



BS 1113 : 1989 Specification for design and manufacture of water-tube steam generating plant (including superheaters, reheaters and steel tube economizers)

Enquiry Cases—Introduction

In accordance with the provisions of clause 1.2, the publication of Enquiry Cases will be notified in *BS/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 a new edition of the standard is published, embracing all previously issued amendments, the relevant enquiry cases will be removed from the list 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 1113)	Date of subsequent action
1113/1	March 1986	Eddy current testing in lieu of hydraulic testing	Incorporated into BS 1113 by Amendment No. 1	May 1989
1113/2	November 1986	Use of ASTM A105, A106, A182, A234 A335 and A321 materials		Issue 2, February 1990
1113/3	January 1987	Local loads	Incorporated into BS 1113 by Amendment No. 4	May 1991
1113/4	August 1988	Implications of BS 3923 'Ultrasonic examination of welds' Part 1 : 1986 'Methods for manual examination of fusion welds in ferritic steels'		Issue 2, October 1989
1113/5	November 1988	British Standard forging and pipe materials	Incorporated into BS 1113 by Amendment No. 1	May 1989
1113/6	January 1990	Use of BS 3640 591 material	Incorporated into BS 1113 by Amendment No. 4	May 1991



Summary of pages

	No. of sheets	
Preliminary pages:	5	(title page, Enquiry Cases— Introduction, pages i to v)
Section one:	2	(pages 1/1 to 1/4)
Section two:	15	(pages 2/1 to 2/28)
Section three:	22	(pages 3/1 to 3/43)
Section four:	13	(pages 4/1 to 4/25)
Section five:	9	(pages 5/1 to 5/17)
Section six:	1	(page 6/1)
Section seven:	2	(pages 7/1 to 7/3)
Appendix A:	1	(pages A/1 to A/2)
Appendix B:	2	(pages B/1 to B/4)
Appendix C:	11	(pages C/1 to C/22)
Appendix D:	1	(pages D/1 to D/2)
Appendix E:	1	(pages E/1 to E/2)
Appendix F:	1	(page F/1)
Appendix G:	1	(page G/1)
Concluding pages:	1	(publications referred to)

Foreword



This British Standard has been prepared under the direction of the Pressure Vessel Standards Committee. BS 1113 was first published in 1943 under the title 'Water tube boilers and their integral superheaters' and subsequently revised in 1951, 1958, 1969 and 1985. This edition supersedes the 1985 edition which is withdrawn.

The 1969 edition incorporated the requirements of ISO/R 831 published by the International Organization for Standardization (ISO). The 1985 edition deviated from these requirements and incorporated a number of developments from BS 5500. Most of these developments, and particularly the adoption of stress tables incorporating a range of design lifetimes related to the creep rupture properties of the material, were subjects of amendments to the 1969 edition. Where design stresses in the creep range were significantly different from those hitherto used successfully, provision was made for alternative design stresses to be used in conjunction with a 'continued service' review at a specified fraction of the design life.

This approach recognized the limitations inherent in any simple design method for boiler components operating in the creep range and also provides a flexible basis that might be used in cases where the design stress values, which have been derived from ISO data, are significantly different from those used with success in the past.

Whilst recognizing that in practice the operating life of a component designed on a time-dependent basis might be extended beyond design lifetime, this aspect of plant operation was recognized as being under the control of the plant owner and therefore outside the scope of this standard. It is the subject of other British Standard publications.

This 1989 edition maintains the developments of the 1985 edition, and additionally incorporates all technical changes up to and including Amendment No. 5 (June 1988) associated with the 1985 edition.

Changes of significance in these amendments have included:

- (a) amplification of requirements for the specification and installation of valves, gauges and fittings;
- (b) development of the rules for the design of openings and branches in cylindrical shells in line with developments in BS 5500;
- (c) a total review and re-presentation of the section covering manufacture and workmanship to provide an improved and more logical layout.

Because of the wide range of types of water-tube steam generating plant that may be designed and manufactured in accordance with this standard, general guidance has been given on some aspects with specific requirements being for agreement between the parties concerned according to the particular design and manufacturing details.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

It is recognized that clauses concerning inspection facilities and testing facilities which have traditionally been incorporated into boiler standards are a contractual matter. Nevertheless their importance is such that the purchaser in agreeing a contract should not overlook them. These clauses are reproduced in appendix G.

As with the previous edition, it is intended to keep this standard up to date by the issue from time to time of replacement pages, or by the addition of 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.

The purchaser is recommended, as an aid to demonstrating the boiler supplier's capability of achieving the required quality level, to specify in the contract, that the manufacturer operates a quality system in compliance with the appropriate parts of BS 5750.

This standard is included in the list of 'Standards significant to health and safety at work' published by the UK Health and Safety Executive (HSE)* and is also referred to by HSE in giving guidance.

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

* Health and Safety Executive, Baynards House, 1 Chepstow Place, London, W2 4TF.

Section one. General



1.1 Scope

1.1.1 This British Standard specifies requirements for the design and the manufacture, including materials and design stresses, workmanship, inspection, testing, documentation and marking, valves, gauges and fittings of:

- (a) water-tube steam generating plant subject to internal pressure; and
- (b) parts of steam and water heating plant used in association with steam generating plant.

1.1.2 In addition to the definitive requirements, this standard also requires the items detailed in 1.5 to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

1.1.3 This British Standard applies to the following types of plant.

- (a) Water-tube boilers including their integral steel tube economizers and superheaters and all other parts connected to the boiler without the interposition of a shut-off valve with the exception of valves and fittings specified in section seven.

Water-tube boilers are divided, for the purposes of this British Standard, into the following three classes.

- (1) Natural circulation boilers, in which the circulation of the water through the tubes is a result of the thermo-syphonic head produced by heating.
- (2) Forced, assisted or controlled circulation boilers, in which a pump is used either entirely or partly to promote circulation of the water through the tubes.
- (3) Once-through boilers, in which the feed pump is used to force the flow of water and steam through the tubes.

- (b) Steam reheaters (either integral with the boiler unit or independently fired) receiving steam which has passed through part of a turbine or other prime mover.

- (c) Independently fired steam superheaters.

- (d) Integral superheaters separated by a shut-off valve from the evaporative circuits.

- (e) Steel tube economizers (either integral with the boiler or independently fired) separated by a shut-off valve from the boiler.

NOTE. For convenience, the term 'boiler' used throughout this standard includes the types of plant described in (a) to (e).

1.1.4 This standard applies to the pressure parts of boilers and superheaters (as described in 1.1.3(a) and (d)) containing water and steam up to and including the valves separating these water and steam spaces from the steam pipes to other equipment, water supply pipes, drain pipes and the surrounding atmosphere (safety valves and vents).

