BS 3G 231 : 1997

Specification for

Conductors for general-purpose aircraft electrical cables and aerospace applications

Confirmed December 2009

ICS 49.060

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee ACE/6, Aerospace avionic, electrical and fibre-optic technology, upon which the following bodies were represented:

British Airways
British Cable Makers Confederation
British Rubber Manufacturers' Association
Civil Aviation Authority (Airworthiness Division)
Federation of the Electronics Industry
Ministry of Defence
Society of British Aerospace Companies

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Amendments issued since publication

Amd. No.	Date	Text affected

The following BSI references relate to the work on this standard:
Committee reference ACE/6
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Contents

Foreword

This British Standard has been prepared by Technical Committee ACE/6.

It is based on ISO 2635 : 1979, published by the International Organization for Standardization (ISO), and constitutes a revision of BS 2G 231 : 1990, which is superseded and withdrawn.

BS G 222 : 1976 was published before international agreement on ISO 2635 was achieved, and therefore differs slightly in its conductor requirements.

Future aerospace cable specifications will be cross-referred to BS G 231 for their conductor requirements.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Specification

1 Scope

This British Standard specifies dimensions and performance requirements for multi-strand circular conductors in two distinct conditions:

a) prior to application of insulation; and

b) after insulation, since processing during cable manufacture may change the conductor characteristics.

The conductors specified in this standard are for general-purpose aircraft electrical cables for aerospace applications over the nominal cross-sectional area range 0.1 mm^2 to 107 mm^2.

NOTE. This standard does not apply to conductors for fire-resistant cables, thermocouple extension cables or equipment wire.

2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Materials

3.1 Conductors shall be manufactured from unused materials that have been exposed only to processes essential to their manufacture and application.

3.2 Conductors shall be manufactured from materials shown in table 1.

3.3 Conductors in copper and high-strength copper alloy shall be unplated (code letter A), or tinned (code letter B), or silver-plated (code letter C) or nickel-plated (code letter D) in accordance with the individual cable specification. The thickness of the silver plating (code letter C) shall be at least 1.0 μm and the thickness of the nickel plating (code letter D) shall be at least 1.3 μm.

3.4 The plating materials shall conform to the appropriate requirements of clause **6**.

Table 1. Conductor material

Size	Material
28	High-strength copper alloy
26 and 24	High-strength copper alloy
22 to 0000	Copper

4 Construction

4.1 Strands shall be clean, bright and free from surface irregularities.

4.2 Conductors shall comprise the number and diameter of strands given in tables 2 and 3. Conductors shall be either concentric stranded as given in table 2 or rope stranded as given in table 3.

4.3 There shall be no kinks, joints or other irregularities in the complete conductor.

4.4 Joints in single strands shall be brazed or hard soldered. There shall be not more than one such joint in any 50 m of single strand. Joints in single strands shall be not within 300 mm of any other joint in the same layer.

5 Electrical resistance after insulation

5.1 The electrical resistance after insulation of concentric-stranded conductors shall conform to table 4.

5.2 The electrical resistance after insulation of rope-stranded conductors shall conform to table 3.

6 Tests

6.1 Tensile strength and elongation

6.1.1 *Method*

Use a tensile tester capable of 1 % accuracy, with jaw separation rates of 200 mm/min to 300 mm/min (copper) and 40 mm/min to 60 mm/min (copper alloy). For copper conductors, test single strands taken from the completed conductor. For copper alloy conductors, test the inner seven strands together to eliminate variance.

6.1.2 *Requirement*

Tensile strength and elongation at break of the conductor prior to insulation shall be as given in table 5, and after insulation shall be as given in table 6, based on an average of three tests. The initial jaw separation shall be 245 mm to 255 mm.

6.2 Mass per unit length

Weigh at least 1 m of conductor. The mass per unit length for each size shall be as given in tables 2 and 3.

6.3 Resistance

6.3.1 *Method*

Measure the electrical resistance of the conductor (in Ω) and correct to 20 °C using the following formula:

$$R_{20} = R_T \{1 + 0.003\,93^{1)} (20 - T)\}$$

where

T is the temperature of the conductor under test (in °C);

R_T is the resistance of sample at temperature T;

R_{20} is the resistance at 20 °C.

6.3.2 *Requirement*

The values calculated shall not exceed those given in tables 2 to 4.

6.4 Strand-plating continuity

6.4.1 *Method*

Take three strands not less than 150 mm in length from a conductor previously straightened by hand. Degrease the strands without causing damage then wipe, using a clean dry cloth. Ensure that any strands cleaned in this manner are not touched by hand. Immerse the strands for 30 s in a solution of sodium polysulfide of density 1.142 g/cm^3 at 20 °C, then wash carefully in distilled water. In addition immerse silver- and nickel-coated strands for 15 s in a hydrochloric acid solution of density 1.088 g/cm^3 at 20 °C and wash carefully in distilled water. Examine the strands under a magnification of × 30.

