BRITISH STANDARD

BS 3601:1987

Specification for

Carbon steel pipes and tubes with specified room temperature properties for pressure purposes

UDC 621.643.2-988-034.14

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards 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 Shipbuilders
British Steel Industry
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
High Pressure Pipework Consultative Committee
Lloyd's Register of Shipping
Process Plant Association
Seamless Steel Tube Association
Water-tube Boilermakers' 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

This British Standard, having been prepared under the direction of the Iron and Steel Standards Committee, was published under the authority of the Board of BSI and comes into effect on 28 August 1987

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Contents

Foreword

This British Standard has been prepared under the direction of the Iron and Steel Standards Committee and supersedes BS 3601:1974 which is withdrawn.

The main technical differences between this edition and the previous edition are that changes have been made to the chemical analysis and the mechanical properties to take into account current steelmaking practice.

The specified minimum tensile strength for steel 410 has been increased to 430 N/mm^2 and the designation has been changed to 430 accordingly. The designations of the other steels remain unchanged from the previous edition.

Changes have been made to the thickness tolerance (excluding weld reinforcement) of submerged arc welded tubes and the length tolerance for cut lengths above 6 m long.

The assessment of the flattening test for welded tubes has been brought into alignment with that for seamless tubes and flattening test constants are specified for welded tubes.

The designation of steel tubes in this specification and their nearest equivalent designations in ISO 2604-2, ISO 2604-3 and ISO 2604-6 are shown in appendix A for information purposes.

This standard is aligned, as far as possible, with the corresponding requirements and test procedures agreed for incorporation in draft ISO standards.

The steels covered by this standard are generally regarded as being weldable. However, care should be taken and welding should be in accordance with the appropriate British Standard for welding, e.g. BS 2633.

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

BS 3602, *Specification for steel pipes and tubes for pressure purposes: carbon and carbon manganese steel with specified elevated temperature properties;*

BS 3602-1:*Seamless, electric resistance welded and induction welded tubes;*

BS 3602-2: *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 3604, *Specification for steel pipes and tubes for pressure purposes: ferritic alloy steel with specified elevated temperature properties.*

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

Purchasers ordering to this British Standard are advised to specify in their purchasing contract that the supplier operates a quality system in compliance with BS 5750-2 to assure themselves that products claimed to comply with BS 3601 consistently achieve the required level of quality.

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 14, an inside back cover and a back cover.

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

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1 Scope

This British Standard specifies requirements for plain end, welded and seamless carbon steel tubes suitable for general pressure purposes. Tubes manufactured in accordance with this standard have specified room temperature properties (see note 1).

In addition to the definitive requirements, this standard 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.

NOTE 1 Carbon steel tubes with specified elevated temperature properties or for special manipulation such as close bending or other special applications are covered by the requirements of BS 3602-1 and BS 3602-2.

NOTE 2 The range of diameters and thicknesses appropriate to this standard is given in appendix B. However, it may be convenient to select from the discrete sizes given in the following British Standards:

a) BS 3600:1976, Table 1;

b) BS 1600-2 (completely interchangeable with ANSI B36.10 and ANSI B36.19);

c) B 3600:1976, Table 4 (for use with compression couplings);

d) BS 1387:1985, Tables 1, 2 and 3 (for buttwelded tubes).

Tubes to diameters and thicknesses not covered by the above standards including tubes made to internal diameter requirements are also available.

NOTE 3 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 fully documented:

a) the number of this British Standard, i.e. BS 3601, the method of manufacture of the product and the grade of steel, as expressed by the appropriate designation in clause **3**, e.g. BS 3601:ERW 430;

b) the tube outside diameter and thickness;

c) the tube length, if exact (see **2.2** i) and **10.4**);

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 where the purchaser identifies the option it shall be fully documented. Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified. In the event that the purchaser does not indicate his requirements at the time of enquiry or order the manufacturer shall select the options.

a) Whether the steelmaking process used has to be reported [see **4.2** and clause **15** 1)].

b) The type of seam weld, longitudinal or spiral for submerged arc welded tube [see clause **5** d)].

c) Whether weld repairs on the body of submerged arc welded tubes are not permitted [see clause **5** d)].

d) Whether a product analysis is required [see **6.2** and clause **15** 2)].

e) Whether selected chemical elements additional to those specified are to be reported [see **6.3** and clause **15** 3)].

f) The final supply condition of electric resistance welded, submerged arc welded and seamless tubes (see clause **7**).

g) Whether the height of the internal weld bead requires to be reduced [see **10.2** b)].

h) Whether the tube tolerances are required to suit compression couplings (see **10.3**).

i) Whether lengths other than random lengths are required (see **10.4**).

j) Whether random lengths down to 1.8 m are acceptable (see **10.4**).

k) Whether the method of leak tightness test to be carried out on tubes up to and including 180 mm outside diameter is the hydraulic test or the eddy current test [see **12.3** and clause **15** 5)].

l) Whether the hydraulic test, if specified, is to be carried out at a pressure in excess of 70 bar[1)] and the pressure required [see **13.3** b) and clause **15** 5)].

m) Whether the tubes are to be supplied uncoated or with the manufacturer's normal mill coating (see clause **16**).

n) Whether marking requirements to BS 5383 are required (see **17.1** and **17.4**).

