BRITISH STANDARD 2871 : Part 3 : 1972

SPECIFICATION FOR

COPPER AND COPPER ALLOYS

TUBES

Part 3. Tubes for heat exchangers

BSi British Standards

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BS 2871 : Part 3 : 1972

Incorporating amendments issued November 1976 (AMD 2155) and June 1979 (AMD 3053)

BRITISH STANDARDS INSTITUTION
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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

A complete list of British Standards, numbering over 5000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook, which may be purchased from BSI Sales Department. It may also be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 427. Method for Vickers hardness test.
BS 1957. Presentation of numerical values (fineness of expression; rounding of numbers).
BS 3889. Methods for non-destructive testing of pipes and tubes. Part 2B. Eddy current testing of non-ferrous tubes.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following BSI references relate to the work on this standard:
Committee reference NFE/17 Draft for comment 70/25711

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CO-OPERATING ORGANIZATIONS

The Non-ferrous Metals Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments, and scientific and industrial organizations:

Aluminium Federation
Association of Bronze and Brass Founders
Board of Trade
British Bronze and Brass Ingot Manufacturers' Association
*British Electrical and Allied Manufacturers' Association
British Lead Manufacturers' Association
*British Non-ferrous Metals Federation
British Non-ferrous Metals Association High conductivity copper Group
*British Non-ferrous Metals Research Association
*Copper Development Association
Department of Trade and Industry (Marine Division)
Electric Cable Makers' Confederation
Institute of British Foundrymen
Institute of Metals
*Institution of Mechanical Engineers (Automobile Division)
Institution of Mining and Metallurgy
Institution of Production Engineers
Institution of Structural Engineers
Lead Development Association
Light Metal Founders' Association
London Metal Exchange
Magnesium Industry Council
*Ministry of Defence (Army Department)
*Ministry of Defence (Navy Department)
National Brassfoundry Association
*Non-ferrous Metal Stockists
Post Office
Royal Institute of British Architects
Society of Motor Manufacturers and Traders Limited
Tin Research Institute
Zinc Development Association
Individual manufacturers

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following were directly represented on the committee entrusted with the preparation of this British Standard:

British Waterworks Association
Copper Tube Fittings Manufacturers' Association
Department of the Environment
Department of Trade and Industry
Electricity Council, The Central Electricity Generating Board and the Area Boards in England and Wales
Engineering Equipment Users' Association
Engineering Industries Association
Gas Council
Institute of Plumbing
Institution of Gas Engineers
Institution of Heating and Ventilating Engineers
National Federation of Plumbers and Domestic Heating Engineers
National Physical Laboratory—(Department of Trade and Industry)
Oil Companies' Materials Association
Institution of Mechanical Engineers
Metropolitan Water Board

BRITISH STANDARD SPECIFICATION FOR

COPPER AND COPPER ALLOYS
TUBES
Part 3. Tubes for heat exchangers

FOREWORD

This British Standard is the first revision in metric terms of one of a series for copper and copper alloys in various wrought forms, the preparation of which was authorized by the Non-Ferrous Metals Industry Standards Committee. Others in the series are:

BS 2870. Rolled copper and copper alloys. Sheet, strip and foil.
BS 2872. Copper and copper alloys. Forging stock and forgings.
BS 2873. Copper and copper alloys. Wire.
BS 2874. Copper and copper alloys. Rods and sections.
BS 2875. Copper and copper alloys. Plate.

In preparing this metric revision of BS 2871 it was decided to produce it in three parts thereby eliminating the large section of particular applications which forms Part 3 of the 1957 edition.

This Part specifies requirements for tubes for heat exchangers expressed in metric units based on those expressed in imperial units in BS 378 (which has now been withdrawn) but it has been considerably extended to cater for the methods of installation currently used and the mechanical properties and test requirements (including non-destructive eddy current testing) have been included accordingly. The tolerances on outside diameter have been amended to bi-lateral instead of uni-lateral thereby to accord with other national standards and codes, particularly A.S.T.M. and A.S.M.E. *As amended Nov. 1976*

NOTE. Attention is drawn to certification facilities offered by BSI; see the back cover of this standard.

SPECIFICATION

1. SCOPE

This Part of this British Standard specifies requirements for solid drawn copper and copper alloy tubes for use in heat exchangers in outside diameters of 6 mm up to and including 50 mm.

NOTE. The titles of the British Standards referred to in this standard are listed on page 2.

