

Austenitic stainless steel pipes and tubes for pressure purposes

Part 2. Specification for longitudinally welded tubes

Committees responsible for this British Standard

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- Associated Offices Technical Committee
- BEAMA Ltd.
- British Compressed Air Society
- British Forging Industry Association
- British Gas plc
- British Steel Industry
- Electricity Supply Industry in England and Wales
- Engineering Equipment and Materials Users' Association
- Lloyds Register of Shipping
- Power Generation Contractors' Association (BEAMA Ltd.)
- Process Plant Association
- Seamless Steel Tube 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 Welded Steel Tube Association
- Confederation of British Industry
- Energy Industries Council
- Stainless Steel Fabricators' Association of Great Britain

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a	1	11 to 24	original
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Foreword

This Part of BS 3605 has been prepared under the direction of the Iron and Steel Standards Policy Committee. It complements Part 1 of BS 3605 which specifies requirements for seamless austenitic stainless steel pipes and tubes. Together with Part 1, which is already published, it supersedes BS 3065 : 1973, which is now withdrawn.

This Part of BS 3605 is one of a series of standards specifying requirements for steel pipes and tubes for pressure purposes. Other standards in the series are as follows:

BS 3601	<i>Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes</i>
BS 3602	<i>Steel pipes and tubes for pressure purposes: carbon and carbon manganese steel with specified elevated temperature properties</i> <i>Part 1 Specification for seamless and electric resistance welded including induction welded tubes</i> <i>Part 2 Specification for longitudinally submerged arc welded tubes</i>
BS 3603	<i>Specification for carbon and alloy steel pipes and tubes with specified low temperature properties for pressure purposes</i>
BS 3604	<i>Steel pipes and tubes for pressure purposes: ferritic alloy steel with specified elevated temperature properties</i> <i>Part 1 Specification for seamless and electric resistance welded tubes</i>
BS 3605	<i>Specification for seamless and welded austenitic stainless steel pipes and tubes for pressure purposes</i> <i>Part 1 Specification for seamless tubes</i>

The steels covered by this Part of BS 3605 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.

The main technical differences in this edition of this Part of BS 3605 are as follows. Reference to spirally welded tubes has been deleted as there is no evidence of the manufacture of spirally welded tubes in the UK. The chemical composition of the steels in table 2 has been aligned with that in other standards in the series. Type 316 steel has been divided into two ranges of molybdenum content. Non-destructive testing requirements are based on BS 3889, with the specific requirements in the annexes of this standard, and include eddy current leak tightness testing as an alternative to hydraulic leak tightness testing.

The designations of steel tubes in this Part of BS 3605 and their nearest equivalent designations in BS 3605 : 1973 and ISO 2604 : Part V are given in annex A for information.

This Part of BS 3605 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).

The specified elevated temperature yield or proof strength values are those derived by the procedure described in BS 3920 : Part 1. Additionally, provision is made for the application of the related procedure for verifying that a product consistently meets specified levels of elevated temperature values.

It is recommended that the results of elevated temperature tests, together with information on the product thickness, the room temperature tensile properties and the chemical composition of the material, should be sent to the committee so that, for future revisions of this Part of BS 3605, minimum elevated temperature proof strength values can be derived from a continuously updated data bank. The address is Secretariat of ISM/73/-/1, British Standards Institution, 3 York Street, Manchester M2 2AT, UK.

The appropriate British Standards for the design and construction of boilers, pressure vessels, pipework, etc. should be consulted for requirements relating to the application and permissible design stress of the products made to this Part of BS 3605.

Assessed capability. Users of this Part of BS 3605 are advised to consider the desirability of quality system assessment and registration against the appropriate Part of BS 5750 by a third party certification body.

It is outside the scope of this Part of BS 3605 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 purposes of this Part of BS 3605, no difference is intended in meaning between 'pipe' and 'tube' though idiomatic use prefers sometimes the one and sometimes the other.

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

Specification

1 Scope

This Part of BS 3605 specifies the requirements for longitudinally welded austenitic stainless steel tubes suitable for general pressure and corrosion-resisting purposes.

This Part of BS 3605 also specifies room temperature properties and 1.0 % proof strength values at elevated temperatures.

In addition to the definitive requirements, this standard also requires the items detailed in 3.1 to be documented. It also requires options selected by the purchaser from those detailed in 3.2 to be documented. For compliance with this Part of BS 3605 both the definitive requirements and the documented items have to be satisfied.

This Part of BS 3605 provides for two categories of room temperature test procedure, designated test category 1 and test category 2 (see clause 12).

All the types of steel specified are suitable for low temperature service. In view of the good notch ductility characteristics of the steels at temperatures down to -196°C , it has not been considered necessary to include specified low temperature impact properties.

NOTE. Diameters and thicknesses appropriate to the tubes specified in this Part of BS 3605 should preferably be selected from table 2 of BS 3600 : 1976 and those for use with compression couplings from table 5 of BS 3600 : 1976. Tubes conforming to this Part of BS 3605 may also be supplied in accordance with the dimensions given in BS 1600 : Part 2.

2 References

2.1 Normative references

This Part of BS 3605 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on page 23. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 3605 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 3605 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page 24, but reference should be made to the latest editions.

3 Information and requirements to be agreed and to be documented

3.1 Information to be supplied by the purchaser

The following information to be supplied by the purchaser shall be fully documented. Both the definitive requirements specified throughout the

standard and the following documented items shall be satisfied throughout the standard and the following documented items shall be satisfied before a claim of compliance with this Part of BS 3605 can be made and verified:

- 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 4, e.g. BS 3605 : Part 2 LWHT 321S31 Cat. 2;
- a) the tube dimensions, e.g. outside diameter and thickness;
- b) the tube length, if exact (see 11.6);
- c) the quantity of tubes in metres or number of lengths.

3.2 Options

If the purchaser wishes to take up any of the optional requirements listed below, such requirements shall be specified and documented at the time of the enquiry and order. In the absence of such information, the manufacturer shall select the options where appropriate:

- a) whether a product analysis is required (see 7.2 and 16g);
- b) whether the upper limit above which the dressing of surface imperfections is required will be 1.5 mm (see 10.8);
- c) whether the tube tolerances are required to suit compression couplings (see 11.3);
- d) whether lengths other than random lengths are required (see 11.6);
- e) whether the method of leak tightness test to be carried out on test category 2 tubes up to and including 180 mm outside diameter is the hydraulic test or the eddy current test (see 13.5 and 16h);
- f) whether the hydraulic test, if specified, is to be carried out at a pressure in excess of 140 bar¹⁾ and the pressure required (see 14.3 and 16h);
- g) whether additional non-destructive testing is required (see 14.6);
- h) whether verification of elevated temperature proof strength values is required (see 14.7);
- i) whether verification of elevated temperature proof stress values by acceptance testing is required and the temperature selected from table 4 at which this is to be carried out (see 14.7.2);
- j) whether intergranular corrosion tests are required (see 14.8);
- k) whether marking in accordance with BS 5383 : 1986 is required. (see 18.4).