[1)] 1 bar = 10^5 N/m^2 = 100 kPa.

3 Designation

The tubes shall be designated by the number of this British Standard, i.e. BS 3601 and, from Table 1, by one of the references which indicates the method of manufacture (see clause **5**) and the grade of steel (see Table 2).

Tubes intended for compression couplings (see **10.3**) shall have the letters CC added to the designation.

Example. BS 3601: ERW 430 denotes electric resistance welded (including induction welded) tube made from steel grade 430.

NOTE The designations for tubes in this standard and their nearest equivalent designations is ISO 2604-2, ISO 2604-3 and ISO 2604-6 are listed in appendix A for information.

4 Manufacture of the steel

4.1 General

The steelmaking process within the provisions of **4.2** and the deoxidation practice within the provisions of **4.3** shall be at the option of the manufacturer.

Table 1 — Method of manufacture of tube, reference and steel grades applicable

Method of manufacture of tube	Reference	Steel grades applicable		
Buttwelded	BW	320	—	—
Electric resistance including induction welded	ERW	320	360	430
Seamless	S	—	360	430
Submerged arc welded	SAW	—	—	430

4.2 Steelmaking process

The steel shall be produced by an electric or one of the basic oxygen processes. If he so requires [see **2.2** a)], the purchaser shall be informed of the steelmaking process used.

4.3 Deoxidation

Steel grade 360 for seamless tubes and steel grade 430 for all methods of manufacture shall be either semi-killed or fully-killed. Steel grades 320 and 360 for welded tubes shall be either semi-killed, fully-killed or rimmed.

5 Manufacture of the product

The tubes (see note 1) shall be manufactured by one of the following processes.

a) *Buttwelded tubes*. The tubes shall be manufactured from hot or cold flat rolled strip, with a longitudinal seam and furnace buttwelded by a continuous process. The tubes shall be hot finished (see note 2).

The finished tubes shall not include welds used for joining lengths of the hot or cold, flat rolled strip prior to tube forming.

b) *Electric resistance welded tubes* (see note 3). The tubes shall be manufactured from hot or cold flat rolled strip, longitudinally welded continuously by the passage of an electric current across the abutting edges or along the edges prior to the closure under welding pressure without the addition of filler metal. If rimmed steel strip is used the strip shall be rolled in single widths and not slit longitudinally except to trim the edges. The tubes shall be as welded, hot finished or cold finished (see note 2). The finished tubes shall not include welds used for joining lengths of the hot or cold, flat rolled strip prior to tube forming.

Ultrasonic or other suitable non-destructive testing method shall be used for the continuous examination of the weld area (see note 4).

c) *Seamless tubes*. The tubes shall be manufactured by a seamless process and shall be hot finished or cold finished (see note 2).

d) *Submerged arc welded tubes*. The tubes shall be manufactured from plate, sheet or strip with either a single or double longitudinal seam or a spiral seam and welded across the abutting edges by an automatic submerged arc welding process using at least two runs, one of which shall be on the inside of the tubes (see note 5). The tubes shall be as welded, hot finished or cold finished (see note 2).

Repairs to the weld seam shall be permitted. Unless otherwise specified by the purchaser [see **2.2** b) and c)] the manufacturer shall have the option of:

1) undertaking weld repairs on the body of the finished tubes;

2) supplying the tubes with either a longitudinal or spiral seam.

Ultrasonic or other suitable non-destructive testing method of the weld area shall be undertaken on at least 10 % of each diameter and thickness manufactured (see note 4).

NOTE 1 The range of dimensions in which the 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.

NOTE 2 The terms "as welded", "hot finished" and "cold finished" apply to the condition of the tubes before heat treatment, if required, in accordance with clause **7**.

NOTE 3 Electric resistance welded tubes cover those produced by both high and low frequency techniques using either direct contact or induction.

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

NOTE 5 By agreement with the purchaser, submerged arc welded tubes with thicknesses less than 6.3 mm or diameters less than 323.9 mm may be welded in one run and automatic gas shielded arc welding may be used.

6 Chemical analysis

6.1 Ladle analysis

The steel shall show on ladle analysis the composition given in Table 2 appropriate to the steel grade specified.

6.2 Product analysis

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

When an analysis on the product is carried out, the permitted deviations given in Table 3 shall apply to the specified ladle analysis in Table 2.

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 for chemical analysis shall be in accordance with British Standard Handbook No. 19 or BS 6200-3 as appropriate.

6.3 Reporting of additional elements

If required by the purchaser [see **2.2** e)], the content of elements, selected by the purchaser, in addition to those specified in Table 2 shall be reported.