6.4.2 *Requirement*

No adherent or distinct black spots shall be observed. Any blackening occurring less than 15 mm from each end shall be disregarded.

6.5 Strand-plating adherence

6.5.1 *Method*

Take three strands not less than 150 mm in length from a conductor previously straightened by hand. Wind each strand around itself, using half the specimen length as a mandrel so as to form 10 adjacent turns. Examine the strands under a magnification of × 100.

6.5.2 *Requirement*

The plating shall not exhibit any detachment or cracks.

6.6 Strand-plating thickness

When measured by any approved method the thickness of silver and nickel plating shall conform to **3.3**.

NOTE. The corresponding mass of silver for a nominal 1.0 μm radial thickness is given in annex A.

Table 2. Concentric stranded conductors prior to insulation

Size	Code[1)]	Nominal cross-sectional area	Circular mil area[2)]		Stranding	Conductor diameter		Maximum electrical resistance at 20 °C		Mass per unit length (max.)
			min.	max.	Number/nominal diameter	min.	max.	Types A and C	Types B and D	
		mm^2			mm	mm	mm	Ω/km	Ω/km	g/m
28[3)]		0.10	179	198	19/0.08	0.37	0.43	233	252[4)]	0.87
26[3)]	001	0.15	282	307	19/0.10	0.46	0.53	147	157[4)]	1.45
24[3)]	002	0.25	396	424	19/0.15	0.55	0.62	102	108[4)]	2.00
22	004	0.4	627	699	19/0.15	0.70	0.80	56.4	58.9	3.31
20	006	0.6	1131	1226	19/0.20	0.95	1.05	31.3	32.3	5.80
18	010	1.0	1782	1900	19/0.25	1.20	1.30	19.9	20.4	9.00
16	012	1.2	2580	2722	19/0.30	1.45	1.55	13.7	14.0	12.9
14	020	2.0	3470	3700	37/0.25	1.68	1.82	10.2	10.5	17.5
12	030	3.0	5546	5836	37/0.32	2.12	2.28	6.18	6.31	27.6
10	050	5.0	8993	9361	37/0.40	2.70	2.90	3.93	4.00	44.3

[1)] For reference only (ISO 2635 code).

[2)] For reference only. The circular mil area (CMA) is equal to $1550.003\,D^2N$ where D is the diameter of the individual strands (in mm) of the conductor and N is the number of strands in the complete conductor.

The conductor cross-sectional area (in mm^2) is the sum of the cross-sectional areas of the component strands of the conductor and is equal to $5.067 \times 10^4 \times$ CMA.

[3)] High-strength copper alloy.

[4)] Not available in tin-plated, high-strength copper alloy. Silver-plated, high-strength copper alloy (code letter C) normally used instead.

[1)] 0.003 5 for copper alloy.

7 Packaging and labelling

7.1 Conductors conforming to this British Standard shall be uniformly wound onto reels or bobbins, or in coils, and shall be protected against damage and the ingress of moisture.

NOTE. The type of protection will vary according to the conductor plating and coil/reel geometry.