2. GENERAL

The tubes shall comply with the general requirements set out in the following clauses and with the appropriate requirements of Tables 1 to 3.

3. INFORMATION TO BE SUPPLIED BY THE PURCHASER

The purchaser shall state on his enquiry and order the following information:

(1) The designation of the material required. (See Table 1.)

(2) The condition of the material. (See Table 1.)

(3) Whether mechanical tests are required. (See **10.**)

(4) Whether a hydrostatic or pneumatic test is required. (See **11.**)

(5) Whether a certification of compliance is required. (See **15.**)

(6) Whether it is the purchaser's intention to inspect the material at the supplier's works. (See **16.**)

(7) If U tubes are required. (See **6.**)

(8) Whether minimum or average wall thickness is required. (See **8.2.**)

(9) If ammonia cracking test is required. (See **12.2.**)

4. FREEDOM FROM DEFECTS

The tubes shall be round, straight, clean, smooth and free from harmful defects and deleterious films in the bore.

5. CHEMICAL COMPOSITION

The chemical compositions shall comply with the appropriate requirements of Table 1.

6. MANUFACTURE

The tubes shall be solid drawn and in no case shall they be re-drawn from used tubes. Unless otherwise ordered they shall be supplied in straight lengths and the ends shall be cut clean and square with the axis of the tube.

7. CONDITION

The tubes shall be supplied in one of the following conditions as specified in Table 1:

M condition. Tubes in the ' as drawn ' condition. Such tubes may be subjected to stress-relieving treatment after the final draw at the option of the supplier.

TA condition. Tubes in the temper annealed condition. These tubes will have been heat treated over their full length to an intermediate temper.

O condition. Tubes in the annealed condition.

½H condition. Tubes in the ' half hard ' temper produced by cold drawing.

Other intermediate tempers may be supplied by agreement between the purchaser and the manufacturer.

8. DIMENSIONS AND TOLERANCES

8.1 Diameter. The mean outside diameter of the tubes shall not vary from the specified outside diameter by more than the amount of tolerance specified in Table 2. The mean outside diameter is half the sum of the two diameters at right angles on one cross section of the tube.

8.2 Thickness.

8.2.1 Average wall thickness*. The wall thickness at any point shall not vary from the specified thickness by more than ± 10 %.

8.2.2 Minimum wall thickness. The wall thickness of any tube at any point shall be not less than the specified thickness nor more than 15% above the specified thickness. The mean thickness of any tube at any cross section shall be not more than 10% greater than the specified thickness. The mean thickness is half the sum of two wall thicknesses, measured at points on a cross section of a tube diametrically opposite to each other.

8.3 Length. Tubes ordered to be of a specified length, shall not vary from that length by more than the amount of the tolerance specified in Table 3 when measured at a temperature of 15°C.

9. SELECTION OF TEST SAMPLES

When tests other than those specified in **11** are requested by the purchaser, tubes of any one composition, size, thickness and temper shall be grouped in batches of 300 tubes or 1000 kg whichever is the greater weight and the purchaser or his representative shall take at random one tube from each and any remaining part of a batch for testing. When the size of the order does not permit of batching in the above quantities, one tube of each composition, size, thickness and temper shall be selected for testing.

10. MECHANICAL TESTS

Mechanical tests shall be made on test pieces taken from samples selected as described in **9** in the condition as supplied except where otherwise specified.

10.1 Hardness test. Hardness tests shall be made in accordance with BS 427 using a 5 kgf load where thickness permits.

The values obtained shall comply with the appropriate requirements of Table 1.

10.2 Flattening test for tubes in the M condition. A test piece from any part of the tube shall be flattened until the distance between the interior surfaces is not more than half the inside diameter of the tube, as shown in Fig. 1. When subjected to this test the tube shall show no sign of cracking.

* Unless otherwise specified average wall thickness will be supplied.

10.3 Flattening test for tubes in the O, TA or ½H condition. A test piece from any part of the tube shall be flattened until the interior surfaces meet as shown in Fig. 2. When subjected to this test the tube shall show no sign of cracking.

10.4 Drifting test. The test piece shall be expanded as shown in Fig. 3 by means of a taper drift having an included angle of 45°, until the outside diameter of the expanded end exceeds the original outside diameter by the amount specified in Table 1. When subjected to this test the tube shall show no sign of cracking. The test piece from ' as drawn ' tubes shall be annealed before testing.

