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Railway applications - Railway rolling stock cables having special fire performance - Thin wall - Part 2: Single core cables

Applications ferroviaires - Câbles pour matériel roulant ferroviaire ayant des performances particulières de comportement au feu - Isolation mince - Partie 2: Câbles monoconducteurs

Bahnanwendungen - Kabel und Leitungen für Schienenfahrzeuge mit verbessertem Verhalten im Brandfall - Reduzierte Isolierwanddicken - Teil 2: Einadrige Kabel und Leitungen

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European Committee for Electrotechnical Standardization
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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (EN 50306-2:2020) has been prepared by CENELEC, "Electric cables".

The following dates are fixed:

- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-12-30
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) 2022-12-30

This document supersedes EN 50306-2:2002 and all of its amendments and corrigenda (if any).

This edition includes the following significant technical changes with respect to the previous edition:

- The documents have been updated to reflect the changes in the test standard EN 50305;
- The range of the conductor cross sections has been extended;
- The reference to cited standards (e.g. 60811 series) has been updated.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Introduction

The EN 50306 series covers a range of sheathed and unsheathed cables with thin wall thickness insulation, based on halogen-free materials, for use in railway rolling stock. It is divided into four parts:

- Part 1: General requirements;
- Part 2: Single core cables;
- Part 3: Single core and multicore cables screened and thin wall sheathed;
- Part 4: Multicore and multipair screened or not screened sheathed cables.

Special test methods referred to in the EN 50306 series are given in EN 50305. A guide to use is given in EN 50355 and rules for installation are given in EN 50343.

The cables in EN 50306-2:2020 are also required in other parts of this series of standards to build up cables with additional screening and sheathing and also in multicore and multipair combinations.

EN 50306-1:2020, General requirements, contains a more extensive introduction to the EN 50306 series and should be read in conjunction with this document.

1 Scope

This document specifies requirements for, and constructions and dimensions of, single core cables, rated voltage $U_0 / U = 300 / 300$ V, of the following type:

Unscreened (0,5 mm² to 2,5 mm² single core)

These cables are rated for occasional thermal stresses causing ageing equivalent to continuous operational life at a temperature of 105 °C. For standard cables, this is determined by the acceptance test defined in EN 50305, using accelerated long-term (5 000 h) thermal ageing indicating a 125 °C/20 000 h temperature index. If the customer were to require lifetime predictions, this would be demonstrated based on the temperature index of the product as supplied by the manufacturer. The maximum temperature for short circuit conditions is 160 °C based on duration of 5 s.

Under fire conditions the cables exhibit special performance characteristics in respect of maximum permissible flame propagation (flame spread) and maximum permissible emission of smoke and toxic gases. These requirements are specified to permit the cables to satisfy Hazard Level 3 of EN 45545-1 and EN 45545-2.

EN 50306-2:2020 is expected to be used in conjunction with EN 50306-1:2020, General requirements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10002-1, *Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature*

EN 45545-1, *Railway applications - Fire protection on railway vehicles - Part 1: General*

EN 50305:2020, *Railway applications - Railway rolling stock cables having special fire performance - Test methods*

EN 50306-1:2020, *Railway applications - Railway rolling stock cables having special fire performance - Thin wall - Part 1: General requirements*

EN 50334, *Marking by inscription for the identification of cores of electric cables*

EN 60332-1-2, *Tests on electric and optical fibre cables under fire conditions - Part 1-2: Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1 kW pre-mixed flame*

EN 60811 (all parts), *Electric and optical fibre cables - Test methods for non-metallic materials*

EN 61034-2, *Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements*

EN 62230, *Electric cables - Spark-test method*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Single-core cables

4.1 General

The cables shall conform to the applicable general requirements given in EN 50306-1:2020 and to the specific requirements of this Part 2.

Conformity with the requirements shall be checked by inspection and by the tests given in Table 4.

4.2 Marking and code designation

4.2.1 Marking of cable

Cables shall be marked with the following:

- Manufacturer's name;
- EN reference;
- Voltage rating (U_0);
- Conductor size;
- A code designation according for use of the cable (see 4.2.2).

For example:

XYZ EN 50306-2 300 V 1x1,5 M

The marking shall conform to the requirements of EN 50306-1:2020, Clause 5.

