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BRITISH STANDARD 1471 : 1955

WROUGHT ALUMINIUM AND ALUMINUM ALLOYS

DRAWN TUBE

BRITISH STANDARDS INSTITUTION

BRITISH STANDARD SPECIFICATION

WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS

For General Engineering Purposes

DRAWN TUBE

B.S. 1471 : 1955

Price 6/- net

BRITISH STANDARDS INSTITUTION

INCORPORATED BY ROYAL CHARTER

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THIS BRITISH STANDARD, having been approved by the Non-ferrous Metals Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 30th December, 1955.

First published December, 1949.
First revision December, 1955.

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.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 2500, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook, price 12s. 6d.

This standard makes reference to the following British Standards :

B.S. 18. Tensile testing of metals.
B.S. 350. Conversion factors and tables.
B.S. 1499. Sampling non-ferrous metals.
B.S. 1728. Methods for the analysis of aluminium and minium alloys.
B.S. 1957. Presentation of numerical values (fineness of alu- expression ; rounding of numbers).

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 B.S.I. references relate to the work on this standard :—
Committee reference NFE/19 Draft for comment CT (NFE) 5869

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* See Amdt 1 page 3

TABLES

APPENDICES

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 :—

*Admiralty
*Aluminium Development Association
*Aluminium Industry Council
Association of Bronze and Brass Founders
Association of Consulting Engineers, Incorporated
*Association of Non-Ferrous Metal Stockists
Brass and Copper Tube Association
Brass Wire Association
British Bronze and Brass Ingot Manufacturers Association
*British Electrical and Allied Manufacturers' Association
*British Non-ferrous Metals Research Association
Cable Makers' Association
Cold Rolled Brass and Copper Association
Copper Development Association
Crown Agents for Oversea Governments and Administrations
General Post Office
High Commission for India
High Conductivity Copper Association
Institute of British Foundrymen
*Institute of Metals
*Institution of Mechanical Engineers (Automobile Division)
Institution of Mining and Metallurgy
*Institution of Structural Engineers
Lead Sheet and Pipe Manufacturers' Federation
Light Metal Founders' Association
London Metal Exchange
Manufactured Copper Association
*Ministry of Supply
National Brassfoundry Association
Nickel Silver Association
*Royal Institute of British Architects
Sheet Makers' Conference
Society of British Aircraft Constructors
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 :—

ALAR (Association of Light Alloy Refiners)
British Aluminium Holloware Manufacturers' Association
Gas Council
Lloyd's Register of Shipping
London Transport Executive, The British Transport Commission
Metal Thread Screw Manufacturers' Association (Rolled Screw Section)
National Association of Drop Forgers and Stampers
National Federation of Vehicle Trades
National Physical Laboratory
Radio Industry Council
Small Rivet Association
Society of Motor Manufacturers and Traders Ltd.
Individual manufacturers

BRITISH STANDARD SPECIFICATION FOR

WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS

FOR GENERAL ENGINEERING PURPOSES

DRAWN TUBE

FOREWORD

This British Standard for drawn tube was first issued in 1949 and forms part of a comprehensive series of British Standards for aluminium and aluminium alloys in various wrought forms for general engineering purposes. This whole series has been reviewed; the requirements for wire previously covered by B.S. 1474-5 have been incorporated in one standard B.S. 1475, and the number 1474 has been allocated to a new standard for extruded round tube and hollow sections. This standard now refers to drawn tube only.

Other British Standards in the revised series are:

B.S. 1470 Sheet and strip.
B.S. 1472 Forgings and forging stock.
B.S. 1473 Rivet, bolt and screw stock for forging.
B.S. 1474 Extruded round tube and hollow sections.
B.S. 1475 Wire.
B.S. 1476 Bars, rods and sections.
B.S. 1477 Plate.

The same system of nomenclature has been adopted for all standards in the series and particular care should be taken to ensure that the correct symbol is quoted.

In this revision of the standard three new materials have been included, namely: H9 and two aluminium-magnesium-silicon type alloys designated H20 and H30, which have been included immediately following H10 because of their similarity to that material. Alloy H20 contains an addition of copper and also manganese or chromium, while H30 is a copper-free alloy with an obligatory manganese content. In addition certain of the other alloys have been included in conditions not previously covered by the standard.

Composition limits and mechanical properties are substantially the same as those in the earlier edition but some minor amendments have been made, and in certain cases limits have been rounded in accordance with B.S. 1957, ' Presentation of numerical values (fineness of expression; rounding of numbers).' Proof stress values for alloys N5, N6 and N7 in the annealed condition are now given ' for information only ' and to indicate this the figures are printed in italics. As in the earlier edition,

major alloying elements are printed in heavy type throughout Section Two.