11. NON-DESTRUCTIVE TESTS

11.1 Eddy current test. Each tube shall be eddy current tested in accordance with the requirements of BS 3889 : Part 2B. By agreement between the manufacturer and the purchaser a hydrostatic test or a pneumatic test may also be specified. If a hydrostatic test or a pneumatic test is required it shall be performed in the manner specified in **11.2** or **11.3** respectively.

11.2 Hydrostatic test. Each tube shall withstand without showing signs of weeping, leaking or permanent increase in diameter, an internal hydrostatic pressure as defined in the following formula. No tubes shall, however, be tested to a hydrostatic pressure beyond 70 bar* unless otherwise agreed.

$$P = \frac{Kt}{D}$$

where P = internal pressure (bar*),
t = wall thickness of the tube (mm),
D = outside diameter of the tube (mm),
K = a constant as specified in Table 1.

11.3 Pneumatic test. Each tube shall be tested to a minimum internal air pressure of 4 bar* for a minimum period of 5 s without showing signs of leakage whilst immersed in water.

NOTE. These tests are intended to determine the soundness of the tube wall and are not to be regarded as an indication of the strength or safe working pressure.

12. STRESS CRACKING TEST

12.1 Mercurous nitrate test. This test is applicable to copper alloy tubes only.

A 150 mm length of tube, in the condition as offered for inspection, shall be first degreased and then dipped in a solution of 50% distilled water and 50% concentrated nitric acid (relative density 1.42) for a period not exceeding 30 s to remove all traces of carbonaceous matter and oxide films. It shall then be well rinsed in cold water and immediately immersed completely in a 1% w/w solution of mercurous nitrate in distilled water to which 1 ml of concentrated nitric acid (relative density 1.42) has been added for each 100 ml of solution.

* 1 bar = 0.1 N/mm^2 = 10^5 N/m^2.

The test specimen shall remain in the solution for 30 min and then be removed, rinsed well in cold water and carefully wiped, and examined immediately. The test specimen shall show no evidence of cracking. Specimens of CN 107 and CN 108 alloys shall be examined 24 h after removal from the solution. The test piece shall not be marked for identification by indenting.

Should any specimen fail to meet the requirements of this test, all the tubes submitted for inspection and represented by that sample shall be withdrawn but may be resubmitted for inspection after stress relieving treatment.

12.2 Ammonia vapour cracking test. By agreement between manufacturer and purchaser tubes of alloys CZ 110, 111 and 126 in either the TA or O condition may be subjected to the ammonia vapour cracking test as an alternative to the mercurous nitrate test.

The test solution is made up as follows:

Dissolve 2 mols (107 g) ammonium chloride in 1000 ml distilled water. *As amended Nov. 1976*

Place the glass electrode of a pH meter in the solution. Add small quantities of sodium hydroxide flakes until pH 10 is obtained.

A 150 mm length of tube in the condition as offered for inspection, is first degreased, pickled in a 10% sulphuric acid solution and then washed and dried. The sample is then suspended in a desiccator above the solution for a period of 24 h with the lid closed. After 24 h remove the samples, lightly pickle in 10% sulphuric acid solution and examine for cracks. Slight drifting or flattening may be necessary to readily reveal any cracking that is present. Cracking associated with the sawn ends of the tube samples should be ignored. Should any specimen fail to meet the requirements of this test, all the tubes submitted for inspection and represented by that sample shall be withdrawn but may be resubmitted for inspection after further heat treatment.

13. MICROSCOPIC EXAMINATION

Test pieces from either annealed or temper annealed tubes shall be prepared from sections of the tube, in the condition as offered for inspection, and shall be subjected to microscopic examination at a magnification of 75 diameters. They shall show uniform re-crystallization and freedom from non-metallic inclusions. This clause does not apply to M or ½H tubes.

The average grain size shall not exceed that specified in Table 1.

14. RETESTS

Should any one of the test pieces first selected by the purchaser or his representative fail to pass any of the tests prescribed in 10 two further samples from the same batch shall be selected for testing, one of which shall be from the tube from which the original test sample was taken, unless that tube has been withdrawn by the supplier.

Should the test pieces from both of these additional samples pass, the batch represented by the test samples shall be deemed to comply with this standard. Should the test pieces from either of these additional samples fail, the batch represented by the test samples shall be deemed not to comply with this standard.

The requirements of this clause shall not apply to **12.**

15. CERTIFICATE OF COMPLIANCE

The supplier shall, if required, certify that the tube complies with the requirements of this standard appropriate to the material ordered.