4.2.2 Code Designation

The following letters shall be used as a code to identify the suitability of a particular cable with the Hazard Level 3 of EN 45545-1, and to indicate performance levels relating to low temperature and to oil and fuel resistance:

Hazard Level EN 45545-1 HL3

- low temperature / oil resistance C
- extra low temperature / oil resistance F
- low temperature / extra oil and fuel resistance J
- extra low temperature / extra oil and fuel resistance M

4.3 Core identification

4.3.1 Single core cables

The colour of the cores shall be white unless otherwise specified in the particular sections.

The colour shall be clearly identifiable and durable. Durability shall be checked by the test given in 10.1 of EN 50305:2020.

Conformity with these requirements shall be verified by visual examination.

4.3.2 Multicore/multipair cables

Cores complying with EN 50306-2:2020 are used as components of multicore and multipair cables, e.g. in EN 50306-3:2020 or EN 50306-4:2020. In such cases the identification of the individual core in a cable or a pair shall be by numbers.

The numbers shall be printed in a colour, which contrasts with the core colour. The numbers on individual cores shall be spaced at a maximum of 25 mm apart.

The marking by numbers shall conform to EN 50334, unless otherwise specified, and conformity shall be checked by visual examination and measurement.

4.4 Rated voltage

The rated voltage recognized for the purposes of this standard shall be

$$U_0 / U = 300/300 \text{ V}$$

NOTE See EN 50355 and EN 50343 for further information.

4.5 Construction

4.5.1 Conductor

The conductor shall conform to the requirements given in Table 1. The wires shall be tin coated annealed copper.

When tested in accordance with EN 10002-1, the minimum elongation of conductors shall be 10 %.

4.5.2 Insulation system

The insulation system shall be manufactured from material as defined in 3.1 of EN 50306-1:2020 and shall meet the requirements of Clause 5 of this Part 2. The insulation shall be applied by extrusion. The insulation thickness shall conform to the specified value given in Table 1 and determined in accordance with EN 50306-1:2020, Annex A.

Table 1 — Requirements for construction

1 Conductor or nominal cross- section mm ²	2 Number x nominal diameter (indicative) of wire mm	3 Conductor diameter		4 Minimum thickness of insulation at any point mm	5 Overall diameter		6 Max. resistance of conductor at 20 °C Ω/km
		min.	max.		min.	max.	
		mm	mm		mm	mm	
0,5	19 × 0,18	0,80	0,95	0,18	1,15	1,45	40,1
0,75	19 × 0,22 37 × 0,16	0,95	1,15	0,18	1,35	1,65	26,7
1,0	19 × 0,26 37 × 0,18	1,05	1,30	0,18	1,40	1,80	20,0
1,5	19 × 0,30 37 × 0,23	1,40	1,60	0,22	1,90	2,30	13,7
2,5	19 × 0,40 37 × 0,30	1,80	2,00	0,28	2,45	2,85	8,21

5 Tests

5.1 Definitions relating to tests

The definition of Type (T), Sample (S) and Routine (R) tests is as given in EN 50306-1:2020, Clause 3.

NOTE Tests classified as Sample (S) or Routine (R) could be required as part of any approval schemes.

It is recommended for the type approval for the full range (or a restricted range) of cables given in Table 1 two cables should be tested, one with the minimum overall diameter and one with the maximum overall diameter of the range defined.

5.2 Voltage test

The test shall be carried out in accordance with EN 50305:2020, 6.2.1, using either an AC or DC voltage and the following conditions:

- sample length 20 m
- voltage (AC) 2 kV
- voltage (DC) 4,8 kV
- duration of application 5 min

- test temperature (20 ± 5) °C

At the conclusion of the test there shall be no breakdown of the insulation.

5.3 Insulation resistance

The test shall be carried out at 20 °C and at 90 °C in accordance with EN 50305:2020, 6.4.1 and 6.4.2.

The values obtained shall not be below those given in columns 2 and 3 of Table 2.

5.4 Dielectric strength

The test shall be carried out in accordance with EN 50305:2020, 6.8, using the following conditions:

- water temperature (20 ± 5) °C
- immersion duration 1 h
- minimum breakdown voltage (AC) 4 kV

At the conclusion of the test there shall be no breakdown below the minimum voltage.

