

Steel pipes and tubes for pressure purposes: ferritic alloy steel with specified elevated temperature properties —

**Part 1: Specification for seamless and
electric resistance welded tubes**

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel standards Policy Committee (ISM/-) to Technical Committee ISM/73, upon which the following bodies were represented:

Associated Offices Technical Committee
BEAMA Ltd. (Power Generation Association)
British Compressed Air Society
British Gas plc
British Steel Industry
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
High Integrity Pipework Group, Power Plant Contractors' Association
Lloyds Register of Shipping
Process Plant Association
Seamless Steel Tube Association
Water Tube Boiler Group, Power Plant Contractors' Association
Welding Institute
Coopted members

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Fluid Power Association
British Forging Industry Association
British Industrial Truck Association
British Welded Steel Tube Association
Confederation of British Industry
Energy Industries Council
Coopted member

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Foreword

This Part of BS 3604 has been prepared under the direction of the Iron and Steel Standards Policy Committee and supersedes BS 3604:1978, which is withdrawn.

A second Part to BS 3604, covering electric arc welded ferritic alloy steel pipes and tubes for pressure purposes, is being prepared. BS 3604 complements BS 3602 which covers carbon and carbon manganese steel tubes for pressure purposes.

This Part of BS 3604 is one of a series specifying requirements for steel pipes and tubes for pressure purposes. Other standards in the series are as follows.

BS 3601, *Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes.*

BS 3602, *Specification for steel pipes and tubes for pressure purposes: carbon and carbon manganese steel with specified elevated temperature properties — Part 1: Specification for seamless and electric resistance welded including induction welded tubes — Part 2: Submerged arc welded tubes.*

BS 3603, *Specification for steel pipes and tubes for pressure purposes: carbon and alloy steel with specified low temperature properties.*

BS 3605, *Specification for seamless and welded austenitic stainless steel pipes and tubes for pressure purposes.*

This edition of BS 3604-1 takes account of current production procedures for seamless and electric resistance welded tubes, including induction welded tubes, as well as grades of ferritic alloy steels now in common industrial use.

The steels covered by this standard are generally regarded as being weldable. However, care should be taken and welding should be carried out in accordance with the appropriate British Standards for welding.

The main technical differences between this edition and the previous edition are that additional visual inspection and appearance requirements are included in this edition and, in a number of cases, changes have been made to the tolerances of tubes. Tolerances for seamless tubes specified by inside diameter and thickness are included in this edition, and the parameters for lower confidence lines of steel type 660 for the verification of elevated temperature proof stress values have been amended. The minimum tempering temperature for steel 762 has been increased from 680 °C to 730 °C.

All the designations of the steels in this edition remain unchanged from the previous edition and their nearest equivalent steel numbers in ISO 2604-II and ISO 2604-III are shown in Appendix A for information.

This Part of BS 3604 is aligned as far as possible with corresponding material requirements and test procedures now agreed for incorporation in documents by the International Organization for Standardization (ISO).

Except for steel types 591 and 91, the specified elevated temperature yield or proof stress values are those derived from national data by the procedure described in BS 3920. Additionally, provision is made for the application of the related procedure for verifying that a product consistently meets specified levels of elevated temperature values. Estimated average stress rupture values (taken from ISO/TR 7468) are shown in Appendix C.

It is recommended that the results of the elevated temperature tests together with information on the product thickness, the room temperature tensile properties, heat treatment particulars and the chemical composition of the material, should be sent to Secretariat of ISO/TC17/SC18, British Standards Institution, 3 York Street, Manchester, M2 2AT, UK, so that, for future revisions of this standard, minimum elevated temperature proof stress values can be derived from a continuously updated data bank.

Impact test values are not specified in this standard but if the purchaser requires an impact test to be carried out then it is recommended that the Charpy impact test should be carried out in accordance with BS 131-2.

The appropriate British Standard for the design and construction of boilers, pressure vessels, pipework, etc. should be consulted for requirements relating to the application and permissible design stress for products made to this standard.

No acceptance levels for non-destructive testing on the weld areas (see note 4 to clause 5) are included in this edition. However, this topic is currently under consideration in ISO/TC17/SC19/WG1 and it is anticipated that their recommendations will be considered for inclusion in future editions of BS 3604-1.

Product certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier's quality systems against the appropriate Part of BS 5750.

Enquiries as to the availability of third party certification schemes will be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

It is outside the scope of this standard to specify formal qualifications for personnel engaged in testing but it is emphasized that the operation of all equipment should be supervised by competent, trained personnel.

For the purpose of this standard, no difference is intended in the meaning between "pipe" and "tube" though idiomatic use prefers sometimes the one and sometimes the other.

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

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

Summary of pages

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

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

1 Scope

This Part of BS 3604 specifies requirements for plain end, ferritic alloy steel tubes suitable for pressure purposes. All the steel types covered by this standard are supplied in the form of seamless tubes, and steel types 620-440 and 621 are also supplied in the form of electric resistance welded, including induction welded, tubes.

Tubes manufactured in accordance with this standard have specified room temperature properties and specified proof stress values at elevated temperatures.