16. INSPECTION

The purchaser shall notify the supplier when placing the order if it is his intention to inspect the material at the supplier's works. The supplier shall afford the purchaser all reasonable facilities to satisfy himself that the material is in accordance with the standard. For this purpose the purchaser or his representative may, by prior arrangement, attend to inspect the material, to select and identify the test samples for testing and to witness the tests being made.

The purchaser shall be at liberty to take samples from the material selected in accordance with **9,** and have them analysed. The cost of such analysis shall be borne by the purchaser and the results shall be communicated to the supplier if they are not in accordance with Table 1 for the appropriate material.

17. INDEPENDENT TEST

Should there be a dispute about the compliance of the material with either the composition or the test requirements of this standard, the purchaser and the supplier shall have the right to have tests made by a mutually acceptable testing authority.

The results obtained by the independent testing authority shall be accepted as final.

18. FACILITIES FOR TESTING

For making tests on samples selected in accordance with **9** the supplier shall provide and prepare the necessary test pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this standard. Unless otherwise agreed, material for testing shall remain the property of the supplier.

Failing facilities in his own works for making the prescribed tests, the supplier shall make the necessary arrangements for making the tests elsewhere.

19. THE ROUNDING OF NUMBERS RULE

Values between the limits of composition and mechanical properties shown (NOT dimensional tolerances) are subject to the application of the ' rounding '

rule in accordance with BS 1957. Under this rule the determined values are ' rounded ' to the last place of figures stated as limits.

The following examples illustrate the application of the rounding rule:

Specification limits		Extreme values which round to specification limits	
Min.	Max.	Min.	Max.
—	0.050	—	0.0505
0.2	0.6	0.15	0.65
6	9	5.5	9.4
7	10	6.6	10.5
7.5	10.5	7.46	10.54

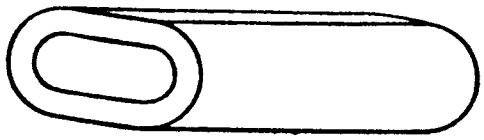

Fig. 1. Flattening test for tubes in the M condition

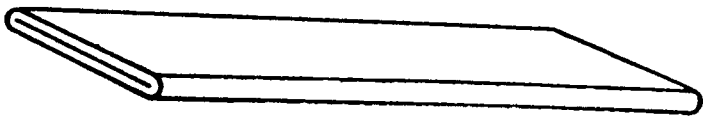

Fig. 2. Flattening test for tubes in the O, TA or ½H condition

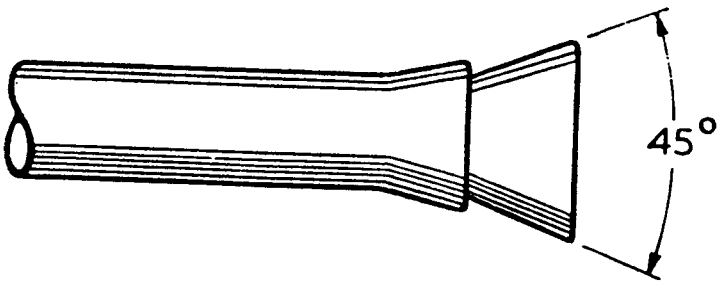

Fig. 3. Drifting test

TABLE 1. CHEMICAL COMPOSITION AND MECHANICAL

For essential alloying elements, limits are in heavy type: Unless otherwise stated figures in total impurities column include those in lighter type. Unless otherwise indicated all limits are maxima.

Designation	Material	Copper	Tin	Lead	Iron	Nickel	Zinc	Arsenic	Antimony	Aluminium	Manganese
		%	%	%	%	%	%	%	%	%	%
C 106	Phosphorus deoxidized non-arsenical copper	**99.85 min. incl. silver**	0.01	0.010	0.030	0.10*	—	0.05	0.005	—	—
CZ 110	Aluminium brass	**76.0/ 78.0**	—	0.07	0.06	—	REM.	**0.02/ 0.06**	—	**1.80/ 2.30**	—
CZ 111	Admiralty brass	**70.0/ 73.0**	**1.0/ 1.5**	0.07	0.06	—	REM.	**0.02/ 0.06**	—	—	—
CZ 126	Special 70/30 Arsenical brass	**69.0/ 71.0**	—	0.07	0.06	—	REM.	**0.02/ 0.06**	—	—	—
CN 102	90/10 Copper-nickel-iron	REM.	—	0.01	**1.00/ 2.00**	**10.0/ 11.0**	—	—	—	—	**0.50/ 1.00**
CN 107	70/30 Copper-nickel	REM.	—	0.01	**0.40/ 1.00**	**30.0/ 32.0**	—	—	—	—	**0.50/ 1.50**
CN 108	66/30/2/2 Copper-nickel-iron-manganese	REM.	—	—	**1.7/ 2.3**	**29.0/ 32.0**	—	—	—	—	**1.5/ 2.5**
CA 102	7% Aluminium bronze	REM.	—	—	**Ni+Fe+Mn 1.0 - 2.5 optional but between these limits if present**		—	—	—	**6.0/ 7.5**	**See iron and nickel**

