	141	129	121	115					91	81	68	58	50	43	37	150 000		
													88	75	63	54	46	40	34	200 000			
											83	70	59	51	43	37	31	250 000					
223-430	430	260 245	M 1	≤ 100 > 100	173	160	148	139	128	114	107		100	99	98	90	77	65	56	48	42	100 000	15
					163	152	134	129	123				95	81	68	58	50	43	37	150 000			
												88	75	63	54	46	40	34	200 000				
											83	70	59	51	43	37	31	250 000					
223-460	460	290 270	M 1	≤ 100 > 100	193	179	164	151	140	127	119		111	110	104	90	77	65	56	48	42	100 000	15
					180	166	153	141	135			110	95	81	68	58	50	43	37	150 000			
												104	88	75	63	54	46	40	34	200 000			
											98	83	70	59	51	43	37	31	250 000				
223-490	490	320 295	M 1	≤ 100 > 100	209	192	179	165	152	139	131	125	123	121	104	90	77	65	56	48	42	100 000	15
					197	182	167	153	146			123	111	95	81	68	58	50	43	37	150 000		
												121	104	88	75	63	54	46	40	34	200 000		
											115	98	83	70	59	51	43	37	31	250 000			
223-510	510	340	M 1	≤ 100	217	203	190	173	159	147	138	132	131	121	104	90	77	65	56	48	42	100 000	15
											128	111	95	81	68	58	50	43	37	150 000			
											121	104	88	75	63	54	46	40	34	200 000			
											115	98	83	70	59	51	43	37	31	250 000			
224-410	410	235 220	M 1	≤ 100 > 100	157	146	136	125	114	101	94		89	88	88	88	77	65	56	48	42	100 000	15
					147	137	127	117	109					88	81	68	58	50	43	37	150 000		
													88	75	63	54	46	40	34	200 000			
											83	70	59	51	43	37	31	250 000					

Table 2.3(e) Design strength values (N/mm²) (continued)

Forgings (see Special note 1b)

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Ruling section mm (See note (d))	Values of f for design temperatures (°C) not exceeding																	Design lifetime h	Notes
					50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480		
Carbon manganese steels to BS 1503																							
224-430	430	250 235	M 1	≤ 100	167	156	145	133	121	108	101		96	95	95	90	77	65	56	48	42	100 000	15
				> 100	157	146	135	123	117							95	81	68	58	50	43	37	
224-460	460	275 255	M 1	≤ 100	183	170	157	145	132	118	111		105	104	104	90	77	65	56	48	42	100 000	15
				> 100	170	158	147	135	127							104	95	81	68	58	50	43	
224-490	490	305 280	M 1	≤ 100	203	187	171	156	142	128	121	116	115	115	104	90	77	65	56	48	42	100 000	15
				> 100	187	173	159	145	137							115	111	95	81	68	58	50	
224-510	510	315	M 1	≤ 100	210	194	179	163	149	135	128	124	122	121	104	90	77	65	56	48	42	100 000	15
				> 100												122	111	95	81	68	58	50	

Table 2.3(e) Design strength values (N/mm²) (continued)

Forgings (see Special note 1b)

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Ruling section mm (See note (d))	Values of f for design temperatures (°C) not exceeding																								Design lifetime h	Notes																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
					50	100	150	200	250	300	350	400	440	450	460	480	490	500	510	520	530	540	550	560	570	580																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Alloy and martensitic stainless steel to BS 1503																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
245-420 0.5 Mo	420	215	M 2	—	143	135	127	117	110	105	103	101																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

2/17

ti C11

BS 5500:1985
Issue 1, January 1985

Table 2.3(e) Design strength values (N/mm²) (continued)
Forgings (see Special note 1b)