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

Table 2 — Chemical composition and mechanical properties at room temperature

Steel grade	Method of manufacture	Chemical composition (ladle analysis) (see notes 1 and 2)						Mechanical properties at room temperatures (see note 3)						
		C	Si	Mn		P	S	R_m		R_e min. For thickness in mm			A	Bend test bar diameter
		max.	max.	min.	max.	max.	max.	min.	max.	≤ 16	> 16 ≤ 40	> 40 ≤ 65	min	
		%	%	%	%	%	%	N/mm² [b]	N/mm²	N/mm²	N/mm²	N/mm²	%	
320	Welded (BW and ERW)	0.16[a]	—	0.30	0.70	0.040	0.040	320	460	195	—	—	25	—
360	Seamless (S)	0.17	0.35	0.40	0.80	0.040	0.040	360	500	235	225	215	25	4a
	Welded (ERW)	0.17[a]	0.35	0.40	0.80	0.040	0.040	360	500	235	—	—	25	—
430	Seamless (S)	0.21	0.35	0.40	1.20	0.040	0.040	430	570	275	265	255	22	4a
	Welded (ERW)	0.21	0.35	0.40	1.20	0.040	0.040	430	570	275	—	—	22	—
	Welded (SAW)	0.25	0.50	—	1.20	0.040	0.040	430	570	275	265	255	22	4a

NOTE 1 Elements not quoted in this table are not intentionally added other than for the purpose of finishing the heat.

NOTE 2 For permissible deviations on product analysis, see Table 3.

NOTE 3 R_e is the yield strength. For acceptance purposes either the upper yield stress R_{eH} or the 0.5 % proof stress (total elongation) $R_{t0.5}$ is determined (see **13.1**).

R_m is the tensile strength.

A is the percentage elongation after fracture on a gauge length of $L_o = 5.65\sqrt{S_o}$. (S_o is the original cross-sectional area of the gauge length.)

a is the thickness of the test piece.

[a] For welded tubes made from rimmed steel the C max. is 0.19 %.

[b] 1 N/mm² = 1 MPa.

Table 3 — Permitted deviations of the product analysis from the specified ladle analysis

Element	Upper limit of range in which the specified maximum for ladle analysis falls	Permitted deviations[a] from the specified limits	
		Greater than maximum	less than minimum
	Up to and including %	%	%
Carbon	0.25	0.03	—
Silicon	0.50	0.05	—
Manganese	2.0	0.10	0.10
Phosphorus	0.050	0.005	—
Sulphur	0.050	0.005	—

[a] These values apply only to fully-killed and semi-killed steels. The deviations apply either above the specified maximum or below the specified minimum but both deviations shall not be applied to different samples from the same cast.

7 Final supply conditions

The final supply condition applicable to each manufacturing process shall be as given in Table 4. Unless otherwise specified by the purchaser on the order [see **2.2** f)] the manufacturer shall have the option of supplying tube in any of the applicable supply conditions given in Table 4.

Table 4 — Tube manufacturing process and final supply conditions

Manufacturing process	Final supply conditions
Buttwelded (BW)	Hot finished Not heat treated
Electric resistance welded (ERW) in sizes ≤ 193.7 mm outside diameter	As welded Not heat treated Weld zone normalized[a] Normalized[b]
	Hot finished Not heat treated
	Cold finished Normalized[b] Sub-critically annealed[c]
Electric resistance welded (ERW) in sizes > 193.7 mm outside diameter	As welded Weld zone normalized[a]
	Cold finished Normalized[b] Sub-critically annealed[c]
Submerged arc welded (SAW) ≤ 35 mm thick	As welded Not heat treated
	Hot finished Not heat treated
	Cold finished Not heat treated Normalized[b] Stress relieved[d]
Submerged arc welded (SAW) > 35 mm thick	Hot finished Not heat treated
	As welded Stress relieved[d] Normalized[b]
Seamless (S)	Hot finished Not heat treated Normalized[b] Sub-critically annealed[c]
	Cold finished Normalized[b] Sub-critically annealed[c]

[a] Weld zone normalizing carried out in the temperature range 880 °C to 980 °C.

[b] Normalizing carried out in the temperature range 880 °C to 940 °C.

[c] Sub-critical annealing carried out in the temperature range 660 °C to 720 °C.

[d] Stress relieving carried out in the temperature range 590 °C to 650 °C.

8 Mechanical properties

8.1 General

The specified mechanical properties shall apply only to tubes in the final supply condition in which they have been tested by the manufacturer.

NOTE The mechanical properties may be affected by subsequent heating or reheat treatments. Purchasers who intend to heat or reheat treat any of the steels are advised to discuss the application and proposed heating or reheat treatment with the supplier.

8.2 Tensile properties

The tensile properties at room temperature[2)] to be obtained on test pieces selected, prepared and tested in accordance with clauses **12** and **13** shall be as given in Table 2.

8.3 Flattening test properties

NOTE The flattening test is not normally applied to buttwelded or submerged arc welded tubes.

