

Specification for

Design and manufacture of water-tube steam generating plant (including superheaters, reheaters and steel tube economizers)

ICS 27.040

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Committees responsible for this British Standard

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- Electricity Association
- Engineering Equipment and Materials Users' Association
- Health and Safety Executive
- Lloyd's Register of Shipping
- Power Generation Contractors' Association
- Safety Assessment Federation
- UK Steel Association

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Foreword

This British Standard, first published in 1943 under the title 'Water tube boilers and their integral superheaters' and subsequently revised in 1951, 1958, 1969, 1985, 1989 and 1992 has been prepared under the direction of the Engineering Sector Board. This edition supersedes the 1992 edition which is withdrawn.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 1998 edition introduces many of the manufacturing practices contained in the draft European Standard currently being developed by CEN/TC 269.

These are:

- forming of drums, headers, and ends;
- forming and bending of tubes and associated procedure tests;
- manufacture of welded tubewalls;
- modification of seal welding requirements;
- modification of post weld heat treatment requirements;
- modification of production control test plate requirements;
- modification of hydrostatic pressure test requirements.

The committee considers that these requirements are not likely to change between now and the publication of the EN, and their introduction will be of economic benefit to industry.

In addition, steel 91 tubes and pipes have been incorporated into table 2.1.2;

Safety valve clauses have been modified to remove ambiguities in the UK requirements.

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 annex G.

Technical changes, made since the last amendment of this standard was published, are indicated by a sideline in the margin. Presentational changes have not been marked in this way.

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 this edition of the 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 EN ISO 9000.

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.

Section 1. 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 7.

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 **1.1.3a)** 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 **1.1.3b)**, this 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 **1.1.3c)**, and economizers (see **1.1.3e)**, 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 4 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 manufacture

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 to be used in the establishment of the minimum scantling thickness of pressure parts.

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 equations 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 4 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 6.1.3b).

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 1.5.2.2a).

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 6.

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 6.1.3c). 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.
- c) Any additional requirements not given in this standard (see 2.2.1.3a)1), 2.2.1.3b)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/documented 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 **6.1.3d**).

- 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 4 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 1c) 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 **6.1.3j**).

- a) The use, for pressure parts, of materials not covered by table 2.1.2 (see **2.1.2.1b**) and whether elevated temperature yield point or proof stress properties related to tests in accordance with BS EN 10002-5 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 annex 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 **2.2.1.1b**).

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 **3.3.2.2b**).

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 **4.3.1.2b**).

h) For post-weld heat treatment:

- 1) the heat treatment conditions if other than those given in table 4.5.4 (see **4.5.4.1.2a2**)); or
- 2) waiver of post-weld heat treatment (see **4.5.4.1.2b**).

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 **5.5.7.4b**).

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 **5.9.2b**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 **5.9.3.2.4a**).

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 **3.1.5h**).

Section 2. 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 conform to 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 conform to BS 1640, BS 1965 : Part 1 or BS 3799, as appropriate.

2.1.1.6 Flanges shall conform to 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) conform to the appropriate British Standards given in table 2.1.2; or
- b) be agreed between the manufacturer and the purchaser and conform to 2.1.2.2 (see 1.5.2.3a).

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 sulfur 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 annex 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. Rimmed 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 $5.65\sqrt{s_0}$ ¹⁾ 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 EN 10002-5 shall be specified unless otherwise agreed between the manufacturer and Inspecting Authority (see 1.5.2.3a).

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 conforming to 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 1.5.2.3b).

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.

¹⁾ S_0 is the original cross-sectional area of the gauge length of the tensile test specimen (see BS EN 10002-1).

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.

2.1.2.2.8 In the case of withdrawn British Standard materials listed in this and previous issues of this standard, by agreement between the manufacturer and Inspecting Authority (see **1.5.2.3a**), 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 stress 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, fins 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 annex A shall be permitted subject to agreement between the manufacturer and the Inspecting Authority (see **1.5.2.3c**).

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, and for materials conforming to BS EN 10028 : Parts 1, 2 and 3, the design stresses shall be determined in accordance with the principles described in annex 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 **1.5.1c**).
- 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 **4.5.4.1.2a**2)), materials that will conform to 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 **4.5.4.1.2a**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 **1.5.1c**).

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 be not 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 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.

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 1.5.1a); 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 super-heater 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 **1.5.2.2c**).

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 4 to table 2.1.2.

Table 2.1.2 Design stress values (N/mm²)**Plates**

Type-grade and method of manufacture	R_m	R_e	Thickness	Values of f for design temperature (°C) not exceeding														Design lifetime	Notes
	N/mm ²	N/mm ²	mm	250	300	350	390	400	410	420	430	440	450	460	470	480	h		
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	5, 13			
		195	40	96					74	65	56	48	40	32			150 000		
		185	63	95					71	62	53	45	37	28			200 000		
		175	100	91					68	59	51	42	35	26			250 000		
		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	13		
		215	40	110				88	83	74	65	56	48	40	32	150 000			
		205	63	108				88	80	71	62	53	45	37	28	200 000			
		200	100	105				87	78	68	59	51	42	35	26	250 000			
		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	13	
		240	40	121				99	93	83	74	65	56	48	40	32	150 000		
		230	63	119				99	90	80	71	62	53	45	37	28	200 000		
		220	100	115				97	87	78	68	59	51	42	35	26	250 000		
		210	150	110															