In the case of reheaters (see 1.1.3(b)), the standard applies to pressure parts from the piping connection(s) at the inlet header to the piping connection(s) at the outlet header except that where a device is provided in reheat piping to blank off the reheater for hydraulic testing, this standard applies up to and including this device. In the case of independently fired superheaters (see 1.1.3(c)), and economizers (see 1.1.3(e)), the standard applies to the pressure parts containing steam and water respectively between the inlet and exit valves, including the respective valves and connections to drain pipes and to the atmosphere.

1.1.5 Section four of this standard (manufacture and workmanship) includes requirements applicable to the normal function of the boilermaker. Requirements for the quality of workmanship of plates, tubes, forgings and castings in the condition in which they are normally supplied to the boilermaker are included in the standards in the series specifying such materials.

1.1.6 This standard does not apply to brickwork or other settings or supports, or to insulation, or to air preheaters, mechanical stokers, fuel burning or ash disposal equipment, forced or induced draught equipment or their accessories. These items are matters for mutual agreement between the purchaser and the manufacturer.

NOTE. Where such items are required or contemplated, it is recommended that all particulars which could affect the boiler(s) should be disclosed by the purchaser to the manufacturer at the time of the enquiry.

1.1.7 This standard applies only to boilers manufactured under the survey of a competent engineering inspecting 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 boiler. 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 boilers for the manufacturer's own use and not for resale.

This standard applies only to boilers made by manufacturers who can satisfy the Inspecting Authority or organization that they are competent and suitably equipped to fulfil the requirements specified.

In assessing the competence of a manufacturer, the Inspecting Authority or organization shall take into consideration any related nationally approved certification against the BS 5750 series of quality system standards.

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

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 Boiler Technical Committee (PVE/2) 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 1113 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 Definitions

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

1.3.1 purchaser. The individual or organization that buys the completed boiler from the manufacturer.

1.3.2 manufacturer. The organization that designs, fabricates and erects the boiler in accordance with the purchaser's order. The design, fabrication and erection functions may be carried out by separate organizations.

1.3.3 Inspecting Authority. The body or association that checks that the design, materials and construction comply with this standard.

1.3.4 Regulating Authority. The authority in the country of installation that is legally charged with the enforcement of the requirements of the law and regulations of that country relating to boilers.

1.3.5 maximum permissible working pressure. For design purposes, one of the following:

- (a) for natural or assisted circulation boilers and directly connected economizers, the highest set pressure of any safety valve mounted on the steam drum;

- (b) for once-through boilers, the highest set pressure of any safety valve mounted on the final superheater outlet; or

- (c) for steam reheaters, independently fired superheaters and economizers separated by a shut-off valve from the boiler, the highest pressure of any safety valve mounted on the steam or water outlet.

1.3.6 calculation pressure. For calculation purposes, either:

- (a) except as defined in (b), the maximum permissible working pressure as defined in 1.3.5, increased where applicable to take account of the pressure drop and hydraulic head corresponding to the most severe conditions of operation; or

- (b) for those components whose design stresses are time-dependent (see table 2.1.2 and A.4), the lowest set pressure of any superheater or reheater safety valve mounted on the steam outlet, increased to take account of the pressure drop corresponding to the most severe conditions of operation.

1.3.7 design temperature. The temperature of a component to be used in the evaluation of the design stress, see 2.2.3.

1.3.8 design lifetime. The operating lifetime to be used in the evaluation of design stresses for a component whose design temperature at calculation pressure is such that its design stress value is time-dependent.

1.3.9 continued service review. A review or series of reviews carried out to establish if a component, designed to the higher of alternative design stresses in the creep range is fit for continued service up to its design life.

1.3.10 design stress. The stress value, f , used in the formulae in this standard for the calculation of the minimum scantling thickness of pressure parts.

1.3.11 pressure part. A component that contains pressurized water or steam or a mixture of the two.

1.3.12 drum. A cylindrical pressure part having a diameter sufficiently large to admit personnel, by design intent, for which purpose an access opening or branch is provided.

NOTE. A drum may have the function of a header, or additionally or alternatively other functions, such as to separate steam from water or to act as a reservoir for boiler water.

1.3.13 header. A pressure part whose principal purpose is to collect fluid from, or distribute fluid to, arrays of tubes directly connected to it.

1.3.14 tube. A tubular pressure part that is either exposed over much of its length to hot gases for purposes of heat transfer, or is directly butt welded to such a tubular pressure part.

NOTE. This definition includes a tube stub on a drum or header.

1.3.15 integral pipe. A tubular pressure part that is not a tube, drum or header.

NOTE 1. The term 'pipe' implies there is no design intent to effect heat transfer through the wall of the pressure part.



NOTE 2. The term 'integral' implies that the pressure part is connected directly to other pressure parts without any intervening valve.

NOTE 3. The term 'integral pipe', subject to note 2, includes those parts of pipes that carry a flow of steam or water during normal operation, those that carry intermittent flow, e.g. drain pipes, and those in which no flow occurs, e.g. instrument piping.

NOTE 4. The terms tube and pipe are used freely in British Standards for material and certain standards (e.g. BS 3602) state that they are interchangeable. The use of the term pipe or tube in any standard for material does not pre-empt the definitions given in 1.3.14 and 1.3.15 and likewise material described as pipe or tube may be used for any duty defined, if appropriate. The selective reference to British Standard materials in section four of this standard is intended for guidance based on the general usage of these standards.

1.4 Responsibilities

1.4.1 Responsibilities of the purchaser

The purchaser shall be responsible for furnishing the manufacturer with the information required by 1.5.1.

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.

1.4.2 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 boiler. 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 Inspecting Authority for approval and shall be recorded as part of the boiler dossier (see 6.1.3(b)).

In cases where the design, fabrication and erection functions are carried out by separate organizations, the manufacturer's responsibilities as laid down in this standard shall be discharged in a manner agreed between the parties concerned (see 1.5.2.2(a)).

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

A certificate of conformity shall be provided by the manufacturer; see section six.

1.4.3 Responsibilities of the Inspecting Authority

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

1.5 Information and requirements to be agreed and to be documented

1.5.1 Information to be supplied by the purchaser

The following information shall be supplied by the purchaser and shall be fully documented (see 6.1.3(c)). Both the definitive requirements specified throughout the standard and the documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

- (a) A specification of the normal working conditions of the boiler, together with details of any transient and/or adverse conditions under which the boiler is required to operate and of any special requirements for in-service inspection.
- (b) The name of the Inspecting Authority to be commissioned by the purchaser, see 1.1.7 and the asterisked footnote to 1.1.7.
- (c) Any additional requirements not given in this standard (see 2.2.1.3(a)(1), 2.2.1.3(b)(3), 3.7.1.2 and 4.1.3).
- (d) Any special statutory or other regulations with which the finished boiler is required to comply.
- (e) The name of the Regulating Authority (if any).