The tolerances on thickness and diameter have been re-arranged in two tables and an additional appendix concerning proof stress measurement has been included. As in the earlier edition, information for designers with regard to moments of inertia and moduli of section is given in Appendix D.

The whole standard has been re-drafted in line with the recommendations of the committee who are co-ordinating the wording of non-ferrous metal specifications.

SYSTEM OF NOMENCLATURE

In this series of British Standards the following symbols have been adopted throughout :—

a. Form of material

S = Sheet (up to and including 0·252 in. thick) and strip (up to and including 0·192 in. thick) (B.S. 1470).
C = Clad sheet and strip (B.S. 1470).
T = Drawn tube (B.S. 1471).
F = Forgings and forging stock (B.S. 1472).
R = Rivet stock (B.S. 1473).
B = Bolt and screw stock (B.S. 1473).
V = Extruded round tube and hollow sections (B.S. 1474).
G = Wire (B.S. 1475).
E = Bars, rods and sections (B.S. 1476).
P = Plate (B.S. 1477).
PC = Clad plate (B.S. 1477).

b. Heat treatment. In the case of the aluminium alloys, the following prefix symbols have been adopted throughout :—

N Non-heat-treatable alloys, i.e. those which are not strengthened by heat treatment.
H Heat-treatable alloys, i.e. those which are strengthened by heat treatment.

Thus the letters NR indicate non-heat-treatable alloys in the form of rivet stock. The letters HT refer to heat-treatable alloys in the form of drawn tube.

c. Condition. Suffix letters have been used to indicate the temper or condition of heat treatment in which the materials are available. These symbols are as follows for aluminium and the non-heat-treatable alloys :—

O Material in the annealed condition.
OD Material which has been annealed and lightly drawn (at present applicable only to rivet stock).

¼ H, ½ H, ¾ H, H	The various harder tempers in the case of sheet and strip, plate, drawn tube, wire and rivet stock.
M	Material in the 'as manufactured' conditions, e.g. as rolled, as extruded, straightened and/or drawn to size, or as forged in the case of forgings.

For the heat-treatable alloys, the suffix letters have the following significance :—

O	Material in the annealed condition.
M	Material in the 'as manufactured' conditions, e.g. as rolled, as extruded, straightened and/or drawn to size, or as forged, without subsequent heat treatment of any kind.
OD	Material which has been annealed and lightly drawn (at present applicable only to rivet, bolt and screw stock).
T	Material which has been solution-treated and requires no precipitation treatment.
W	Material which has been solution-treated and will respond effectively to precipitation treatment.
WP	Material which has been solution-treated and precipitation-treated.
WD	Material which has been drawn after solution treatment (at present applicable only to wire).
P	Material which has been precipitation-treated only.

d. Numerical classification. The different grades of pure aluminium and the aluminium alloys are listed under numbers, and the same number has been used to indicate any given grade of pure aluminium or aluminium alloy in whatever wrought form it may be obtainable.

Aluminium of 99·99 per cent purity has been given the classification 1, whilst the three other grades of pure aluminium have been identified by the suffix letters A, B and C.

e. Examples. The following are examples of the nomenclature specified above :—

TIC-H	indicates pure aluminium of grade 1C, in the form of drawn tube, in the hard condition.
NT5-½H	indicates non-heat-treatable alloy No. 5 in the form of drawn tube in the half-hard temper.
HT30-WP	indicates heat-treatable aluminium alloy No. 30, in the form of drawn tube, which has been solution-treated and precipitation-treated.

WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS FOR GENERAL ENGINEERING PURPOSES