¹⁾ 1 bar = 10^5 N/m^2 = 100 kPa.

4 Designation

The tubes shall be designated by the number and Part of this British Standard, i.e. BS 3605 : Part 2, and from table 1, by one of the references which indicates the method of manufacture (see clause 5), the appropriate type of steel (see table 2), and the test category (see clause 12).

Table 1. Method of manufacture of tubes and reference	
Method of manufacture	Reference
As-welded	LW
Welded and heat treated	LWHT
Welded, cold finished and heat treated	LWCF

Tubes intended for compression couplings shall have the letters CC added to the end of the designation.

As an example BS 3605 : Part 2 : LW 304S11 : Cat.1 designates a longitudinally welded tube supplied in the as-welded condition made from steel 304S11 tested to test category 1.

NOTE. The designations for tubes in this Part of BS 3605 and their nearest equivalent steel numbers in ISO 2604 : Part V are listed in annex A.

5 Manufacture of the steel

The steel shall be produced by an electric process.

6 Manufacture of the product

The tube shall be manufactured from hot or cold rolled flat strip in the solution treated condition, longitudinally welded across the abutting edges by a continuous automatic process with, or without, the addition of filler metal. If filler wire is used it shall conform to BS 2901 : Part 2 : 1990 and the appropriate requirements of table 2.

The finished tubes shall not include welds used for joining lengths of the flat rolled strip prior to welding.

Electric resistance welding shall not be used.

An ultrasonic or other suitable non-destructive testing method shall be used for continuous examination of the weld area (see note 2).

Cold finished tube (LWCF), subsequent to welding and prior to heat treatment, shall be cold worked for a minimum reduction in thickness of 25 %.

NOTE 1. The range of dimensions and tolerances in which tubes are available is dependent upon the method of manufacture. The thicknesses are also dependent upon the diameter. Tolerances are given in clause 11.

NOTE 2. Ultrasonic or other suitable non-destructive testing is made for the purpose of quality control by a method and at a place chosen by the manufacturer.

NOTE 3. By agreement between the purchaser and the manufacturer, prior to heat treatment the tube may be bead conditioned by a process which reduces the height of the weld bead. Such tube may be supplied as-welded (LW), or welded and heat treated (LWHT) (see 11.5.2).

7 Chemical analysis

7.1 Ladle analysis

The chemical composition of the steel, on ladle analysis, shall be as given in table 2 appropriate to the type of steel specified.

7.2 Product analysis

If a product analysis for acceptance purposes is required by the purchaser this shall be stated in the enquiry or order (see 3.2a).

When an analysis on the product is carried out the permitted deviations given in table 3 shall apply to the specified chemical composition 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 tube at the same location as for the mechanical test samples.

In case of dispute the methods for chemical analysis shall be in accordance with British Standard Handbook 19 : 1970 or BS EN 24937 : 1991 or the following subsections of BS 6200 : Part 3 as appropriate.

- Subsection 3.8.2 : 1991
- Subsection 3.8.3 : 1990
- Subsection 3.10.2 : 1989
- Subsection 3.18.2 : 1985
- Subsection 3.18.4 : 1991
- Subsection 3.19.1 : 1985
- Subsection 3.20.1 : 1989
- Subsection 3.20.3 : 1985
- Subsection 3.21.1 : 1986
- Subsection 3.22.3 : 1986
- Subsection 3.24.1 : 1985
- Subsection 3.26.3 : 1987
- Subsection 3.26.4 : 1989
- Subsection 3.28.1 : 1985
- Subsection 3.28.2 : 1990
- Subsection 3.32.1 : 1991

7.3 Additional elements

Elements not listed in table 2 shall not be intentionally added to the steel except for the purposes of deoxidation, inclusion modification and hot workability. The content of such elements shall be reported.

Table 2. Chemical composition, mechanical properties at room temperature, and heat treatment

Table 2. Chemical composition, mechanical properties at room temperature, and heat treatment																					
Steel type	Chemical composition (ladle analysis)(see note 1)										R_m (see note 2) N/mm ²		$R_e/R_p 1.0$ (see notes 2 and 3) N/mm ²	A min. on 5.65/ S_0 (see notes 2 and 3) %	Solution treatment temperature ° C		Treatment time for intergranular corrosion test (see note 4) min.				
	C %	Si %	Mn %	P %	S %	Cr %	Mo %		Ni %	Others %					min.	max.					
							min.	max.		min.	max.	min.	max.								
304S11	0.030	1.00	2.00	0.04	0.03	17.00	19.00	—	—	9.00	12.00	—	—	480	680	215	35	1000	1100	30	—
304S31	0.070	1.00	2.00	0.04	0.03	17.00	19.00	—	—	8.00	11.00	—	—	490	690	230	35	1000	1100	30	(see note 5)
316S11	0.030	1.00	2.00	0.04	0.03	16.50	18.50	2.00	2.50	11.00	14.00	—	—	490	690	225	35	1000	1100	30	—
316S13	0.030	1.00	2.00	0.04	0.03	16.50	18.50	2.50	3.00	11.50	14.50	—	—	490	690	225	35	1000	1100	30	—
316S31	0.070	1.00	2.00	0.04	0.03	16.50	18.50	2.00	2.50	10.50	13.50	—	—	510	710	240	35	1000	1100	30	(see note 5)
316S33	0.070	1.00	2.00	0.04	0.03	16.50	18.50	2.50	3.00	11.00	14.00	—	—	510	710	240	35	1000	1100	30	(see note 5)
321S31	0.080	1.00	2.00	0.04	0.03	17.00	19.00	—	—	9.00	12.00	Ti-5×C		510	710	235	35	1000	1100	30	—
347S31	0.080	1.00	2.00	0.04	0.03	17.00	19.00	—	—	9.00	12.00	Nb-10×C		510	710	240	35	1000	1100	30	—

NOTE 1. For permissible variations in product analysis (see table 3).

NOTE 2.