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Ruling section mm (See note (d))	Values of f for design temperatures (°C) not exceeding																							Design lifetime h	Notes
					50	100	150	200	250	300	350	400	440	450	460	480	490	500	510	520	530	540	550	560	570	580			
Alloy and martensitic stainless steel to BS 1503																													
271-560 MnCrMoV	560	370	M 4	—	238	229	220	215	208	204	199	192	188	185	155	129	107	87	69	54	41	30						100 000	
															145	118	95	76	60	44	31	23						150 000	
															132	108	87	68	51	38	26	18						200 000	
															129	105	83	65	48	35	23	14						250 000	
622-490 2½Cr1Mo	490	275	M 9	—	183	176	169	163	157	153	149	145	137	135	131	118	105	94	82	72	61	53	45	39	34			100 000	5, 15
															121	108	97	85	73	63	56	48	41	36	31			150 000	
															117	104	92	79	68	59	52	45	38	33	28			200 000	
															113	100	87	75	65	57	49	42	36	32	27			250 000	
622-560 2½Cr1Mo	560	370	M 9	—	238	231	224	219	213	209	201	197	170	157	131	118	105	94	82	72	61	53	45	39	34			100 000	5, 15
													161	148	121	108	97	85	73	63	56	48	41	36	31			150 000	
													156	143	117	104	92	79	68	59	52	45	38	33	28			200 000	
													152	139	113	100	87	75	65	57	49	42	36	32	27			250 000	
622-650 2½Cr1Mo	650	475	M 9	—																								1f, 15	
625-520 5Cr½Mo	520	365	M 10	—																								1f, 15	
625-590 5Cr½Mo	590	450	M 10	—																								1f, 15	
503-490 3½Ni	490	300	M 5	100	200																							1d, 13, 15	
509-690 9Ni	690	490	M 6	150	294																							1d, 13, 15	
410-S21 12Cr	590	395	—	—	251	232	214	209	202	198	165	133																1d, 15	
420-S29 12Cr	700	515	—	—	298	295	293	287	279	272	215	158																1d, 15	
403-S17 12Cr	470	265	—	—	177	154	131	125	121	119	115	110																1d, 15	
405-S17 12Cr	420	210	—	—	140	118	96	91	88	86	83	77																1d, 15	

Table 2.3(f) Design strength values (N/mm²)

Castings

Grade, type & method of manufacture	R_m	R_e	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																			Design lifetime h	Notes
	N/mm ²	N/mm ²			50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480				
Carbon steel to BS 1504																									
161 430A	430	230	M 0		153	139	126	119	115	104	95		87										1c, 1d		
161 430E	430	230	M 0		153	139	126	119	115	104	95		93		92	84	71	60	51	44	37		1c		
															89	75	63	54	46	38	30				
															82	69	58	49	42	34					
															78	65	54	46	38						
161 480A	480	245	M 1		163	153	143	136	128	115	105		100										1c, 1d		
161 480E					163	153	143	136	128	115	109		107		99	84	71	60	51	44	37		1c		
															89	75	63	54	46	38	30				
															82	69	58	49	42	34					
															78	65	54	46	38						
161 540A	540	280	M 1		186	176	165	154	144	130	119		100										1c, 1d		

Table 2.3(f) Design strength values (N/mm²) (continued)

Castings

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																								Design lifetime h	Notes
					50	100	150	200	250	300	350	400	440	450	460	480	490	500	510	520	530	540	550	560	570	580				
Low alloy steel to BS 1504																														
245A ½Ni	460	260	M 2		173	162	157	145	131	116	116	116		103															1c, 1d	
245E ½Mo	460	260	M 2		173	167	161	155	140	121	116	116		110	109	108	94	78	62	52	41	32							1c	
																107	87	70	57	46	37	30								
																100	81	65	53	42	34	28								
																95	77	62	50	40	32	25								
503A 3½Ni	460	280	M 5		184																							1c		
621A 1½CrMo	480	280	M 7		187	175	161	146	141	136	123	114	108	108														1c, 1d		
660A CrMnV	570	295	M 8		196	180	168	156	145	137	128	118		112				106										1c, 1d		
622A 2¼CrMo	540	325	M 9		217	204	195	190	185	181	175	171																1c, 1d		
622E 2¼CrMo	540	325	M 9		217	212	208	203	197	193	187	182	170	170	153	120	107	95	85	76	65	61	53	45	39	34		1c, 5		
																161	144	112	98	88	77	68	57	56	48	41	36	31		
																165	139	107	94	83	71	63	53	52	45	38	33	28		
																152	135	103	91	79	68	60	57	49	42	36	32	27		
623A 3½Cr½Mo	620	370	M 9		246	234	224	207	191	176	160	145																1c		
625A, E 5Cr½Mo	620	420	M 10		264																							1c		

ti D1

BS 5500:1985
Issue 1, January 1985

Table 2.3(f) Design strength values (N/mm²) (concluded)

