BRITISH STANDARD

BS 215-1: 1970

Specification for

Aluminium conductors and aluminium conductors, steel-reinforced —

For overhead power transmission —

Part 1: Aluminium stranded conductors

UDC 621.315.55:669.71

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
Association of Consulting Engineers
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 Federation—High Conductivity Copper Group
British Non-ferrous Metals Research Association
Copper Development Association
Crown Agents for Oversea Governments and Administrations
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 Ltd.
Tin Research Institute
Zinc Development Association
Individual manufacturer

The Government department 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 Railways Board
Electricity Council, the Central Electricity Generating Board and the Area Boards in England and Wales
Institute of Iron & Steel Wire Manufacturers
Institute of Sheet Metal Engineering

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Contents

	Page
Co-operating organizations	Inside front cover
Foreword	ii
1 General	
1.1 Scope	1
1.2 Definitions	1
1.3 Standards for hard-drawn aluminium wire	1
2 Material	
3 Dimensions and constructions	
3.1 Standard sizes of wires	1
3.2 Standard sizes of aluminium stranded conductors	1
3.3 Joints in wires	1
3.4 Stranding	2
3.5 Completed conductor	2
4 Tests	
4.1 Selection of test samples	2
4.2 Place of testing	2
4.3 Tests	2
4.4 Certificate of compliance	2
Appendix A Notes on the calculation of Table 3	4
Appendix B Note on modulus of elasticity and coefficient of linear expansion	4
Appendix C Code names for standard aluminium stranded conductors	4
Appendix D Non-standard constructions	Inside back cover
Table 1 — Lay ratios for aluminium stranded conductors	2
Table 2 — Aluminium wires used in the construction of standard aluminium stranded conductors	3
Table 3 — Standard aluminium stranded conductors	3
Table 4 — Stranding constants	4

Foreword

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 6000, 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 205, *Glossary of terms used in electrical engineering.*

BS 2627, *Wrought aluminium for electrical purposes. Wire.*

This British Standard was first published as BS 215-1 in 1956; previously the requirements for aluminium stranded conductors were included together with those for steel-cored aluminium conductors, now covered by BS 215-2, in the one publication.

In this revision all dimensions are included in metric units and the requirements of the standard have been amended to conform substantially with those of IEC Publication 207, "Aluminium stranded conductors".

As a result there are a number of changes in the specification. Lay ratio is now defined as the ratio of the axial length of a complete turn of the helix to the external diameter of the helix instead of to the mean diameter of the helix as hitherto. The basis for calculating conductor breaking loads has been altered. Values of the moduli of elasticity quoted in an appendix are practical values obtained by test, which are considered to be of more practical significance than the calculated values formerly quoted.

In the course of metrication the sizes of standard conductors, of which the number has been restricted, have been maintained unchanged except for negligible differences due to the expression of wire diameters in millimetres. The sizes of conductors are designated by nominal aluminium areas (mm^2) in place of the formerly used nominal copper areas (in^2). For convenience the nominal aluminium areas have been taken as being numerically 1 000 times the previous nominal copper areas.

At the present time there is an increasing use of conductors of constructions other than those covered in this standard. To facilitate standardization of these constructions lay ratio limits and the appropriate stranding factors are included in an appendix.

Detailed requirements for aluminium wires are not included in this standard, but are specified in BS 2627, "Wrought aluminium for electrical purposes. Wire".

All stresses are quoted in terms of the hectobar (hbar[1)]).

Other British Standards dealing with aluminium conductors for overhead lines are listed below:

BS 215, *Aluminium conductors and aluminium conductors, steel-reinforced for overhead power transmission.*

BS 215-2, *Aluminium conductors, steel-reinforced.*

BS 3242, *Aluminium alloy stranded conductors for overhead power transmission.*

[1)] 1 hbar = 10 MN/m^2 = 10 N/mm^2.

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 to iv, pages 1 to 4, 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 General

1.1 Scope

Part 1 of this British Standard applies to aluminium stranded conductors for overhead power transmission.

