



BS 3602 : Part 2 : 1978

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Specification for

**Steel pipes and tubes for pressure purposes:
carbon and carbon manganese steel with
specified elevated temperature properties**

Part 2. Submerged arc welded tubes

Spécification des tubes en acier pour service sous pression: acier au carbone
et carbone manganèse avec des propriétés spécifiées aux températures élevées
Partie 2. Tubes soudés à l'arc immergé

Spezifikation für Stahlrohre für erhöhten Innenüberdruck: Warmfeste unlegierte Stähle
Teil 2. Unterpulver geschweißte Rohre

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Foreword

This edition of BS 3602, prepared under the direction of the Iron and Steel Standards Committee, has been metricated and extensively revised technically.

In Part 2 general and specific requirements are given for tubes and pipes manufactured by the submerged arc welding process in carbon and carbon manganese steel.

Requirements for tubes made by the seamless and electric resistance or induction welding processes are given in Part 1 of this standard.

BS 3602 is one of a series of standards specifying the requirements for pipes and tubes for pressure purposes.

The others are as follows:

- BS 3601 Steel pipes and tubes for pressure purposes: carbon steel with specified room temperature properties
- BS 3603 Steel pipes and tubes for pressure purposes: carbon and alloy steel with specified low temperature properties
- BS 3604 Steel pipes and tubes for pressure purposes: ferritic alloy steel with specified elevated temperature properties
- BS 3605 Seamless and welded austenitic stainless steel pipes and tubes for pressure purposes

As far as possible, composition ranges of the steels included have been aligned with those agreed internationally within the International Organization for Standardization (ISO). Elevated temperature yield or proof stress values now included are those derived by the procedure described in BS 3920. Additionally, provision is made for application of the related procedure for verifying that a product consistently meets the specified levels of elevated temperature values.

Tubes complying with the requirements of Part 2 of this standard may now be supplied to two test categories, both of which require mandatory non-destructive testing.

Dimensions of tubes appropriate to this standard are now specified separately in BS 3600. Details of methods for converting percentage elongation are specified in BS 3894 : Part 1.

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.

NOTE. For the purposes of this standard no difference is intended in the meaning between 'pipe' and 'tube' although idiomatic use prefers sometimes the one and sometimes the other.

British Standard Specification for

Steel pipes and tubes for pressure purposes: carbon and carbon manganese steel with specified elevated temperature properties

Part 2. Submerged arc welded tubes

1. Scope

1.1 This Part of BS 3602 specifies requirements for plain end longitudinally submerged arc welded carbon and carbon manganese steel tubes suitable for pressure purposes.

1.2 Diameters and thicknesses appropriate to the tubes specified in this standard should preferably be selected from BS 3600 : 1976, table 1. Tubes complying with the requirements of this standard may also be supplied in accordance with the dimensions given in BS 1600 : Part 2.

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

1.4 This standard provides for two categories of room temperature* test procedure, designated categories 1 and 2 (see clause 13). Test category 1 requires 100 % non-destructive acceptance testing of the weld. Category 1 in this standard is equivalent to category VIII in ISO 2604 : Part VI; category 2 in this standard is equivalent to category VII in ISO 2604 : Part VI.

1.5 Long term elevated temperatures stress-rupture values for the materials specified are given in appendix E. The data may be used for design purposes.

2. References

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

3. Information to be supplied by the purchaser

3.1 The purchaser shall state the following in his enquiry and order:

(a) the number and Part of this British Standard, the method of manufacture of the tube, the grade of steel and the category of test as expressed by the appropriate designation (see clause 4), e.g. BS 3602 : Pt 2 : SAW 410 : Cat. 1;

(b) the tube dimensions, i.e. outside diameter, thickness and length (see 1.2);

(c) the quantity in metres or number of lengths.

3.2 Certain alternatives are permitted by this standard and the purchaser may also state in his enquiry and order his requirements as follows (but if no such statement is made, supply will be at the option of the manufacturer):

(a) the steelmaking process and deoxidation practice (see clause 5);

(b) whether a welding procedure approval certificate or welding procedure approval tests are required (see clause 6);

(c) whether the plate to be used is to be ordered to special quality requirements (see 6.1);

(d) whether a check analysis on the product is required (see 7.2);

(e) the heat treatment condition of supply (see clause 8);

(f) whether additional mechanical tests are required (see 9.1);

(g) any special requirements for freedom from defects (see 10.4);

(h) any special requirements regarding straightness (see 10.6);

(i) whether end sizing is required (see 11.3);

(j) whether he or his representative desires to witness mechanical or other tests, and the name of the inspecting authority, if any (see clause 12);

(k) whether room temperature impact tests are required and the values to be obtained (see 14.1.5 and 15.3);

(l) whether the hydraulic test is to be omitted (see 14.3);

(m) the hydraulic test pressure required if in excess of 140 bar† (see 15.4);

(n) the details of non-destructive tests (see 15.5);

(o) whether a protective coating other than the manufacturer's mill coating is required (see clause 19);

(p) whether special protection of the tubes for transit is required (see clause 19);

(q) the marking required (see 20.1);

(r) whether verification of elevated temperature proof stress values is required (see 21.2.1) and the temperature selected from appendix C at which the value is to be verified (see 21.2.2 and 21.2.3).