8.3.1 When a flattening test is carried out on test pieces selected, prepared and tested in accordance with clauses **12** and **13** the results shall be as follows.

a) *Electric resistance welded including induction welded tubes.* At the first stage, which is a test for ductility of the weld, no opening of the weld shall take place until the distance between the platens, H, is less than the value calculated using the constant specified for the weld (see Table 6). At the second stage, which is a test for ductility other than at the weld, the metal shall show no cracks or flaws except as permitted in **8.3.2** until the distance between the platens, H, is less than the value calculated using the constant specified for the material (see Table 6).

b) *Seamless tubes.* The ring shall withstand being flattened without showing cracks or flaws in the metal except as specified in **8.3.2** until the distance between the platens, H, is less than the value calculated using the constant specified for the material (see Table 6).

8.3.2 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.

8.4 Bend test properties

NOTE The bend test is not applied to electric resistance welded including induction welded tubes.

When the bend test is carried out on test pieces selected, prepared and tested in accordance with clauses **12** and **13** the results shall be as follows.

a) *Buttwelded tubes.* The test piece shall not develop any cracks and the weld shall not open during the bending operation.

b) *Seamless tubes.* The test piece shall not show any crack or flaw except as specified in **8.3.2**.

c) *Submerged arc welded tubes.* In the case of a test on the tube material not containing the weld, the test piece shall not show any crack or flaw except as specified in **8.3.2**.

In the case of the tests on the weld, the test pieces shall not show any cracks or flaws except as permitted in **8.3.2** in the weld metal, fusion line, heat affected zone or parent metal. The opening out of a slight defect due to incomplete root penetration or lack of fusion shall not be considered cause for rejection, provided that the defect has sound metal at the back and on each side of it. In borderline cases further tests shall be made on test pieces from the same weld adjacent to the original test piece.

9 Visual inspection and appearance

9.1 The tubes shall be clean and free from such defects as can be established by visual inspection in accordance with this standard.

9.2 It shall be permitted to dress by grinding or machining surface marks and imperfections such as scabs, seams, tears, laps, slivers or gouges provided that the thickness of the tube after dressing does not fall below the nominal thickness by more than the tolerance specified in this standard.

9.3 All dressed areas shall blend smoothly into the contour of the tube.

9.4 For tubes which have a thickness to diameter (a/D) ratio equal to or less than 0.03, isolated dents shall not be cause for rejection provided that they do not exceed a depth greater than 10 % of the tube diameter or 6 mm whichever is smaller, measured as a gap between the lowest point of the dent and a prolongation of the original contour of the tube. The length of the dent in any direction shall not exceed one half the tube diameter.

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

9.5 The tubes shall not deviate from straightness by more than 1 in 600 at the centre of the tube length.

9.6 The ends shall be cut nominally square with the axis of the tube and shall be free from excessive burrs.

10 Tolerances

10.1 General

The maximum tolerances on the dimensions of the tubes shall be as specified in **10.2** and **10.4** or, if specified by the purchaser on his order [see **2.2** h)], as specified in **10.3** and **10.4**.

10.2 Outside diameter, thickness and size of weld bead or reinforcement

The tolerances on outside diameter shall include ovality except for submerged arc welded tube [see item d)]. The tolerance on thickness shall include eccentricity.

The tolerances on the outside diameter and thickness of tubes shall be as given in a) to d) for the appropriate method of manufacture.

a) *Buttwelded (BW).* The specified limits on outside diameter and the tolerances on thickness and mass shall be as specified in BS 1387.

b) *Electric resistance welded including induction welded (ERW)*

Outside diameter:	
up to and including 168.3 mm	± 1 % with a minimum tolerance of ± 0.50 mm
over 168.3 mm	± 0.75 %
Thickness:	± 10 %

The thickness tolerance shall not apply to the weld area. The external weld upset ("flash") shall be removed completely, i.e. flush with the outside surface of the tube. The maximum height of the weld upset on the internal surface of the tube shall not exceed 1.5 mm. If specified by the purchaser on the order [see **2.2** g)] the weld upset on the internal surface of the tube shall be reduced throughout the length of the tube so that its maximum height does not exceed 0.5 mm. The depth of any groove resulting from trimming of the internal surface of the weld shall not exceed 10 % of the tube thickness or 0.5 mm, whichever is the less.

NOTE 1 Closer tolerances on the outside diameter and thickness can be obtained by a cold finishing process.

c) *Seamless (S)*

Outside diameter:	± 1 % with a minimum tolerance of ± 0.50 mm
Thickness as a percentage of outside diameter:	
up to and including 3 %	± 15 %
over 3 %	± 12.5 %

NOTE 2 Closer tolerances on the outside diameter and thickness can be obtained by a cold finishing process.

d) *Submerged arc welded (SAW).* The outside diameter of the body of the tube as measured by taping the circumference shall not deviate from the specified diameter by more than ± 0.75 % or ± 10 mm, whichever is the less.

Ovality shall not exceed ± 1 % of the specified diameter for tubes having diameter to thickness ratios not exceeding 100.

NOTE 3 Where the diameter to thickness ratio exceeds 100 the tolerance on ovality is not specified and should be agreed between the manufacturer and the purchaser.

Thickness (excluding weld reinforcement): ± 7.5 %

Neither the inside nor the outside weld reinforcement shall exceed the following values.

