BRITISH STANDARD

BS 3059-1: 1987

Steel boiler and superheater tubes —

Part 1: Specification for low tensile carbon steel tubes without specified elevated temperature properties

UDC 621.184.2-034.14

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

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Contents

Foreword

This Part of BS 3059 has been prepared under the direction of the Iron and Steel Standards Committee and supersedes BS 3059-1:1978 which is withdrawn.

As with the previous edition, this standard is published in two Parts, as follows, to assist users of the standard in selecting tubes for particular duties.

— *Part 1: Specification for low tensile carbon steel tubes without specified elevated temperature properties;*

— *Part 2: Carbon, alloy and austenitic stainless steel tubes with specified elevated temperature properties.*

This Part of BS 3059 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 designations of steel tubes in this specification and their nearest equivalent designations in ISO 2604-2 and ISO 2604-3 are given in Appendix A for information.

Most of the dimensions for tubes and also the tube tolerances are taken from ISO 1129 but the range of dimensions in this standard is wider than that in ISO 1129.

The main technical differences between this edition and the previous edition are that changes have been made to the specified ladle analysis to take into account current steelmaking practice and the length tolerance for "exact" or "cut" lengths has been changed to align with other standards covering steel tubes for pressure purposes. Also, typical physical properties of steel 320 are given in an Appendix C for information only.

Whilst this standard does not specify elevated temperature properties, the proof stress values at temperatures up to 400 °C are given in Appendix B for information but they are not subject to verification.

The steel covered by this standard is 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.

The appropriate British Standard for the design and construction of boilers should be consulted for requirements relating to the application and permissible design stresses for products made in accordance with this Part of BS 3059.

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 3059-1 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 and ii, pages 1 to 10, an inside back cover and a back cover.

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

1 Scope

This Part of BS 3059 specifies requirements for plain end, seamless and welded, low tensile carbon steel tubes, not exceeding 127 mm outside diameter and not exceeding 12.5 mm thickness for use in boilers and superheaters.

Only one grade of steel is included in the specification and is designated 320.

In addition to the definitive requirements, this Part of BS 3059 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 Part of BS 3059 both the definitive requirements and the documented items have to be satisfied.

NOTE 1 The preferred outside diameters and thicknesses appropriate to this standard are given and masses per unit length included in Appendix D for information.

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

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

2.1 Information to be supplied by the purchaser

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

a) the number of this British Standard, i.e. BS 3059-1, the method of manufacture of the product, and the grade of steel as expressed by the appropriate designation in clause **3**, e.g. BS 3059-1:HFS 320;

b) the tube outside diameter and thickness;

c) the tube length, if exact (see **2.2** e) and **10.3**);

d) the quantity in metres or number of lengths.

2.2 Options to be documented

A number of options are permitted by this Part of BS 3059 as listed below and where the purchaser identifies the option it shall be fully documented. Both the definitive requirements specified throughout this Part of BS 3059 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) Whether a product analysis is required [see **6.2** and clause **15** 2)].

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

d) The final supply condition (see clause **7**).

e) Whether lengths other than random lengths are required (see **10.3**).

f) Whether the method of leak tightness test to be carried out is the hydraulic test or the eddy current test [see **12.3** and clause **15** 5)].

g) 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 **13.4** and clause **15** 5)].

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

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

3 Designation

The tubes shall be designated by the number of this British Standard, i.e. BS 3059-1, and, from Table 1, by one of the references which indicates the method of manufacture (see clause **5**) and by the number 320, which indicates the grade of steel.

Table 1 — Method of manufacture of tube and reference

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

Example. BS 3059-1:HFS 320 denotes hot finished seamless tube made from steel 320.

NOTE The designations for tubes in this Part of BS 3059 and their nearest equivalent designations in ISO 2604-2 and ISO 2604-3 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.

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.

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

4.3 Deoxidation

For seamless tubes the steel shall be fully-killed. For welded tubes it shall be either fully-killed, rimmed or semi-killed.

5 Manufacture of the product

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

a) *Seamless tubes.* The tubes shall be manufactured by a seamless process and shall be hot finished or cold finished (see note 1).

b) *Electric resistance welded tubes.* 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 1). 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 2).

NOTE 1 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 2 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 3 Electric resistance welded tubes cover those produced by both high and low frequency techniques using either direct contact or induction.