1.5.2 Requirements to be agreed and documented

1.5.2.1 *General.* The items listed in 1.5.2.2 and 1.5.2.3 to be agreed, as appropriate, between the parties concerned, which are specified in the clauses referred to, shall be fully documented. Both the definitive requirements specified throughout this standard and the documented items shall be satisfied before a claim of compliance with this standard can be made and verified.

NOTE. Users of this standard should appreciate that a number of items of agreement, i.e. those listed under 1.5.2.3, cannot be agreed/documentated at the time of placing the contract or order for the boiler and do not necessarily apply in every case; they make provisions for individual agreements that may be necessary during the manufacturer's operations to deal with certain practical eventualities (see also 1.4.2). It is important to distinguish these items (1.5.2.3) from those listed under 1.5.2.2, which do need to be agreed and documented when the contract or order is placed.

1.5.2.2 *Requirements to be agreed and documented at the contract or order stage.* The following items, as appropriate, shall be agreed and documented (see 6.1.3(d)).

- (a) The manner in which the manufacturer's responsibilities are to be discharged in cases where the design, fabrication and erection functions are carried out by separate organizations (see 1.4.2).
- (b) Increased design stresses for certain alloy steels (see note 6 to table 2.1.2).
- (c) The design lifetime, related to the creep rupture properties of the material, for each component whose design temperature is such that the nominal design stress given in table 2.1.2 is time dependent (see 2.2.4).



(d) Design stress values and the basis for extrapolation for design temperatures above those for which design stress values are given in table 2.1.2 (see general note (b) and note 1(c) to table 2.1.2).

(e) The maximum values for forces and moments imposed by external piping at the boiler terminals for main steam, reheat steam and feedwater (see 3.1.2).

(f) If applicable, design parameters for wind and earthquake loads (see 3.1.2).

1.5.2.3 Requirements to be agreed and documented during the manufacturer's operations. The following items, as appropriate, shall be agreed and documented (see also 1.4.2 and 6.1.3(j)).

(a) The use, for pressure parts, of materials not covered by table 2.1.2 (see 2.1.2.1(b)) and whether elevated temperature yield point or proof stress properties related to tests in accordance with BS 3688 are not required for such materials (see 2.1.2.2.5).

(b) The heat treatment condition for materials not covered by table 2.1.2, if an alternative to the condition appropriate to the nearest equivalent British Standard material is required (see 2.1.2.2.7).

(c) The use of design stress values (f) determined by reference to appendix A from the properties of the actual materials, where these properties have been proved by test to be higher than those given in the relevant material specification (see 2.2.1.1(b)).

(d) The method of calculating the thicknesses of the cylindrical shells of drums and headers, for time-dependent (creep) conditions where the resultant thickness exceeds half the internal diameter (see 3.3.2.2(b)).

(e) The scantlings for headers of rectangular section that are not straight (see 3.5.3).

(f) Assembly tolerances for middle line alignments (see 4.2.5.1.1).

(g) The welding materials to be used if these are not covered by British Standards (see 4.3.1.2(b)).

(h) For post-weld heat treatment:

(1) the heat treatment conditions if other than those given in table 4.5.4 (see 4.5.4.1.2(a)(2)); or

(2) waiver of post-weld heat treatment (see 4.5.4.1.2(b)).

(i) Post-weld heat treatment of joints between any combinations of ferritic steels not included in table 4.5.4 (see 4.5.4.6.3).

(j) The requirement for heat treatment of austenitic steel tubes or pipes that are hot or cold bent for integral piping (see 4.2.3.5), the bending temperature range to be used for hot bending, and the post-bend heat treatment procedures to be used (see 4.5.2.2.3).

(k) Where necessary, acceptance, as fit for the intended purpose, of welds represented by charpy V-notch impact test specimens from boiler drum production control test plates that give impact values less than required by 5.5.7.3 (see 5.5.7.4(b)).

(l) Where necessary, acceptance of computations if any tensile test specimen from the boiler drum production control test plates fails to comply with specified requirements (see 5.5.8).

(m) Where necessary, remedial measures to be adopted if either of the bend retest specimens from the boiler drum production control test plates fails to comply with the specified requirements (see 5.5.8).

(n) A reduction in the percentage rate of non-destructive examination for welds, where the manufacturer has demonstrated that the welds consistently comply with the standards of acceptance given in 5.9 (see 5.8.1.1).

(o) Non-destructive examination before final stress relief, for the following weld types in carbon, carbon manganese type 620 and type 621 steels (see 5.8.1.4):

- (i) butt welds in drums and headers;
- (ii) branch, nozzle and stub welds;
- (iii) attachment welds.

(p) Where necessary, the use of a fitness for purpose analysis to assess the acceptability of particular flaws in excess of the acceptance levels specified in 5.9.3 to 5.9.8 (see 5.9.2(b)(2)).

(q) Disregarding of ultrasonic indications of flaws in zone A (see figure 5.9.3.2(4)) of butt welds in drums and headers ≥ 20 mm thickness (see 5.9.3.2.4(a)).

(r) The procedure to be used with regard to small pockets of trapped air which may remain after filling following venting or evacuation of air prior to hydraulic testing (see 3.1.5(h)).

Section two. Materials and design stresses

2.1 Materials

2.1.1 General

2.1.1.1 The selection of the materials of construction for pressure-containing parts of boilers and their integral attachments shall take into account the suitability of the material with regard to fabrication, e.g. cold forming, weldability and expanding, as appropriate, and the conditions under which they will eventually operate.

2.1.1.2 Welding material shall comply with 4.3.1.2.

2.1.1.3 Cast iron shall not be used in the construction of pressure parts, except for valves and fittings within the limits specified in BS 759 : Part 1 or BS 6759 : Part 1.

2.1.1.4 Studs, bolts and nuts shall be in accordance with the material specifications given in BS 4882.

2.1.1.5 Pipe fittings shall comply with BS 1640, BS 1965 : Part 1 or BS 3799, as appropriate.

2.1.1.6 Flanges shall comply with BS 10, BS 1560 : Section 3.1 or BS 4504 : Section 3.1.

2.1.2 Materials for pressure parts

2.1.2.1 General. With the exceptions of the materials covered by 2.1.1.2 to 2.1.1.6, all the materials used in the manufacture of pressure parts shall either:

- (a) comply with the appropriate British Standards given in table 2.1.2; or
- (b) be agreed between the manufacturer and the purchaser and comply with 2.1.2.2 (see 1.5.2.3(a)).

A combination of materials given in table 2.1.2 and corrosion resistant material is permitted for metallurgically bonded co-extruded tubes.