4. Designation

The tubes shall be designated by the number and Part of this British Standard and the reference SAW indicating submerged arc welding, together with the reference indicating the grade of steel and the test category.

For tubes complying with the requirements of this Part of the standard the grades of steel are designated 410 or 460 (see table 1).

*In case of dispute, room temperature is taken as 20 °C.

†1 bar = 10⁵ N/m² = 100 kPa.

Example: BS 3602 : Pt 2 : SAW 410 : Cat. 1 designates submerged arc welded tubes made from steel grade 410 and tested to category 1. The number 410 corresponds to the minimum tensile strength of the steel in N/mm^2 * (see table 1).

5. Manufacture of the steel

5.1 General. Unless otherwise stated in the enquiry and order, the steelmaking process and the deoxidation practice within the provisions of 5.2 and 5.3 shall be at the option of the steel manufacturer.

5.2 Steelmaking process. The steel shall be produced by the open hearth, an electric or one of the basic oxygen processes. Other processes may be used by agreement between the purchaser and the manufacturer. If he so requests, the purchaser shall be informed of the steelmaking process used.

5.3 Deoxidation. All steels shall be fully killed except that grade 410 may be semi-killed.

Standards covering the use of tubes for pressure purposes place additional limitations on deoxidation practice for certain applications. For such applications the purchaser shall ensure that these limitations are stated in the enquiry and order.

6. Manufacture of the product

6.1 The tubes shall be manufactured from steel plate or sheet longitudinally welded continuously across the abutting edges by an automatic submerged arc welding process using at least one pass on the inside and at least one pass on the outside of the tube. The filler metal used shall be compatible with the parent metal (see BS 4165).

By agreement between the purchaser and the manufacturer the plate to be used may be ordered to special quality requirements.

The tubes may be hot finished or cold finished.

6.2 The manufacturer shall on request supply details of his welding procedure and, if necessary, a welding procedure approval certificate acceptable to the purchaser and the manufacturer. The manufacturer shall if required provide evidence that the welding machine operator is approved for the work on which he is to be employed (see BS 4870 : Part 1).

If the purchaser requires welding procedure approval for his particular order, this shall be agreed at the time of the enquiry and order.

6.3 The dimensional limitations generally applicable to this standard are as shown below; the thickness available are also dependent upon the diameter.

Outside diameter	Thickness
152 mm to 2220 mm	≤ 32 mm

7. Chemical composition

7.1 Ladle analysis. The steel shall show on ladle analysis the composition given in table 1 appropriate to the steel grade specified.

7.2 Product analysis. If a check analysis on the product is carried out, the permissible deviations given in table 2 apply

to the ladle analysis specified in table 1 for samples taken from the standard position. If a check analysis for acceptance purposes is required, this shall be stated in the enquiry and order and the number of samples shall be agreed between the purchaser and the manufacturer. The samples shall be taken either from the test pieces used for the verification of the mechanical properties or from 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 No. 19.

8. Heat treatment

8.1 Except as provided for in 8.2, the tubes shall be supplied in the heat treated condition as given in table 1.

8.2 By agreement between the purchaser and the manufacturer the tubes may be delivered in a condition other than the final heat treated condition given in table 1, in which case they shall be suitable for subsequent manipulation and the purchaser shall be informed of the heat treatment necessary to give the required properties (see also 9.1 and 14.1.2).

9. Mechanical properties and weldability

9.1 Mechanical properties. The mechanical properties at room temperature† to be obtained on test pieces selected, prepared and tested in accordance with clauses 14 and 15 are given in table 1. For the requirements for values at elevated temperatures see clause 21.

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 enquiry and order additional mechanical tests on samples that have been given heat treatments different from, or additional to, those given in table 1. In this case the heat treatment of the samples and the mechanical properties to be obtained from tests on them shall be agreed between the purchaser and the manufacturer at the time of enquiry and order.

9.2 Weldability. 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 requirements of the appropriate British Standards for welding, e.g. BS 2633.

10. Appearance and soundness

10.1 The tubes shall have a workmanlike finish and shall be clean and free from such defects as can be established by visual inspection and testing in accordance with the appropriate test category (see clause 13).