5.5 Spark test

The test shall be carried out in accordance with EN 50305:2020, 6.5 and EN 62230, using one of the following conditions:

a) AC (50 Hz):

- < 0,25 mm tabulated insulation thickness 3,0 kV
- 0,25 mm ≤ 0,35 mm tabulated insulation thickness 4,0 kV

b) impulse:

- < 0,25 mm tabulated insulation thickness 8,0 kV
- 0,25 mm ≤ 0,35 mm tabulated insulation thickness 8,0 kV

c) DC:

- < 0,25 mm tabulated insulation thickness 4,5 kV
- 0,25 mm ≤ 0,35 mm tabulated insulation thickness 6,0 kV

d) High frequency:

- < 0,25 mm tabulated insulation thickness 4,5 kV
- 0,25 mm ≤ 0,35 mm tabulated insulation thickness 4,5 kV

5.6 DC stability

The test shall be carried out in accordance with EN 50305:2020, 6.7, using the following conditions:

- water temperature (85 ± 2) °C
- voltage test (DC) 300 V

— duration of immersion and application of voltage (240 ± 2) h

At the conclusion of the test there shall be no breakdown of the insulation.

5.7 Strippability and adhesion of insulation to the conductor

The tests shall be carried out in accordance with EN 50305:2020, 5.5.1 and 5.5.2.

The insulation shall strip easily from each end of the test specimen.

The force required to cause the conductor to slip inside the insulation shall be between the limits given in column 6 of Table 2.

Table 2 — Test requirements

1 Conductor nominal cross-section mm ²	2	3	4	5	6	
	Insulation resistance for 1 km at 20 °C min. MΩ	Insulation resistance for 1 km at 90 °C min. MΩ	Minimum load for dynamic cut-through N	Load on the needle for abrasion resistance N	Strippability force for adhesion of insulation to the conductor min. max. N	
0,5	600	0,30	60	6	7	45
0,75	500	0,25	60	7	8	60
1,0	500	0,25	65	8	12	70
1,5	400	0,20	80	9	15	90
2,5	400	0,20	100	11	25	150

5.8 Hot set test

NOTE This test is only applicable to cross-linked materials (see 3.1 of EN 50306-1:2020).

The test shall be carried out in accordance with EN 60811-507, using the following conditions:

- temperature (200 ± 3) °C
- time under load 15 min
- mechanical stress 20 N/cm²

The maximum elongation shall be:

- 100 % under load,
- 25 % after unloading.

5.9 Long term ageing - Thermal endurance

The test shall be carried out in accordance with EN 50305:2020, 5.3. The electrical failure of a given specimen, in accordance with EN 50305:2020, 7.2.4, shall be determined using a voltage test duration of 1 min.

The time to reach the end-point of the test shall be not less than 20 000 hours, when determined by extrapolation to a temperature of 125 °C.

5.10 Mineral oil resistance

The test shall be carried out in accordance EN 50305:2020, 8.1, using the following conditions:
treatment:

- type of oil IRM 902
- temperature (100 ± 2) °C
- duration 24 h

test after treatment

- 1,5 kV
- 49 Hz to 61 Hz
- duration 1 min

At the conclusion of the test there shall be no breakdown of the insulation.

5.11 Fuel resistance

The test shall be carried out in accordance with EN 50305:2020, 8.1, using the following conditions:
treatment:

- type of liquid IRM 903
- temperature (70 ± 2) °C
- duration 168 h

test after treatment

- 1,5 kV
- 49 Hz to 61 Hz
- duration 1 min

At the conclusion of the test there shall be no breakdown of the insulation.

5.12 Acid and alkali resistance

The test shall be carried out in accordance with EN 50305:2020, 8.2, using the following conditions:
treatment:

- type of acid: N-Oxalic acid solution
- type of alkali: N-Sodium hydroxide solution

EN 50306-2:2020 (E)

- temperature $(23 \pm 2) ^\circ\text{C}$
- duration 168 h

test after treatment

- 1,5 kV
- 49 Hz to 61 Hz
- duration 1 min

At the conclusion of the test there shall be no breakdown of the insulation.

NOTE Two separate tests are required; one in acid solution and one in alkali solution.