 R_m is the tensile strength; $R_{p1.0}$ is the yield strength; $R_{p1.0}$ is the 1.0 % proof strength; (non-proportional elongation);A is the percentage elongation after fracture on a gauge length of $L_0 = 5.65\sqrt{S_0}$ (where S_0 is the original cross-sectional area of the gauge length).

NOTE 3. Values listed are for test pieces taken in the longitudinal direction. Transverse values are reduced by 5 %.

NOTE 4. Heat treatment time if an intergranular test is required (for procedure see 14.8).

NOTE 5. For this steel the intergranular corrosion test is applicable (for procedure see 14.8) but the intergranular corrosion test piece heat treatment is not applied.

Table 3. Permitted deviations of the product analysis from the specified chemical composition			
Element	Range in which the specified maximum for the chemical composition falls %	Permitted deviations from specified limits ¹⁾ %	
		Greater than maximum	Less than minimum
Carbon	Up to and including 0.030	0.005	—
	Over 0.030, up to and including 0.080	0.01	—
Silicon	Up to and including 1.00	0.05	—
Manganese	Up to and including 2.00	0.05	—
Phosphorus	Up to and including 0.040	0.004	—
Sulfur	Up to and including 0.030	0.003	—
Chromium	Over 15.00	0.20	0.20
Molybdenum	Over 2.00, up to and including 3.00	0.08	0.08
Nickel	Over 8.00, up to and including 10.00	0.10	0.10
	Over 10.00	0.15	0.15
Titanium ²⁾	All ranges	0.05	0.05
Niobium ³⁾	All ranges	0.05	0.05

¹⁾ 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.

²⁾ On product analysis shall be not less than $4 \times \% \text{ carbon}$.

³⁾ On product analysis shall be not less than $8 \times \% \text{ carbon}$.

8 Final supply condition

8.1 Tubes shall be supplied in either the as-welded condition or the solution treated condition.

8.2 Solution treatment shall consist of heating the tubes uniformly to the solution treatment temperature and cooling rapidly. The solution treatment temperature shall be from within the range in table 2 and shall refer to the metal temperature (see note 1).

NOTE 1. The supplier should demonstrate, if required by the purchaser, that the appropriate heat treatment cycle has been achieved.

NOTE 2. The purchaser may require a passivation treatment to be applied if the tubes have been subjected to descaling or grinding.

9 Mechanical properties

9.1 Mechanical properties at room temperature

The mechanical properties at room temperature to be obtained on test pieces selected, prepared and tested in accordance with clauses 13 and 14 shall be as specified in table 2.

NOTE 1. In cases of dispute, room temperature is to be taken as $20^\circ\text{C} \pm 5^\circ\text{C}$.

NOTE 2. Heat treatment carried out after delivery of the pipe may have an adverse effect on the mechanical properties. The purchaser may therefore request, at the time of enquiry and order, additional mechanical tests on samples that have been given heat treatment different from or additional to those specified in clause 8. 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.

9.2 Elevated temperature 1 % proof strength values

The elevated temperature minimum 1.0 % proof strength values shall be as specified in table 4 when sampled as described in 13.7 and tested or verified as described in 14.7.

NOTE 1. The values are not normally subject to verification unless requested by the purchaser (see 14.7).

NOTE 2. Minimum 0.2 % proof strength values at elevated temperatures are given in annex E for comparison purposes.

9.3 Flattening test properties

9.3.1 When tested in accordance with 14.2.2, the test ring shall withstand being flattened without showing any cracks or flaws in the metal except as specified in 9.3.2 until the distance between the platens, H , is equal to or less than the value calculated using the constant specified.

9.3.2 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 conformity to this Part of BS 3605.

9.4 Weld bend test properties

Test pieces selected in accordance with 13.2.6 and 14.2 shall not show any crack or flaw exceeding 3 mm in length in any direction as measured on the surface of the test piece, in the weld metal, fusion line, heat affected zone or parent metal.

Table 4. Minimum 1.0 % proof strength ($R_{p1.0}$) values at elevated temperatures								
Steel type	Minimum 1.0 % proof strength (in N/mm ²) at a temperature (in °C) of:							
	100	150	200	250	300	350	400	450
304S11	168	150	137	128	122	116	110	108
304S31	178	160	147	139	132	125	120	117
316S11	177	161	149	139	133	127	123	119
316S13								
316S31	189	172	159	150	143	137	133	129
316S33								
321S31	192	180	172	164	158	152	148	144
347S31	204	192	182	172	166	162	159	157

10 Visual inspection and appearance

10.1 The tubes shall be clean and free from such defects as can be established by visual inspection in accordance with this Part of BS 3605. (See 13.4)

10.2 Visual inspection shall be carried out on the internal and external surfaces. In the case of the internal surface, the tube shall be viewed from each end.

NOTE 1. Visual inspection should be carried out in suitable lighting, i.e. an illuminance of 500 lux or greater.

NOTE 2. It is recognized that the ability to examine visually the inner surface from the tube ends is limited in the case of small diameter tubes.

10.3 The tubes shall have a finish and surface condition which permits surface imperfections or marks requiring dressing to be identified.

NOTE. Any special needs for surface condition should be agreed between the purchaser and manufacturer at the time of enquiry and order.

10.4 It shall be permissible 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 Part of BS 3605.

10.5 Surface imperfections which encroach on the minimum wall thickness shall be considered defects and shall be deemed not to conform to the requirements of this Part of BS 3605.

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

10.7 A sufficient number of surface marks and imperfections identified during visual inspection shall be subjected to grinding to verify conformity with 10.8.

10.8 Subject to the limitations given in 10.4, surface imperfections found by exploration in accordance with 10.7 to be deeper than 5 % of the nominal wall thickness, but not less than 0.5 mm, shall be dressed. The purchaser has the option to specify an upper limit of 1.5 mm, above which dressing of surface imperfections shall be carried out (see 3.2b).

10.9 If surface imperfections acceptable under 10.8 are not scattered and appear over a large area in excess of what is considered to be an acceptable surface condition, tubes shall be rejected, or alternatively subjected to dressing as agreed at the time of enquiry and order.

10.10 The tubes shall not deviate from straightness by more than 1 in 600 over the full length.

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

11 Tolerances

11.1 General

The maximum tolerances on the dimensions of the tubes shall be as specified in 11.2, 11.3, 11.4 and 11.5. The tolerances on outside diameter shall include ovality, and those on thickness shall include eccentricity.

11.2 Outside diameter

The outside diameter tolerance on as-welded, welded and heat treated and longitudinally welded cold finished and heat treated tubes (LW, LWHT and LWCF) shall be as follows.