Castings

Grade, type & method of manufacture	R_m N/mm ²	R_t N/mm ²	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																										Design lifetime h	Notes		
					50	100	150	200	250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700	720	740	750					
High alloy steel to BS 1504																																		
629A 9Cr1Mo	620	420			264	240	216	200	184	176	157	144	123	87			55			21												1c, 1d		
420C 29A 13Cr	620	450			264	246	228	222	219	214	176	138	100	62			26			14												1c, 1d		
425 C11A 13Cr4N	770	620			328	328	328	290	255	220	192	170																				1c, 1d		
304 C12A	430	215			143	132	120	110	103	98	95	93																				1c, 1d		
304 C15A	480	240			163	143	127	115	109	104	101	99	95	92	90	81	75	68	57	47	38	31	27	23	18							1c		
															88	76	68	67	51	41	33	26	23	20	15							100 000		
															83	72	65	58	48	38	31	24	21	18								150 000		
															81	68	61	56	45	36	28	22	19	17								200 000		
347 C17A	480	240			163	150	141	135	132	128	126	122	119	116	114	113	108	99	81	66	53	41	35	31	24								250 000	
															111	102	93	75	61	48	37	32	28	21								100 000		
															106	98	88	71	58	45	34	28	25	19								150 000		
															102	94	85	68	55	42	31	27	24	19								200 000		
																																	250 000	
315 C16A	480	240			160	147	134	122	114	110	107	103	100	95																			1c	
316 C12A	430	215			143	134	127	116	109	104	101	99																					1c	
316 C16	480	240			160	147	134	122	114	110	107	103	100	95	94	93	93	92	91	72	58	46	41	35	28	23							1c	
																			85	66	52	41	36	31	25	19							100 000	
																			79	61	48	37	33	29	22	18							150 000	
																			75	58	45	35	31	27	21	18							200 000	
316 C71	510	260			173	156	140	129	122	116	110	106	102	96	94	93	93	92	91	72	58	46	41	35	28	23							250 000	
																			85	66	52	41	36	31	25	19							100 000	
																			79	61	48	37	33	29	22	18							150 000	
																			75	58	45	35	31	27	21	18							200 000	
318 C17A	480	240			160	160	160	160	160	158	157	152	144	135	130																			250 000
317 C12A	430	215			143	134	127	116	109	104	101	99																					1c	
317 C16A	480	240			160	147	134	122	114	110	107	103	100	95																			1c	
364 C11A	430	215			134																												1c	
332	430	215			134																												1c	
310 C40A	450	215			143	137	130	124	116	112	107	104	101	97	80				69			58			46							1c		
330 C11A	450				150	177	174	170	167	164	160	156	153	150		148	147				100			65		40							1c	

Table 2.3(g) Design strength values (N/mm²)

Steel boiler and superheater tubes

Grade, type & method of manufacture	R_m	R_e	BS 5500 grade	Values of f for design temperatures (°C) not exceeding																	Design lifetime h	Notes			
	N/mm ²	N/mm ²		50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480					
Carbons steel to BS 3059 : Part 1																									
320 HFS, CFS, ERW & CEW	320	195	M 0	130	119	108	97	86	77	71			68												
Carbon and carbon manganese steel tubes to BS 3059 : Part 2																									
360 S1, S2, ERW & CEW	360	215	M 0	143	134	125	117	111	97	87	78	77	76	69	60	52	44	36			100 000	9			
													73	65	56	48	40	32						150 000	
													71	62	53	45	37	28						200 000	
													68	59	51	42	35	26						250 000	
440 S1, S2, ERW & CEW	440	245	M 0	163	157	152	144	134	119	106	101	101	100	90	77	65	56	48	42			100 000	9		
													95	81	68	58	50	43	37						150 000
													88	75	63	54	46	40	34						200 000
													83	70	59	51	43	37	31						250 000

2/23

ti D3

BS 5500:1985
Issue 1, January 1985

AVA Documents
Document Sharing Hub
2155 1472

Table 2.3(g) Design strength values (N/mm²) (continued)
Steel boiler and superheater tubes