7.2 Each reel, bobbin or coil shall have a label firmly attached to it bearing the following details:

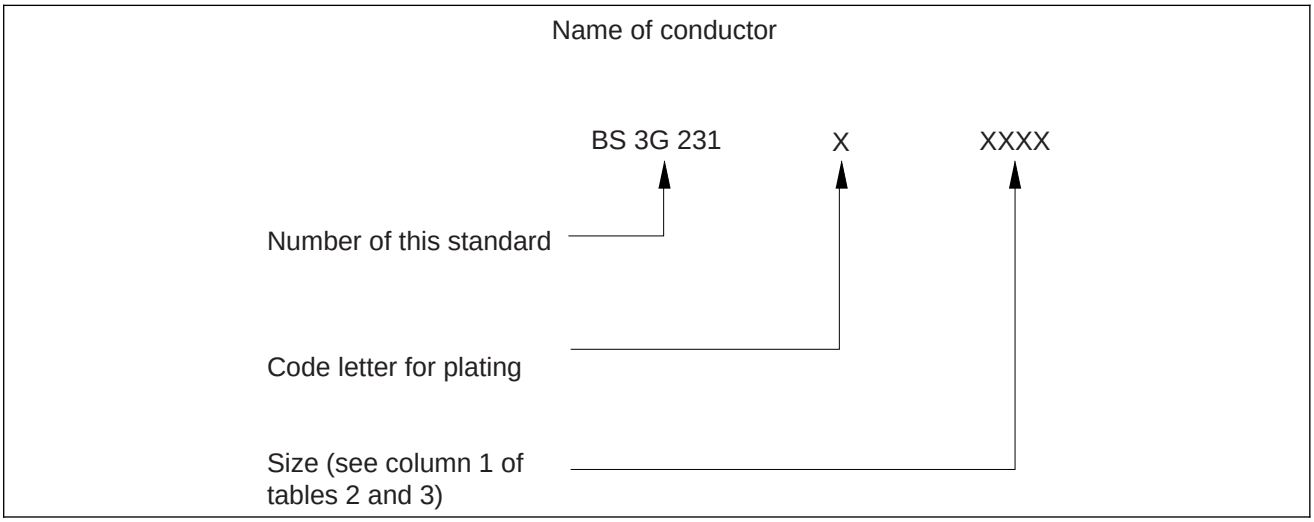

Table 3. Rope stranded conductors prior to insulation

Size	Code[1)]	Nominal cross-sectional area	Circular mil area[2)]		Stranding	Conductor diameter (max.)	Maximum electrical resistance at 20 °C		Mass per unit length (max.)
			min.	max.	Number/nominal diameter		Types A and C	Types B and D	
		mm^2			mm	mm	Ω/km	Ω/km	g/m
8	090	9	17273	18158	127 = 127/0.30	4.40	2.1	2.3	87
6	140	14	25705	27024	27 × 7 = 189/0.30	5.50	1.44	1.58	133
4	220	22	41937	44087	37 × 12 = 444/0.25	6.80	0.88	0.97	216
2	340	34	66400	69805	37 × 19 = 703/0.25	8.60	0.56	0.61	342
1	420	42	80379	84501	37 × 23 = 851/0.25	9.50	0.46	0.51	414
0	530	53	101348	106545	37 × 29 = 1073/0.25	10.70	0.36	0.40	522
00	680	68	129306	135937	37 × 37 = 1369/0.25	12.10	0.29	0.32	666
000	850	85	163215	171585	48 × 36 = 1728/0.25	13.60	0.23	0.25	841
0000	107	107	207418	218055	61 × 36 = 2196/0.25	15.20	0.18	0.20	1069

[1)] For reference only (ISO 2635 code).

[2)] For reference only. The circular mil area (CMA) is equal to $1550.003\,D^2N$ where D is the diameter of the individual strands (in mm) of the conductor and N is the number of strands in the complete conductor.

The conductor cross-sectional area (in mm^2) is the sum of the cross-sectional areas of the component strands of the conductor and is equal to $5.067 \times 10^4 \times$ CMA.

Table 4. Electrical resistance of concentric stranded conductors after insulation

Size	Code[1)]	Maximum electrical resistance at 20°C single core cables	
		Types A and C Ω/km	Types B and D Ω/km
28[2)]		242	263[3)]
26[2)]	001	153	164[3)]
24[2)]	002	106	113[3)]
22	004	58.6	61.3
20	006	32.5	33.6
18	010	20.6	21.2
16	012	14.3	14.6
14	020	10.4	10.7
12	030	6.30	6.44
10	050	4.01	4.08

[1)] For reference only (ISO 2635 code).

[2)] High-strength copper alloy.

[3)]Not available in tin-plated, high-strength copper alloy. Silver-plated, high-strength copper alloy (code letter C) normally used instead.

Table 5. Tensile strength and elongation at break of conductor prior to insulation

Strand diameter mm	Tensile strength min. N/mm^2	Tensile strength max. N/mm^2	Elongation min. %
Copper alloy 0.08 to 0.12	350 (for 7 strands)	—	6
Copper 0.08 to 0.12	220	300	11
0.15 to 0.40	220	300	12

Table 6. Tensile strength and elongation at break of conductor after insulation

Strand diameter mm	Tensile strength min. N/mm^2	Tensile strength max. N/mm^2	Elongation min. %
Copper alloy 0.08 to 0.12	350 (for 7 strands)	—	6
Copper 0.08 to 0.12	220	300	9
0.15 to 0.40	220	300	10

Annex

Annex A (normative)
Corresponding mass per unit length of silver for a nominal 1 μm radial thickness

The mass per unit length of silver corresponding to a nominal 1 μm radial thickness is given in table **A.1**.

Table A.1 Corresponding mass per unit length of silver for a nominal 1 μm radial thickness

Nominal diameter of strand mm	Mass per unit length of silver (min.) mg/m
0.08	2.7
0.10	3.3
0.12	3.9
0.15	5.0
0.20	6.6
0.25	8.3
0.30	9.9
0.32	10.5
0.40	13.2

blank

List of references (see clause 2)

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS G 222 : 1976	*Specification for Efglas type electric cables (metric units)*

ISO standards publications

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO), Geneva. (All publications are available from BSI sales.)

ISO 2635 : 1979	*Aircraft — Conductors for general purpose aircraft electrical cables and aerospace applications — Dimensions and characteristics*

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