SUMMARY OF CHEMICAL COMPOSITIONS

Material	Aluminium min.	Copper min.	Copper max.	Magnesium min.	Magnesium max.	Silicon min.	Silicon max.	Iron min.	Iron max.	Manganese min.	Manganese max.	Nickel min.	Nickel max.	Zinc‖ max.	Lead‖ max.	Tin‖ max.	Titanium etc.* (optional) max.	Chromium min.	Chromium max.	Anti-‖ mony max.
	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
1	99·99	†See below		—	—	†See below		†See below		—	—	—	—	—	—	—	—	—	—	—
¶1A	99·8	—	0·02	—	—	—	0·15	—	0·15	—	—	—	—	—	—	—	—	—	—	—
¶1B	99·5	—	0·05	—	—	—	0·3	—	0·4	—	0·05	—	—	—	—	—	—	—	—	—
¶1C	99·0	—	0·10	—	—	—	0·5	—	0·7	—	0·1	—	—	0·10	—	—	—	—	—	—
N2	remainder	—	0·10	—	‖0·25	10·0	13·0	—	0·6	—	0·5	—	‖0·2	0·2	0·05	0·05	—	—	—	—
N21	remainder	—	0·10	—	‖0·25	4·5	6·0	—	0·6	—	0·5	—	‖0·2	0·2	0·05	0·05	—	—	—	—
N3	remainder	—	0·15	—	—	—	0·6	—	0·7	1·0	1·5	—	—	0·1	—	—	0·20	—	—	—
¶N4	remainder	—	0·10	1·8	2·7	—	0·6	—	0·7	—	0·5	—	—	0·1	—	—	0·20	—	0·5	—
¶N5	remainder	—	0·10	3·0	4·0	—	0·6	—	0·7	—	1·0	—	—	0·1	—	—	0·20	—	0·5	—
¶N6	remainder	—	0·10	4·5	5·5	—	0·6	—	0·7	—	1·0	—	—	0·1	—	—	0·20	—	0·5	—
N5/6	remainder	—	0·10	3·5	5·5	—	0·6	—	0·7	—	1·0	—	—	0·1	—	—	0·20	—	0·5	—
¶N7	remainder	—	0·10	6·5	7·5	—	0·6	—	0·7	—	0·5	—	—	0·1	—	—	0·20	—	0·5	—
¶H9	remainder	—	0·10	0·4	0·9	0·3	0·7	—	0·6	—	0·5	—	—	0·1	—	—	0·20	—	0·5	—
¶H10	remainder	—	0·10	0·4	1·5	0·60	1·3	—	0·6	—	0·6	—	—	0·1	—	—	0·20	—	—	—
¶H20	remainder	0·15	0·40	0·8	1·2	0·4	0·8	—	0·7	‡0·2	0·8	—	—	0·2	—	—	0·20	—	0·5	—
¶H30	remainder	—	0·10	0·4	1·5	0·60	1·3	—	0·6	0·40	1·0	—	—	0·1	—	—	0·20	‡0·15	0·35	—
H11	remainder	1·0	2·0	0·5	1·2	0·8	1·3	—	0·7	—	1·0	—	‖0·2	0·2	0·05	0·05	0·3	—	—	0·05
H12	remainder	1·8	2·8	0·6	1·2	0·5	1·3	0·6	1·2	—	0·5	0·6	1·4	0·2	0·05	0·05	0·3	—	—	0·05
¶H14	remainder	3·5	5·0	0·4	1·2	—	0·7	—	0·7	0·4	1·2	—	‖0·2	0·2	0·05	0·05	§0·3	—	§0·3	0·05
¶H15	remainder	3·5	4·8	—	0·85	—	0·90	—	1·0	—	1·2	—	‖0·2	0·2	0·05	0·05	§0·3	—	§0·3	0·05
H18	remainder	1·8	2·7	1·2	1·6	—	1·3	0·6	1·2	—	‖0·2	0·6	1·4	0·2	0·05	0·05	0·3	—	—	0·05

* Titanium and/or other grain refining elements may be present at the option of the supplier provided the total content does not exceed 0·20 or 0·3 per cent according to the specification.
† The combined copper, silicon and iron content shall not exceed 0·01 per cent.
‡ Either manganese within the limits stated or chromium within the limits stated shall be included.
§ Titanium and/or other grain refining elements and/or chromium may be present at the option of the supplier provided the total content does not exceed 0·3 per cent.
‖ The supplier shall undertake that the material does not contain impurities in excess of the amount shown.
¶ These materials are covered by this standard for drawn tube.

¼ H, ½ H, ¾ H, H	The various harder tempers in the case of sheet and strip, plate, drawn tube, wire and rivet stock.
M	Material in the ' as manufactured ' conditions, e.g. as rolled, as extruded, straightened and/or drawn to size, or as forged in the case of forgings.

For the heat-treatable alloys, the suffix letters have the following significance :—

O	Material in the annealed condition.
M	Material in the ' as manufactured ' conditions, e.g. as rolled, as extruded, straightened and/or drawn to size, or as forged, without subsequent heat treatment of any kind.
OD	Material which has been annealed and lightly drawn (at present applicable only to rivet, bolt and screw stock).
T	Material which has been solution-treated and requires no precipitation treatment.
W	Material which has been solution-treated and will respond effectively to precipitation treatment.
WP	Material which has been solution-treated and precipitation-treated.
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Aluminium of 99·99 per cent purity has been given the classification 1, whilst the three other grades of pure aluminium have been identified by the suffix letters A, B and C.

e. Examples. The following are examples of the nomenclature specified above :—

TIC-H indicates pure aluminium of grade 1C, in the form of drawn tube, in the hard condition.