Table 2.1.2 Design stress values (N/mm ²) (continued)																															
Plates																															
Type-grade and method of manufacture	<i>R</i> _m	<i>R</i> _e	Thickness	Values of <i>f</i> for design temperature (°C) not exceeding														Design lifetime	Notes												
	N/mm ²	N/mm ²	mm	250	300	350	390	400	410	420	430	440	450	460	470	480	h														
BS 1501 : Part 1 Carbon steel (fully-killed aluminium treated)																															
164–360A	360	255	3 to 16	]	97	86	79	73	73	72	71	69	60	52	44	36	100 000	5, 10													
		235	40																71	65	56	48	40	32	150 000						
		220	63																					71	62	53	45	37	28	200 000	
		202	100																					68	59	51	42	35	26	250 000	
		180	150																												
164–360B	360	255	3 to 16	]	107	95	87	83	82	81	79	69	60	52	44	36	100 000	10													
		235	40																				81	74	65	56	48	40	32	150 000	
		220	63																				80	71	62	53	45	37	28	200 000	
		202	100																				78	68	59	51	42	35	26	250 000	
		180	150																												
164–400A	400	275	3 to 16	]	111	98	91	86	85	84	79	69	60	52	44	36	100 000	5, 10													
		265	40																				83	74	65	56	48	40	32	150 000	
		245	63																				80	71	62	53	45	37	28	200 000	
		225	100																				78	68	59	51	42	35	26	250 000	
		201	150																												
164–400B	400	275	3 to 16	]	121	108	101	95	94	88	79	69	60	52	44	36	100 000	10													
		265	40																				93	83	74	65	56	48	40	32	150 000
		245	63																				90	80	71	62	53	45	37	28	200 000
		225	100																				87	78	68	59	51	42	35	26	250 000
		201	150																												

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

Type-grade and method of manufacture	R_m	R_e	Thickness	Values of f for design temperature (°C) not exceeding														Design lifetime	Notes
	N/mm ²	N/mm ²	mm	250	300	350	390	400	410	420	430	440	450	460	470	480	h		
BS 1501 : Part 1 Carbon manganese steel (fully-killed niobium treated)																			
223-460A	460	340	3 to 16	]	143	130	124	117	115	114	105	90	77	65	56	48	42	100 000	5, 10
		330	40						115	111	95	81	68	58	50	43	38	150 000	
		320	63						115	104	88	75	63	54	46	40	34	200 000	
		294	100						115	98	83	70	59	51	43	37	32	250 000	
		262	150																
223-460B	460	340	3 to 16	]	158	139	131	125	124	121	105	90	77	65	56	48	42	100 000	5, 10
		330	40						124	111	95	81	68	58	50	43	38	150 000	
		320	63						121	104	88	75	63	54	46	40	34	200 000	
		294	100						115	98	83	70	59	51	43	37	32	250 000	
		262	150																
223-490A	490	355	3 to 16	]	158	139	131	125	124	121	105	90	77	65	56	48	42	100 000	5, 10
		345	40						124	111	95	81	68	58	50	43	38	150 000	
		340	63						121	104	88	75	63	54	46	40	34	200 000	
		313	100						115	98	83	70	59	51	43	37	32	250 000	
		279	150																
223-490B	490	355	3 to 16	]	168	147	137	133	132	121	105	90	77	65	56	48	42	100 000	5, 10
		345	40						128	111	95	81	68	58	50	43	38	150 000	
		340	63						121	104	88	75	63	54	46	40	34	200 000	
		313	100						115	98	83	70	59	51	43	37	32	250 000	
		279	150																

Table 2.1.2 Design stress values (N/mm ²) (continued)																			
Plates																			
Type–grade and method of manufacture	<i>R</i> _m	<i>R</i> _e	Thickness	Values of <i>f</i> for design temperature (°C) not exceeding														Design lifetime	Notes
	N/mm ²	N/mm ²	mm	250	300	350	390	400	410	420	430	440	450	460	470	480	h		
BS 1501 : Part 1 Carbon manganese steel (fully-killed aluminium treated)																			
224–400A	400	275	3 to 16	]	111	98	91	86	85	84	83	77	65	56	48	42	100 000	5, 10	
		265	40														150 000		
		245	63														200 000		
		225	100														250 000		
		201	150																
224–400B	400	275	3 to 16	]	121	108	101	95	94	93	90	77	65	56	48	42	100 000	10	
		265	40														150 000		
		245	63														200 000		
		225	100														250 000		
		201	150																
224–430A	430	305	3 to 16	]	121	108	101	95	94	93	90	77	65	56	48	42	100 000	5, 10	
		285	40														150 000		
		275	63														200 000		
		253	100														250 000		
		225	150																
224–430B	430	305	3 to 16	]	132	117	111	105	104	103	90	77	65	56	48	42	100 000	10	
		285	40														150 000		
		275	63														200 000		
		253	100														250 000		
		225	150																
224–460A	460	325	3 to 16	]	132	117	111	105	104	103	90	77	65	56	48	42	100 000	5, 10	
		315	40														150 000		
		305	63														200 000		
		281	100														250 000		
		250	150																