Up to and including 168.3 mm	± 0.5 % with a minimum of ± 0.15 mm
Over 168.3 mm	± 1 %

11.3 Tubes specified for use with compression couplings

If specified by the purchaser at the time of enquiry and order (see 3.2c) tubes shall be supplied to the following outside diameter tolerances suitable for use with compression couplings.

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 54 mm	± 0.20 mm

11.4 Thickness

The tolerance on thickness excluding the weld shall be $\pm 7.5\%$.

11.5 Weld geometry

11.5.1 The height of the internal weld bead shall be not greater than 15 % of the specified thickness.

11.5.2 For bead conditioned LW or LWHT tube, the external and internal weld bead height shall not exceed 0.1 mm (see note 3 to clause 6).

11.5.3 Misalignment between the abutting edges of tubes shall not exceed 10 % of the specified thickness.

11.6 Length

Unless otherwise specified by the purchaser (see 3.2d), tubes shall be supplied in random lengths.

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

Where the length is specified as 'exact length' or 'cut length' the following tolerances on length shall apply.

Lengths up to and including 6 m $+ \begin{smallmatrix} 3 \\ 0 \end{smallmatrix}$ mm

Lengths over 6 m $+ \begin{smallmatrix} 6 \\ 0 \end{smallmatrix}$ mm

12 Tests

The tubes shall be subjected to the tests specified in table 5 appropriate to the test category.

The elevated temperature properties (see 9.2) shall apply to tubes of both test category 1 and test category 2.

The intergranular corrosion test, when required by the purchaser (see 3.2 j) shall be carried out in accordance with 14.8.

Table 5. Tests for test category 1 and test category 2

Test category 1	Test category 2
Visual inspection (see clause 10 and 13.4)	Visual inspection (see clause 10 and 13.4)
Tensile test (see 9.1, 13.2 and 14.1)	Tensile test (see 9.1, 13.2 and 14.1)
Flattening test or bend test (see 9.1, 13.2 and 14.2)	Flattening test or bend test (see 9.1, 13.2 and 14.2)
Macroscopic examination (see 13.3)	Macroscopic examination (see 13.3)
Ultrasonic test (see 13.6 and 14.5)	Leak tightness test (see 13.5 and 14.3 or 14.4)

13 Number, selection and preparation of samples and test pieces

13.1 General

A batch shall consist only of tubes of the same diameter and thickness, manufactured from the same cast, subjected to the same finishing treatment in a continuous furnace or heat treated in the same furnace charge in a batch-type furnace. If the number of tubes to be tested, as determined by 13.2, includes a fraction, it shall be rounded up to the next whole number.

13.2 Mechanical tests at room temperature

NOTE. In cases of dispute room temperature is to be taken as $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

13.2.1 For test category 1 the number of tubes on which mechanical tests at room temperature are to be performed shall be 2 % of the tubes from each batch.

13.2.2 For test category 2 the number of tubes on which mechanical tests at room temperature are to be performed shall be as follows:

- up to and including 323.9 mm outside diameter: 0.5 % of the tubes from each batch;
- Over 323.9 mm outside diameter: 1.0 % of the tubes for each batch.

13.2.3 Test samples shall be cut from the tube in the final supply condition. If the tubes are to be delivered in a condition different from the specified final heat treatment condition, the test sample shall be in the appropriate reference heat treatment condition given in 8.1.

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 12.

13.2.4 For the tensile test (see 14.1), the dimensions of the test piece shall conform to the appropriate requirements of BS EN 10002-1 : 1990.

The strip test piece shall not include the weld.

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

13.2.5 For the flattening test (see 14.2.2), a ring not less than 40 mm in length shall be taken from one end of each selected tube.

13.2.6 For the weld bend test (see 14.2.3), the test piece shall be a segment cut from a ring not less than 12.5 mm wide taken from one end of each selected tube with the centre of the weld, at the centre of the test piece.

NOTE. The edges of the test pieces may be rounded to a radius of 1.5 mm.

13.3 Macroscopic examination

13.3.1 A sample for the flattening or weld bend test shall be macroscopically examined before testing. The edge of the sample for a distance of at least 25 mm each side of the weld, or the complete section, shall be ground to at least a 600 grit finish and etched in a suitable reagent to reveal the weld structure.

13.3.2 When examined at a magnification of $\times 10$, the weld shall be free from defects such as cracks, porosity and undercutting, and shall exhibit complete fusion with the parent metal through the full thickness of the tube.

13.4 Visual inspection

Every tube shall be inspected visually (see clause 10).

13.5 Leak tightness

All test category 2 tubes shall be subjected to a leak tightness test. This shall be by a hydraulic test in accordance with 14.3 for all tube sizes above 180 mm outside diameter. For sizes 180 mm outside diameter and below, this shall be by either a hydraulic test in accordance with 14.3 or by an eddy current test in accordance with 14.4, as decided by the manufacturer unless otherwise specified by the purchaser (see 3.2e).

NOTE 1. The hydraulic leak tightness 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 14.3 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.

NOTE 2. Both the hydraulic test and the eddy current test may leave a short length at each end of the tube incompletely tested. If specified at the time of the enquiry and order the length affected should be determined by the manufacturer and reported to the purchaser. Further, if specified 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.

13.6 Ultrasonic testing

All test category 1 tubes shall be ultrasonically tested (see 14.5).

NOTE. Automatic ultrasonic testing may leave a short length at each end of the tube incompletely tested.

Untested lengths shall be either cut off or tested by an alternative procedure agreed between the manufacturer and the purchaser.

13.7 Elevated temperature proof strength testing

If elevated temperature acceptance testing is carried out (see 14.7), one test shall be made on each cast using a test piece taken at a position adjacent to the test pieces used for the tensile test at room temperature. If tubes of more than one thickness are to be supplied from one cast, the test piece shall be taken from a tube with the nominally thickest dimension.

13.8 Intergranular corrosion test

The intergranular corrosion test (see 14.8) shall be carried out when specified by the purchaser. The number of pieces on which the test shall be carried out shall be 1 % of the number of tubes in each batch.

14 Test methods

14.1 Tensile test

The tensile test shall be carried out in accordance with BS EN 10002-1 : 1990.

The tensile strength R_m , the 1.0 % proof strength (non-proportional elongation) $R_{p1.0}$ and the percentage elongation A shall be determined.

For the purposes of this Part of BS 3605, $R_{t1.0}$ may be determined instead of $R_{p1.0}$ for acceptance testing, but in cases of dispute $R_{p1.0}$ shall be determined.