5.13 Pressure test at high temperature

The test shall be carried out in accordance with EN 50305:2020, 7.5, using the following conditions:

- temperature $(125 \pm 2) ^\circ\text{C}$
- weight as test method
- duration 4 h
- test after treatment 1,5 kV, 49 Hz to 61 Hz
- duration 1 min

At the conclusion of the test there shall be no breakdown of the insulation.

5.14 Dynamic cut through

The test shall be carried out in accordance with EN 50305:2020, 5.6, using the following conditions:

- temperature $(20 \pm 2) ^\circ\text{C}$
- rate of application of load 1 N/sec

The mean value, from the four measurements, of the load required to cut-through the insulation shall not be less than that given in column 4 of Table 2.

5.15 Notch propagation

The test shall be carried out in accordance with EN 50305:2020, 5.3, using a voltage test duration of 1 min.

At the conclusion of the test there shall be no breakdown of the insulation.

5.16 Heat Shrinkage

The test shall be carried out in accordance with EN 50305:2020, 7.6, using the following conditions:

- temperature $(150 \pm 2) ^\circ\text{C}$
- duration 1 h

At each end of the sample the insulation shrinkage shall not exceed 1,5 mm.

5.17 Blocking of cores

The test shall be carried out in accordance with EN 50305:2020, 1.5, using the following conditions:

- temperature $(150 \pm 2) ^\circ\text{C}$
- duration 6 h

At the conclusion of the test the cores shall easily separate from the mandrel and from each other, and there shall be no damage to their outer layer.

5.18 Bending test at low temperature

The test shall be carried out at $(-40 \pm 2) ^\circ\text{C}$ in accordance with EN 60811-504.

At the conclusion of the test there shall be no cracks in the insulation.

5.19 Abrasion resistance

The test shall be carried out in accordance with EN 50305:2020, 5.2.

The test shall be carried out with a load on the needle as given in column 5 of Table 2.

The mean number of cycles from the four measurements shall be greater than or equal to 150, with a minimum of 100 cycles for any individual measurement.

5.20 Pliability

The test shall be carried out in accordance with EN 50305:2020, 5.4, using the mandrel diameters and loads given in Table 3, and the following conditions:

preconditioning:

- temperature $(80 \pm 2) ^\circ\text{C}$
- load $1/2 \times$ maximum permitted applied load during test

storage:

- time 72 h
- temperature $(20 \pm 2) ^\circ\text{C}$
- relative humidity $(50 \pm 5) \%$

The angle after recoil shall not be greater than that given in Table 3.

Table 3 — Pliability test requirements

Conductor nominal cross-section mm ²	Mandrel diameter mm	Load (max.) N	Recoil angle (max.) degree
0,5	7	11	40
0,75	8	12	40
1,0	8	12	45
1,5	10	15	45
2,5	13	20	45

5.21 Ozone resistance

The test shall be carried out in accordance with EN 50305:2020, 7.4.1, using either Method A or Method B, as given below.

The choice of test method A or B may be made by the supplier.

Method A:

concentration (%) $(250 \text{ to } 300) \times 10^{-4}$

test temperature $(25 \pm 2) \text{ }^\circ\text{C}$

test duration 24 h

test after treatment

1,5 kV

49 Hz to 61 Hz

1 min

test requirement no cracks or breakdown

Method B:

concentration (%) $(200 \pm 50) \times 10^{-6}$

test temperature $(40 \pm 2) \text{ }^\circ\text{C}$

relative humidity (%) 55 ± 5

test duration 72 h

test after treatment

1,5 kV

49 Hz to 61 Hz

1 min

test requirement no cracks or breakdown

5.22 Stress cracking test

The test shall be carried out in accordance with EN 50305:2020, 7.7.

At the conclusion of the ageing period there shall be no cracks in the insulation, either before or after the unwinding and re-bending procedure.

There shall be no breakdown of the insulation in the subsequent voltage withstand test.

5.23 Fire performance

The completed cable shall conform to the requirements given in EN 50306-1:2020, 8.1, 8.2.3 and 8.3.

The insulation system shall conform to the requirements of EN 50306-1:2020, Clause 9.