1.2 Definitions

For the purposes of this Part of this British Standard the following definitions apply:

stranded conductor

a conductor consisting of seven or more aluminium wires of the same nominal diameter twisted together in concentric layers. When the conductor consists of more than one layer, successive layers are twisted in opposite directions

diameter

the mean of two measurements at right angles taken at the same cross section

direction of lay

the direction of lay is defined as right-hand or left-hand. With right-hand lay, the wires conform to the direction of the central part of the letter Z when the conductor is held vertically. With left-hand lay, the wires conform to the direction of the central part of the letter S when the conductor is held vertically

lay ratio

the ratio of the axial length of a complete turn of the helix formed by an individual wire in a stranded conductor to the external diameter of the helix

For other definitions reference should be made to BS 205[2)].

1.3 Standards for hard-drawn aluminium wire

1.3.1 Resistivity. The resistivity of aluminium wire depends upon its purity and its physical condition. For the purposes of this British Standard the maximum value permitted is 2.8264 μΩ cm at 20 °C, and this value shall also be used as the standard resistivity for the purpose of calculation.

1.3.2 Density. At a temperature of 20 °C the density of hard-drawn aluminium wire is to be taken as 2.703 g/cm^3.

1.3.3 Coefficient of linear expansion. The coefficient of linear expansion of hard-drawn aluminium is to be taken as 23×10^{-6}/°C.

1.3.4 Constant-mass temperature coefficient. At a temperature of 20 °C the "constant mass" temperature coefficient of resistance of hard-drawn aluminium wire, measured between two potential points rigidly fixed to the wire, is taken as 0.004 03/°C.

2 Material

The aluminium wires used in the construction of the conductor shall be material GIE in the H9 condition as specified in BS 2627[3)].

By agreement between the purchaser and the manufacturer a suitable grease may be applied to the centre wire, or additionally to wires in specific layers, evenly throughout the length of the conductor.

3 Dimensions and construction

3.1 Standard sizes of wires

The aluminium wires for the standard constructions covered by this specification shall have the diameters specified in Table 2.

3.2 Standard sizes of aluminium stranded conductors

3.2.1 The sizes of standard aluminium stranded conductors are given in Table 3.

3.2.2 The masses (excluding the mass of grease for corrosion protection) and resistances may be taken as being in accordance with Table 3.

3.3 Joints in wires

3.3.1 Conductors containing seven wires. There shall be no joints in any wire of a stranded conductor containing seven wires, except those made in the base rod or wire before final drawing.

3.3.2 Conductors containing more than seven wires. In stranded conductors containing more than seven wires, joints in individual wires are permitted in addition to those made in the base rod or wire before final drawing, but no two such joints shall be less than 15 m apart in the complete stranded conductor. Such joints shall be made by resistance or cold-pressure butt-welding. They are not required to fulfil the mechanical requirements for unjointed wires. Joints made by resistance butt-welding shall, subsequent to welding, be annealed over a distance of at least 200 mm on each side of the joint.

[2)] BS 205, "Glossary of terms used in electrical engineering".

[3)] BS 2627, "Wrought aluminium for electrical purposes. Wire".

Table 1 — Lay ratios for aluminium stranded conductors

1	2	3	4	5	6	7
Number of wires in conductor	Lay ratio					
	6-wire layer		12-wire layer		18-wire layer	
	min.	max.	min.	max.	min.	max.
7	10	14	—	—	—	—
19	10	16	10	14	—	—
37	10	17	10	16	10	14

3.4 Stranding

3.4.1 The wire used in the construction of a stranded conductor shall, before stranding, satisfy all the relevant requirements of this standard.

3.4.2 The lay ratio of the different layers shall be within the limits given in Table 1.

NOTE It is important to note that lay ratio is now defined as the ratio of the axial length of a complete turn of the helix formed by an individual wire in a stranded conductor to the *external* diameter of the helix.