The percentage elongation shall be reported with reference to a gauge length of $L_0 = 5.65\sqrt{S_0}$, where S_0 is the original cross-sectional area. If other gauge lengths are used, the corresponding percentage elongation on $5.65\sqrt{S_0}$ shall be obtained by reference to BS 3894 : Part 2 : 1985. In cases of dispute, a gauge length of $5.65\sqrt{S_0}$ shall be used.

14.2 Flattening or weld bend test

14.2.1 General

At the option of the manufacturer, and dependent upon the dimensions of the tube and method of manufacture, either a flattening test (see 14.2.2) or a weld bend test (see 14.2.3) shall be carried out.

14.2.2 Flattening test

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

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

where

- a is the specified thickness (in mm);
- D is the specified diameter, (in mm);
- C is the flattening test constant = 0.09.

The centre of the weld, when visible, shall be placed at the line of maximum bending.

NOTE. In cases of dispute room temperature is taken as $20^\circ\text{C} \pm 5^\circ\text{C}$.

14.2.3 Weld bend test

The test piece shall be bent at room temperature with the root of the weld in tension through an angle of 180° around a bar of diameter $3a$ with a minimum of 6 mm, where a is the specified thickness, in millimetres.

14.3 Hydraulic test

For test category 2 tubes which are hydraulically tested for verification of leak tightness (see 13.5), the test pressure P (in bar) shall be calculated from the equation:

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

where

- D is the specified outside diameter (in mm);
- a is the specified thickness, (in mm);
- S is the stress (in N/mm²)²⁾ which shall be taken as 70 % of the specified minimum 1.0 % proof strength at room temperature.

The test shall be carried out at the pressure P or at 140 bar ³⁾ whichever is lower but when 140 bar is lower than P , the purchaser has the option (see 3.2f) to specify that the test shall be carried out at a pressure higher than 140 bar but not greater than the value P determined from the equation above.

The test pressure shall be maintained sufficiently long for any leakage to be observed. Any tube failing to withstand the hydraulic pressure test shall be deemed not to conform to this Part of BS 3605.

14.4 Eddy current testing

For test category 2 tubes which are eddy current tested for verification of leak tightness (see 13.5), the eddy current test and the assessment of the results shall be carried out in accordance with annex C.

14.5 Ultrasonic testing

All test category 1 tubes shall be subjected to ultrasonic testing in accordance with annex D.

14.6 Additional non-destructive testing

The purchaser has the option to specify additional non-destructive tests, e.g. those required for the detection of transverse and laminar defects. The additional methods of test and the basis of acceptance shall be stated on the enquiry and order (see 3.2g).

14.7 Elevated temperature proof strength tests or verification procedure

14.7.1 If the purchaser requires verification of elevated temperature proof strength values, this shall be carried out in accordance with 14.7.2 or 14.7.3 (see 3.2h). The method of verification shall be at the option of the manufacturer unless the purchaser specifies verification in accordance with 14.7.2.

14.7.2 When the purchaser requires verification of elevated temperature proof strength values by testing, the tests shall be carried out in accordance with BS 3688 : Part 1 : 1963 at a temperature selected by the purchaser from table 4 and specified at the time of the enquiry and order (see 3.2i).

NOTE. The specified strain rate in BS 3688 : Part 1 is 0.001/min. to 0.003/min.

14.7.3 For verification of elevated temperature proof strength values without testing, the values shall be verified by the procedure given in BS 3920 : Part 1 : 1973 (see annex B).

14.8 Intergranular corrosion test

If the purchaser requires intergranular corrosion tests this shall be stated in the enquiry and order (see 3.2j). The tests shall be carried out and evaluated in accordance with BS 5903 : 1980.

The sensitizing treatment shall consist of heating the specimens to 650 °C for the length of time specified in table 2, followed by air cooling.

15 Retests

Should a tube selected for testing fail in any of the tests specified in 14.1, 14.2, 14.7 or 14.8, the tube and the batch of tubes that it represents shall be deemed not to conform to this Part of BS 3605 unless:

- a) two further tests of the kind that produced failure are made from the same tube, and both these further tests prove satisfactory; or
- b) the first tube tested is rejected and all the tests specified in 14.1, 14.2, 14.7 and 14.8 are carried out on two further tubes from the batch and all these tests are satisfactory; or
- c) if either of the further tests required by a) or b) proves unsatisfactory, the tubes represented are suitably heat treated or reheat treated and samples are selected and tested in accordance with all the tests specified in 14.1, 14.2, 14.7 and 14.8 and all these tests are satisfactory.

16 Test certificate

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

- a) the designation (see clause 4);
- b) the ladle analysis for elements specified in table 2 for each of the casts used;
- c) the mechanical test results for each of the batches tested;
- d) the purchaser's order number or other appropriate mark (see 18.2d);

²⁾ 1 N/mm² = 1 MPa.

³⁾ 10 bar = 1 MPa.

The test certificate shall also give the following information where appropriate for options selected by the purchaser (see 3.2):

- e) for solution treated tubes, the heat treatment time, temperature, and the cooling medium (see clause 8);
- f) the content of additional elements (see 7.3);
- g) the product analysis (see 7.2);
- h) for test category 2 tubes, the method of verification of leak tightness, either by eddy current or hydraulic test and, in the latter case, the pressure applied (see 13.5);
- i) the elevated temperature test results (see 14.7.2 or statement of verification of values (see 14.7.3);
- j) the results of additional non-destructive testing (see 14.6).

17 Protective coating

The tubes shall be supplied uncoated.

NOTE 1. If the purchaser requires measures to protect the tubes during delivery or storage then this should be the subject of agreement between purchaser and manufacturer.

NOTE 2. If carbon steel strapping is used to bundle the tubes, then the strapping and/or tubes should be protected such that the carbon steel strapping does not come into contact with the surface of the stainless steel tubes.

18 Marking

18.1 Before dispatch from the manufacturer's works, the tubes shall be marked in accordance with 18.2 or, if specified by the purchaser in the enquiry and order (see 3.2k), in accordance with 18.4).

18.2 Except as provided for as follows for tubes that are bundled, each tube shall be legibly marked at intervals along the length, 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 as given in clause 4, e.g. BS 3605 : Part 2, LW304S11 Cat.1⁴⁾;
- c) the cast number;
- d) the purchaser's order number or other appropriate mark to identify it with the test certificate.

For small diameter tubes that are bundled, the information given in a), b), c) and d) 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 type shall be included in any one bundle.

Tubes shall not be marked by hard stamping except on the end face.

18.3 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 any of the following metals: lead, tin, copper, zinc.