In addition to the definitive requirements this Part of BS 3604 requires the items detailed in 2.1 to be documented. It also requires options selected by the purchaser from those detailed in 2.2 to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

This Part of BS 3604 provides for two categories of room temperature test procedure, designed category 1 and category 2 (see clause 11).

NOTE 1 The range of diameters and thicknesses appropriate to this standard are given in Appendix B. However, it may be convenient to select from the discrete sizes given in the following standards.

- a) BS 3600:1976, Table 1.
- b) BS 1600-2:1970 (completely interchangeable with ANSI B36.10M and ANSI B36.19M).

Tubes to diameters and thicknesses not covered by the above standards are available including those supplied to inside diameter and thickness criteria manufactured by hot or cold finishing processes.

NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Information to be supplied by the purchaser and options to be documented

2.1 Information to be supplied by the purchaser

The following information shall be supplied by the purchaser and shall be fully documented:

- a) the designation of the tubes, i.e. the number and Part of this British Standard, the method of manufacture of the tube, the type of steel and the category of test as specified in clause 3, e.g. BS 3604-1: HFS 621: Cat 1;
- b) the tube outside diameter and thickness for electric resistance welded tubes, or the outside diameter or inside diameter and thickness for hot and cold finished seamless tubes (see 10.2);
- c) the tube length if exact (see 10.3);
- d) the quantity in metres or number of lengths.

2.2 Options to be documented

A number of options are permitted by this standard as listed below and the purchaser shall identify the options required. Both the definitive requirements specified throughout this standard and the following documented items shall be satisfied before a claim of compliance with this standard can be made and verified. In the event that the purchaser does not indicate his requirements at the time of enquiry and order the manufacturer shall select the options where appropriate.

- a) the steel making process (see 4.1);
- b) whether a product analysis is required [see 6.2 and 15 g)];
- c) whether selected chemical elements additional to those specified are to be reported [see 6.3 and 15 h)];
- d) the heat treatment condition of the tubes (see 7);
- e) whether the upper limit above which the dressing of surface imperfections required will be 1.5 mm [see 9.8 a)];
- f) whether lengths other than random lengths are required (see 10.3);
- g) whether the method of leak tightness test to be carried out on test category 2 tubes up to and including 180 mm o.d. is the hydraulic test or the eddy current test (see 12.4);
- h) whether the hydraulic test, if specified, is to be carried out at a pressure in excess of 140 bar and the pressure required (see 13.3);
- i) whether additional non-destructive testing is required (see 13.6);
- j) whether verification of elevated temperature proof stress values is required (see 13.7);
- k) whether verification of elevated temperature proof stress values by testing is required and the temperature selected from Table 5 at which this is to be carried out (see 13.7.2);
- l) whether the tubes are to be supplied uncoated or with the manufacturer's normal mill coating (see clause 16);
- m) whether marking requirements in accordance with BS 5383 are required (see 17.1 and 17.4).

3 Designation

The tubes shall be designated by the number and Part of this British Standard, i.e. BS 3604-1 and, from Table 1, by one of the references which indicates the method of manufacture of the tube (see clause 5), from Table 2, by a number which indicates the type of steel and the test category (see clause 11).

Table 1 — Method of manufacture of tube and reference

Method of manufacture	Reference
Hot finished seamless	HFS
Cold finished seamless	CFS
Electric resistance welded including induction welded	ERW
Cold finished electric resistance welded including induction welded	CEW

Table 2 — Steel type and type number

Steel type	Type number
1 % chromium 0.5 % molybdenum	620-440
1.25 % chromium 0.5 % molybdenum	621
0.5 % chromium 0.5 % molybdenum	660 ^a
0.25 % vanadium	
2.25 % chromium 1 % molybdenum	622 ^a
5 % chromium 0.5 % molybdenum	625 ^a
9 % chromium 1 % molybdenum (annealed)	629-470 ^a
9 % chromium 1 % molybdenum (normalized and tempered)	629-590 ^a
12 % chromium molybdenum vanadium	762 ^a
1.25 % nickel copper molybdenum niobium	591 ^a
9 % chromium 1 % molybdenum vanadium niobium nitrogen	91 ^a
<i>Example.</i> BS 3604-1: CFS 660: Cat 1 designates cold finished seamless tubes in 0.5 % chromium, 0.5 % molybdenum, 0.25 % vanadium steel tested to category 1. NOTE The designations for tubes in this standard and their nearest equivalent steel numbers in ISO 2604-II and ISO 2604-III are listed in appendix A for information.	
^a Welded tubes complying with this standard are not available in these steels.	

4 Manufacture of the steel

4.1 Steelmaking process

The steel shall be produced by an electric process or one of the basic oxygen processes at the option of the manufacturer unless otherwise specified by the purchaser [see 2.2 a)].

4.2 Deoxidation

All steels shall be fully killed.

