BS EN 2235:2015

BSI Standards Publication

Aerospace series — Single and multicore electrical cables, screened and jacketed — Technical specification

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National foreword

This British Standard is the UK implementation of EN 2235:2015. It supersedes BS EN 2235:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/6, Aerospace avionic electrical and fibre optic techn.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Aerospace series - Single and multicore electrical cables, screened and jacketed - Technical specification

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Luft- und Raumfahrt - Ein- und mehradrige geschirmte und ummantelte elektrische Leitungen - Technische Lieferbedingungen

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

European foreword

This document (EN 2235:2015) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2016, and conflicting national standards shall be withdrawn at the latest by February 2016.

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1 Scope

This European Standard specifies the required characteristics, test methods, qualification and acceptance conditions of single and multicore cables, screened, jacketed and multicore jacketed cables for use in aircraft electrical systems.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 2083, *Aerospace series — Copper or copper alloy conductors for electrical cables — Product standard*

EN 2084, *Aerospace series — Cables, electrical, single-core, general purpose, with conductors in copper or copper alloy — Technical specification*

EN 3475-100 (all parts), *Aerospace series — Cables, electrical, aircraft use — Test methods — Part 100: General*

EN 3838, *Aerospace series — Requirements and tests on user-applied markings on aircraft electrical cables*

EN 4434, *Aerospace series — Copper or copper alloy lightweight conductors for electrical cables — Product standard (Normal and tight tolerances)*

EN 9133, *Aerospace series — Quality management systems — Qualification procedure for aerospace standard parts*

ISO 2574, *Aircraft — Electrical cables — Identification marking*

ISO 8815, *Aircraft — Electrical cables and cable harnesses — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8815 and EN 3475-100 apply.

4 Materials and construction of cables

4.1 General

The individual cores shall be qualified to EN 2083 or EN 4434, EN 2084 and the product standards.

4.2 Materials

The materials shall conform to the product standard.

4.3 Construction of cables

4.3.1 General

The permissible operating temperature of conductors shall not be lower than the maximum operating temperature of the cable as a whole.

4.3.2 Cabled cores

The lay length of the outer lay shall not be less than eight times and not more than 16 times the nominal diameter of the cabled cores.

The core shall not be spliced.

Where filler cores are used, this shall be specified in the product standard.

4.3.3 Screened cables

4.3.3.1 General

The individual strands used for the screen shall be free from kinks, loops or breaks; their surface shall be free from corrosion and other contamination. They shall satisfy the mechanical tests in EN 3475-505 to EN 3475-508 before use.

The screen shall be in contact with all the cabled cores.

Where spiral screening is used, the lay direction shall be contrary to that of the cabled cores.

4.3.3.2 Joints

Joints in the individual strands of the screen shall be made by soldering or by laying the individual strands together over a length of at least 10 mm.

There shall be no more than one joint per 3 m cable length (measured between different individual strands).

4.3.3.3 Braid screen pushback capability

In accordance with Table 1, test 6.48.

4.3.3.4 Angle of spiral screening or braiding

The angle γ of spiral screening or braiding (as shown in Figure 1), measured against the longitudinal axis of the cable shall be at least 10°.

4.3.3.5 Screen coverage

The screen shall have a coverage β of at least 90 % for spiral screening and at least 85 % for braiding.

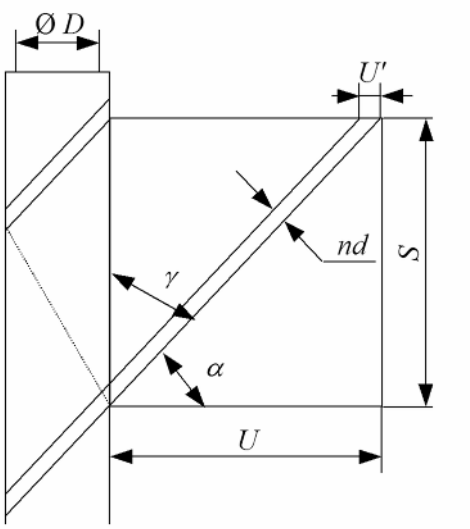

Figure 1 — Screen coverage

The cable covering is calculated using the following formula:

— for spirals:

$U = \pi\ (D + d)$ and $S = \pi\ (D + d)\ \tan\ \alpha$ $F = U'\ Z\ /\ U = n\ d\ Z\ /\ [\pi\ (D + d)\ \sin\ \alpha]$ $\beta = F \times 100\ (\%)$

— for braids:

$U = \pi\ (D + 2d)$ and $S = \pi\ (D + 2d)\ \tan\ \alpha$

— For spiral screen:

the maximum length T of the non-covered area is 2 mm, and

the relative aperture (versus lay length) of the screening 100 T/L shall be less than 5 %.