6 Chemical analysis

6.1 Ladle analysis

The steel shall show on ladle analysis the composition given in Table 2.

6.2 Product analysis

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

When an analysis on the product is carried out, the permitted deviations given in Table 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 of chemical analysis shall be in accordance with British Standard Handbook No. 19 or BS 6200-3 as appropriate.

6.3 Content of elements

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

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

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** d)], the manufacturer shall have the option of supplying tube in any of the applicable supply conditions given in Table 4.

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

8.3.1 The test piece, when selected, prepared and tested in accordance with clauses **12** and **13** shall show no cracks or flaws except as permitted in **8.3.2**.

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.

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

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 temperature (see note 3)							
		C	Mn		Si		P	S	R_e	R_m		A	Flattening test constant C	Drift expanding test: increase in D		
														d/D ratio		
		max.	min.	max.	min.	max.	max.	max.	min.	min.	max.	min.		⩽ 0.6	> 0.6 ⩽ 0.8	> 0.8
		%	%	%	%	%	%	%	N/mm^{2a}	N/mm^2	N/mm^2	%		%	%	%
320	Seamless	0.16	0.30	0.70	0.10	0.35	0.040	0.040	195	320	480	25	0.10	12	15	19
320	Welded	0.16[b]	0.30	0.70	—	0.35	0.040	0.040	195	320	480	25	0.10	12	15	19

NOTE 1 Elements not quoted in the 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) $R_{t0.5}$ may be used (see **13.1**).

R_m is the tensile strength.

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

d is the inside diameter.

D is the outside diameter.

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

[b] For rimmed or semi-killed steel the C max. is 0.19 %.

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

Element	Upper limit of range in which the specified maximum for the 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	—
Manganese	2.0	0.10	0.10
Silicon	0.50	0.05	0.05
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.

Table 4 — Tube manufacturing process and final supply conditions

Manufacturing process	Final supply conditions
Hot finished seamless (HFS)	Hot finished Not heat treated Normalized[a] Sub-critically annealed[b]
Cold finished seamless (CFS)	Cold finished Normalized[a] Sub-critically annealed[b]
Electric resistance welded (ERW)	As welded Normalized[a] Sub-critically annealed[b]
	Hot finished Not heat treated Normalized[a] Sub-critically annealed[b]
Cold finished electric resistance welded (CEW)	Cold finished Normalized[a] Sub-critically annealed[b]

[a] Normalizing carried out in the temperature range 880 °C to 940 °C.
[b] Sub-critical annealing carried out in the temperature range 660 °C to 720 °C.

8.4 Drift expanding test

The test piece, when selected, prepared and tested in accordance with clauses **12** and **13** shall show no cracking.

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 Part of BS 3059.

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 Part of BS 3059.

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

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

9.5 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 **10.3**.

10.2 Outside diameter, thickness and size of weld upset

The tolerances on outside diameter shall include ovality and those on thickness shall include eccentricity.

a) *Hot finished seamless (HFS)*

Outside diameter: ± 1 % with a minimum tolerance of ± 0.50 mm

Thickness: ± 12.5 %

b) *Cold finished seamless (CFS)*

Outside diameter: ± 0.5 % with a minimum tolerance of ± 0.10 mm

Thickness: ± 7.5 %

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

Outside diameter: ± 0.75 % with a minimum tolerance of ± 0.30 mm

Thickness: up to and including 3.2 mm ± 10 %

over 3.2 mm ± 7.5 %

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. Where practicable the internal weld upset shall be trimmed throughout the length of the tube so that its maximum height shall not exceed 0.25 mm.

d) *Cold finished electric resistance welded including induction welded (CEW)*

Outside diameter: ± 0.5 % with a minimum tolerance of ± 0.10 mm

Thickness: ± 7.5 %

10.3 Length

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

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

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

c) flattening test (see clause **8**, **12.1** and **13.2**);

d) drift expanding test (see clause **8**, **12.1** and **13.3**);

e) leak tightness test (see **12.3**).

12 Number, selection and preparation of samples and test pieces

12.1 Mechanical tests

12.1.1 Tensile, flattening and drift expanding 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 no more than 200 tubes 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.

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.

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 drift expanding test, a ring equal in length to 1.5 times the outside diameter of the tube, but not less than 50 mm long, shall be taken from one end of each selected tube.