NT5-½H indicates non-heat-treatable alloy No. 5 in the form of drawn tube in the half-hard temper.

HT30-WP indicates heat-treatable aluminium alloy No. 30, in the form of drawn tube, which has been solution-treated and precipitation-treated.

See Amdt 2.

WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS FOR GENERAL ENGINEERING PURPOSES

SUMMARY OF CHEMICAL COMPOSITIONS See Amdt 1 page 7.

Material	Aluminium	Copper		Magnesium		Silicon		Iron		Manganese		Nickel		Zinc‖	Lead‖	Tin‖	Titanium etc.* (optional)	Chromium		Anti-‖mony
	min.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	max.	max.	max.	max.	min.	max.	max.
	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
1	99·99	†See below		—	—	†See below		†See below		—	—	—	—	—	—	—	—	—	—	—
¶1A	99·8	—	0·02	—	—	—	0·15	—	0·15	—	—	—	—	—	—	—	—	—	—	—
¶1B	99·5	—	0·05	—	—	—	0·3	—	0·4	—	0·05	—	—	—	—	—	—	—	—	—
¶1C	99·0	—	0·10	—	—	—	0·5	—	0·7	—	0·1	—	—	0·10	—	—	—	—	—	—
N2	remainder	—	0·10	—	‖0·25	10·0	13·0	—	0·6	—	0·5	—	‖0·2	0·2	0·05	0·05	—	—	—	—
N21	remainder	—	0·10	—	‖0·25	4·5	6·0	—	0·6	—	0·5	—	‖0·2	0·2	0·05	0·05	—	—	—	—
N3	remainder	—	0·15	—	—	—	0·6	—	0·7	1·0	1·5	—	—	0·1	—	—	0·20	—	—	—
¶N4	remainder	—	0·10	1·8	2·7	—	0·6	—	0·7	—	0·5	—	—	0·1	—	—	0·20	—	0·5	—
¶N5	remainder	—	0·10	3·0	4·0	—	0·6	—	0·7	—	1·0	—	—	0·1	—	—	0·20	—	0·5	—
¶N6	remainder	—	0·10	4·5	5·5	—	0·6	—	0·7	—	1·0	—	—	0·1	—	—	0·20	—	0·5	—
N5/6	remainder	—	0·10	3·5	5·5	—	0·6	—	0·7	—	1·0	—	—	0·1	—	—	0·20	—	0·5	—
¶N7	remainder	—	0·10	6·5	7·5	—	0·6	—	0·7	—	0·5	—	—	0·1	—	—	0·20	—	0·5	—
¶H9	remainder	—	0·10	0·4	0·9	0·3	0·7	—	0·6	—	0·5	—	—	0·1	—	—	0·20	—	—	—
¶H10	remainder	—	0·10	0·4	1·5	0·60	1·3	—	0·6	—	0·6	—	—	0·1	—	—	0·20	—	0·5	—
¶H20	remainder	0·15	0·40	0·8	1·2	0·4	0·8	—	0·7	‡0·2	0·8	—	—	0·2	—	—	0·20	‡0·15	0·35	—
¶H30	remainder	—	0·10	0·4	1·5	0·60	1·3	—	0·6	0·40	1·0	—	—	0·1	—	—	0·20	—	0·5	—
H11	remainder	1·0	2·0	0·5	1·2	0·8	1·3	—	0·7	—	1·0	—	‖0·2	0·2	0·05	0·05	0·3	—	—	0·05
H12	remainder	1·8	2·8	0·6	1·2	0·5	1·3	0·6	1·2	—	0·5	0·6	1·4	0·2	0·05	0·05	0·3	—	—	0·05
¶H14	remainder	3·5	5·0	0·4	1·2	—	0·7	—	0·7	0·4	1·2	—	‖0·2	0·2	0·05	0·05	§0·3	—	§0·3	0·05
¶H15	remainder	3·5	4·8	—	0·85	—	0·90	—	1·0	—	1·2	—	‖0·2	0·2	0·05	0·05	§0·3	—	§0·3	0·05
H18	remainder	1·8	2·7	1·2	1·6	—	1·3	0·6	1·2	—	‖0·2	0·6	1·4	0·2	0·05	0·05	0·3	—	—	0·05

* Titanium and/or other grain refining elements may be present at the option of the supplier provided the total content does not exceed 0·20 or 0·3 per cent according to the specification.
† The combined copper, silicon and iron content shall not exceed 0·01 per cent.
‡ Either manganese within the limits stated or chromium within the limits stated shall be included.
§ Titanium and/or other grain refining elements and/or chromium may be present at the option of the supplier provided the total content does not exceed 0·3 per cent.
‖ The supplier shall undertake that the material does not contain impurities in excess of the amount shown.
¶ These materials are covered by this standard for drawn tube.