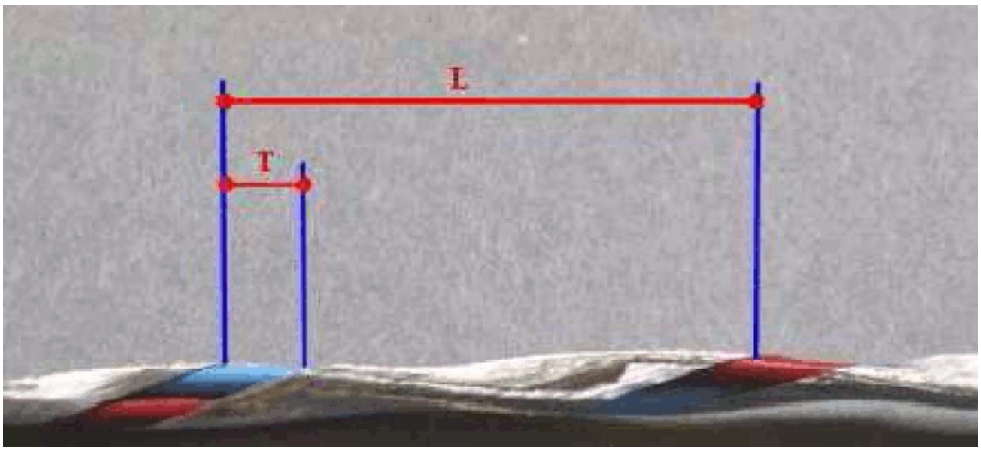

Figure 2

For braids, the filling factor F and coverage β, taking into account both braiding directions and a symmetrical braiding pattern are:

$$F = (U'/U)\,(Z/2) = \{n\,d / [\pi\,(D + 2d)\,\sin\,\alpha]\}\,(Z/2) \quad \text{and} \quad \beta = F\,(2 - F) \times 100\ (\%)$$

where

S = lay length of screen in mm;

D = diameter under screen in mm (for cables with 2 or more cores without fillers: $D = (\pi + N)\,b / \pi$);

d = diameter of screen strands in mm;

N = number of cores;

n = number of strands per carriers;

b = diameter of core in mm;

Z = total number of carriers;

F = filling factor;

β = optical coverage;

U = see Figure 1;

U' = $n\,d$ / sin α;

γ = strand angle;

α = $\pi/2 - \gamma$.

5 Required characteristics

The characteristics of the cables, tested according to the methods described hereafter shall comply with the values given in the product standard.

6 Tests methods

See Table 1.

Table 1 — Tests, methods, application, requirements *(1 of 4)*

§ No.	**Tests**							**Requirements** (and/or particulars)
	Description	**EN 3475-** (and/or particulars)	Qualification [a] (see 7.1).	First article (see 7.1.5)	**Each delivery**		Periodic every three years (7.2.4)	
					On all cables (7.2.1 and 7.2.2)	Prior to delivery (7.2.1 and 7.2.2)		
6	Test conditions	100	X	X	X	X	X	
6.1	Coverage		X	X		X		See 4.3.3.5.
6.2	Spiral screening or braiding angle		X	X			X	See 4.3.3.4.
6.3	Visual examination	201	X	X	X			Marking: according to Clause 8.