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 shall be by either a hydraulic test in accordance with **13.4** or, alternatively, an eddy current test in accordance with **13.5** at the discretion of the manufacturer unless otherwise specified by the purchaser [see **2.2** f)].

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 enquiry and order, the length affected should be determined by the manufacturer and reported to the purchaser. Further, if requested at the time of 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 **13.4** 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 test

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 equal to 0.10.

For electric resistance welded, including induction welded, tubes the weld shall be positioned at 90° to the direction of flattening.

13.3 Drift expanding test

The test piece shall be expanded by a tapered mandrel having an included angle of 45° or 60° (at the option of the manufacturer) and the outside diameter shall be increased by not less than the amount specified in Table 2.

13.4 Hydraulic test

For tubes which are hydraulically tested (see **12.3**), the hydraulic test pressure, P (in bar), shall be calculated from the following equation:

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

where

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 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** g)], 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.

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 Part of BS 3059.

13.5 Eddy current test

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

14 Retests

Should a tube selected for testing fail in any of the tests specified in **13.1**, **13.2** or **13.3**, 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 the failure are made from the same batch, and both of 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**, **13.2** and **13.3** 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)].

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**).

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

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** h)].

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** i)], 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[4)] as given in clause **3**, e.g. BS 3059-1:HFS 320;

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.

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 contain not 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 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** i)] 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 requirement in BS 5383 and, if required, should be specified by the purchaser on the enquiry and order.

[4)] Marking BS 3059-1 on or in relation to a product is a claim by the manufacturer that the product has been manufactured to the requirements of the 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 3059-1:1987 and the nearest equivalent designations in BS 3059-1:1978 and ISO 2604-2 and ISO 2604-3

Table 5 lists the designations for tubes in this Part of BS 3059 and gives the nearest equivalents in BS 3059-1:1978 and ISO 2604-2 and ISO 2604-3.

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

Table 5 — Designation of steel tubes in BS 3059-1:1987 and the nearest equivalent designations in BS 3059-1:1978 and ISO 2604-2 and ISO 2604-3

BS 3059-1: 1987	BS 3059-1: 1978	ISO 2604-2 and ISO 2604-3
HFS 320	HFS 320	TS 1 Cat. III
CFS 320	CFS 320	TS 1 Cat. III (cold finished)
ERW 320	ERW 320	TW 1 Cat. III
CEW 320	CEW 320	TW 1 Cat. III (cold finished)

Appendix B Minimum 0.2 % proof stress ($R_{p0.2}$) values at elevated temperatures

Table 6 gives proof stress values at temperatures up to 400 °C. These values are given for information and are not subject to verification.

Table 6 — Minimum 0.2 % proof stress ($R_{p0.2}$) values at elevated temperatures

Steel grade	$R_{p0.2}$ at a temperature of			
	250 °C	300 °C	350 °C	400 °C
	N/mm^{2a}	N/mm^2	N/mm^2	N/mm^2
320	130	113	102	94

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

Appendix C Physical properties of steel grade 320

Table 7 has been compiled on the basis of data obtained from a number of sources. The properties are believed to be typical for steel grade 320.

Table 7 — Physical properties of steel grade 320

Temperature	Physical property					
	Density	Modulus of elasticity	Coefficient of thermal expansion from 20 °C to temperature	Electrical resistivity	Specific heat capacity from 20 °C to temperature	Thermal conductivity
	kg/dm^3	kN/mm^2	$K^{-1} \times 10^{-6}$	μΩ·m	J/(kg·K)	W/(m·K)
20 °C	7.85	212	—	0.210	—	54.7
100 °C	—	206	11.9	0.248	468	53.8
200 °C	—	198	12.6	0.310	492	50.5
300 °C	—	191	13.1	0.394	516	47.0
400 °C	—	183	13.7	0.496	541	43.5

Appendix D Preferred outside diameters and thicknesses for tubes appropriate to this standard and masses per unit length

Table 8 gives preferred outside diameters and thicknesses for tubes appropriate to this standard and masses per unit length.