NOTE. The figures in British measures are to be regarded as the standard. The metric figures for linear dimensions and weight are approximate equivalents and are given only for the guidance of users in countries in which the metric system has been generally adopted. To determine a more precise metric equivalent, the appropriate conversion factor should be used. See B.S. 350, 'Conversion factors and tables'.

SPECIFICATION

SCOPE

1. This British Standard specifies requirements for drawn tube made from three grades of aluminium and from ten aluminium alloys in various conditions.

SECTION ONE : GENERAL CLAUSES

DEFINITIONS

2. For the purposes of this British Standard, the following definitions shall apply :—

Purchaser — The party, whether user, retailer, wholesaler or corporate body, or their agent(s) as appropriate, responsible for ordering the material standardized.

Heat-treatment batch — A quantity of material of one alloy, of the same dimensions and produced in the same way, solution-treated and subsequently precipitation-treated in one furnace load. It is permissible to heat-treat more than one batch in the same furnace load.

FREEDOM FROM DEFECTS

3. The tubes shall be seamless and straight and free from harmful defects.

TOLERANCES

4. The tubes shall be of the dimensions shown in Tables 1, A and B, subject to the tolerances shown in that table.

SELECTION OF TEST SAMPLES

5. *a. Tubes of pure aluminium or non-heat-treatable aluminium alloys.* The tubes of the same dimensions, produced in the same way and of the same composition, shall be grouped in parcels.

The supplier shall sample each parcel at such a rate that he can, on the results of the mechanical tests on the samples, certify that the material conforms to this specification.

Before the test samples are cut off, they shall be marked to identify them with the parcel they represent.

The test samples shall be taken from the tubes as supplied and shall not be annealed or mechanically worked (except by machining to the shape of the test piece) before they are tested.

b. Tubes of heat-treatable aluminium alloys. One test sample shall be cut from a tube selected from each heat-treatment batch. Before any of the test samples are cut off, they shall be marked to identify them with

the heat-treatment batch they represent.

For materials supplied in the M condition, the test samples shall be tested in the M, T, W or WP condition, as specified by the purchaser. The test samples shall not be mechanically worked (except by straightening and machining to the shape of the test piece) before they are tested.

Material in the M condition can be expected to have the mechanical properties of the T, W and WP conditions on appropriate heat treatment.

For material supplied in the W condition, the test samples shall be tested in the condition as supplied unless the purchaser has specified that he requires the test samples to be tested in the WP condition. The test samples shall not be mechanically worked (except by machining to the shape of the test piece) before they are tested.

For material supplied in the T or WP condition, the test samples shall be tested in the condition as supplied. The test samples shall not be further heat-treated or mechanically worked (except by machining to the shape of the test piece) before they are tested.

MECHANICAL TESTS

6. The following tests shall be made on test pieces prepared from test samples selected as specified in Sub-clauses 5 *a* and *b*.

(i) *Tensile test.* The tensile test shall be made in accordance with B.S. 18, 'Tensile testing of metals'. Where possible the tensile test shall be made on a length of the tube with the ends either flattened or suitably plugged for gripping. The effective unflattened or unplugged length shall be not less than 4 in. and the elongation shall be measured on a gauge length of 2 in. or $4\sqrt{A}$.

Alternatively the test shall be made on a test piece of the dimensions of British Standard test piece A cut from the test sample and having a gauge length 2 in. or $4\sqrt{A}$. (See Appendix A, 'Dimensions of tensile test pieces'.)

(ii) 0·1 *per cent proof stress.* The 0·1 per cent proof stress is defined as the stress (load divided by the original area of cross-section of a test piece) which is just sufficient to produce, under load, a non-proportional elongation equal to 0·1 per cent of the original gauge length.

The proof stress shall be determined as specified in B.S. 18 (see Appendix B).

(iii) *Flattening test.* A test piece not less than 2 in. long, cut from each selected tube shall be flattened until the interior surfaces of the tube meet.

RE-TESTS

7. Should any one of the test pieces first selected fail to pass the mechanical tests, two further samples from the same parcel shall be selected for testing, one of which shall be from the tube from which the