Table 1 — Tests, methods, application, requirements *(2 of 4)*

§ No.	Tests							Requirements (and/or particulars)
	Description	EN 3475- (and/or particulars)	Qualification a (see 7.1).	First article (see 7.1.5)	Each delivery		Periodic every three years (7.2.4)	
					On all cables (7.2.1 and 7.2.2)	Prior to delivery (7.2.1 and 7.2.2)		
6.4	Mass	202 minimum length: 0,5 m	X	X		X		Product standard
6.5	Dimensions (all) outer diameter	203	X	X	X	X		Product standard
6.6	Ohmic resistance per unit length	301	X	X		X		Product standard
6.7	Voltage proof test:	302						
	— immersion test;		X	X				500 V a.c.
	— dry test;				X			1 kV a.c.
	— dry impulse test;	Alternative to dry test	X	X	X			1,5 kV a.c. peak voltage
	— dielectric strength of cores.				X			1,5 kV a.c.
6.8	Insulation resistance at (20 ± 2) °C:	303	X	X				For a length of 1 km:
	— dry test;					X		1 500 MΩ
	— immersion test at (20 ± 2) °C.						X	500 MΩ
	at (95 ± 2) °C:						X	15 MΩ
	— immersion test						X	15 MΩ
6.9	Surface resistance	304	X					Minimum: 1 250 MΩ.mm
6.10	Overload resistance	305	Not applicable					
6.11	Continuity of conductors	306	X	X	X			
6.12	Corona extinction voltage	307	Not applicable					
6.13	Accelerated ageing	401 Mandrel diameter and test load: Table 2 Temperature: product standard	X				X	
6.14	Shrinkage and delamination	402 Temperature: product standard	X	X		X		Product standard
6.15	Delamination and blocking	403 Mandrel diameter: Table 2 Temperature: product standard	X	X		X		
6.16	Thermal shock	404 Product standard	X	X		X		Product standard
6.17	Bending at ambient temperature	405 Mandrel diameter: Table 2	X					

Table 1 — Tests, methods, application, requirements *(3 of 4)*

§ No.	Tests							Requirements (and/or particulars)
	Description	**EN 3475-** (and/or particulars)	Qualification a (see 7.1).	First article (see 7.1.5)	**Each delivery**		Periodic every three years (7.2.4)	
					On all cables (7.2.1 and 7.2.2)	Prior to delivery (7.2.1 and 7.2.2)		
6.18	Cold bend test	406 Mandrel diameter and test load: Table 2	X	X			X	
6.19	Flammability	407	X				X	Product standard
6.20	Fire resistance	408	Not applicable					
6.21	Air-excluded ageing	409	Not applicable					
6.22	Thermal endurance	410	Not applicable					
6.23	Resistance to fluids	411	1 per fluid				X	b
6.24	Humidity resistance	412	Not applicable					
6.25	Wrap back test	413	Not applicable					
6.26	Differential scanning calorimeter (DSC test)	414	Applicable for PTFE jackets only					
6.27	Rapid change of temperature	415	Not applicable					
6.28	Thermal stability	416	Not applicable					
6.29	Dynamic cut-through	501	Applicable single conductor only					
6.30	Notch propagation	502 Cut depth: product standard	X				X	
6.31	Scrape abrasion	503 Load: product standard	X					For screened only requirements to be considered at 20 °C unless otherwise specified
6.32	Torsion	504	Not applicable					
6.33	Tensile test on conductors and strands	505	X			X		Applicable on raw material and on finished cable
6.34	Plating continuity	506	X				X	Strands of screened cables Applicable on raw material and on finished cable
6.35	Adherence of plating	507	X				X	Strands of screened cables
6.36	Plating thickness	508	X				X	Strands of screened cables and product standard
6.37	Solderability	509	X			X		Product standard
6.38	Tensile strength and elongation of extruded insulation, sheath and jacket material	510	Not applicable					
6.39	Cable-to-cable abrasion	511	Not applicable					

Table 1 — Tests, methods, application, requirements *(4 of 4)*

§ No.	Tests							Requirements (and/or particulars)
	Description	**EN 3475-** (and/or particulars)	Qualification [a] (see 7.1).	First article (see 7.1.5)	**Each delivery**		Periodic every three years (7.2.4)	
					On all cables (7.2.1 and 7.2.2)	Prior to delivery (7.2.1 and 7.2.2)		
6.40	Flexure endurance	512	Not applicable					
6.41	Deformation resistance (Installation with plastic cable ties)	513	Not applicable					
6.42	Smoke density	601	X					Product standard
6.43	Toxicity	602	X					Product standard
6.44	Resistance to wet arc tracking	603	Not applicable					
6.45	Resistance to dry arc tracking	604	Not applicable					
6.46	Wet short circuit test	605	Not applicable					
6.47	Strippability and adherence of insulation to the conductor	701	X	X		X		
6.48	Braid screen pushback capability	702	X	X		X		
6.49	Permanence of manufacturer's marking	703	X			X		
6.50	Flexibility	704	Not applicable					
6.51	Permanence of user-applied marking	EN 3838	X				X	Product standard
	Contrast measurement	705 Laser parameters: 706	X			X		Product standard
6.52	Capacitance per unit length	801	X	X		X		
6.53	Capacitance unbalance (within one pair)	802	Not applicable					
6.54	Capacitance variation	803	Not applicable					
6.55	Velocity of propagation	804	Not applicable					
6.56	Characteristic impedance	805	Not applicable					
6.57	Attenuation	806	Not applicable					
6.58	Transfer impedance	807	X	X			X	
6.59	Cross-talk	808	Not applicable					

[a] Number of specimens per cross-section for each test unless otherwise specified.