Thickness	Maximum height of weld reinforcement
Up to and including 12.5 mm	3 mm
Over 12.5 mm	4.5 mm

10.3 Tubes for use with compression couplings

If specified by the purchaser on his order [see **2.2** h)] tubes shall be supplied to the following tolerances suitable for use with compression couplings.

Outside diameter:	
up to and including 30 mm	± 0.10 mm
over 30 mm up to and including 38 mm	± 0.15 mm
over 38 mm up to and including 50 mm	± 0.20 mm
Thickness:	± 10%

10.4 Length

Unless otherwise specified by the purchaser [see **2.2** i)] tubes shall be supplied as random lengths.

NOTE The actual range of the random lengths may be the subject of agreement between the purchaser and the manufacturer.

For orders of over 150 m of any one size in random lengths it shall be permissible, unless otherwise specified by the purchaser [see **2.2** j)], to supply short random lengths down to 1.8 m provided that the number of such lengths does not exceed 7 % of the total number of lengths for sizes up to and including 114.3 mm outside diameter and 5 % for all other sizes.

Where the length is specified as "exact length" or "cut length", the permissible deviation shall be + 6, – 0 mm for lengths up to and including 6 m. For every 3 m increase in length above 6 m, the plus tolerance shall be increased by 1.5 mm with a maximum of 12.0 mm.

11 Tests

The tubes shall be subjected to the following tests:

a) visual inspection (see clause **9** and **12.2**);

b) leak tightness test (see **12.3** and **13.4**);

c) tensile test (see clause **8**, **12.1** and **13.1**);

d) flattening test or bend test (see clause **8**, **12.1** and **13.2**).

12 Number, selection and preparation of samples and test pieces

12.1 Mechanical tests

12.1.1 Tensile and flattening or bend tests shall be carried out on test pieces cut from samples taken from one length of tube from each batch or part thereof. A batch shall consist of the number of tubes specified in Table 5 of the same diameter, same thickness and same cast, manufactured using the same processing conditions.

The samples shall be taken at random from each batch. If the number of samples specified in this clause, when applied to a particular order, necessitates a number of tubes that includes a fraction, the fraction shall be treated as unity.

Table 5 — Number of tubes per batch

Outside diameter	Number of batch
mm	
Up to and including 114.3	400 tubes as made
Over 114.3 up to and including 323.9	200 tubes as made
Over 323.9	100 tubes as made

12.1.2 The test sample shall be cut from a tube in the final condition of supply.

12.1.3 From the test sample from each tube selected for testing, one test piece shall be prepared for each of the mechanical tests specified in clause **11**.

12.1.4 For the tensile test, the dimensions of the test piece shall comply with the appropriate requirements of BS 18.

For welded tubes the tensile test piece shall not include the weld unless the tube is tested in full section.

NOTE For the tensile test, the test piece may be taken either longitudinally or transversely from the tube at the option of the manufacturer.

12.1.5 For the flattening test, a ring not less than 40 mm in length shall be taken from one end of each selected tube.

12.1.6 For the bend test on buttwelded tubes the test piece shall consist of a length of full section tube cut from one end of each selected tube. The length of the test piece shall be selected by the manufacturer to suit the equipment on which the bend test is carried out.

12.1.7 For the bend test on seamless tubes, the test piece shall be cut circumferentially from one end of each selected tube. The test piece shall not be less than 40 mm wide. The length of the test piece shall be selected by the manufacturer to suit the equipment on which the bend test is carried out.

NOTE Where the tube is over 20 mm thick the test piece may be machined to provide a rectangular cross section, 40 mm wide × 20 mm thick and the edges rounded to a radius of 1.5 mm.

12.1.8 For the bend test on submerged arc welded tubes, test pieces shall be prepared as follows.

a) For a bend test on the tube material not containing the weld, the test piece, not less than 40 mm wide, shall be cut transversely from the plate or strip prior to forming the tube or, alternatively, circumferentially from one end of each selected tube after forming, at the manufacturer's option. The length of the test piece shall be selected by the manufacturer to suit the equipment used for the test.

NOTE 1 Where the tube, plate or strip is over 20 mm thick the test piece may be machined to provide a rectangular cross section 40 mm × 20 mm thick and the edges rounded to a radius of 1.5 mm.

b) For a bend test on the weld, two test pieces shall be prepared, one for a face bend test and one for a root bend test. Both test pieces shall be not less than 40 mm wide and cut circumferentially from one end of each selected tube so that the weld is in the middle of the test piece and 90° to the longer sides. The weld reinforcement shall be removed from both faces. The length of the test pieces shall be selected by the manufacturer to suit the equipment used for the test.

NOTE 2 The test pieces may be flattened before testing.

12.2 Visual inspection

Every tube shall be inspected visually (see clause **9**).

12.3 Leak tightness

All tubes shall be subjected to a leak tightness test. This shall be by an hydraulic test in accordance with **13.3** for all tube sizes above 180 mm outside diameter. For sizes 180 mm and below, this shall be either by an hydraulic test in accordance with **13.3** or by an eddy current test in accordance with **13.4**, at the discretion of the manufacturer unless otherwise specified by the purchaser [see **2.2** k)].

