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BRITISH STANDARD 1476 : 1955

Revised 1963

WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS

BARS, RODS AND SECTIONS

BRITISH STANDARDS INSTITUTION

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BRITISH STANDARD SPECIFICATION

WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS

For General Engineering Purposes

BARS, RODS & SECTIONS

B.S. 1476 : 1955

REVISED PRICE 7/-
Price 6/- net

BRITISH STANDARDS INSTITUTION
INCORPORATED BY ROYAL CHARTER
BRITISH STANDARDS HOUSE, 2 PARK ST., LONDON, W.1
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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 22nd 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 aluminium alloys.
B.S. 1957. Presentation of numerical values (fineness of 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)5874

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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 :—

*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 Section)
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

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BRITISH STANDARD SPECIFICATION FOR

WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS

FOR GENERAL ENGINEERING PURPOSES

BARS, RODS AND SECTIONS

FOREWORD

This British Standard for bars, rods and sections, 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 applies only to solid bars, rods and sections.

Other British Standards in the revised series are :—

B.S. 1470 Sheet and strip.
B.S. 1471 Drawn tube.
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. 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 two new materials have been included, namely : 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 and material H9 has been included in the ' precipitation-treated P ' condition which was previously only applicable to castings.

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, N7 in the ' as manufactured ' condition are now given ' for information only ' and to indicate this the figures are printed in italics. The tolerance tables have been expanded to include additional sizes. As in the earlier edition, major alloying elements are printed in heavy type throughout Section Two.

An additional appendix concerning proof stress measurement has been included.

The whole standard has been redrafted 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 NE indicate non-heat-treatable alloys in the form of bars, rods or sections. The letters HP refer to heat-treatable alloys in the form of plate.

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).

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WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS FOR GENERAL ENGINEERING PURPOSES

SUMMARY OF CHEMICAL COMPOSITIONS

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.
	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	†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	5·5	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	—	—
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	—	—
¶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
¶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
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	—	—

* 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 bars, rods and sections.

¼H, ½H, ¾H, 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 :—

EIC-M — indicates pure aluminium of grade 1C, in the form of bars, rods or sections, in the 'as manufactured' condition.

NE5-M — indicates non-heat-treatable alloy No. 5 in the form of bars, rods or sections, in the 'as manufactured' condition.

HE30-WP — indicates heat-treatable aluminium alloy No. 30 in the form of bars, rods or sections, which has been solution-treated and precipitation-treated.

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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.

SPECIFICATION

SCOPE

1. This British Standard specifies requirements for solid bars, rods and sections made from three grades of aluminium, and from eleven 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 in one furnace load, or such material so 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 material shall be sound and free from harmful defects.

TOLERANCES

4. *a. Regular sections.* The dimensional tolerances for regular sections shall comply with the following tables unless otherwise specified by the purchaser the wider tolerances shall apply :—

Table 1. Tolerances (Classes A and B) for round bar.
Table 2. Tolerances for hexagon bar for nuts and bolts.
Table 3. Tolerances on overall widths and widths across flats (for regular sections and solid bar up to 12·999 in. wide (other than bar covered by Tables 1 and 2).
Table 4. Tolerances on thickness for regular sections and solid bar up to and including 8 in. thick (other than bar covered by Tables 1 and 2).

Tolerances for bars and sections of dimensions larger than those covered by Tables 3 and 4 shall be subject to agreement between the supplier and the purchaser.

Regular sections shall include square and rectangular bars, angles, T sections, I beams, H sections, Z sections, and any other normal types

of sections which can conveniently be divided into approximate rectangles with measurable dimensions.