NOTE. The requirements of this British Standard have been drafted largely on the basis of experience with the materials specified in the British Standards referred to in table 2.1.2; the selection of such materials should therefore be preferred. However, it is accepted that special circumstances may occur in which the selection of materials other than those covered by table 2.1.2 is necessary; the requirements of 2.1.2.2 have been specified to provide a basis for material selection in such circumstances.

2.1.2.2 Materials not covered by table 2.1.2

2.1.2.2.1 The material shall be covered by a written specification at least as comprehensive as the British Standards listed in table 2.1.2 for the nearest equivalent material. For ferritic steels, the phosphorus and sulphur content shall not exceed 0.05 % (m/m) each in the ladle analysis.

NOTE. For ferritic steels intended for welding, the upper limit of the carbon range (in the ladle analysis) should not exceed 0.25 % (m/m). Steels with a higher carbon content that are intended for welding may be used subject to appropriate welding procedures and heat treatment.

2.1.2.2.2 The design stresses shall be determined in accordance with the principles described in appendix A.

2.1.2.2.3 The deoxidation practice shall be appropriate to the type of steel ordered. Semi-killed steel shall be used

only for plates, and 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. Rimming steel shall be used only for welded tubes in carbon and carbon manganese steel with an upper limit of the specified tensile strength range of 490 N/mm² and under service temperature conditions of 400 °C or less.

2.1.2.2.4 Mechanical properties at room temperature shall be determined by means of acceptance tests covering tensile strength, yield stress and elongation.

The specified minimum percentage elongation at fracture referred to a gauge length of $5.65\sqrt{s_0}$ * shall be appropriate to the type of steel, with a lower limit of 16 % for plates, 15 % for castings and 14 % for tubes and forgings.

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

2.1.2.2.5 For all pressure parts, elevated temperature yield point or proof stress properties related to tests in accordance with BS 3688 shall be specified unless otherwise agreed between the manufacturer and Inspecting Authority (see 1.5.2.3(a)).

Where no elevated temperature yield point or proof stress property values exist or where the material cannot be related to another material for which values exist, property values shall be verified using the procedure described in BS 3920 or shall be established by the recognized standards of other countries.

2.1.2.2.6 Stress rupture properties shall be specified for materials which will be used in the creep range.

The manufacturer of the boiler shall be assured by the material supplier that the product supplied is capable of complying with 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.

2.1.2.2.7 Materials shall be supplied in a heat treated condition appropriate to the nearest equivalent British Standard material unless otherwise agreed between the interested parties (see 1.5.2.3(b)).

NOTE. Plates for hot forming may be supplied in any suitable condition, e.g. hot finished, normalized, normalized and tempered.

Carbon and carbon manganese steel plates for cold forming shall be supplied in the normalized condition.

Low alloy steel plates for cold forming shall be supplied in the normalized and tempered condition except that, where metallurgically suitable and where post-weld heat treatment will suffice as the tempering treatment, plates supplied in the normalized condition shall be permitted.

Electric resistance welded or induction welded tubes shall be used in the as welded condition only where the specified upper limit of tensile strength does not exceed 540 N/mm².

* S_0 is the original cross-sectional area of the gauge length of the tensile test specimen (see BS EN 10 002-1).

2.1.2.2.8 In the case of withdrawn British Standard materials listed in previous issues of this standard, by agreement between the manufacturer and Inspecting Authority (see 1.5.2.3(a)), compliance with the requirements of 2.1.2.2.1 and 2.1.2.2.3 to 2.1.2.2.7 may be waived. The requirements of 2.1.2.2.2 for the determination of design stresses shall however continue to apply.

NOTE. This waiver may be applied for a period of up to 3 years from the date of withdrawal of the material from listing in this standard.

2.1.3 Materials for non-pressure parts

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

2.2 Design stresses

2.2.1 General

2.2.1.1 For materials covered by table 2.1.2, the design stress (f) shall be either:

- (a) not more than the appropriate nominal design stress value given in table 2.1.2 for the material of construction at the design temperature; or
- (b) where the materials used have properties proved by a test to be higher than those given in the relevant material specification, the use of those higher properties to determine the design stress value (f) at the design temperature by reference to appendix A shall be permitted subject to agreement between the manufacturer and the Inspecting Authority (see 1.5.2.3(c)).

NOTE The design stresses provided by table 2.1.2 in accordance with (a), which have been derived on the basis of accepted principles and established by practice, are intended for general application. However, it is recognized that, during fabrication, unexpected situations may arise where use may be made of the design stresses derived from the mechanical properties of the actual materials being used; the provisions of (b) are intended to be used in such special circumstances rather than as a general rule.

2.2.1.2 For materials not covered by table 2.1.2, the design stresses shall be determined in accordance with the principles described in appendix A.

2.2.1.3 In determining the design stress, the following points shall be taken into account.

(a) *Carbon and carbon manganese steels.* The following points shall be taken into account.

- (1) The nominal design stresses given in table 2.1.2 are intended for general use with the steels listed and acceptance tests on material heat treated with a complete component are not required, any reduction in properties of such steels due to post-weld heat treatment being consistent with the overall benefit obtained by stress relief of the structure. A purchaser requiring such tests, or tests on samples subject to non-standard heat treatments, shall specify them in the supplementary specification together with appropriate acceptance criteria (see 1.5.1(c)).
- (2) In designs where slight deformation is important, or where post-weld heat treatment conditions other

than those specified in table 4.5.4 are agreed (see 4.5.4.1.2(a)(2)), materials that will comply with the properties in the material specification in the normalized plus simulated post-weld heat treated condition shall be specified.

(b) *Alloy steels.* The following points shall be taken into account.

- (1) The nominal time-independent design stresses given in table 2.1.2 shall be used provided that the proposed post-weld heat treatment conditions are in accordance with 4.5.4 and table 4.5.4.
- (2) Where post-weld heat treatment conditions other than those specified in table 4.5.4 are agreed (see 4.5.4.1.2(a)(2)), the effect of any proposed heating or reheating during fabrication shall be determined in liaison with the material supplier before selecting the appropriate time-independent design stress. The time-independent properties in the material specification, or such properties determined from the selected nominal design stress, shall be satisfied by the testing of material in the simulated heat treated condition.
- (3) Acceptance tests on materials heat treated with the completed component are not required. A purchaser requiring such tests or tests on samples subject to non-standard heat treatments shall specify them together with the appropriate acceptance criteria (see 1.5.1(c)).

2.2.2 Cast steels

The allowable design stress for castings tested in accordance with BS 1504 test category I shall be not greater than 90 % of the values given in table 2.1.2, and for those tested in accordance with BS 1504 test category II shall not be greater than 80 % of the said value. The acceptance level for both test categories shall be accordance with 5.7.5.