10.2 The misalignment of abutting edges for thicknesses up to 12.7 mm shall not exceed 1.6 mm and for thicknesses over 12.7 mm shall not exceed $0.125a\ddagger$ or 3.2 mm, whichever is the smaller.

10.3 Misalignment of the weld seam is acceptable provided that complete penetration and complete fusion have been achieved.

10.4 Any special requirements for freedom from defects shall be agreed between the purchaser and the manufacturer at the time of the enquiry and order.

*1 $\text{N/mm}^2 = 1 \text{ MPa}$.

† In cases of dispute, room temperature is taken as 20°C .

‡ a is the specified thickness of tube.

10.5 Defects in the tube outside the weld area and not encroaching upon the required minimum thickness may be removed by grinding provided that a smooth curved surface is maintained.

Repairs by arc welding of defects in the tube encroaching upon the required minimum thickness are permitted only with the approval of the purchaser.

Defects in the weld seam may be repaired by arc welding.

Repairs shall be made by completely removing defects by flame gouging, grinding, or chipping, cleaning the cavity and then welding. The cleaned cavity shall be inspected by magnetic crack detection. Repair welds shall be effected only by welders approved in accordance with BS 4871 : Part 1.

All tubes repaired by welding shall be hydraulically tested in accordance with 15.4 on completion of repairs and shall be non-destructively tested in accordance with the appropriate test category.

10.6 The tubes shall be reasonably straight. Any special requirements regarding straightness shall be agreed between the purchaser and the manufacturer.

10.7 The ends shall be cut nominally square with the axis of the tube within 3 mm.

11. Tolerances

11.1 Diameter and thickness. The tolerances on the diameter and thickness of the tubes, which apply only to plain end tubes, shall be as follows:

Outside diameter: The outside diameter of the body of the tube as calculated from measurements of the circumference shall not deviate from the specified diameter by more than $\pm 0.75\%$ or ± 6 mm, whichever is less.

Thickness (apart from weld reinforcement): $+10 - 5\%$

11.2 Weld reinforcement. The outside and inside weld reinforcements shall not exceed the following values:

Thickness	Maximum height of weld reinforcement
up to and including 12.7 mm	3 mm
over 12.7 mm	4.5 mm

11.3 End sizing. If required by the purchaser, the tolerance on the outside diameter within 100 mm of the ends of the tube as calculated from measurements of the circumference shall not exceed $+2.4, -0.8$ mm.

11.4 Length. Tubes are normally supplied in random lengths with a tolerance of $+300, -600$ mm. By agreement between the purchaser and the manufacturer, pipes may be supplied in 'cut lengths' to a tolerance of $+6 - 0$ 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 12.5 mm.

12. Inspection

The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on the production and testing of the tubes he has ordered.

Test pieces shall, if required, be marked by the authorized inspector before cutting off from the tubes and shall be tested in his presence to demonstrate compliance with the requirements of this standard.

13. Test categories

The tubes shall be subjected to the following tests for the appropriate test category.

Test category	
1	2
Visual inspection	Visual inspection
Tensile (material)	Tensile (material)
Tensile (weld)	Tensile (weld)
Bend (weld)	Bend (weld)
Hydraulic	Hydraulic
100 % non-destructive testing (weld)	Random non-destructive testing (weld)

NOTE. If required, an impact test at room temperature may be carried out for either of the test categories (see 14.1.5 and 15.3).

14. Number, selection and preparation of samples and test pieces

14.1 Mechanical tests at room temperature*

14.1.1 The number of tubes on which mechanical tests at room temperature are to be performed shall be as follows.

2 % of the tubes from each batch.

The samples shall be taken at random from batches containing not more than 100 tubes. 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 is treated as unity.

A batch shall consist only of tubes of the same diameter and thickness and of the same steel grade subjected to the same finishing treatment in a continuous furnace or heat treated in the same furnace charge in a batch type furnace.

NOTE. Cast separation is required for all tubes of both categories when acceptance tests for verification of the elevated temperature values are required.

14.1.2 Test samples shall be cut from the tube after final heat treatment. If the tubes are to be delivered in a condition different from the specified final heat treatment condition, the test samples shall be in the appropriate reference heat treatment condition given in table 1.

From the test samples from each tube selected for testing, one test piece shall be prepared for each of the mechanical tests specified in clause 13.

14.1.3 For the tensile test, the test piece may be taken longitudinally or transversely at the option of the manufacturer. The dimensions of the test piece shall comply with the appropriate requirements of BS 18 : Part 4.

For the tensile test on the material, the test piece shall be cut clear of the weld.

For the tensile test on the weld, the weld shall be at the centre of the test piece and at right angles to the longitudinal axis of the test piece. The weld may be dressed.