[b] Single core screened cables of nominal cross-section 0,6 mm^2 only.

Table 2 — Mandrel diameter and test load

Code	Nominal cross-section of conductor mm^2	AWG [a]	Mandrel diameter mm	Test load N
001	0,15	26	12 times the maximum cable diameter	5
002	0,25	24		7
004	0,4	22		9
006	0,6	20		10
010	1	18		10
012	1,2	16		10
020	2	14		15
030	3	12		15
050	5	10		15

[a] AWG: Closest American Wire Gage.

7 Quality assurance

7.1 Qualification

7.1.1 General requirements

See EN 9133.

7.1.2 Qualification conditions

The cables shall be submitted for qualification tests on drums, spools or in coils in sufficient lengths, wound evenly and uniformly.

Each drum, spool or coil shall have a label containing information given in 9.1.

7.1.3 Qualification tests

See Table 1.

7.1.4 Extension of qualification

The qualification granted may be applicable to adjacent cross section in accordance with Tables 3 and 4.

Table 3 — Qualified cables and extension of qualification up to 4 conductors

Number of conductors	Qualified cables		Cables covered by the same qualification	
	Nominal cross-section mm^2	AWG [a]	Nominal cross-section mm^2	AWG [a]
3	0,15	26	0,25	24
3	0,25	24	0,15	26
1	0,6	20	0,4 to 1	22 to 18
2	2	14	1,2 to 5	16 to 10

[a] AWG: Closest American Wire Gage.

Table 4 — Qualified cables and extension of qualification from 5 conductors and above

Number of conductors	Qualified cables		Cables covered by the same qualification	
	Nominal cross-section mm^2	AWG [a]	Nominal cross-section mm^2	AWG [a]
5	0,15	24	0,15 to 5	26 to 10

[a] AWG: Closest American Wire Gage.

7.1.5 First article inspection

The first article inspection tests are to be carried out on all cable designs that were not included in the qualification demonstration. See Table 1.

7.2 Acceptance test

7.2.1 Required conditions

7.2.1.1 General

The acceptance tests shall be carried out on cables delivered against an order to check that the cable characteristics are maintained.

See Table 1.

7.2.1.2 Tests to be carried out on all cables

The cables which fail any of the tests specified in 7.2.1 shall be rejected.

7.2.1.3 Random sampling tests: retest

If any of the specimens fails one the tests specified in 7.2.3, that test shall be repeated on another set of specimens of the same cross-section selected at random from the same batch. If one of these new specimens fails the test, the batch submitted for acceptance shall be rejected.

7.2.2 Production routine tests

The tests shall be carried out on all cables delivered.

See Table 1.

7.2.3 Tests prior to delivery

They shall be carried out by sampling on each inspection batch.

See Table 1.

7.2.4 Periodic tests

They shall be carried out by sampling at least every three years in accordance with Table 1 by sampling from cables that have been manufactured and released within the last 6 months. Samples are to be included from each of the cable groups in Tables 3 and 4 that have been released.

8 Identification marking

Unless otherwise specified, a core or the jacket shall be marked indelibly with the type, cross section and a reference for identification of country of origin, manufacturer and year of manufacture in accordance with ISO 2574.

9 Packaging, labelling and delivery lengths

9.1 Packaging and labelling

Cables supplied on drums, spools or in coils shall be wound evenly and uniformly.

All cable ends shall be easily accessible and protected where necessary.

Each drum, spool or coil shall have a label indicating:

— manufacturer’s name and designation;

— cable designation according to the EN product standard;

— batch number;

— date of manufacture (month, year);

— inspector’s mark;

— total length and length of each piece of cable in metres from inside to outside.

9.2 Delivery lengths

They shall conform to Table 5 unless otherwise specified.

Table 5 — Delivery lengths

Nominal cross-section mm^2	**AWG** [a]	**Minimum acceptable continuous lengths**	
		for at least 85 % of cables delivered m	for not more than 15 % of cables delivered m
0,15 to 1	26 to 18	100	30
1,2 to 5	16 to 10	80	20

[a] AWG: Closest American Wire Gage.

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