3.4.3 In all constructions, the successive layers shall have opposite directions of lay, the outermost layer being right-handed. The wires in each layer shall be evenly and closely stranded.

3.4.4 In aluminium stranded conductors having multiple layers of wires, the lay ratio of any layer shall be not greater than the lay ratio of the layer immediately beneath it.

3.5 Completed conductor

The completed conductor shall be free from dirt, grit, excessive amounts of drawing oil and other foreign deposits.

4 Tests

4.1 Selection of test samples

4.1.1 Samples for the tests specified in **4.3**, shall be taken by the manufacturer before stranding, from not less than 10 % of the individual lengths of aluminium wire which will be included in any one consignment of stranded conductor.

One sample, sufficient to provide one test specimen for each of the appropriate tests, shall be taken from each of the selected lengths of wire.

4.1.2 Alternatively, when the purchaser states at the time of ordering that he desires tests to be made in the presence of his representative, samples of wire shall be taken from lengths of stranded conductor selected from approximately 10 % of the lengths included in any one consignment.

One sample, sufficient to provide one specimen for each of the appropriate tests, shall be taken from each of an agreed number of wires of the conductor in each of the selected lengths.

4.2 Place of testing

Unless otherwise agreed between the purchaser and the manufacturer at the time of ordering, all tests shall be made at the manufacturer's works.

4.3 Tests

The test samples taken under **4.1.1** shall be subjected to the following tests in accordance with BS 2627[4)] and shall meet the requirements of that standard:

Tensile test.

Wrapping test.

Resistivity test.

Test samples taken under **4.1.2** shall be subjected to the same tests, but in the case of the tensile test the tensile strength of the specimen shall be not less than 95 % of the appropriate minimum value specified in BS 2627[4)].

4.4 Certificate of compliance

When the purchaser does not call for tests on wires taken from the stranded conductor, the manufacturer shall, if requested, furnish him with a certificate giving the results of the tests made on samples taken in accordance with **4.1.1**.

[4)] BS 2627, "Wrought aluminium for electrical purposes. Wire".

Table 2 — Aluminium wires used in the construction of standard aluminium stranded conductors

1	2	3	4	5	1
Standard diameter	**Cross-sectional area of standard diameter wire**	**Mass per km**	**Standard resistance at 20 °C per km**	**Minimum breaking load for standard diameter wire**	**Standard diameter**
mm	mm^2	kg	Ω	N	mm
2.06	3.333	9.009	8.480	600	2.06
3.10	7.548	20.40	3.745	1 250	3.10
3.25	8.296	22.42	3.407	1 370	3.25
3.40	9.079	24.54	3.113	1 490	3.40
3.78	11.22	30.33	2.519	1 800	3.78
4.22	13.99	37.81	2.021	2 240	4.22
4.39	15.14	40.91	1.867	2 410	4.39
4.65	16.98	45.90	1.664	2 700	4.65

NOTE The values given in Columns 2 to 5 are given for information only.

Table 3 — Standard aluminium stranded conductors

1	2	3	4	5	6	7	1
Nominal aluminium area	**Stranding and wire diameter**	**Sectional area**	**Approximate overall diameter**	**Approximate mass per km**	**Calculated d.c. resistance at 20 °C per km**	**Calculated breaking load**	**Nominal aluminium area**
mm^2	mm	mm^2	mm	kg	Ω	kN	mm^2
22	7/2.06	23.33	6.18	64	1.227	3.99	22
50	7/3.10	52.83	9.30	145	0.541 9	8.28	50
60	7/3.40	63.55	10.20	174	0.450 5	9.90	60
100	7/4.39	106.0	13.17	290	0.270 2	16.00	100
150	19/3.25	157.6	16.25	434	0.182 5	25.70	150
200	19/3.78	213.2	18.90	587	0.134 9	32.40	200
250	19/4.22	265.7	21.10	731	0.108 3	40.40	250
300	19/4.65	322.7	23.25	888	0.089 16	48.75	300
400	37/3.78	415.2	26.46	1 145	0.069 44	63.10	400

NOTE 1 For the basis of calculation of this table, see Appendix A.
NOTE 2 The sectional area of a stranded conductor is the sum of the cross-sectional areas of the individual wires.
NOTE 3 Attention is drawn to the fact that the sectional areas of standard conductors covered by this specification are larger than the nominal aluminium areas by which they are identified; they should not be compared directly with conductors manufactured exactly to those nominal areas.