Grade, type & method of manufacture	R _m N/mm ²	R _e N/mm ²	BS 5500 grade	Values of f for design temperatures (°C) not exceeding																										Design lifetime h	Notes
				50	100	150	200	250	300	350	400	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600			
Alloy steel to BS 3059 : Part 2																															
620-460 1Cr ½Mo S1, S2, ERW & CEW	460	180	M 7								129	120			116			114	113	112	93	76	62	52	42	33	27		100 000	3,9	
																			113	102	83	67	55	44	35	29	25		150 000		
																			113	94	76	61	49	40	32	26	22		200 000		
																			107	88	70	57	45	37	30	25	20		250 000		
622-490 2¼Cr 1Mo S1, S2	490	275	M 9	183	176	169	163	157	153	149	145		137	135	133	131	118	105	94	82	72	61	53	45	39	34	29	26	100 000	2,5	
																													150 000		
																													200 000		
																													250 000		
629-470 9Cr Mo S1, S2	470	185		123	110	98	91	87	83	81	78		77						75	74	69	61	53	47	42	38	34		100 000	8	
																				74	65	56	49	44	39	35	31		150 000		
																				71	61	54	47	41	37	33	29		200 000		
																				68	59	51	45	40	35	31	27		250 000		
629-590 9Cr 1Mo S1, S2	590	400		251	241	232	223	220	217	215	211	208	207	195	176	159	144	129	115	103	91	80	68	57	48	38	31	26	100 000		
																													150 000		
																													200 000		
																													250 000		
762-720 12Cr Mo V S1, S2	720	470		306	290	275	256	241	234	230	235		215			205	201	191	173	155	138	122	107	93	80	69	58	48	100 000		
																													150 000		
																													200 000		
																													250 000		

Table 2.3(h) Design strength values (N/mm²)
Steel pipes and tubes for pressure purposes

Steel pipes and tubes for pressure purposes																					Design lifetime h	Notes		
Grade, type & method of manufacture	R _m N/mm ²	R _e N/mm ²	BS 5500 grade	Values of f for design temperatures (°C) not exceeding																				
				50	100	150	200	250	300	350	390	400	410	420	430	440	450	460	470	480				
Seamless and electric resistance welded carbon and carbon manganese steel to BS 3601																								
320 ERW, S	320	195	M 0	130	119	108	97	86	77	71		68												
360 ERW, S	360	215	M 0	143	131	119	107	96	86	79		75												
410 ERW, S	410	235	M 0	157	144	132	120	109	98	90		82												
Seamless, electric resistance, induction or submerged arc welded carbon and carbon manganese steel to BS 3602 : Parts 1 and 2																								
360 HFS, CFS, ERW & CEW	360	215	M 0	143	134	125	117	111	97	87		78	77	76	69	60	52	44	36	100 000	9			
														73	65	56	48	40	32	150 000				
														71	62	53	45	37	28	200 000				
														68	59	51	42	35	26	250 000				
410 HFS, CFS, ERW, CEW & SAW	410	245	M 0	163	153	142	129	119	105	96		92	91	88	78	69	60	52	44	36	100 000	9, 10		
														91	83	74	65	56	48	40	32		150 000	
														89	80	71	62	53	45	37	28		200 000	
														87	78	68	59	51	42	35	26		250 000	
460 HFS, CFS, ERW CEW & SAW	460	280	M 1	187	172	158	147	135	121	112		106	105	104	90	77	65	56	48	42	100 000	4, 10		
														105	95	81	68	58	50	43	38		150 000	
														104	88	75	63	54	46	40	34		200 000	
														98	83	70	59	51	43	37	32		250 000	
490-Nb HFS, CFS	490	340	M 1	209	200	191	175	160	145	133	125	123	121	105	90	77	65	56	48	42	100 000			
														123	111	95	81	68	58	50	43		38	150 000
														121	104	88	75	63	54	46	40		34	200 000
														115	98	83	70	59	51	43	37		32	250 000
Seamless, electric resistance and induction welded carbon and alloy steel to BS 3603																								
410-LT50 HFS, CFS, ERW & CEW	410	235	M 1	157																				
503-LT100 3½Ni HFS, CFS	440	245	M 5	164																				
509-LT196 9Ni HFS, CFS	690	510	M 6	294																				

Table 2.3(i) Design strength values (N/mm²)