2.2.3 Design temperature

2.2.3.1 General. The design temperature used to evaluate the nominal design stress (f) shall not be less than the highest of:

- (a) the maximum mean wall temperature of the pressure part, calculated by the manufacturer. In the case of pressure parts carrying superheated steam the factors specified in 2.2.3.8 shall be taken into account;
- (b) the design temperatures specified in 2.2.3.2 to 2.2.3.7;
- (c) 250 °C.

2.2.3.2 Drums and headers. Where drums and headers are not heated by hot gases or are adequately protected by insulation from hot gases, the design temperature shall be equal to the maximum temperature of the internal fluid.

NOTE. A covering of refractory or insulating material that may be liable to become dislodged is not considered to be adequate protection.

Where drums and headers are heated by hot gases, the design temperature shall be taken as not less than 25 °C in excess of the maximum temperature of the internal fluid.



2.2.3.3 Boiler tubes. The design temperature shall be taken as not less than:

- (a) 50 °C for tubes subject to radiant heat from the combustion chamber;
- (b) 25 °C for other tubes;

in excess of the saturated steam temperature at the calculation pressure.

2.2.3.4 Superheater and reheater tubes. The design temperature shall be taken as not less than:

- (a) 50 °C for tubes subject to radiant heat from the combustion chamber;
- (b) 35 °C for other tubes;

in excess of the steam temperature expected in the part being considered.

2.2.3.5 Economizer tubes. The design temperature shall be taken as not less than 25 °C in excess of the maximum temperature of the internal fluid.

2.2.3.6 Integral pipes and those parts of tubes not heated by gases. The design temperature shall be taken as the maximum temperature of the fluid inside the pipe or tube.

2.2.3.7 Parts beyond the final superheater header(s). Where, because of design arrangements, factors such as inequalities in gas temperature and flow occurring in any cross section of the gas path cannot have any sustained effect on the steam temperature, the design temperature shall be the rated steam temperature at the superheater outlet, provided that in service:

- (a) the average temperature during any one year of operation does not exceed the design temperature; and
- (b) for systems having a rated temperature of 380 °C and below, fluctuations in temperature do not exceed the design temperature by more than 10 %; or
- (c) for systems having a rated temperature above 380 °C:
 - (1) normal fluctuations in temperature do not exceed the rated temperature by more than 8 °C; and
 - (2) abnormal fluctuations in temperature do not exceed the rated temperature by more than 20 °C for a maximum of 400 h in any one year or 30 °C for a maximum of 100 h in any one year or 40 °C for a maximum of 60 h in any one year.

Where the maximum temperature will exceed these limits, the design temperature shall be increased by the amount of the excess.

NOTE. The limits in (a), (b) and (c) represent realistic figures for modern control systems and boilers meeting normal load demands. It is the responsibility of the purchaser to advise the manufacturer, before design of the plant is commenced, of any circumstances that could prevent these limits being complied with (see 1.5.1(a)); it is the responsibility of the purchaser also to ensure that the boiler is operated within these or any other agreed limits.

2.2.3.8 Additional factors

2.2.3.8.1 In determining the maximum temperature of superheated steam and the related pressure part mean wall temperature, the following factors shall be taken into account:

- (a) variation in the steam flow, from the mean value, in individual tubes of a tube bank, produced by entry and exit conditions and by manufacturing tolerances on thickness and diameter;
- (b) variation in the heat input to the tube bank under consideration, resulting from deviation in the performance of preceding heating surfaces and deviation from ideal combustion conditions;
- (c) variation in steam inlet temperature resulting from deviation in gas temperature and flow occurring in any cross section of the gas path.

2.2.3.8.2 For drums, headers and parts beyond the superheater header(s), where the expected steam temperature is not in excess of 425 °C in the part under consideration, an addition of 15 °C shall be deemed to cover the factors listed in 2.2.3.8.1.

2.2.3.8.3 For superheater and reheater tubes where, in the part under consideration:

- (a) the tube is not subjected to direct radiant heat from the combustion chamber;
- (b) the expected steam temperature is not in excess of 425 °C;

the factors listed in 2.2.3.8.1 shall be deemed to be included in the requirements of 2.2.3.4.

2.2.4 Design lifetime

A design lifetime related to the creep rupture properties of the material shall be agreed between the manufacturer and the purchaser for each component whose design temperature is such that the nominal design stress given in table 2.1.2 is time-dependent (see 1.5.2.2(c)).

NOTE 1. It is not necessarily intended that one lifetime be used to cover all components; therefore replaceable items may be designed for lifetimes shorter than the general life expectancy of the boiler.

NOTE 2. The basis of the design in this standard is that no component remains in service after its operational hours have exceeded the design lifetime. However, experience has demonstrated that components designed to these rules can be expected to exceed their design life and reference may be made to PD 6510 for procedures for assessing whether the life could be extended.

Components of certain alloy materials designed on the basis of increased design stress value (see note 3) shall be identified on the drawings and listed by the manufacturer. Continued service reviews shall be instituted at not later than two-thirds of the design lifetime.

NOTE 3. The design stress values of certain alloy materials may be increased by agreement between the manufacturer and purchaser; see note 6 to table 2.1.2.

Table 2.1.2 Design stress values (N/mm ²)																			
Plates																			
Type—grade and method of manufacture	R _m N/mm ²	R _e N/mm ²	Thickness mm	Values of f for design temperature (° C) not exceeding												Design lifetime h	Notes		
				250	300	350	390	400	410	420	430	440	450	460	470			480	
BS 1501 : Part 1 — Carbon steel (semi- or fully-killed)																			
151—, 161—360 (A and B)	360	205	3 to 16	100	86	81	78	77	76	69	60	52	44	36	100 000 150 000 200 000 250 000	7			
		195	40	96					74	65	56	48	40	32					
		185	63	95					71	62	53	45	37	28					
		175	100	91					68	59	51	42	35	26					
		170	150	88															
151—, 161—400 (A and B)	400	225	3 to 16	117	97	92	89	88	87	79	69	60	52	44	36	100 000 150 000 200 000 250 000			
		215	40	110					88	83	74	65	56	48	40			32	
		205	63	108					88	80	71	62	53	45	37			28	
		200	100	105					87	78	68	59	51	42	35			26	
		195	150	102															
151—, 161—430 (A and B)	430	250	3 to 16	128	107	102	100	99	98	88	79	69	60	52	44	36	100 000 150 000 200 000 250 000		
		240	40	121					99	93	83	74	65	56	48	40			32
		230	63	119					99	90	80	71	62	53	45	37			28
		220	100	115					97	87	78	68	59	51	42	35			26
		210	150	110															