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

Type-grade and method of manufacture	R_m	R_e	Thickness	Values of f for design temperature (°C) not exceeding														Design lifetime	Notes				
	N/mm ²	N/mm ²	mm	250	300	350	390	400	410	420	430	440	450	460	470	480	h						
BS 1501 : Part 1 Carbon manganese steel (fully-killed aluminium treated)																							
224-460B	460	325	3 to 16	]	142	128	121	116	115	114	105	90	77	65	56	48	42	100 000	10				
		315	40								115	111	95	81	68	58	50	43		38	150 000		
		305	63								115	104	88	75	63	54	46	40		34	200 000		
		281	100								115	98	83	70	59	51	43	37		32	250 000		
		250	150																				
224-490 (A and B)	490	325	3 to 16	]	142	128	121	116	115	114	105	90	77	65	56	48	42	100 000	10				
		315	40								115	111	95	81	68	58	50	43		38	150 000		
		305	63								115	104	88	75	63	54	46	40		34	200 000		
		281	100								115	98	83	70	59	51	43	37		32	250 000		
		250	150																				
BS 1501 : Part 1 Carbon manganese steel (fully-killed niobium and aluminium treated)																							
225-490A	490	355	3 to 16	]	158	139	131	125	124	121	105	90	77	65	56	48	42	100 000	5, 10				
		345	40										124	111	95	81	68	58		50	43	38	150 000
		340	63										121	104	88	75	63	54		46	40	34	200 000
		313	100									115	98	83	70	59	51	43		37	32	250 000	
		279	150																				
225-490B	490	355	3 to 16	]	168	147	137	133	132	121	105	90	77	65	56	48	42	100 000	5, 10				
		345	40										128	111	95	81	68	58		50	43	38	150 000
		340	63										121	104	88	75	63	54		46	40	34	200 000
		313	100									115	98	83	70	59	51	43		37	32	250 000	
		279	150																				

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

Type–grade and method of manufacture	R_m	R_e	Thickness mm	Values of f for design temperature (°C) not exceeding																		Design lifetime h	Notes			
	N/mm ²	N/mm ²		250	300	350	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540			550		
BS 1501 : Part 2 Low alloy steel																										
271 MnCrMoV	640	500	Up to 25	237	237	237	234					231	209	181	155	129	107	87	69	54	41	30	100 000	13		
																									150 000	
																									200 000	
																									250 000	
	610	460	75	226	226	226	221					219	209	181	155	129	107	87	69	54	41	30	100 000	13		
																									150 000	
																									200 000	
																									250 000	
	590	420	150	219	207	201	195					193	190	181	155	129	107	87	69	54	41	30	100 000	13		
																									150 000	
																									200 000	
																									250 000	
281 NiCrMoV	640	500	Up to 25	237	237	237	234	233	233	226	209	188	168	145	124	103	85	69	55	44	33	24	100 000	13		
																									150 000	
																									200 000	
																									250 000	
	610	460	75	226	226	226	221					220	209	188	168	145	124	103	85	69	55	44	33	24	100 000	13
																								150 000		
																								200 000		
																								250 000		
	590	430	150	219	207	201	195					193	188	168	145	124	103	85	69	55	44	33	24	100 000	13	
																								150 000		
																								200 000		
																								250 000		

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

Type-grade and method of manufacture	R_m	R_e	Thickness	Values of f for design temperature (°C) not exceeding																	Design lifetime h	Notes		
	N/mm ²	N/mm ²	mm	250	300	350	400	450	460	470	480	490	500	510	520	530	540	550	560	570				
BS 1501 : Part 2 Low alloy steel																								
620 A 1Cr½Mo	480	340	Up to 75	154	143	134	132	129		127													10	
	450	280	100	136	121	113	110	108		106														
	430	255	150	125	108	99	96	94				92												
620 B 1Cr½Mo	480	340	Up to 75	165	152	143	141	137		136	135	134	112	93	76	62	52	42	33	27	100 000	10		
											135	124	102	83	67	55	44	35	29	24	150 000			
											135	114	94	76	61	49	40	32	26	22	200 000			
											131	107	88	70	57	45	37	30	25	20	250 000			
	450	280	100	145	129	121	117	115		113	112	111	93	76	62	52	42	33	27	100 000	10			
											112	102	83	67	55	44	35	29	24	150 000				
											112	94	76	61	49	40	32	26	22	200 000				
											107	88	70	57	45	37	30	25	20	250 000				
	430	255	150	133	115	105	103	100			98	97	93	76	62	52	42	33	27	100 000	10			
												97	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				
621 A 1¼Cr½Mo	515	340	Up to 75	175	166	159	157	153	152														13	
	500	320	100	166	156	149	146	143		141														
	490	310	150	160	149	142	139	136		134														
621 B 1¼Cr½Mo	515	340	Up to 75	187	177	170	167	163	162	161	160	136	112	93	76	62	52	42	33	27	100 000	13		
											161	149	124	102	83	67	55	44	35	29	24		150 000	
											161	138	114	94	76	61	49	40	32	26	22		200 000	
											155	131	107	88	70	57	45	37	30	25	20		250 000	
	500	320	100	177	167	159	156	152		150	149	136	112	93	76	62	52	42	33	27	100 000	13		
												149	124	102	83	67	55	44	35	29	24		150 000	
												138	114	94	76	61	49	40	32	26	22		200 000	
												131	107	88	70	57	45	37	30	25	20		250 000	
	490	310	150	171	159	151	148	145		142	142	136	112	93	76	62	52	42	33	27	100 000	13		
												142	124	102	83	67	55	44	35	29	24		150 000	
												138	114	94	76	61	49	40	32	26	22		200 000	
												131	107	88	70	57	45	37	30	25	20		250 000	