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

18.4 If specified by the purchaser in the enquiry and order (see 3.2k), each tube shall be marked in accordance with BS 5383 : 1986.

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

⁴⁾ Marking BS 3605 : Part 2 : 1992 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

Annexes

Annex A (informative)

Designations of steel tubes in BS 3605 : Part 2 : 1992 and the nearest equivalent designations in BS 3605 : 1973 and the nearest equivalent designations in ISO 2604 : Part V

Table A.1 lists the designations for tubes in this edition of BS 3605 : Part 2 and the nearest equivalent designations in BS 3605 : 1973 and the nearest equivalent designations in ISO 2604 : Part V.

Table A.1. Designations of steel tubes in BS 3605 : Part 2 : 1992 and the nearest equivalent designations in BS 3605 : 1973 and the nearest equivalent designations in ISO 2604 : Part V			
BS 3605 : Part 2 : 1992	Colour code in accordance with BS 5383	BS 3605 : 1973	ISO 2604 : Part V
LW 304S11 CAT 1 LWHT 304S11 CAT 1 LWCF 304S11 CAT 1 LW 304S11 CAT 2 LWHT 304S11 CAT 2 LWCF 304S11 CAT 2	red	LW 304S22 CAT 1 LWHT 304S22 CAT 1 LWCF 304S22 CAT 1 LW 304S22 CAT 2 LWHT 304S22 CAT 2 LWCF 304S22 CAT 2	TW46-LW-CAT IV TW46-LWHT-CAT IV TW46-LWCF-CAT IV TW46-LW-CAT II TW46-LWHT-CAT II TW46-LWCF-CAT II
LW 304S31 CAT 1 LWHT 304S31 CAT 1 LWCF 304S31 CAT 1 LW 304S31 CAT 2 LWHT 304S31 CAT 2 LWCF 304S31 CAT 2		LW 304S25 CAT 1 LWHT 304S25 CAT 1 LWCF 304S25 CAT 1 LW 304S25 CAT 2 LWHT 304S25 CAT 2 LWCF 304S25 CAT 2	TW47-LW-CAT IV TW47-LWHT-CAT IV TW47-LWCF-CAT IV TW47-LW-CAT II TW47-LWHT-CAT II TW47-LWCF-CAT II
LW 316S11 CAT 1 LWHT 316S11 CAT 1 LWCF 316S11 CAT 1 LW 316S11 CAT 2 LWHT 316S11 CAT 2 LWCF 316S11 CAT 2 LW 316S13 CAT 1 LWHT 316S13 CAT 1 LWCF 316S13 CAT 1 LW 316S13 CAT 2 LWHT 316S13 CAT 2 LWCF 316S13 CAT 2		LW 316S22 CAT 1 LWHT 316S22 CAT 1 LWCF 316S22 CAT 1 LW 316S22 CAT 2 LWHT 316S22 CAT 2 LWCF 316S22 CAT 2 — — — — — —	TW57-LW-CAT IV TW57-LWHT-CAT IV TW57-LWCF-CAT IV TW57-LW-CAT II TW57-LWHT-CAT II TW57-LWCF-CAT II TW58-LW-CAT IV TW58-LWHT-CAT IV TW58-LWCF-CAT IV TW58-LW-CAT II TW58-LWHT-CAT II TW58-LWCF-CAT II
LW 316S31 CAT 1 LWHT 316S31 CAT 1 LWCF 316S31 CAT 1 LW 316S31 CAT 2 LWHT 316S31 CAT 2 LWCF 316S31 CAT 2 LW 316S33 CAT 1 LWHT 316S33 CAT 1 LWCF 316S33 CAT 1 LW 316S33 CAT 2 LWHT 316S33 CAT 2 LWCF 316S33 CAT 2		LW 316S26 CAT 1 LWHT 316S26 CAT 1 LWCF 316S26 CAT 1 LW 316S26 CAT 2 LWHT 316S26 CAT 2 LWCF 316S26 CAT 2 — — — — — —	TW60-LW-CAT IV TW60-LWHT-CAT IV TW60-LWCF-CAT IV TW60-LW-CAT II TW60-LWHT-CAT II TW60-LWCF-CAT II TW61-LW-CAT IV TW61-LWHT-CAT IV TW61-LWCF-CAT IV TW61-LW-CAT II TW61-LWHT-CAT II TW61-LWCF-CAT II
LW 321S31 CAT 1 LWHT 321S31 CAT 1 LWCF 321S31 CAT 1 LW 321S31 CAT 2 LWHT 321S31 CAT 2 LWCF 321S31 CAT 2 LW 347S31 CAT 1 LWHT 347S31 CAT 1 LWCF 347S31 CAT 1 LW 347S31 CAT 2 LWHT 347S31 CAT 2 LWCF 347S31 CAT 2		LW 321S22 CAT 1 LWHT 321S22 CAT 1 LWCF 321S22 CAT 1 LW 321S22 CAT 2 LWHT 321S22 CAT 2 LWCF 321S22 CAT 2 LW 347S17 CAT 1 LWHT 347S17 CAT 1 LWCF 347S17 CAT 1 LW 347S17 CAT 2 LWHT 347S17 CAT 2 LWCF 347S17 CAT 2	TW53-LW-CAT IV TW53-LWHT-CAT IV TW53-LWCF-CAT IV TW53-LW-CAT II TW53-LWHT-CAT II TW53-LWCF-CAT II TW50-LW-CAT IV TW50-LWHT-CAT IV TW50-LWCF-CAT IV TW50-LW-CAT II TW50-LWHT-CAT II TW50-LWCF-CAT II

Annex B (normative)**Procedure for the verification of elevated temperature values**

As an alternative to verification of individual casts by testing at elevated temperatures, the manufacturer, unless otherwise specified by the purchaser, may verify that his product consistently meets the minimum elevated temperature proof strength values given in the specification for the relevant types of steel by adopting the procedure described in BS 3920 : Part 1 : 1973.

The basis of the procedure is that the manufacturer compares appropriate data relating to his product with the confidence lines that have been determined from the analysis of a large body of data that has been used to derive the specification minima given in this Part of BS 3605.

An example of confidence lines for steel type 347S31 is shown in figure B.1. To achieve the appropriate degree of accuracy, however, it is necessary to construct the confidence lines on a larger scale. To enable this to be done the coordinates of two suitably spaced points on the lines, appropriate to the various grades of steel at each temperature, are given in tables B.1 to B.4.