NOTE 1 Both the hydraulic test and the eddy current test may leave a short length at each end of the tube incompletely tested. If requested at the time of the enquiry and order, the length affected should be determined by the manufacturer and reported to the purchaser. Further, if requested at the time of the enquiry and order, the manufacturer should either cut off the untested lengths or test them by an agreed alternative procedure.

NOTE 2 The hydraulic test is capable of detecting defects of a size and disposition permitting the test fluid to leak through the tube wall. It may not detect through-wall defects that are tight or defects extending an appreciable depth into the tube wall without complete penetration. The test specified in **13.3** should not be regarded as a test of strength since the maximum pressure specified will develop only limited stress in the wall of tubes having low diameter to thickness ratio.

13 Test methods

13.1 Tensile test

The tensile test shall be carried out in accordance with BS 18.

The tensile strength R_m, the yield strength R_e and the elongation A shall be determined. For the yield strength, either the upper yield stress R_{eH} or the 0.5 % proof stress (total elongation) $R_{t0.5}$ shall be determined.

The elongation shall be reported with reference to a gauge length of $L_o = 5.65\sqrt{S_o}$, where S_o is the original cross-sectional area of the gauge length. If other gauge lengths are used, the corresponding percentage elongation on $5.65\sqrt{S_o}$ shall be obtained by reference to BS 3894-1.

In cases of dispute, a gauge length of $5.65\sqrt{S_o}$ shall be used.

13.2 Flattening or bend test

13.2.1 *General.* At the option of the manufacturer, and dependent upon the dimensions of the tube and method of manufacture, either a flattening test or a bend test shall be carried out.

13.2.2 *Flattening test*

NOTE The flattening test is not normally applied to buttwelded tubes.

The test piece shall be flattened at room temperature[3)] between parallel, flat platens until the distance between the platens H, (in mm), measured under load, is not greater than the value given by the following equation:

$$H = \frac{(1 + C)\,a}{C + \frac{a}{D}}$$

where

a is the specified thickness of the tube (in mm);

D is the specified outside diameter of the tube (in mm);

C is the flattening test constant (see Table 6).

Table 6 — Flattening test constant C

Steel grade	Flattening test constant C	
	Weld	Material
320	0.029	0.10
360	0.026	0.09
430	0.023	0.08

For electric resistance welded, including induction welded, tubes the weld shall be positioned at 90° to the direction of flattening and the test on the ring shall be carried out in two stages. At the first stage, which is a test for ductility of the weld, the distance between the platens, H, is calculated using the constant specified for the weld (see Table 6). At the second stage, which is a test for ductility other than at the weld, the distance between the platens, H, is calculated using the constant specified for the material (see Table 6).

For seamless tubes the ring shall be flattened until the distance between the platens, H, is the value calculated using the constant specified for the material (see Table 6).

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

13.2.3 ***Bend test***

NOTE The bend test is not normally applied to electric resistance including induction welded tubes.

13.2.3.1 For buttwelded tubes the test piece shall be bent at room temperature[4] along its longitudinal axis through 180° around a grooved former. The former shall have a radius measured to the bottom of the groove of six times the original outside diameter of the tube. The test piece shall be bent with the weld located at 90° to the plane of bending.

13.2.3.2 For seamless tubes the test piece shall be bent at room temperature[4] in the direction of the original curvature through an angle of 180° around a bar of the diameter specified in Table 2.

13.2.3.3 For submerged arc welded tubes a bend test shall be carried out on the tube material not containing the weld and one face and one root bend test shall be carried out on the weld.

In the case of the test on the tube material not containing the weld, when the test piece is from the formed tube it shall be bent in the direction of the original curvature, at room temperature[4] through an angle of 180° around a bar of the diameter specified in Table 2.

In the case of the tests on the weld, the test pieces shall be bent at room temperature[4] through an angle of 180° around a bar of the diameter specified in Table 2.

13.3 Hydraulic test

For tubes which are hydraulically tested, the hydraulic test pressure, P (in bar) shall be:

a) for buttwelded tubes: 50 bar;

b) for electric resistance welded, seamless and submerged arc welded tubes the hydraulic test pressure shall be calculated from the following equation:

$$P = \frac{20\ Sa}{D}$$

where

D is the specified outside diameter of the tube (in mm);

a is the specified thickness of the tube (in mm);

S is a stress (in N/mm^2 [5]) which shall be taken as 80 % of the specified minimum yield strength appropriate to thickness at room temperature.

The test shall be carried out at the pressure P or at 70 bar, whichever is lower but when 70 bar is lower than P, the purchaser has the option [see **2.2** l)] to specify that the test shall be carried out at a pressure higher than 70 bar but not greater than the value P determined from the equation above.

For all tubes the test pressure shall be maintained sufficiently long for proof and inspection. Any tube failing to withstand the hydraulic pressure test shall be deemed not to comply with the requirements of this standard.