Table 2.1.2 Design stress values (N/mm ²) (continued)																																								
Plates		Type–grade and method of manufacture	<i>R</i> _m	<i>R</i> _e	Thickness	Values of <i>f</i> for design temperature (°C) not exceeding																							Design lifetime	Notes										
			N/mm ²	N/mm ²		mm	250	300	350	360	370	380	390	400	440	450	460	470	480	490	500	510	520	530	540	550	560	570			580	h								
BS 1501 : Part 2 Low alloy steel																																								
622-515 A 2¼Cr1Mo		515	310	Up to 100	166	163	158											153	146												10									
		500	285	150	155	151	147											143	134																					
622-515 B 2¼Cr1Mo		515	310	Up to 100	177	173	168											163	156	154	152	143	131	118	105	94	82	72	61	53	45	39	34	100 000	2, 4, 10					
																									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
622-515 B 2¼Cr1Mo		500	285	Up to 150	165	161	157											153	143	141	139	131	118	105	94	82	72	61	53	45	39	34	100 000	10						
																									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 2¼Cr1Mo		690	555	Up to 50	256	256	256	256																						10										
622-690 B 2¼Cr1Mo		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	100 000	4, 10		
																									161	148	135	122	108	97	85	73	63	56	48	42	36		31	150 000
																									156	143	130	117	104	92	79	68	59	52	45	38	33		28	200 000
																									152	139	126	113	100	87	75	65	57	49	42	36	32		27	250 000

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

Type-grade and method of manufacture	R_m	R_e	Thickness mm	Values of f for design temperature (°C) not exceeding																				Design lifetime h	Notes	
	N/mm ²	N/mm ²		250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700	720	740			750
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		
																82	72	61	51	46	42	36	31	150 000		
																81	69	58	48	44	40	34	30	200 000		
																78	66	55	46	42	38	33	29	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	8	
																103	101	93	78	64	49	36	32	27		150 000
																103	97	89	74	58	45	33	28	25		200 000
																100	93	85	71	55	42	31	26	22		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
347SS1	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	4		
																										150 000
																										200 000
																										250 000

Table 2.1.2 Design stress values (N/mm ²) (continued)				
Plates				
Steel grade		Tensile strength <i>R_m</i>	Yield strength <i>R_e</i>	Notes
Name	Material no.	N/mm ²	N/mm ²	
Plates to BS EN 10028 : Part 2				
P235GH	1.0345	350 to 480	185 to 235	11, 12
P265GH	1.0425	400 to 530	200 to 265	11, 12
P295GH	1.0481	440 to 580	235 to 295	11, 12
P335GH	1.0473	480 to 650	295 to 355	11, 12
16 Mo 3	1.5415	420 to 590	220 to 275	11, 12
13 CrMo 4-5	1.7335	430 to 600	255 to 300	11, 12
10 CrMo 9-10	1.7380	460 to 630	250 to 310	11, 12
11 CrMo 9-10	1.7383	520 to 670	310	11,12
Plates to BS EN 10028 : Part 3				
P275N	1.0486	350 to 510	275	11, 12
P275NH	1.0487			
P275NL1	1.0488			
P275NL2	1.1104			
P355N	1.0562	450 to 630	355	11, 12
P355NH	1.0565			
P355NL1	1.0566			
P355NL2	1.1106			
P460N	1.8905	520 to 720	460	11, 12
P460NH	1.8935			
P460NL1	1.8915			
P460NL2	1.8918			

Table 2.1.2 Design stress values (N/mm²) (*continued*)**Sections and bars**

Type- grade	R_m	R_e	Nominal diameter/thickness (values in parenthesis apply to sections and flat bars)		Values of f for design temperature (°C) not exceeding															Design lifetime	Notes									
					250	300	350	400	410	420	430	440	450	460	470	480	490	500												
			Over	Up to and including																										
	N/mm ²	N/mm ²	mm	mm																h										
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)	63 (40)														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)	63 (40)															121		95	81	68	58	50	43	38	32	26	150 000
		230	63 (40)	100 (63)															119		88	75	63	54	46	40	34	28	200 000	
		220	100 (63)	160 (100)															115		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)	63 (40)															93		81	68	58	50	43	38	32	26	150 000	
		245	63 (40)	100 (63)															88		75	63	54	46	40	34	28	200 000		
		240	100 (63)	160 (100)															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)	63 (40)															111		95	81	68	58	50	43	38	32	26	150 000
		305	63 (40)	100 (63)															104		88	75	63	54	46	40	34	28	200 000	
		300	100 (63)	160 (100)															98		83	70	59	51	43	37	32	25	250 000	