Table 4 — Schedule of tests

1 Ref No	2 Test	3 Category of test	4 Test method given in		6 Requirements given in ^a
			EN	(Sub) clause	
1	Electrical tests				
1.1	Electrical resistance of conductors	T, S	EN 50305	6.1	Table 1
1.2	Voltage test on complete cable	T, S	EN 50305	6.2.1	5.2
1.3	Dielectric strength	T	EN 50305	6.8	5.4
1.4	Spark test	R	EN 50305	6.5	5.5
1.5	DC stability	T	EN 50305	6.7	5.6
1.6	Insulation resistance at 20 °C	T, S	EN 50305	6.4.1	5.3 and Table 2
	at 90 °C	T	EN 50305	6.4.2	5.3 and Table 2
2	Provisions covering constructional and dimensional characteristics				
2.1	Checking of conformity with constructional provisions	T, S	EN 50306-1	Inspection	3.5 and 6 of EN 50306-1:2020
2.2	Conductor material and construction	T, S	EN 50306-2	Inspection and measurement	4.5.1 and Table 1
2.3	Insulation				
	(a) Application	S	EN 50306-1	Inspection and manual test	6.2.2 of EN 50306-1:2020
	(b) Thickness	T, S	EN 50306-1	A.1	Table 1
	(c) Concentricity	T, S	EN 50306-1	A.1.3	6.2.3 of EN 50306-1:2020
2.4	Overall diameter	T, S	EN 50306-1	6.7	Table 1
2.5	Cable identification and marking	T, S	EN 50306-2	Inspection and measurement	4.2.1 and 4.3.1
2.6	Durability of identification	T, S	EN 50305	10.1	5.3 of EN 50306-1:2020

1	2	3	4	5	6
Ref No	Test	Category of test	Test method given in		Requirements given in ^a
			EN	(Sub) clause	
3	Tests on insulation system				
3.1	Strippability of insulation	T, S	EN 50305	5.5.1	5.7
3.2	Adhesion of insulation to the conductors	T, S	EN 50305	5.5.2	5.7 and Table 2
3.3	Hot set	T, S	EN 60811-507		5.8
3.4	Long term ageing	T	EN 50305	7.2	5.9
3.5	Mineral oil resistance	T	EN 50305	8.1	5.10
3.6	Fuel resistance	T	EN 50305	8.1	5.11
3.7	Acid and alkali resistance	T	EN 50305	8.2	5.12
3.8	Pressure test at high temperature	T	EN 50305	7.5	5.13
3.9	Dynamic cut-through	T, S	EN 50305	5.6	5.14
3.10	Notch propagation	T, S	EN 50305	5.3	5.15
3.11	Shrinkage	T, S	EN 50305	7.6	5.16
3.12	Blocking of cores	T	EN 50305	10.2	5.17
3.13	Bending test at low temperature	T	EN 60811-504		5.18
3.14	Abrasion resistance	T	EN 50305	5.2	5.19
3.15	Pliability	T	EN 50305	5.4	5.20
3.16	Ozone resistance	T	EN 50305	7.4.1	5.21
3.17	Stress cracking	T	EN 50305	7.7	5.22
4	Fire performance tests				
4.1	Flame propagation:				
	(a) single cable	T, S	EN 60332-1-2	-	4.23 and 8.1 of EN 50306-1:2020
	(b) bunched cable	T	EN 50305	9.1.2	4.23 and 8.2.3 of EN 50306-1:2020
4.2	Halogen-Free / Determination of halogens – Elemental test	T, S	EN 50305	Annex: F and G	
4.3	Smoke emission	T	EN 61034-2	-	4.23 and 8.3 of EN 50306-1:2020
4.4	Toxicity of insulation system	T	EN 50305	9.2	4.23 and 9 of EN 50306-1:2020
^a According to EN 50306-2 unless otherwise specified.					
^b Applicable if the material is cross-linked.					

Bibliography

EN 45545-2, *Railway applications - Fire protection of railway vehicles - Part 2: Requirements for fire behaviour of materials and components*

EN 50343, *Railway applications - Rolling stock - Rules for installation of cabling*

EN 50355, *Railway applications - Railway rolling stock cables having special fire performance - Guide to use*

EN 60754-1, *Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content*

EN 60754-2, *Test on gases evolved during combustion of materials from cables - Part 2: Determination of acidity (by pH measurement) and conductivity*