Plates

Type-grade and method of manufacture	R _m N/mm ²	R _e N/mm ²	Thickness mm	Values off f for design temperature (° C) not exceeding																			Design lifetime h	Notes							
				250	300	350	360	370	380	390	400	440	450	460	470	480	490	500	510	520	530	540			550	560	570	580			
BS 1501 : Part 2 — Low alloy steel																															
622-515 A 2 1/4Cr1Mo	515	310	Up to 100 150	166	163	158	153	146																							
	500	285		155	151	147	143	134																							
622-515 B 2 1/4Cr1Mo	515	310	Up to 100	177	173	168	163	156	154	152	143	131	118	105	94	82	72	61	53	45	39	34			2, 6						
									154	148	135	122	108	97	85	73	63	56	48	42	36	31	150	000							
									154	143	130	117	104	92	79	68	69	52	45	38	33	28	200	000							
									152	139.	126	113	100	87	75	65	57	49	42	36	32	27	250	000							
	500	285	150	165	161	157	153	143	141	139	131	118	105	94	82	72	61	53	45	39	34			100	000						
									141	135	122	108	97	85	73	63	56	48	42	36	31	150	000								
									141	130	117	104	92	79	68	69	52	45	38	33	28	200	000								
									139	126	113	100	87	75	65	57	49	42	36	32	27	250	000								
622-690 A 2 1/4Cr1Mo	690	555	Up to 50	256	256	256	256																								
622-690 B 2 1/4Cr1Mo	690	555	Up to 50	256	256	256	256	256	256	248	235	170	157	143	131	118	105	94	82	72	61	53	45	39	34						
												256	251	238	225	161	148	135	122	108	97	85	73	63	56	48	42	36	31		
												256	247	234	221	156	143	130	117	104	92	79	68	59	52	45	38	33	28	200	000
												255	242	229	216	152	139	126	113	100	87	75	65	57	49	42	36	32	27	250	000



Table 2.1.2 Design stress values (N/mm ²) (continued)																								
Plates																								
Type—grade and method of manufacture	R _m N/mm ²	R _e N/mm ²	Thickness mm	Values of f for design temperature (°C) not exceeding																		Design lifetime h	Notes	
				250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700			720
BS 1501 : Part 3 — Austenitic stainless steel																								
304S51	490	230	Up to and including 100	103	98	93	89	87	85	83	82	82	76	65	55	50	45	38	33	28	100 000			
																							150 000	
																								200 000
																								250 000
321S31	510	235	Up to and including 100	121	117	113	110	107	104	103	103	102	102	86	71	57	42	36	31	100 000	11			
																								150 000
																								200 000
																								250 000
321S51	490	210	Up to and including 100	104	99	96	93	90	87	86	86	85	82	68	55	49	44	34	26	100 000				
																								150 000
																								200 000
																								250 000
347S51	510	240	Up to and including 100	127	123	120	118	116	115	114	113	113	99	82	66	53	47	41	31	23	100 000			
																								150 000
																								200 000
																								250 000
316S51, S53	510	240	Up to and including 100	111	106	101	99	96	93	90	89	88	74	58	53	46	35	28	23	100 000	6			
																								150 000
																								200 000
																								250 000

Table 2.1.2 Design stress values (N/mm^2) (continued)

Table 2.1.2. Design stress values (N/mm ²) (continued)																						
Sections and bars																						
Type— grade	R _m N/mm ²	R _e N/mm ²	Nominal diameter/thickness (values in parenthesis apply to sections and flat bars)		Values of f for design temperature (° C) not exceeding																Design lifetime h	Notes
			Over mm	Up to and including mm	250	300	350	400	410	420	430	440	450	460	470	480	490	500				
BS 1502 — Carbon steel (semi- or fully-killed)																						
151, 161	430	250	—	25 (16)	128	107	102	99	98	88	79	69	60	52	44	36	28	100 000				
		240	25 (16)	121			99	93	83	74	65	56	48	40	32	22	150 000					
		230	63 (40)	100 (63)	119			99	90	80	71	62	53	45	37	28	18	200 000				
		220	100 (63)	160 (100)	115			97	87	78	68	59	51	42	35	26	250 000					
BS 1502 — Carbon manganese steel (semi- or fully-killed)																						
211, 221	430	250	—	25 (16)	128	107	102	99	98	97	90	77	65	56	48	42	36	32	100 000			
		240	25 (16)	121			99	93	81	68	58	50	43	38	32	26	150 000					
		230	63 (40)	100 (63)	119			99	88	75	63	54	46	40	34	28	200 000					
		220	100 (63)	160 (100)	115			97	83	70	59	51	43	37	32	25	250 000					
BS 1502 — Carbon manganese steel (fully-killed aluminium treated)																						
224—430	430	275	—	25 (16)	121	108	101	95	94	93	90	77	65	56	48	42	36	32	100 000			
		265	25 (16)	121			95	81	68	58	50	43	38	32	26	150 000						
		245	63 (40)	100 (63)	119			93	88	75	63	54	46	40	34	28	200 000					
		240	100 (63)	160 (100)	115			91	83	70	59	51	43	37	32	25	250 000					
224—490	490	325	—	25 (16)	142	128	121	115	114	105	90	77	65	56	48	42	36	32	100 000			
		315	25 (16)	142			111	95	81	68	58	50	43	38	32	26	150 000					
		305	63 (40)	100 (63)	121			104	88	75	63	54	46	40	34	28	200 000					
		300	100 (63)	160 (100)	121			98	83	70	59	51	43	37	32	25	250 000					

Table 2.1.2 Design stress values (N/mm^2) (continued)

Table 2.1.2 Design stress values (N/mm ²) (continued)																										
Sections and bars.																										
Type— grade	R _m N/mm ²	R _e N/mm ²	Limiting ruling section mm	Values of f for design temperature (° C) not exceeding																				Design lifetime h	Notes	
				250	300	350	400	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590			600
BS 1502 — Low alloy steel																										
271	560	370	160	208	204	199	192	188	186	181	155	129	107	87	69	54	41	30							10	
																										100 000
																										150 000
																										200 000
																								250 000		
620—440	440	265	160	139	123	113	109	107																	10	
																									100 000	
																									150 000	
																									200 000	
																							250 000			
620—470	470	300	160	159	144	136	133	130																10		
																									100 000	
																									150 000	
																									200 000	
																							250 000			
620—540	540	375	160	200	196	189	186	182	181	180	162	136	112	93	76	62	52	42	33	27				10		
																									100 000	
																									150 000	
																									200 000	
																							250 000			
622	490	275	160	157	153	149	145	137	135	132	131	118	105	94	82	72	61	53	45	39	34	29	26	2, 6, 10		
																									100 000	
																									150 000	
																									200 000	
																							250 000			
629—590	590	400	160	219	217	215	211	208	207	195	176	159	144	129	115	103	91	80	68	58	48	38	31	26		
																									100 000	
																									150 000	
																									200 000	
																							250 000			