Table 2.1.2 Design stress values (N/mm²) (*continued*)**Sections and bars**

Type- grade	R_m	R_e	Limiting ruling section	Values of f for design temperature (°C) not exceeding																				Design lifetime	Notes					
	N/mm ²	N/mm ²		mm	250	300	350	400	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580			590	600	h		
BS 1502 Low alloy steel																														
271	560	370	160	208	204	199	192		188	186	181	155	129	107	87	69	54	41	30								100 000	7		
											173	145	118	95	76	60	44	32	23								150 000			
											160	132	108	87	68	51	38	26	18								200 000			
											157	129	105	83	65	48	35	23	14							250 000				
620–440	440	265	160	139	123	113	109		107				105	104	93	76	62	52	42	33	27					100 000	7			
																													150 000	
																														200 000
																														250 000
620–470	470	300	160	159	144	136	133		130			128	127	112	93	76	62	52	42	33	27					100 000	7			
																													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					100 000	7			
																												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	100 000	2, 4, 7				
																												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/mm²) (*continued*)**Sections and bars**

Type- grade	R_m	R_e	Limiting ruling section mm	Values of f for design temperature (°C) not exceeding																				Design lifetime h	Notes		
	N/mm ²	N/mm ²		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		
														82	78	72	61	51	46	42	36	31		150 000			
														81	75	69	58	48	44	40	34	30		200 000			
														78	72	66	55	46	42	38	33	29		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	100 000	4	
															88	85	66	52	46	41	32	25	19	16	150 000		
															88	79	62	48	43	38	29	22	18	15	200 000		
															85	75	58	45	40	35	27	22	18	15	250 000		
321S51–490	490	190	160	93	87	84	81	79	78		77			76	76	68	55	49	44	34	26			100 000			
																76	62	50	44	38	29			150 000			
																72	58	46	41	35	27			200 000			
																68	55	44	38	33	25			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/mm ²) (continued)																						
Type–grade and method of manufacture		<i>R</i> _m	<i>R</i> _e	Ruling section (see note d)) mm	Values of <i>f</i> for design temperature (°C) not exceeding														Design lifetime h	Notes		
		N/mm ²	N/mm ²		250	300	350	390	400	410	420	430	440	450	460	470	480					
BS 1503 Carbon manganese steel (fully-killed)																						
164	490	305	≤ 100	142	128	121	116	115	114	105	90	77	65	56	48	42	100 000	1a), 7				
		280	> 100 ≤ 150	137									111	95	81	68	58		50	43	38	150 000
													104	98	75	63	54		46	40	34	200 000
													98	83	70	59	51		43	37	32	250 000
221–410	410	215	≤ 100	112	100	95	92		92	90	77	65	56	48	42	100 000	1a), 7					
		205	> 100	108								92	81	68	58	50		43	38	150 000		
												88	75	63	54	46		40	34	200 000		
												83	70	59	51	43		37	32	250 000		
221–430	430	225	≤ 100	119	107	102	99	99	98	90	77	65	56	48	42	100 000	1a), 7					
		215	> 100	115								99	95	81	68	58		50	43	38	150 000	
												99	88	75	63	54		46	40	34	200 000	
												98	83	70	59	51		43	37	32	250 000	
221–460	460	245	≤ 100	129	117	112	108	108	105	90	77	65	56	48	42	100 000	1a), 7					
		235	> 100	125								108	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	
221–490	490	265	≤ 100	140	128	122	119	118	118	105	90	77	65	56	48	42	100 000	1a), 7				
		255	> 100	135								118	111	95	81	68	58		50	43	38	150 000
												118	104	88	75	63	54		46	40	34	200 000
												115	98	83	70	59	51		43	37	32	250 000
221–510	510	285	≤ 100	147	135	129	125	124	121	105	90	77	65	56	48	42	100 000	1a), 7				
												124	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

Table 2.1.2. Design stress values (N/mm²) (*continued*)**Forgings**

Type-grade and method of manufacture	R_m	R_e	Ruling section (see note d)) mm	Values of f for design temperature (°C) not exceeding														Design lifetime h	Notes	
	N/mm ²	N/mm ²		250	300	350	390	400	410	420	430	440	450	460	470	480				
BS 1503 Carbon manganese steel (fully-killed)																				
223-410	410	245 230	≤ 100 > 100	120	106	99	92			91	90	77	65	56	48	42	100 000	1a), 7		
				115						91	81	68	58	50	43	38	150 000			
										88	75	63	54	46	40	34	200 000			
										83	70	59	51	43	37	32	250 000			
223-430	430	260 245	≤ 100 > 100	128	114	107	100	99		98	90	77	65	56	48	42	100 000	1a), 7		
				123						95	81	68	58	50	43	38	150 000			
										88	75	63	54	46	40	34	200 000			
										83	70	59	51	43	37	32	250 000			
223-460	460	290 270	≤ 100 > 100	140	127	119	111	110		105	90	77	65	56	48	42	100 000	1a), 7		
				135						110	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	
223-490	490	320 295	≤ 100 > 100	152	139	131	125	123		121	105	90	77	65	56	48	42	100 000	1a), 7	
				146						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
223-510	510	340	≤ 100	159	147	138	132	131		121	105	90	77	65	56	48	42	100 000	1a), 7	
										128	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
224-410	410	235 220	≤ 100 > 100	114	101	94	89	88		88	88	77	65	56	48	42	100 000	1a), 7		
				109						88	81	68	58	50	43	38	150 000			
										88	75	63	54	46	40	34	200 000			
										83	70	59	51	43	37	32	250 000			