Appendix A Notes on the calculation of Table 3

A.1 Increase in length due to stranding. When straightened out, each wire in any particular layer of a stranded conductor, except the central wire, is longer than the stranded conductor by an amount depending on the lay ratio of that layer.

A.2 Resistance and mass of conductor. The resistance of any length of a stranded conductor is the resistance of the same length of any one wire multiplied by a constant, as set out in Table 4.

The mass of each wire in any particular layer of stranded conductor, except the central wire, will be greater than that of an equal length of straight wire by an amount depending on the lay ratio of that layer (see **A.1** above). The total mass of any length of an aluminium stranded conductor is, therefore, obtained by multiplying the mass of an equal length of straight wire by an appropriate constant, as set out in Table 4.

In calculating the stranding constants in Table 4, the mean lay ratio, i.e. the arithmetic mean of the relevant minimum and maximum values in Table 1, has been assumed for each layer.

A.3 Calculated breaking load of conductor. The breaking load of an aluminium stranded conductor containing not more than 37 wires, in terms of the strengths of the individual component wires, may be taken to be 95 % of the sum of the strengths of the individual aluminium wires calculated from the specified minimum tensile strength.

Table 4 — Stranding constants

1	2	3
Number of wires in conductor	Stranding constants	
	Mass	Electrical resistance
7	7.091	0.144 7
19	19.34	0.053 57
37	37.74	0.027 57

Appendix B Note on modulus of elasticity and coefficient of linear expansion

The practical moduli of elasticity given below are based on an analysis of the final moduli determined from a large number of short term stress/strain tests and may be taken as applying to conductors stressed between 15 % and 50 % of the breaking load of the conductor. They may be regarded as being accurate to within ± 300 hbar[5)].

Number of wires in conductor	Practical (final) modulus of elasticity	Coefficient of linear expansion/°C
	hbar[a]	
7	5 900	23.0×10^{-6}
19	5 600	23.0×10^{-6}
37	5 600	23.0×10^{-6}

NOTE These values are given for information only.

[a] 1 hbar = 10 MN/m^2 = 10 N/mm^2.

Appendix C Code names for standard aluminium stranded conductors

NOTE These code names are not an essential part of the standard. They are given for convenience in ordering conductors.

Nominal aluminium area	Stranding	Code name
mm2	mm	
22	7/2.06	MIDGE
50	7/3.10	ANT
60	7/3.40	FLY
100	7/4.39	WASP
150	19/3.25	HORNET
200	19/3.78	CHAFER
250	19/4.22	COCKROACH
300	19/4.65	BUTTERFLY
400	37/3.78	CENTIPEDE

[5)] 1 hbar = 10 MN/m^2 = 10 N/mm^2.

Appendix D Non-standard constructions

D.1 Lay ratios and stranding constants

1	2	3	4	5	6	7	8	9	10	11	12	13
Number of wires in conductor	Lay ratio										Stranding constants	
	6-wire layer		12-wire layer		18-wire layer		24-wire layer		30-wire layer		Mass	Electrical resistance
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.		
61	10	17	10	16	10	15	10	14	—	—	62.35	0.016 76
91	10	17	10	16	10	15	10	14	10	13	93.26	0.011 26

D.2 Calculated breaking load. The breaking load of an aluminium stranded conductor containing more than 37 wires, in terms of the strengths of the individual component wires, may be taken to be 90 % of the sum of the strengths of the individual aluminium wires calculated from the specified minimum tensile strength.

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