Table 2.1.2 Design stress values (N/mm ²) (continued)																										
Sections and bars																										
Type— grade	R _m N/mm ²	R _e N/mm ²	Limiting ruling section mm	Values of f for design temperature (° C) not exceeding																		Notes				
				250	300	350	400	450	500	540	550	560	570	580	590	600	620	640	650	660	680		700	720	740	750
BS 1502 — Austenitic stainless steel																										
304S51	490	230	160	103	98	93	89	87	85	83	82	82	81	76	65	55	50	45	38	33	28				100 000	
																									150 000	
																										200 000
																										250 000
316S51	510	240	160	111	106	101	99	96	93	90	89	88	88	74	58	53	46	35	28	23	19	18		6		
																									100 000	
																										150 000
																										200 000
321S51—490	490	190	160	93	87	84	81	79	78	77	76	76	68	55	49	44	34	26						100 000		
																									150 000	
																										200 000
																										250 000
321S51—510	510	235	160	121	117	113	110	107	104	103	102	102	95	86	78	71	57	42	36	31	24	18		100 000		
																									150 000	
																										200 000
																										250 000
347S51	510	240	160	127	123	120	118	116	115	114	113	113	109	99	91	82	66	53	47	41	31	23	17	100 000		
																									150 000	
																										200 000
																										250 000

Table 2.1.2 Design stress values (N/mm²) (continued)

Forgings

Type—grade and method of manufacture	R_m N/mm ²	R_s N/mm ²	Ruling section (see note (d)) mm	Values of f for design temperature (° C) not exceeding													Design lifetime h	Notes
				250	300	350	390	400	410	420	430	440	450	460	470	480		
BS 1503 — Carbon manganese steel (fully-killed)																		
164	490	305 280	≤ 100 > 100 ≤ 150	142]	128	121	116	115	114	105	90	77	65	56	48	42	1(a), 10	
				137]					111	95	81	68	58	50	43	38		
									104	88	75	63	54	46	40	34		
									98	83	70	59	51	43	37	32		
221—410	410	215 205	≤ 100 > 100	112]	100	95	92	92	92	90	77	65	56	48	42	1(a), 10		
				108]					92	81	68	58	50	43	38		34	
									88	75	63	54	46	40	34		32	
									83	70	59	51	43	37	32		32	
221—430	430	225 215	≤ 100 > 100	119]	107	102	99	99	98	90	77	65	56	48	42	1(a), 10		
				115]					99	95	81	68	58	50	43		38	
									99	88	75	63	54	46	40		34	
									98	83	70	59	51	43	37		32	
221—460	460	245 235	≤ 100 > 100	129]	117	112	108	108	105	90	77	65	56	48	42	1(a), 10		
				125]					108	95	81	68	58	50	43		38	
									104	88	75	63	54	46	40		34	
									98	83	70	59	51	43	37		32	
221—490	490	265 255	≤ 100 > 100	140]	128	122	119	118	118	105	90	77	65	56	48	42	1(a), 10	
				135]					118	111	95	81	68	58	50	43		38
									118	104	88	75	63	54	46	40		34
									115	98	83	70	59	51	43	37		32
221—510	510	285	≤ 100	147	135	129	125	124	121	105	90	77	65	56	48	42	1(a), 10	
									124	111	95	81	68	58	50	43		38
									121	104	88	75	63	54	46	40		34
									115	98	83	70	59	51	43	37		32

Table 2.1.2 Design stress values (N/mm²) (continued)

Table 2.1.2 Design stress values (N/mm ²) (continued)																														
Forgings																														
Type-grade and method of manufacture	R _m N/mm ²	R _e N/mm ²	Ruling section (see note (d)) mm	Values of <i>f</i> for design temperature (°C) not exceeding																Design lifetime h	Notes									
				250	300	350	400	410	420	430	440	450	460	470	480	490	500	510	520			530	540	550	560	570	580	590	600	610
BS 1503 — Ferritic alloy steel																														
620-440 1Cr½Mo	440	275		131 123 113 108					105	101 101 93 76 62 52 42 33 27 101 83 67 55 44 35 29 24 94 76 61 49 40 32 26 22 88 70 57 45 37 30 25 20																	1(a), 10			
620-540 1Cr½Mo	540	375	≤200	200 196 189 186					182 181 180 162 136 112 93 76 62 52 42 33 27 181 174 149 124 102 83 67 55 44 35 29 24 181 162 138 114 94 76 61 49 40 32 26 22 179 155 131 107 88 70 57 45 37 30 25 20																		1(a), 10			
621-460 1¼Cr½Mo	460	275		145 137 127 122					117	115 114 112 93 76 62 52 42 33 27 114 102 83 67 55 44 35 29 24 114 94 76 61 49 40 32 26 22 107 88 70 57 45 37 30 25 20																		1(a), 10		
660-460 CrMoV	460	300		161 150 144 139					135	134 133 131 115 100 87 76 66 56 133 122 106 92 80 69 59 47 132 115 100 87 75 65 55 128 111 96 83 72 62 50																		1(a), 10		
271-560 MnCrMoV	560	370		208 204 199 192					188 186 181 155 129 107 87 69 54 41 30 173 145 118 95 76 60 44 32 23 160 132 108 87 68 51 38 26 18 157 129 105 83 65 48 35 23 14																			1(a), 10		
222-490 2¼Cr1Mo	490	275		157 153 149 145					137 135 132 131 118 105 94 82 72 61 53 45 39 34 132 122 108 97 85 73 63 56 48 42 36 31 130 117 104 92 79 68 59 52 45 38 33 28 126 113 100 87 75 65 57 49 42 36 32 27																			1(a), 6, 10		
602-560 2¼Cr1Mo	560	370		207 207 201 197 196 195 194 183 170 157 143 131 118 105 94 82 72 61 53 45 39 34 195 186 173 161 148 135 122 108 97 85 73 63 56 48 42 36 31 195 182 169 156 143 130 117 104 92 79 68 59 52 45 38 33 28 190 178 165 152 139 126 113 100 87 75 65 57 49 42 36 32 27																									1(a), 6, 10	
762-690 1¼Cr1Mo 0.3Va	690	490	≤ 250	240 233 227 219					206	190 187 173 155 138 122 107 93 80 68 58 48 40 33 184 168 152 135 115 98 85 72 62 52 44 37 30 180 164 146 128 110 94 80 68 58 40 41 34 28 176 160 142 124 105 90 77 65 55 46 38 32 25																				1(a), 10