13.4 Eddy current testing

Eddy current testing for verification of leak tightness and the assessment of the results shall be carried out in accordance with appendix C.

14 Retests

Should a tube selected for testing fail in any of the tests specified in **13.1** or **13.2**, the batch of tubes that it represents shall be deemed not to comply with the requirements of this standard unless it has been retested successfully in accordance with either a) or b) as follows:

a) two further tests of the same kind as produced failure are made from the same batch, and both these further tests prove satisfactory;

b) if either of the further tests required by a) proves unsatisfactory, the tubes represented are suitably heat treated and samples are selected and tested in accordance with all the tests specified in **13.1** and **13.2** and all these tests are satisfactory.

Any tube which has failed in tests shall be deemed not to comply with the requirements of this standard, unless it has itself been retested successfully in accordance with a) or b).

15 Test certificate

A manufacturer's test certificate shall be supplied giving the following information:

a) the grade designation (see clause **3**);

b) the ladle analysis for elements specified in Table 2;

c) the mechanical test results;

d) the purchaser's order number or other appropriate mark [see **17.2** c)].

[4] In cases of dispute, room temperature is to be taken as 20 ± 5 °C.

[5] 1 N/mm^2 = 1 MPa.

The certificate shall also give the following information where appropriate for options selected by the purchaser (see **2.2**):

1) the steelmaking process used (see **4.2**);

2) the product analysis (see **6.2**);

3) the content of selected elements in addition to those specified in Table 2 (see **6.3**);

4) the final heat treatment carried out by the manufacturer (see clause **7**);

5) the method of verification of leak tightness, either by eddy current or hydraulic tests and, in the latter case, the pressure applied (see **12.3**).

16 Protective coating

The tubes shall be supplied either uncoated or with the manufacturer's normal mill coating at the option of the purchaser [see **2.2** m)].

NOTE If the purchaser requires additional measures for protection during delivery then this should be the subject of agreement between the purchaser and the manufacturer.

17 Marking

17.1 Before despatch from the manufacturer's works, the tubes shall be marked in accordance with **17.2** or, if specified by the purchaser on his order [see **2.2** n)], in accordance with **17.4**.

17.2 Each tube shall be legibly marked at one end commencing not more than 300 mm from the end by stencilling or other indelible marking.

The marking shall consist of the following in the sequence indicated:

a) the manufacturer's name or identification mark;

b) the designation[6] as given in clause **3**, e.g. BS 3601:ERW 430;

c) the purchaser's order number or other appropriate mark to identify it with the test certificate.

Alternatively, for tubes that are bundled, the information given in a), b) and c) shall be either stamped on one or more metal or other durable tags, or printed on banding clips or straps, which shall be securely attached to each bundle.

Not more than one steel grade shall be included in any one bundle.

NOTE If traceability of cast identity is required this should be the subject of an agreement between the manufacturer and the purchaser at the time of the enquiry and order.

17.3 The quality of the paint or ink applied shall be such that it shall have a life of at least 1 year in unheated storage under cover.

The dried film shall not contain more than 0.025 % (*m*/*m*) of each of the following metals:

lead, tin, copper, zinc.

NOTE For certain applications limits may be required on the levels of sulphur and halogens in the paint. These limits should be subject to agreement between the supplier and the purchaser.

17.4 If specified by the purchaser on his order [see **2.2** n)] each tube shall be marked in accordance with BS 5383 and shall include the information specified in **17.2** a), b) and c).

NOTE Colour coding is an optional additional requirement in BS 5383 and, if required, should be specified by the purchaser on the enquiry and order.

[6] Marking BS 3601 on or in relation to a product is a claim by the manufacturer that the product has been manufactured to the requirements of this standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility. Enquiries as to the availability of third party certification should be addressed to the appropriate certification body.

Appendix A Designation of steel tubes in BS 3601:1987 and the nearest equivalent designations in BS 3601:1974 and ISO 2604-2, ISO 2604-3 and ISO 2604-6

Table 7 lists the designation for tubes in BS 3601:1987 and gives the nearest equivalents in BS 3601:1974 and ISO 2604-2, ISO 2604-3 and ISO 2604-6.

It should be noted that the designations are indicated as nearest equivalents and are not necessarily identical.

Table 7 — Designation of steel tubes in BS 3601:1987 and the nearest equivalent designations in BS 3601:1974 and ISO 2604-2, ISO 2604-3, and ISO 2604-6

BS 3601: 1987	BS 3601: 1974	ISO 2604-2, ISO 2604-3 and ISO 2604-6
BW 320	BW 320	—
ERW 320	ERW 320	Part 3 — TW 1 Cat. II
ERW 360	ERW 360	Part 3 — TW 4 Cat. II
S 360	S 360	Part 2 — TS 4 Cat. II (hot finished and cold finished)
ERW 430	ERW 410	Part 3 — TW 9 Cat. II
S 430	S 410	Part 2 — TS 9 Cat. II (hot finished and cold finished)
SAW 430	SAW 410	Part 6 — TSAW 9 Cat. VI (LW and LWHT)

Appendix B Dimensional limits of tubes in relation to the method of manufacture

The range of dimensions shown in Table 8 will cover most applications for which the standard will be used. However, if thicker pipes are required these may be available depending on the method of manufacture.