Table B.1. Parameters for lower confidence lines: steel types 304S11 and 304S31

Temperature °C	1.0 % proof strength at levels of room temperature 1.0 % proof strength	
	220 N/mm ²	350 N/mm ²
100	158	248
150	139	228
200	126	217
250	118	207
300	112	199
350	106	190
400	101	184
450	99	180

Table B.2. Parameters for lower confidence lines: steel type 321S31

Temperature °C	1.0 % proof strength at two levels of room temperature 1.0 % proof strength	
	200 N/mm ²	350 N/mm ²
100	140	281
150	130	265
200	123	256
250	116	247
300	110	240
350	105	233
400	103	227
450	99	220

Table B.3. Parameters for lower confidence lines: steel types 316S11, 316S13, 316S31 and 316S33

Temperature °C	1.0 % proof strength at two levels of room temperature 1.0 % proof strength	
	220 N/mm ²	350 N/mm ²
100	157	263
150	143	241
200	131	224
250	121	215
300	115	207
350	110	200
400	105	194
450	102	190

Table B.4. Parameters for lower confidence lines: steel type 347S31

Temperature °C	1.0 % proof strength at two levels of room temperature 1.0 % proof strength	
	250 N/mm ²	350 N/mm ²
100	196	285
150	184	271
200	172	263
250	164	254
300	158	248
350	153	242
400	150	238
450	149	232

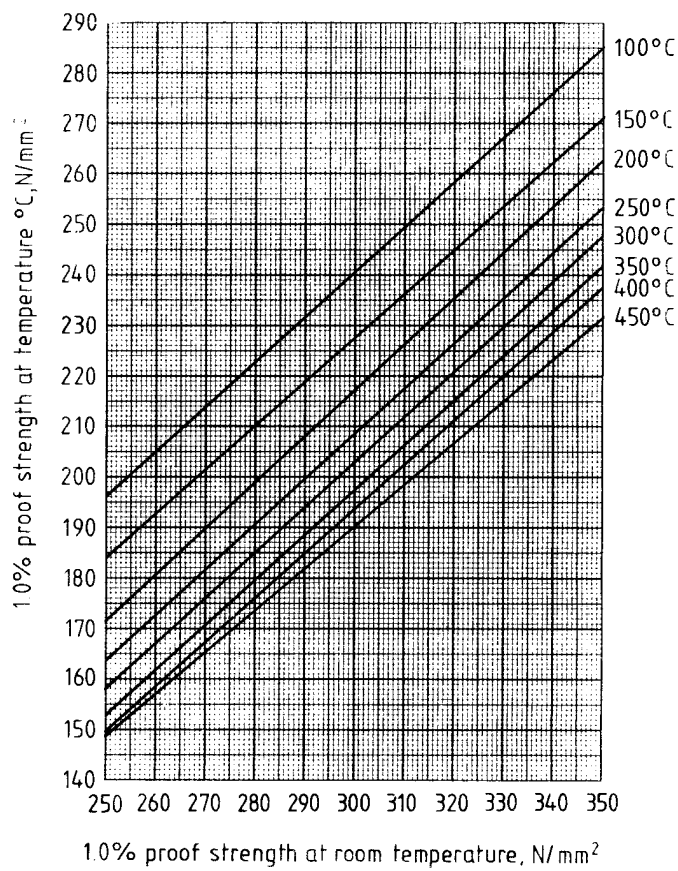


Figure B.1. Example of lower confidence lines for steel type 347S31

Annex C (normative)

Eddy current testing of tubes for verification of leak tightness

C.1 General

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 : Part 2A : 1986, with the options of BS 3889 : Part 2A : 1986 as specified in C.2 and C.3 of this annex and with the modification to BS 3889 : Part 2A as specified in C.4 of this annex.

C.2 Test procedure

The tubes shall be tested for verification of leak tightness using a concentric coil or a rotating tube/rotating coil eddy current technique as described for methods A and B of BS 3889 : Part 2A : 1986.

C.3 Reference standards

The equipment shall be calibrated using reference standards prepared in accordance with item a) of 5.2.4 for method A of BS 3889 : Part 2A : 1986 and item b) of 5.2.4 for method B of BS 3889 : Part 2A : 1986. The dimensions of the reference hole (method A) and the reference notch (method B) shall be as given in tables C.1 and C.2 respectively of this Part of BS 3605.

C.4 Assessment of results

The results of the test shall be assessed in accordance with clause 7 of BS 3889 : Part 2A : 1986, except that item (b) of 7.3 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 annex 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 dye penetrant inspection in accordance with BS 6443 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 C.1. Dimensions of reference holes for method A

Outside diameter mm	Drill diameter mm
≤ 25	1.20
> 25 ≤ 45	1.70
> 45 ≤ 65	2.20
> 65 ≤ 100	2.70
> 100 ≤ 140	3.20
> 140 ≤ 180	3.70

Table C.2. 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 Not greater than notch depth with a minimum of 0.50 mm
Length	A convenient length selected by the manufacturer for calibration and checking purposes

Annex D (normative)**Ultrasonic testing of tubes for the detection of longitudinal imperfections****D.1 General**

The tube shall be tested in accordance with BS 3889 : Part 1 : 1983 with the options of BS 3889 : Part 1 : 1983 as specified in **D.2** and **D.3** of this annex, and with the modification to clause 9 of BS 3889 : Part 1 : 1983 as specified in **D.4** of this annex.

D.2 Test procedure

The tube shall be tested for the detection of imperfections that are oriented predominantly longitudinally to the major axis of the tube in accordance with method A of BS 3889 : Part 1 : 1983. Scanning shall be carried out in both directions of beam travel in accordance with figure 1a) of BS 3889 : Part 1 : 1983.

D.3 Reference standards

The equipment shall be calibrated using longitudinal reference notches parallel to the major axis of the tube, in accordance with **7.1**, **7.2.1**, **7.2.2** and **7.2.5** of BS 3889 : Part 1 : 1983. The dimensions of the reference notches shall be as given in table D.1.

Table 13. Reference notch dimensions and tolerances

Depth	5 % of specified tube thickness
Minimum depth	0.3 mm
Maximum depth	1.5 mm
Tolerance on depth	± 15 % of notch depth or ± 0.05 mm whichever is the larger
Maximum width	1.5 mm
Length	A convenient length selected by the manufacturer for calibration and checking purposes

D.4 Assessment of results

D.4.1 Any tube that does not produce signals giving a trigger/alarm condition shall be deemed to have passed the test.

D.4.2 Any tube that produces signals giving a trigger/alarm condition shall be designated 'suspect', or, at the manufacturer's option, shall be retested on the same automatic equipment as used in the original test.