* In cases of dispute, room temperature is taken as 20°C .

14.1.4 For the weld bend test, one face and one root bend test piece 40 mm wide by 20 mm thick shall be cut from one end of each selected specimen with the weld at the centre of the test piece. Alternatively, for thicknesses 20 mm and over, two side bend test pieces for a side bend test in both directions shall be cut.

The weld shall be dressed flush with the surface of the test piece and the edges may be rounded to a radius of 1.6 mm.

14.1.5 If the dimensions of the tube permit the taking of a full size (10 mm x 10 mm) test piece, and if agreed between the purchaser and the manufacturer and stated at the time of enquiry and order, three Charpy V-notch impact test pieces shall be taken from one of the tubes selected.

The form and dimensions of the test pieces shall be in accordance with BS 131 : Part 2.

The test pieces shall be cut so that the longitudinal axes are transverse to the longitudinal axis of the tube. The notch shall be perpendicular to the original surface of the tube.

14.2 Visual inspection. All tubes shall be visually inspected (see clause 10).

14.3 Hydraulic test. A hydraulic test in accordance with 15.4 shall be carried out on each tube except that by agreement between the purchaser and the manufacturer the hydraulic test may be omitted for tubes of test category 1 that have been non-destructively tested for acceptance purposes. The test shall be carried out at the manufacturer's works unless it is agreed between the purchaser and the manufacturer that the test shall be carried out elsewhere.

14.4 Non-destructive testing. The tube welds shall be subjected to non-destructive testing as follows:

(a) *Test category 1.* A 100 % non-destructive examination of the tube weld shall be effected.

(b) *Test category 2.* One length of tube, selected at random from every ten lengths of tube of the same thickness, shall be non-destructively tested at the weld at not less than two positions, one of which shall be at the end of the tube. The selection of tubes to be non-destructively tested shall represent the proportionate production of the machine employed.

15. Test methods and test results

15.1 Tensile test. The tensile test shall be carried out in accordance with the requirements of BS 18 : Part 4.

The tensile strength R_m , the yield strength R_o and the elongation A shall be determined and the results obtained shall comply with the requirements given in table 1. For the yield strength either the upper yield stress R_{oH} or the 0.5 % proof stress (total elongation) $R_{t0.5}$ may be determined.

The percentage elongation shall be reported with reference to a gauge length of $L_o = 5.65 \sqrt{S_o}$ *. If other gauge lengths are used, the corresponding percentage elongation on $5.65 \sqrt{S_o}$ shall be obtained by reference to BS 3894 : Part 1. In case of dispute, a gauge length of $5.65 \sqrt{S_o}$ shall be used.

The tensile test across the weld shall show a tensile strength not less than the minimum tensile strength specified in table 1 for the particular grade of steel. The yield stress and the percentage elongation do not require measurement.

15.2 Bend test (weld). The test pieces shall be bent cold through an angle of 180° round a mandrel of the following diameter:

Steel grade	Diameter of mandrel
410	4a
460	6a

where a equals the specified thickness of tube.

The bend test shall be acceptable if no cracks or other defects exceeding 3 mm in length in any direction are present in the weld metal or between the weld and the tube metal after bending. Slight premature failure at the edges shall not be considered a cause for rejection.

15.3 Impact test at room temperature. The Charpy V-notch impact test shall be carried out in accordance with the requirements of BS 131 : Part 2.

The value to be obtained shall be agreed between the purchaser and the manufacturer.

The average value obtained shall meet the agreed requirements. One individual value may be below the agreed value provided that it is not less than 70 % of that value.

15.4 Hydraulic test. The hydraulic test pressure shall be the pressure calculated from the following formula, except that the maximum test pressure to be applied shall be 140 bar unless otherwise agreed between the purchaser and the manufacturer.

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

where

P is the test pressure (in bar);

D is the specified outside diameter (in mm);

a is the specified thickness (in mm);

S is a stress in N/mm^2 which shall be taken as 80 % of the specified minimum yield strength at room temperature.

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.

15.5 Non-destructive testing. Non-destructive testing for acceptance purposes shall be carried out on tubes tested to categories 1 and 2 by the methods detailed below.

15.5.1 Test category 1. The full length of the weld of the finished tube shall be inspected either by radiography or by an ultrasonic method. If an automatic ultrasonic method is used, the tubes shall also have the ends radiographed or ultrasonically tested by an agreed method for a distance sufficient to ensure complete inspection of the whole weld. The technique specified in BS 2600 : Part 1 or an agreed equivalent procedure shall be used for radiographic testing. The procedure given in appendix A shall be used for ultrasonic testing.

Details given in appendix B shall be used as the basis for radiographic acceptance levels.

* S_o is the original cross-sectional area of the gauge length.