Appendix C Eddy current testing of tubes for verification of leak tightness

Eddy current testing shall be used only on tube sizes up to and including 180 mm outside diameter. The tubes shall be tested in accordance with BS 3889-2A, with the options of BS 3889-2A as specified in a) and b) of this appendix and with the modification to BS 3889-2A as specified in c) of this appendix.

a) *Test procedure.* The tubes shall, be tested for verification of leak tightness using concentric coil or a rotating tube/rotating coil eddy current technique as described for methods A and B of BS 3889-2A.

b) *Reference standards.* The equipment shall be calibrated using reference standards prepared in accordance with **5.2.4** a) for method A and **5.2.4** b) for method B of BS 3889-2A:1986. The dimensions of the reference hole (method A) and the reference notch (method B) shall be as given in Table 9 and Table 10 of this standard.

c) *Assessment of results.* The results of the test shall be assessed in accordance with clause **7** of BS 3889-2A:1986, except that **7.3** b) shall be replaced by the following.

Explore the suspect area of the tube by dressing. If the tube thickness within the dressed area remains within the thickness tolerance either:

1) retest the tube using the selected eddy current method in accordance with this appendix and if no signals are obtained that give a trigger/alarm condition the tube shall be deemed to have passed the test; or

2) subject the suspect area to magnetic particle inspection in accordance with BS 6072 to ensure that dressing has resulted in complete removal of the imperfection. The tube shall then be deemed to have passed the test.

If the tube thickness within the dressed area does not remain within the thickness tolerance or, if on retesting using the eddy current test method signals are obtained that give a trigger/alarm condition either:

3) cut off the suspect area, the remaining length being deemed to have passed the test; or

4) the tube shall be deemed not to have passed the test.

Table 8 — Dimensional limits of tubes in relation to the method of manufacture

Method of manufacture	Outside diameter	Thickness
	mm	mm
Buttwelded	8 to 50 (nominal size)	Up to and including 4.5
Electric resistance welded[a]	12.7 to 508	Up to and including 12.5
Seamless[a]	12.7 to 1 016	Up to and including 65
Submerged arc welded	114.3 to 2 220	Up to and including 50

[a] For tubes for use with compression couplings, see **10.3**.

Table 9 — Dimensions of reference holes for method A

Outside diameter	Drill diameter
mm	mm
≤ 25	1.2
> 25 ≤ 45	1.7
> 45 ≤ 65	2.2
> 65 ≤ 100	2.7
> 100 ≤ 140	3.2
> 140 ≤ 180	3.7

Table 10 — Notch dimensions for method B

Depth	12.5 % of the specified tube thickness
Minimum depth	0.6 mm
Maximum depth	1.5 mm
Tolerance on depth	± 15 % of notch depth
Width	Not greater than notch depth with a minimum of 0.50 mm
Length	A convenient length selected by the manufacturer for calibration and checking purpose

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Publications referred to

BS 18, *Methods for tensile testing of metals.*

BS 1387, *Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads.*

BS 1600, *Specification for dimensions of steel pipe for the petroleum industry.*

BS 1600-2, *Metric units.*

BS 2633, *Specification for Class 1 arc welding of ferritic steel pipework for carrying fluids*[7)].

BS 3600, *Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes.*

BS 3602, *Specification for steel pipes and tubes for pressure purposes: carbon and carbon manganese steel with specified elevated temperature properties.*

BS 3602-1, *Seamless, electric resistance welded and induction welded tubes.*

BS 3602-2, *Submerged arc welded tubes.*

BS 3603, *Specification for steel pipes and tubes for pressure purposes: carbon and alloy steel with specified low temperature properties*[7)].

BS 3604, *Specification for steel pipes and tubes for pressure purposes: ferritic alloy steel with specified elevated temperature properties*[7)].

BS 3605, *Specification for seamless and welded austenitic stainless steel pipes and tubes for pressure purposes*[7)].

BS 3889, *Methods for non-destructive testing of pipes and tubes.*

BS 3889-2A, *Automatic eddy current testing of wrought steel tubes.*

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

BS 3889-1, *Carbon and low alloy steels.*

BS 5383, *Specification for material identification of steel, nickel alloy and titanium alloy tubes by continuous character marking and colour coding of steel tubes.*

BS 5750, *Quality systems*[7)].

BS 5750-2, *Specification for production and installation.*

BS 6072, *Method for magnetic particle flaw detection.*

BS 6200, *Sampling and analysis of iron, steel and other ferrous metals.*

BS 6200-3, *Methods of analysis.*

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

ISO 2604, *Steel products for pressure purposes — Quality requirements.*

ISO 2604-2, *Wrought seamless tubes.*

ISO 2604-3, *Electric resistance and induction — Welded tubes.*

ISO 2604-6, *Submerged arc longitudinally or spirally welded steel tubes.*

[7)] Referred to in the foreword only.

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