For purposes of tolerances, any such section shall be divided into a series of equivalent rectangles—an angle, for example, being divided into two rectangles. For the purpose of determining tolerances on thickness and width, the widths of each such rectangle shall be the same as the major linear dimension of the angle, and the tolerance on thickness of each leg of the angle shall be taken as if that leg were a rectangle of the same overall dimension.

b. Sections of complicated shape. Complicated sections shall be regarded as those sections which are not covered by Tables 1 to 4. In such cases, the tolerances shall be agreed between the supplier and the purchaser. The tolerances shall be based, as far as possible, on those for regular sections.

c. Sections for which specially close tolerances are required. Additional manufacturing operations are necessary where specially close tolerances are required, and such tolerances shall be agreed between the supplier and the purchaser.

d. Tolerances for concavity and convexity, twist and straightness. All bars and sections shall be supplied straightened and reasonably free from twist. Special tolerances for straightness, twist, or surface flatness shall be the subject of agreement between the supplier and the purchaser.

e. Angular tolerance. The tolerances on angles of regular sections measured at the extremities of the section shall be as follows :—

Thickness of thinnest leg	Allowable deviation from angle specified
in.	±
Up to and including 0·199	2°
0·200 up to and including 0·749	1½°
0·750 and above	1°

Tolerances on angles of other sections shall be as agreed between supplier and purchaser.

SELECTION OF TEST SAMPLES

5. *a. Bars, rods and sections of pure aluminium or the non-heat-treatable aluminium alloys.* Bars, rods and sections of the same dimensions, produced in the same way, and of the same composition, shall be grouped into parcels as follows :—

Material up to and including ⅜ in. diameter or equivalent cross-section—½ ton of material.

Material over ⅜ in. and up to and including ¾ in. diameter or equivalent cross-section—1 ton of material.

Material over ¾ in. and up to and including 2 in. diameter or equivalent cross-section—1½ tons of material.

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Material over 2 in. diameter or equivalent cross-section—2 tons of material.

One test sample shall be cut from a bar, rod or section selected from each parcel.

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 material as supplied, and shall not be annealed or mechanically worked (except by straightening and machining to the shape of the test piece) before they are tested.

b. Bars, rods and sections of heat-treatable aluminium alloys. Bars, rods and sections of the same dimensions, produced in the same way and of the same composition, shall be grouped into parcels as follows :—

Material up to and including ⅜ in. diameter or equivalent cross-section—1 ton of material, or a heat-treatment batch, whichever is the lesser.

Material over ⅜ in. diameter or equivalent cross-section—2 tons of material, or a heat-treatment batch, whichever is the lesser.

One test sample shall be cut from a bar selected from each parcel.

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

For materials supplied in the M or O condition, the test samples shall either be tested as supplied or be heat-treated and tested in the T, W or WP condition, as specified by the purchaser. The test samples, after heat treatment, 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 or O 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 in the straightened and stretched condition, unless the purchaser has specified that he requires the test sample to be tested in the WP condition. The test samples shall not be mechanically worked (except by straightening and machining to the shape of the test piece) before they are tested.

For materials in the T, P 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 straightening and 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 *5a* 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

piece shall be of the dimensions of either the British Standard round test piece shown in the appendix, or British Standard test piece A (see Appendix A).

If the bars, rods or sections are too small for either of the above test pieces to be obtained, the test pieces shall be machined to the largest possible dimensions having the same geometrical proportions as the round test piece, or, if the supplier desires, the bars, rods or sections may be tested in full section with a gauge length of 2 in. or $4\sqrt{A}$.

(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).

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 bar, rod or section from which the original test sample was taken, unless that bar, rod or section has been withdrawn by the supplier.

For heat-treatable alloys the supplier shall have the right if he so desires, to re-heat-treat the material before the two further samples are selected.

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

CERTIFICATE OF COMPLIANCE

8. The supplier shall certify that the material complies with the requirements of the standard.

INSPECTION

9. If the purchaser wishes to inspect the material at the supplier's works he shall notify the supplier at the time of placing the order.

INDEPENDENT TEST

10. Should there be a dispute about the compliance of the material with 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. If the material does not comply with the standard, the

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