Steel pipes and tubes for pressure purposes

Grade, type & method of manufacture	R _m N/mm ²	R _e N/mm ²	BS 5500 grade	Values of f for design temperatures (°C) not exceeding																															Design lifetime h	Notes	
				50	100	150	200	250	300	350	400	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600									
Seamless, electric resistance or induction welded alloy steel to BS 3604																																					
620-440 1Cr ½Mo HFS, CFS, ERW & CEW	440	290	M 7	187	178	169	163	157	128	121	116	112		112	111	111	93	76	62	52	42	33	27											100 000	3.9		
															111	102	83	67	55	44	35	29	25										150 000				
															111	94	76	61	49	40	32	26	22										200 000				
															107	88	70	57	45	37	30	25	20										250 000				
620-460 1Cr ½Mo HFS, CFS, ERW & CEW	460	180									129	120		116	114	113	112	93	76	62	52	42	33	27										100 000			
																113	102	83	67	55	44	35	29	25										150 000			
																113	94	76	61	49	40	32	26	22										200 000			
																107	88	70	57	45	37	30	25	20										250 000			
621-420 1¼Cr ½Mo HFS, CFS	420	275	M 7	179	168	158	152	145	116	110	105	101		100	100	100	93	76	62	52	42	33	27											100 000	5		
																100	83	67	55	44	35	29	24											150 000			
																94	76	61	49	40	32	26	22											200 000			
																88	70	57	45	37	30	25	20											250 000			
660-460 ½Cr Mo V HFS, CFS	460	300	M 8	196	190	184	178	161	150	144	139	135		134	133	131	115	101	89	77	65	55	45											100 000	2.5		
																133	120	105	92	78	65	54	44	35										150 000			
																130	112	98	84	70	58	47	37	28										200 000			
																123	106	92	78	64	52	42	32	25										250 000			
622-490 2¼Cr 1Mo HFS, CFS	490	275	M 9	183	176	169	163	157	153	149	145	137	135	133	131	118	105	94	82	72	61	53	45	39	34	29	26								100 000	1e	
																133	122	108	97	85	73	63	56	48	42	36	31	27	23					150 000			
																130	117	104	92	79	68	59	52	45	38	33	28	25	22					200 000			
																126	113	100	87	75	65	57	49	42	36	32	27	23	20					250 000			
625-450 5Cr ½Mo HFS, CFS	450	170	M 10																																	8	
629-470 9Cr 1Mo HFS, CFS	470	185		223	110	98	91	87	83	81	78	77					75	74	69	61	53	47	42	38	34									100 000	8		
																		74	65	56	49	44	39	35	31									150 000			
																		71	61	54	47	41	37	33	29									200 000			
																		68	59	51	45	40	35	31	27									250 000			
629-590 9Cr 1Mo HFS, CFS	590	400		251	241	232	223	220	217	215	211	208	207	195	176	159	144	129	115	103	91	80	68	57	48	38	31	26							100 000		
																																			150 000		
																																			200 000		
																																			250 000		
762-720 12Cr Mo V HFS, CFS	720	470		306	290	275	256	241	234	230	235	215		205	201	191	173	155	138	122	107	93	80	69	58	48								100 000			
																																			150 000		
																																			200 000		
																																			250 000		

BS 5500: 1985
Issue 1, January 1985

Table 2.3(j) Design strength values (N/mm²)

Steel pipes and tubes for pressure purposes

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																												Design lifetime h	Notes						
					50	100	150	200	250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700	720	740	750											
Seamless and welded austenitic stainless steel to BS 3605																																								
304-S14 (S) 304-S22 (W)	490	205			137	110	94	83	79	75	71	68																												
304-S14E (S) 304-S22E (W)	490	205			137	118	101	89	85	80	76	73																												
304-S18 (S) 304-S25 (W)	490	235			157	128	113	102	94	90	87	85	82																											
304-S18E (S) 304-S25E (W)	490	235			157	137	121	109	101	97	94	91	88																											
304-S59E (S)	490	235			157	137	121	109	101	97	94	91	88	86	82	81	81	68	57	47	38	35	31	23	18						100 000	6								
																81	76	62	51	41	33	30	26	20	15						150 000									
																78	72	58	48	38	31	27	24	18						200 000										
																75	68	56	45	36	28	25	22	17						250 000										
316-S14 (S) 316-S22 (W)	490	215			147	123	111	104	100	96	92	89	86																											
316-S14E (S) 316-S22E (W)	490	215			147	132	119	112	107	103	99	95	92																											
316-S18 (S) 316-S26 (W)	510	245			165	140	125	117	113	109	104	100	97																											
316-S18E (S) 316-S26E (W)	510	245			165	150	134	126	122	117	112	108	104																											
316-S59E (S)	510	245			165	150	134	126	122	117	112	108	104	99	96	94	91	72	58	53	46	35	28	23						100 000	6									
																85	66	52	46	41	31	25	19						150 000											
																79	61	48	43	37	29	22	18						200 000											
																75	58	45	40	35	27	21	18						250 000											
321-S18 (S) 321-S22 (W)	510	235			154	131	125	121	118	116	114	110	108																											
321-S18E (S) 321-S22 (W)	510	235			154	141	134	130	127	125	122	118	116																											
321-S59E (S) (1010)	510	235			154	141	134	130	127	125	122	118	116	115	115	114	114	104	86	71	57	42	36	31						100 000										
																113	109	94	78	64	49	36	32	27						150 000										
																109	102	88	74	58	45	33	28	25						200 000										
																102	95	83	71	55	42	31	26	22						250 000										
321-S59E (S) (1105)	490	195			130	117	110	105	102	99	96	93	89	87	84	83	81	68	55	49	44	34	26						100 000											
																	76	61	50	44	38	29						150 000												
																	72	58	46	41	35	27						200 000												
																	68	55	44	38	33	25						250 000												