Table 2.1.2 Design stress values (N/mm^2) (continued)

Forgings

Type-grade and method of manufacture	R_m N/mm ²	R_e N/mm ²	Ruling section (see note (d)) mm	Values of f for design temperature (° C) not exceeding																			Design lifetime h	Notes	
				250	300	350	400	450	500	520	540	550	560	580	590	600	620	640	650	660	680	700			720
BS 1503 — Austenitic stainless steel																									
304S51	490	230		103	98	93	89	87	85	83	82	82	81	76	65	55	50	45	38	33	28			1(a),	
																								100 000	
																									150 000
																									200 000
																								250 000	
316S51	510	240		111	106	101	99	96	93	90	89	88	88	74	58	53	46	35	28	23			1(a), 6		
																								100 000	
																									150 000
																									200 000
																								250 000	
321S51-490	490	190		93	87	84	81	79	78	77	76	76	76	68	55	49	44	34	26				1(a)		
																								100 000	
																									150 000
																									200 000
																								250 000	
321S51-510	510	235		121	117	113	110	107	104	103	102	102	86	71	57	42	36	31				1(a)			
																								100 000	
																									150 000
																									200 000
																								250 000	
347S51	510	240		127	123	120	118	116	115	114	113	113	99	82	66	53	47	41	31	23			1(a)		
																								100 000	
																									150 000
																									200 000
																								250 000	

Table 2.1.2 Design stress values (N/mm ²) (continued)																									
Castings																									
Type—grade and method of manufacture	R _m N/mm ²	R _e N/mm ²	Thickness mm	Values of f for design temperature (° C) not exceeding													Design lifetime h	Notes							
				250	300	350	400	450	500	520	540	550	560	580	600	620			640	650	660	680	700	720	740
BS 1504 — High alloy steel																									
629A 9Cr1Mo	620	420		184	176	157	144	123	87	55	21													1(b)	
BS 1504 — Austenitic stainless steel																									
304C15A	480	240		109	104	101	99	95	92	90	81	75	68	57	47	38	31	27	23	18					1(b), 11
										90	76	68	62	52	42	33	26	23	20	15					100 000
										85	72	65	58	48	38	31	24	21	18						150 000
										82	68	61	56	45	36	28	22	19	17						200 000
																									250 000
347C17A	480	240		132	128	126	122	119	116	114	113	109	99	82	66	53	41	35	31	22					1(b), 11
													112	102	93	75	61	48	37	32	28	22			100 000
													106	98	88	72	58	45	34	29	25	19			150 000
													102	94	85	68	55	42	32	28	24	19			200 000
																									250 000
316C71	510	260		122	116	110	106	102	96	93	92	91	74	58	46	41	35	28	23						1(b), 11
													85	66	52	41	36	32	25	19					100 000
																									150 000
																									200 000
																									250 000



Table 2.1.2 Design stress values (N/mm²) (continued)

Steel boiler and superheater tubes

Type—grade and method of manufacture	R_m N/mm ²	R_e N/mm ²	Thickness mm	Values of f for design temperature (° C) not exceeding													Design lifetime h	Notes
				250	300	350	390	400	410	420	430	440	450	460	470	480		
BS 3059 : Part 1 — Carbon steel																		
320 HFS, CFS, ERW and CEW	320	195		86	77	71	68											
BS 3059 : Part 2 — Carbon and carbon manganese steel																		
360 S1, S2, ERW and CEW	360	235		111	97	87	78	77	76	69	60	52	44	36				7
									74	65	56	48	40	32				100 000
									71	62	53	45	37	28				150 000
									68	59	51	42	35	26				200 000
																		250 000
440 S1, S2, ERW and CEW	440	245		134	119	106	101	101	100	90	77	65	56	48	42			7
									101	95	81	68	58	50	43	38		100 000
									101	88	75	63	54	46	40	34		150 000
									98	83	70	59	51	43	37	32		200 000
																		250 000

Table 2.1.2 Design stress values (N/mm²) (continued)
Steel boiler and superheater tubes

Table 2.1.2 Design stress values (N/mm ²) (continued)																											
Steel boiler and superheater tubes																											
Type—grade and method of manufacture	R _m N/mm ²	R _e N/mm ²	Thickness mm	Values of f for design temperature (°C) not exceeding																			Design lifetime h	Notes			
				250	300	350	400	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580			590	600	610
BS 3059 : Part 2 — Alloy steel																											
243 0.3 Mo S1, S2, ERW and CEW	480	275		149	128	120	117	115	113	112	95	78	62	51	41	32											
620 1Cr½Mo S1, S2, ERW and CEW	460	180		129	129	129	120	116	114	113	112	93	76	62	52	42	33	27									
622—490 2¼Cr1Mo S1, S2,	490	275		157	153	149	145	137	135	133	131	118	105	94	82	72	61	53	45	39	34	29	26				
629—590 9Cr1Mo S1, S2,	590	400		219	217	215	211	208	207	195	176	159	144	129	115	103	91	80	68	58	48	38	31	26			
762 12CrMoV S1, S2,	720	470		241	234	230	225	215	205	201	191	173	155	138	122	107	93	80	68	58	48	40	33				



Table 2.1.2 Design stress values (N/mm²) (continued)

Steel boiler and superheater tubes

Type—grade and method of manufacture	R_m N/mm ²	R_e N/mm ²	Thickness mm	Values of f for design temperature (° C) not exceeding																			Design lifetime h	Notes				
				250	300	350	400	450	500	540	550	560	570	580	590	600	610	620	630	640	650	660			680	700		
BS 3059 : Part 2 — Austenitic stainless steel																												
304S51 CFS	490	230		101	97	94	91	88	86	83	82	82	81	76	71	65	60	55	50	45	38	33	100 000	7				
																									150 000			
																										200 000		
																										250 000		
316S51, S52 CFS	510	240		111	106	102	98	96	93	90	89	88	88	82	74	66	58	53	46	35	28	100 000	7 6					
																									150 000			
																										200 000		
																										250 000		
321S51 (1010) CFS	510	235		121	117	112	110	107	104	102	102	101	95	86	78	71	63	57	49	42	36	100 000						
																										150 000		
																											200 000	
																											250 000	
321S51 (1105) CFS	490	190		93	87	84	82	79	77	76	75	75	68	60	55	49	44	38	33	25		100 000	7					
																									150 000			
																										200 000		
																										250 000		
347S51 CFS	510	240		135	130	124	122	119	119	117	117	116	109	99	91	82	74	66	59	53	47	41	31	23	100 000	7		
																											150 000	
																												200 000
																												250 000
215S15 CFS	540	270		141	139	136	135	133	132	130	126	125	124	123	107	87	71	52	40			100 000						
																											150 000	
																												200 000
																												250 000