Table 2.1.2. Design stress values (N/mm ²) (continued)																					
Forgings																					
Type–grade and method of manufacture	<i>R</i> _m	<i>R</i> _e	Ruling section (see note d)) mm	Values of <i>f</i> for design temperature (°C) not exceeding														Design lifetime h	Notes		
	N/mm ²	N/mm ²		250	300	350	390	400	410	420	430	440	450	460	470	480					
BS 1503 Carbon manganese steel (fully-killed)																					
224–430	430	250	≤ 100	121	108	101		96	95	95	90	77	65	56	48	42	100 000	1a), 7			
		235	> 100	117																150 000	
																					200 000
																					250 000
224–460	460	275	≤ 100	132	118	111		105	105	104	90	77	65	56	48	42	100 000	1a), 7			
		255	> 100	127																	150 000
																					200 000
																					250 000
224–490	490	305	≤ 100	142	128	121	116	115	115	105	90	77	65	56	48	42	100 000	1a), 7			
		280	> 100	137																	150 000
																					200 000
																					250 000
224–510	510	315	≤ 100	149	135	128	124	122	121	105	90	77	65	56	48	42	100 000	1a), 7			
																					150 000
																					200 000
																					250 000
225–490	490	340	≤ 100	160	147	137	131	130	121	105	90	77	65	56	48	42	100 000	1a), 7			
		300	> 100	154						145											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	R_e	Ruling section (see note d))	Values of f for design temperature (°C) not exceeding																										Design lifetime	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	620				
	N/mm ²	N/mm ²	mm																											h			
BS 1503 Ferritic alloy steel																																	
620–440 1Cr½Mo	440	275		131	123	113	108					105					101	101	93	76	62	52	42	33	27					100 000	1a), 7		
																														150 000			
																														200 000			
																														250 000			
620–540 1Cr½Mo	540	375	≤ 200	200	196	189	186					182	181	180	162	136	112	93	76	62	52	42	33	27					100 000	1a), 7			
																													150 000				
																													200 000				
																													250 000				
621–460 1¼Cr½Mo	460	275		145	137	127	122					117			115	114	112	93	76	62	52	42	33	27					100 000	1a), 7			
																													150 000				
																													200 000				
																													250 000				
660–460 CrMoV	460	300		161	150	144	139					135			134	133	131	115	100	87	76	66	56					100 000	1a), 7				
																												150 000					
																												200 000					
																												250 000					
271–560 MnCrMoV	560	370		208	204	199	192					188	186	181	155	129	107	87	69	54	41	30					100 000	1a), 7					
																											150 000						
																											200 000						
																											250 000						
622–490 2¼Cr1Mo	490	275		157	153	149	145					137	135	132	131	118	105	94	82	72	61	53	45	39	34			100 000	1a), 4, 7				
																												150 000					
																												200 000					
																												250 000					

Table 2.1.2 Design stress values (N/mm ²) (continued)																																	
Forgings																																	
Type–grade and method of manufacture	<i>R</i> _m	<i>R</i> _e	Ruling section (see note d))	Values of <i>f</i> for design temperature (°C) not exceeding																												Design lifetime	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	620				
	N/mm ²	N/mm ²	mm																													h	
BS 1503 Ferritic alloy steel																																	
622–560 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						100 000	1a), 4, 7	
																																	150 000
																																	200 000
																																	250 000
762–690 12Cr1Mo 0.3Va	690	480	≤ 250	240	233	227	219					206					190	187	173	155	138	122	107	93	80	68	58	48	40	33	100 000	1a), 7	
																															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	R_e	Ruling section (see note d))	Values of f for design temperature (°C) not exceeding																				Design lifetime	Notes		
	N/mm ²	N/mm ²		mm	250	300	350	400	450	500	520	540	550	560	580	590	600	620	640	650	660	680	700			720	740
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	100 000	1a)		
														82	78	72	61	51	46	42	36	31	150 000				
														81	75	69	58	48	44	40	34	30	200 000				
														78	72	66	55	46	42	38	33	29	250 000				
316S51	510	240		111	106	101	99	96	93			90	89	88	88	74	58	53	46	35	28	23	100 000	1a), 4			
														88	85	66	52	46	41	32	25	19	150 000				
														88	79	62	48	43	38	29	22	18	200 000				
														85	75	58	45	40	35	27	22	18	250 000				
321S51–490	490	190		93	87	84	81	79	78			77	76	76	76	68	55	49	44	34	26	100 000	1a)				
														76	76	62	50	44	38	29	150 000						
														76	72	58	46	41	35	27	200 000						
														76	68	55	44	38	33	25	250 000						
321S51–510	510	235		121	117	113	110	107	104			103	102	102	86	71	57	42	36	31	100 000	1a)					
														103	101	93	78	64	49	36	32		27	150 000			
														103	97	89	74	58	45	33	28		25	200 000			
														100	93	85	71	55	42	31	26		22	250 000			
347S51	510	240		127	123	120	118	116	115			114	113	113	99	82	66	53	47	41	31	23	100 000	1a)			
														113	112	93	75	62	48	42	37	28	22		150 000		
														113	106	88	72	58	45	39	34	25	19		200 000		
														112	102	85	68	55	42	37	32	24	19		250 000		