D.4.3 If upon retesting, no signal giving a trigger/alarm condition is obtained, the tube shall be deemed to have passed the test. Tubes giving a trigger/alarm condition upon retesting shall be designated 'suspect'.

D.4.4 For 'suspect' tubes one or more of the following actions shall be taken.

a) It shall be shown to the satisfaction of the purchaser that the trigger/alarm condition arises from a combination of minor imperfections, individually not serious enough to cause a trigger/alarm condition and the tube shall then be deemed to have passed the test.

b) For inside surface defects, the 'suspect' area shall be explored by dressing, using an acceptable method, and, after checking that the remaining thickness is within tolerance, the 'suspect' area shall be retested by an ultrasonic shear wave method using equipment with the same ultrasonic parameters and calibrated to give the same test sensitivity as that used in the original ultrasonic test. If no signals are obtained that give a trigger/alarm condition, the tube shall be deemed to have passed the test.

c) For outside surface defects, the 'suspect' area shall be explored by dressing, using an acceptable method, and, after checking that the remaining thickness is within tolerance, the 'suspect' area shall be retested non-destructively, using the dye penetrant inspection method in accordance with BS 6443 : 1984, until it can be shown that the imperfection has been completely removed.

The 'suspect' area shall then be retested by an ultrasonic shear wave method using equipment with the same ultrasonic parameters and calibrated to give the same test sensitivity as that used in the original ultrasonic test. If no signals are obtained that give a trigger/alarm condition, the tube shall be deemed to have passed the test.

d) The full circumference of the surface of the tube shall be dressed using an acceptable method, either completely or locally along its length to include the 'suspect' area, and, after checking that the thickness is within tolerance, the tube shall be retested on the same automatic equipment as that used in the original test. If no signals are obtained that give a trigger/alarm condition, the tube shall be deemed to have passed the test.

e) The 'suspect' area shall be cropped off, the remaining length being deemed to have passed the test.

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

Annex E (informative)**Minimum 0.2 % proof strength values at elevated temperatures**

Minimum 0.2 % proof strength values at elevated temperatures are given in table E.1 for purposes of comparison with other specifications.

Table E.1. Minimum 0.2 % proof strength values at elevated temperatures									
Steel type	Minimum 0.2 % proof strength (in N/mm ²) at a temperature (in °C) of:								
	20	100	150	200	250	300	350	400	450
304S11	180	121	108	98	90	82	76	74	71
304S31	195	132	120	109	100	93	87	84	81
316S11 316S13	190	130	120	109	101	96	90	87	84
316S31 316S33	205	155	144	132	121	113	107	101	98
321S31	200	154	149	144	139	135	129	124	119
347S31	205	171	162	153	147	139	133	129	126

List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

- | | |
|------------------------------------|--|
| BS 2901 : | <i>Filler rods and wires for gas-shielded arc welding</i> |
| BS 2901 : Part 2 : 1990 | <i>Specification for austenitic stainless steels</i> |
| BS 3688 : | <i>Methods for mechanical testing of metals at elevated temperatures</i> |
| BS 3688 : Part 1 : 1986 | <i>Tensile testing</i> |
| BS 3889 : | <i>Non-destructive testing of pipes and tubes</i> |
| BS 3889 : Part 1 : 1983 | <i>Methods of automatic ultrasonic testing for the detection of imperfections in wrought steel tubes</i> |
| BS 3889 : Part 2A : 1986 | <i>Automatic eddy current testing of wrought steel tubes</i> |
| BS 3894 : | <i>Conversion of elongation values for steel</i> |
| Part 2 : 1985 | <i>Method of conversion for application to austenitic steels</i> |
| BS 3920 : | <i>Derivation and verification of elevated temperature properties for steel products for pressure purposes</i> |
| BS 3920 : Part 1 : 1973 | <i>Method for deriving the minimum elevated temperature yield or proof stress properties when data on a minimum of 50 casts are available</i> |
| BS 5383 : 1986 | <i>Specification for material identification of steel, nickel alloy and titanium alloy tubes by continuous character marking and colour coding of steel tubes</i> |
| BS 5903 : 1980 | <i>Method for determination of resistance to intergranular corrosion of austenitic stainless steels: copper sulphate-sulphuric acid method (Moneypenny Strauss test)</i> |
| BS 6200 : | <i>Sampling and analysis of iron, steel and other ferrous metals</i> |
| BS 6200 : Part 3 : | <i>Methods of analysis</i> |
| BS 6200 : Section 3.8 : | <i>Determination of carbon</i> |
| BS 6200 : Subsection 3.8.2 : 1991 | <i>Steel and cast iron: non-aqueous titrimetric method after combustion</i> |
| BS 6200 : Subsection 3.8.3 : 1990 | <i>Steel and cast iron: infra-red absorption method after combustion in an induction furnace</i> |
| BS 6200 : Section 3.10 : | <i>Determination of chromium</i> |
| BS 6200 : Subsection 3.10.2 : 1989 | <i>Steel and cast iron: flame atomic absorption spectrometric method</i> |
| BS 6200 : Section 3.18 : | <i>Determination of manganese</i> |
| BS 6200 : Subsection 3.18.2 : 1985 | <i>Steel: spectrophotometric method</i> |
| BS 6200 : Subsection 3.18.4 : 1991 | <i>Steel and cast iron: volumetric method</i> |
| BS 6200 : Section 3.19 | <i>Determination of molybdenum</i> |
| BS 6200 : Subsection 3.19.1 : 1985 | <i>Steel and cast iron: photometric method</i> |
| BS 6200 : Section 3.20 | <i>Determination of nickel</i> |
| BS 6200 : Subsection 3.20.1 : 1989 | <i>Steel and cast iron: gravimetric or titrimetric method</i> |
| BS 6200 : Subsection 3.20.3 : 1985 | <i>Steel and cast iron: spectrophotometric method</i> |
| BS 6200 : Section 3.21 | <i>Determination of niobium</i> |
| BS 6200 : Subsection 3.21.1 : 1986 | <i>Steel: spectrophotometric method</i> |

BS 6200 : Section 3.22	<i>Determination of nitrogen</i>
BS 6200 : Subsection 3.22.3 : 1986	<i>Steel: spectrophotometric method (for trace amounts)</i>
BS 6200 : Section 3.24	<i>Determination of phosphorus</i>
BS 6200 :	<i>Subsection 3.24.1 : 1985 Steel and cast iron: spectrophotometric method</i>
BS 6200 : Section 3.26	<i>Determination of silicon</i>
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Longitudinally welded austenitic stainless steel tubes

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