Table 8 — Preferred outside diameters and thicknesses for tubes appropriate to this standard and masses per unit length

Outside diameter	Conventional mass per unit length for a tube thickness (mm) of																
	2.0	2.3	2.6	2.9	3.2	3.6	4.0	4.5	5.0	5.6	6.3	7.1	8.0	8.8	10.0	11.0	12.5
mm	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m	kg/m
25.4	1.15	1.31	1.46	1.61	1.75	1.94	2.11	2.32	2.52	—	—	—	—	—	—	—	—
26.9	1.23	1.40	1.56	1.72	1.87	2.07	2.26	2.49	2.70	—	—	—	—	—	—	—	—
31.8	1.47	1.67	1.87	2.07	2.26	2.50	2.74	3.03	3.30	3.62	3.96	—	—	—	—	—	—
33.7	1.56	1.78	1.99	2.20	2.41	2.67	2.93	3.24	3.54	3.88	4.26	—	—	—	—	—	—
38	1.78	2.02	2.27	2.51	2.75	3.05	3.35	3.72	4.07	4.47	4.93	5.41	5.92	—	—	—	—
42.4	—	2.27	2.55	2.82	3.09	3.44	3.79	4.21	4.61	5.08	5.61	6.18	6.79	—	—	—	—
44.5	—	2.39	2.69	2.98	3.26	3.63	4.00	4.44	4.87	5.37	5.94	6.55	7.20	7.75	—	—	—
48.3	—	2.61	2.93	3.25	3.56	3.97	4.37	4.86	5.34	5.90	6.53	7.21	7.95	8.57	—	—	—
51	—	2.76	3.10	3.44	3.77	4.21	4.64	5.16	5.67	6.27	6.94	7.69	8.48	9.16	10.1	—	—
57	—	—	3.49	3.87	4.25	4.74	5.23	5.83	6.41	7.10	7.88	8.74	9.67	10.5	11.6	—	—
60.3	—	—	3.70	4.11	4.51	5.03	5.55	6.19	6.82	7.55	8.39	9.32	10.3	11.2	12.4	13.4	—
63.5	—	—	3.90	4.33	4.76	5.32	5.87	6.55	7.21	8.00	8.89	9.88	10.9	11.9	13.2	14.2	—
70	—	—	4.32	4.80	5.27	5.90	6.51	7.27	8.01	8.89	9.90	11.0	12.2	13.3	14.8	16.0	—
76.1	—	—	—	5.24	5.75	6.44	7.11	7.95	8.77	9.74	10.8	12.1	13.4	14.6	16.3	17.7	19.6
82.5	—	—	—	—	6.26	7.00	7.74	8.66	9.56	10.6	11.8	13.2	14.7	16.0	17.9	19.4	21.6
88.9	—	—	—	—	6.76	7.57	8.38	9.37	10.3	11.5	12.8	14.3	16.0	17.4	19.5	21.1	23.6
101.6	—	—	—	—	—	8.70	9.63	10.8	11.9	13.3	14.8	16.5	18.5	20.1	22.6	24.6	27.5
114.3	—	—	—	—	—	—	10.9	12.2	13.5	15.0	16.8	18.8	21.0	22.9	25.7	28.0	31.4
127	—	—	—	—	—	—	—	13.6	15.0	16.8	18.8	21.0	23.5	25.7	28.9	31.5	35.3

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

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 a 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 Part of BS 3059.

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 9 — Drill diameter sizes for method A

Outside diameter of tube	Drill diameter
mm	mm
⩽ 25	1.2
> 25 ⩽ 45	1.7
> 45 ⩽ 65	2.2
> 65 ⩽ 100	2.7
> 100 ⩽ 127	3.2

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 the notch depth, with a minimum of 0.5 mm
Length	A convenient length selected by the manufacturer for calibration and checking purposes

Publications referred to

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

BS 2633, *Specification for Class 1 arc welding of ferritic steel pipework for carrying fluids*[5)].

BS 3059, *Specification for steel boiler and superheater tubes*[5)].

BS 3059-2, *Carbon, alloy and austenitic stainless steel tubes with specified elevated temperature properties*[5)].

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 3894-1, *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*[5)].

BS 5750-2, *Specification for production and installation*[5)].

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 1129, *Steel tubes for boilers, superheaters and heat exchangers — Dimensions, tolerances and conventional masses per unit length*[5)].

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

ISO 2604-2, *Wrought seamless tubes.*

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

[5)] Referred to in the foreword only.

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