Table 2.1.2. Design stress values (N/mm ²) (continued)																			
Castings																			
Type–grade and method of manufacture	<i>R</i> _m	<i>R</i> _e	Thickness	Values of <i>f</i> for design temperature (°C) not exceeding													Design lifetime	Notes	
	N/mm ²	N/mm ²		mm	250	300	350	390	400	410	420	430	440	450	460	470			480
BS 1504 Carbon steel																			
161–430A	430	230		115	104	95		87										1b), 1c)	
161–430E	430	230		115	104	95		93	93	92	84	71	60	51	44	37	100 000	1b)	
										93	89	75	63	54	46	38	30		150 000
										92	82	69	58	49	42	34	200 000		
										88	78	65	54	46	38	250 000			
161–480A	480	245		128	115	105	101											1b), 1c)	
161–480E	480	245		128	115	109	107	107	106	99	84	71	60	51	44	37	100 000	1b)	
									107	100	89	75	63	54	46	38	30		150 000
									103	92	82	69	58	49	42	34	200 000		
									99	88	78	65	54	46	38	250 000			
161–540A	540	280		144	130	119		109										1b), 1c)	

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

Type–grade and method of manufacture	R_m	R_e	Thickness	Values of f for design temperature (°C) not exceeding																		Design lifetime	Notes		
	N/mm ²	N/mm ²		mm	250	300	350	400	440	450	460	470	480	490	500	510	520	530	540	550	560			570	590
BS 1504 Low alloy steel																									
245E ½Mo	460	260		140	121	116	113		110		109	108	95	78	62	51	41	32						100 000	1b)
												107	88	70	57	46	37	30							
												100	81	65	53	42	35	28							
												95	77	62	50	40	32	25							
621A 1¼CrMo	480	280		141	136	123	114		108																1b), 1c)
660A CrMoV	510	295		145	137	128	118		112					106											1b), 1c)
622E 2¼CrMo	540	325		197	193	187	182	174	170	153	137	120	107	95	85	76	65	61	53	45	39	34	100 000	1b), 4	
								174	161	144	129	112	98	88	77	68	63	56	48	41	36	31	150 000		
								172	156	139	124	107	94	83	71	63	59	52	45	38	33	28	200 000		
								170	152	135	119	103	91	79	68	60	57	49	42	36	32	27	250 000		