2/28

ii D8

2155 1477

AVA

Documents

Document Sharing Hub

Table 2.3(k) Design strength values (N/mm²) (continued)

Steel tubes for heat exchangers

Grade, type & method of manufacture	R_m N/mm ²	R_e N/mm ²	BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																												Design lifetime h	Notes
					50	100	150	200	250	300	350	400	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600					
Alloy steel to BS 3606																																		
243-450 0.3 Mo CFS, ERW & CEW	450	250	M 3		167	162	158	149	137	117	106	103	100		98	97	94	78	62	52	41	32												
245-450 0.5 Mo CFS, ERW & CEW	450	250	M 2		167	156	145	138	130	121	117	114																						
261-540 0.5 Mo B CFS, ERW & CEW	540	400	M 3		230	230	230	230	230	230	230	227																						
620-460 1Cr ½Mo CFS, ERW & CEW	460	180	M 7								129	120	116			114	113	112	93	76	62	52	42	33	27									
621-420 1½Cr ½Mo CFS	420	275	M 7		179	168	158	152	145	116	110	105	101			100	100	100	93	76	62	52	42	33	27									
622-490 2½Cr 1Mo CFS	490	275	M 9		183	176	169	163	157	153	149	145	137	135	133	131	118	105	94	82	72	61	53	45	39	34	29	26						
625-450 5Cr ½Mo CFS	450	170	M 10																															

2/30

D10

2155 1479

AVA

Document Sharing Hub

Table 2.3(k) Design strength values (N/mm²) (concluded)

Steel tubes for heat exchangers

Steel tubes for heat exchangers			BS 5500 grade	Thickness mm	Values of f for design temperatures (°C) not exceeding																												Design lifetime h	Notes
Grade, type & method of manufacture	R _m N/mm ²	R _e N/mm ²																																
					50	100	150	200	250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700	720	740	750					
Austenitic stainless steel to BS 3606																																		
304-S22 CFS, LWHT, LWCF & LWBC	490	205			137	124	111	101	95	90	86	81	80																					
304-S25 CFS, LWHT LWCF & LWBC	490	235			157	137	121	109	101	97	94	91	88	86	82	81	81	68	57	47	38	35	31	23	18						100 000 150 000 200 000 250 000	6		
																81	76	62	51	41	33	30	26	20	15									
																78	72	58	48	38	31	27	24	18										
																75	68	56	45	36	28	25	22	17										
316-S24, S29 CFS, LWHT, LWCF & LWBC	490	215			147	132	119	112	107	103	99	95	92																					
316-S25, S30 CFS, LWHT LWCF & LWBC	510	245			165	150	134	126	122	117	112	108	104	99	96	94	91	72	58	53	46	35	28	23						100 000 150 000 200 000 250 000	6			
																	85	66	52	46	41	31	25	19										
																	79	61	48	43	37	29	22	18										
																	75	58	45	40	35	27	21	18										
321-S22 CFS, LWHT LWCF & LWBC	510	235			154	141	134	130	127	125	122	118	116	115	115	114	114	104	86	71	57	42	36	31						100 000 150 000 200 000 250 000				
																113	109	94	78	64	49	36	32	27										
																109	102	88	74	58	45	33	28	25										
																102	95	83	71	55	42	31	26	22										
347-S17	510	245			163	157	147	141	136	132	128	125	122	120	118	118	118	118	99	81	66	53	47	41	31	24						100 000 150 000 200 000 250 000	7	
																118	111	93	75	61	48	41	37	28	21									
																116	106	88	71	58	45	39	34	25	19									
																112	102	85	68	55	42	37	31	24	19									