* Impurity or optional addition.

PROPERTIES OF COPPER AND COPPER ALLOYS TUBES *As amended Nov. 1976*

Sulphur	Carbon	Bismuth	Phosphorous	Selenium	Tellurium	Total impurities	Condition	Hardness HV 5	Drifting test† min.	Hydrostatic test (Constant K)	Grain size max.
%	%	%	%	%	%	%			%		mm
—	—	0.0030	0.013/ 0.050		0.010	0.06 excl. silver, arsenic, nickel, phosphorus	M	105 min.	25	1100	—
							½H	80–100	25	1000	—
				Se + Te	0.020		O	60 max.	25	800	0.05
—	—	—	—	—	—	0.30	M	150 min.	25	1600	—
							TA	85–110	25	1300	0.05
							O	75 max.	25	1200	—
—	—	—	—	—	—	0.30	M	150 min.	25	1500	—
							TA	80–105	25	1200	0.05
							O	75 max.	25	1100	—
—	—	—	—	—	—	0.30	M	150 min.	25	1500	—
							TA	80–105	25	1200	0.05
							O	75 max.	25	1100	—
0.05	0.05	—	—	—	—	0.30	M	150 min.	25	1600	—
							O	80–110	25	1250	0.05
0.08	0.06	—	—	—	—	0.30	M	150 min.	25	1800	—
							O	90–120	25	1500	0.05
—	—	—	—	—	—	0.30	M	150 min.	25	1800	—
							O	90–120	25	1500	0.05
—	—	—	—	—	—	0.50	M	150 min.	25	1800	—
							O	110 max.	25	1500	0.05

† Test pieces from tubes in the M and $^1/_2$H condition to be annealed before testing.

TABLE 2. TOLERANCES ON OUTSIDE DIAMETER

1	2
Specified outside diameter	**Tolerances on specified outside diameter**
mm	mm
Up to 12	± 0.05
Over 12 to 18	± 0.07
Over 18 to 25	± 0.1
Over 25 to 35	± 0.15
Over 35 to 50	± 0.18

TABLE 3. TOLERANCES ON LENGTH *As amended Nov. 1976*

1		2	3
Specified length		**Tolerance on specified length**	
Over	**Up to and including**	**M or $^1/_2$H**	**O or TA**
m	m	mm	mm
	5.0	+1.5 −0	+3.0 −0
5.0	6.5	+2.5 −0	+4.0 −0
6.5	10	+3.0 −0	+5.0 −0
10	20	+6.0 −0	+9.0 −0
20	30	+9.0 −0	+12.0 −0

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BRITISH STANDARDS INSTITUTION

The British Standards Institution was founded in 1901 and incorporated by Royal Charter in 1929.

The principal objects of the Institution as set out in the charter are to co-ordinate the efforts of producers and users for the improvement, standardization and simplification of engineering and industrial materials; to simplify production and distribution; to eliminate the waste of time and material involved in the production of an unnecessary variety of patterns and sizes of articles for one and the same purpose; to set up standards of quality and dimensions, and to promote the general adoption of British Standards.

In carrying out its work the Institution endeavours to ensure adequate representation of all viewpoints. Before embarking on any project it must be satisfied that there is a strong body of opinion in favour of proceeding and that there is a recognized need to be met.

The Institution is a non-profit-making concern. It is financed by subscriptions from firms, trade associations, professional institutions and other bodies interested in its work, by a Government grant and by the sale of its publications. The demands on the services of the Institution are steadily increasing and can only be met if continuing and increased financial support is provided.

Membership of the Institution is open to British subjects, companies, technical and trade associations, and local and public authorities.