Table 2.1.2 Design stress values (N/mm ²) (continued)																											
Castings																											
Type-grade and method of manufacture	<i>R</i> _m	<i>R</i> _e	Thickness	Values of <i>f</i> for design temperature (°C) not exceeding																				Design lifetime	Notes		
	N/mm ²	N/mm ²		mm	250	300	350	400	450	500	520	540	550	560	580	600	620	640	650	660	680	700	720			740	750
BS 1504 High alloy steel																											
629A 9Cr1Mo	620	420		184	176	157	144	123	87			55			21												1b)
BS 1504 Austenitic stainless steel																											
304C15A	480	240		108	104	101	99	95	92	90	81	75	68	57	47	38	31	27	23	18					100 000	1b), 8	
										90	76	68	62	52	42	33	26	23	20	15					150 000		
										85	72	65	58	48	38	31	24	21	18					200 000			
										82	68	61	56	45	36	28	22	19	17					250 000			
347C17A	480	240		132	128	126	122	119	116	114	113	109	99	82	66	53	41	35	31	22					100 000	1b), 8	
											112	102	93	75	61	48	37	32	28	22					150 000		
											106	98	88	72	58	45	34	29	25	19					200 000		
											102	94	85	68	55	42	32	28	24	19					250 000		
316C71	510	260		122	116	110	106	102	96			93	92	91	74	58	46	41	35	28	23				100 000	1b), 8	
														85	66	52	41	36	32	25	19				150 000		
														79	62	48	38	33	29	22	18				200 000		
														75	58	45	35	31	27	22	18				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	R_e	Thickness	Values of f for design temperature (°C) not exceeding														Design lifetime h	Notes
	N/mm ²	N/mm ²	mm	250	300	350	390	400	410	420	430	440	450	460	470	480			
BS 3059 : Part 1 Carbon steel																			
320 HFS, CFS, ERW amd 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	100 000	5	
											74	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 and CEW	440	245		134	119	106		101	101	100	90	77	65	56	48	42	100 000	5	
									101	95	81	68	58	50	43	38	150 000		
									101	88	75	63	54	46	40	34	200 000		
									98	83	70	59	51	43	37	32	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	R_e	Thickness	Values of f for design temperature (°C) not exceeding																									Design lifetime	Notes															
	N/mm ²	N/mm ²		mm																																									
	250 300 350 400 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660																																												
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													100 000														
																107	88	70	57	46	37	30													150 000										
																100	81	65	53	42	35	28													200 000										
																95	77	62	50	40	32	25													250 000										
620 1Cr½Mo S1, S2, ERW and CEW	460	180		129	129	129	120		116		114	113	112	93	76	62	52	42	33	27													100 000	5											
																113	102	83	67	55	44	35	29	24													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 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													100 000	2, 4							
																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			
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													100 000								
																207	188	169	152	137	123	110	97	85	74	62	52	42	34	28	23													150 000	
																204	183	165	148	132	118	105	93	81	69	58	48	38	31	25	22													200 000	
																199	179	161	144	129	115	102	89	78	66	55	45	35	28	24	21													250 000	
91 9CrMoVNbN S1, S2	630	450		233	233	229	221		207	204	201	198	194	190	176	163	149	137	125	112	102	91	81	72	64	57	50	44	38	32	100 000														
																194	185	171	158	145	132	119	108	97	86	77	68	60	53	47	42		35	28	150 000										
																194	182	168	154	141	128	116	105	93	83	74	65	58	52	45	39		33	200 000											
																192	178	165	152	138	125	113	102	91	81	72	64	56	49	43	38		32	250 000											
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													100 000							
																200	184	168	152	135	115	98	85	72	62	52	44	37	30													150 000			
																197	180	164	146	128	110	94	80	68	58	49	41	34	28													200 000			
																192	176	160	142	124	105	90	77	65	55	46	38	32	25													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	R_e	Thickness	Values of f for design temperature (°C) not exceeding																										Design lifetime	Notes		
	N/mm ²	N/mm ²		mm	250	300	350	400	450	500	540	550	560	570	580	590	600	610	620	630	640	650	660	680	700	h							
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	5							
													82	78	72	66	61	55	51	46	42	36	31	150 000									
													81	75	69	63	58	53	48	44	40	34	30	200 000									
													78	72	66	61	55	51	46	42	38	33	29	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	5 4								
													88	85	75	66	58	52	46	41	32	25	150 000										
													88	79	70	62	55	48	43	38	29	22	200 000										
													85	75	66	58	52	45	40	35	27	22	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									
												101	93	86	78	72	64	56	49	42	36	32	150 000										
												97	89	82	74	66	58	52	45	38	33	28	200 000										
												93	85	78	71	62	55	48	42	35	31	26	250 000										
321S51 (1105) CFS	490	190		93	87	84	82	79	77		76		75	75	75	68	60	55	49	44	34			100 000	5								
														75	68	62	56	50	44	38	29	150 000											
														72	65	58	52	46	41	35	27	200 000											
														68	62	55	49	44	38	33	25	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	5							
												117	112	102	93	84	75	68	61	55	48	42	37	28	22		150 000						
												116	106	98	88	79	72	64	58	51	45	39	34	25	19		200 000						
												112	102	94	85	76	68	61	55	48	42	37	32	24	19		250 000						
215S15 CFS	540	270		141	139	136	135	133	132		130					126	125	124	123	107	87	71	52	40	100 000								
																		124	114	93	75	62	46	35	150 000								
																		124	104	83	67	56	42	32	200 000								
																		118	96	76	62	52	40	250 000									

Table 2.1.2 Design stress values (N/mm²) (*continued*)**Steel pipes and tubes for pressure purposes**

Type–grade and method of manufacture	R_m	R_e	Thickness mm	Values of f for design temperature (°C) not exceeding														Design lifetime h	Notes
	N/mm ²	N/mm ²		250	300	350	390	400	410	420	430	440	450	460	470	480			
BS 3601 Seamless and electric resistance or induction welded carbon and carbon manganese steel																			
320 ERW	320	195		86	77	71		68										5	
360 S, ERW S S	360	235 225 215	≤ 16 > 16 ≤ 40 > 40 ≤ 65	96	86	79		75										5	
430 S, ERW S S	430	275 265 255	≤ 16 > 16 ≤ 40 > 40 ≤ 65	115	103	95		89										5	
BS 3602 : Part 1 Seamless and electric resistance welded, including induction welded, carbon and carbon manganese steel																			
360 HFS, CFS, } ERW, CEW }	360	235	≤ 16	111	97	87		78		77	76	69	60	52	44	36	100 000	5	
											74	65	56	48	40	32	150 000		
HFS, CFS,		225	> 16 ≤ 40								71	62	53	45	37	28	200 000		
HFS, CFS		215	> 40 ≤ 65								68	59	51	42	35	26	250 000		
430 HFS, CFS, } ERW, CEW }	430	275	≤ 16	120	109	101		95	95	98	79	69	60	52	44	36	100 000		
									93	83	74	65	56	48	40	32	150 000		
HFS, CFS		265	> 16 ≤ 40						90	80	71	62	53	45	37	28	200 000		
HFS, CFS		255	> 40 ≤ 65						87	78	68	59	51	42	35	26	250 000		
500-Nb HFS, CFS	500	355 345 325	≤ 16 > 16 ≤ 40 > 40 ≤ 65	163	148	135	127	125	121	105	90	77	65	56	48	42	100 000		
								125	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		
BS 3602 : Part 2 Longitudinally arc welded carbon and carbon manganese steel																			
430 LAW	430	250 240	≤ 16 > 16 ≤ 40	120	109	101												6	
500 LAW	490	325 315	≤ 16 > 16 ≤ 40	143	131	121												6	