5 Manufacture of the product

The tubes shall be manufactured by one of the following processes.

a) *Seamless.* The tubes shall be manufactured by a seamless process and shall be hot finished or cold finished.

b) *Electric resistance welded* (see note 2). The tubes shall be manufactured from hot or cold flat-rolled steel strip, longitudinally welded continuously by the passage of an electric current across the abutting edges or along the edges prior to closure under welding pressure without the addition of filler metal. The tubes shall be as-welded, hot finished or cold finished (see notes). The finished tubes shall not include welds used for joining lengths of the hot or cold, flat-rolled strip prior to tube forming. For tubes of both test categories ultrasonic or other suitable non-destructive testing method shall be used for continuous examination of the weld area (see note 4).

NOTE 1 The terms “as-welded”, “hot finished” and “cold finished” apply to the conditions of the tube before heat treatment, in accordance with clause 7.

NOTE 2 Electric resistance welded tubes cover those produced by both high frequency and low frequency techniques using either direct contact or induction.

NOTE 3 The range of dimensions and tolerances in which tubes are available is dependent upon the method of manufacture. The thicknesses available are also dependent upon the diameter. The dimensional limits generally applicable to this standard are shown in Appendix B and the tolerances in clause 10.

NOTE 4 For welded tubes, ultrasonic or other suitable non-destructive testing is used for the purpose of quality control during the process of manufacture by a method and at a place chosen by the manufacturer.

NOTE 5 Hot and cold finished seamless tubes are produced to outside diameter and thickness or to inside diameter and thickness dimensions. Electric resistance welded tubes are produced to outside diameter and thickness dimensions.

6 Chemical analysis

6.1 Ladle analysis

The steel shall show on ladle analysis the composition given in Table 3 appropriate to the steel type number specified.

6.2 Product analysis

If a product analysis for acceptance purposes is required by the purchaser this shall be stated in the enquiry and order [see 2.2 b)].

When an analysis on the product is carried out the permitted deviations given in Table 4 shall apply to the specified ladle analysis in Table 3.

The number of samples to be taken shall be one per cast. The samples shall be taken either from the test pieces used for the verification of the mechanical properties or from the whole thickness of the tube at the same location as for the mechanical test samples.

In cases of dispute, the methods of chemical analysis shall be in accordance with British Standard Handbook 19 or BS 6200-3 as appropriate.

6.3 Content of elements

If required by the purchaser [see 2.2 c)] the content of elements, selected by the purchaser, in addition to those specified in Table 3 shall be reported.

NOTE The purchaser may require, for example, to know the content of elements relating to weldability.

7 Heat treatment

The tubes shall be supplied in the heat treated condition as given in Table 3 unless otherwise specified by the purchaser (see note 1).

Heat treatment temperatures shall be selected from within the temperature ranges given in Table 3 and shall refer to the metal temperature (see note 2).

NOTE 1 In the event that the tubes are required for subsequent manipulation the purchaser may request delivery of the tubes in a condition other than the final heat treated condition given in Table 3. In this case the purchaser should be informed of the heat treatment necessary to give the required properties (see clause 8).

NOTE 2 The supplier should demonstrate if required that the appropriate heat treatment cycle has been achieved.

8 Mechanical properties

8.1 Mechanical properties at room temperature

The mechanical properties at room temperature¹⁾ to be obtained on test pieces selected, prepared and tested in accordance with clauses 12 and 13 shall be as specified in Table 3.

NOTE If heat treatments different from, or additional to, the normal reference heat treatment (which may have an adverse effect on the mechanical properties) are to be carried out after the delivery of the tubes, the purchaser may request, at the time of the enquiry and order, additional mechanical tests on samples that have been given heat treatments different from, or additional to, those given in Table 3. In this case, the heat treatment of the samples, and the mechanical properties to be obtained from tests on them should be agreed between the purchaser and the manufacturer at the time of enquiry and order.

8.2 Elevated temperature minimum 0.2 % proof stress properties

The elevated temperature minimum 0.2 % proof stress values shall be as specified in Table 5 when sampled as described in 12.6 and tested or verified as described in 13.7.

NOTE The values are not normally subject to verification, except for steels 591 and 91 unless requested by the purchaser (see 13.7).

8.3 Stress rupture properties

The stress rupture properties shall not be subject to verification.

NOTE For tubes complying with this standard the estimated average stress rupture values are shown in Appendix C and can be used for design purposes.

8.4 Flattening test properties

8.4.1 When tested in accordance with 13.2.2 the ring shall withstand being flattened without showing any cracks or flaws in the metal, except as specified in 8.4.2, until the distance between the platens, H , is equal to or less than the value calculated using the constant specified.

8.4.2 Test pieces are normally tested without preparation of the cut edges and in this condition cracks originating at the edges of the test piece which are less than 6 mm long and which do not penetrate through the wall shall be deemed not to affect compliance with this standard.

8.5 Bend test properties

8.5.1 When tested in accordance with 13.2.3, the test piece shall not show any crack or flaw except as specified in 8.5.2.

8.5.2 Test pieces are normally tested without preparation of the cut edges and, in this condition, cracks originating at the edges of the test pieces which are less than 6 mm long and which do not penetrate the thickness of the piece shall be deemed not to affect compliance with this standard.

¹⁾ In cases of dispute, room temperature is to be taken as 20 ± 5 °C.