INTERNATIONAL STANDARD

ISO 6722-2

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Road vehicles — 60 V and 600 V single-core cables —

Part 2: **Dimensions, test methods and requirements for aluminium conductor cables**

Véhicules routiers — Câbles monoconducteurs de 60 V et 600 V —

Partie 2: Méthodes d'essai des dimensions et exigences pour les câbles conducteurs en aluminium

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This fourth edition of ISO 6722-2 cancels and replaces ISO 6722:2006.

ISO 6722 consists of the following parts, under the general title *Road vehicles — 60 V and 600 V single-core cables*:

— *Part 1: Dimensions, test methods and requirements for copper conductor cables*

— *Part 2: Dimensions, test methods and requirements for aluminium conductor cables*

Introduction

ISO 6722 deals with single-core cables, with copper conductor cables covered in ISO 6722-1 and aluminium conductor cables covered in this part of ISO 6722. The performance of aluminium conductor cables is, in general, not to be expected to be the same as the performance of copper conductor cables in a one-to-one comparison basis.

Road vehicles — 60 V and 600 V single-core cables —

Part 2:
Dimensions, test methods and requirements for aluminium conductor cables

WARNING — The use of this part of ISO 6722 may involve hazardous materials, operations, and equipment. This part of ISO 6722 does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this part of ISO 6722 to establish appropriate safety practices and determine the applicability of regulatory limitations prior to use.

1 Scope

This part of ISO 6722 specifies the dimensions, test methods, and requirements for single-core 60 V cables intended for use in road vehicle applications where the nominal system voltage is ≤ 60 V d.c. or 25 V a.c. It also specifies additional test methods and/or requirements for 600 V cables intended for use in road vehicle applications, where the nominal system voltage is from > 60 V d.c. or 25 V a.c. to ≤ 600 V d.c. or 600 V a.c. It also applies to individual cores in multi-core cables.

This part of ISO 6722 specifies requirements for aluminium conductor cables.

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.

ISO 6722-1, *Road vehicles — 60 V and 600 V single-core cables — Part 1: Dimensions, test methods and requirements for copper conductor cables*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

EN 573-1, *Aluminium and aluminium alloys – Chemical composition and form of wrought products – Part 1: Numerical designation system*

EN 573-3:2009, *Aluminium and aluminium alloys – Chemical composition and form of wrought products – Part 3: Chemical composition and form of products*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6722-1 apply.

NOTE Whenever a.c. voltage is specified throughout this part of ISO 6722, the a.c. rms value shall be used.

4 General

4.1 Safety concerns

See “WARNING” at the beginning of this part of ISO 6722.

4.2 Temperature classes

Temperature classes are defined in Table 1.

Table 1 — Temperature class rating

Class	Temperature
A	−40 °C to 85 °C
B	−40 °C to 100 °C
C	−40 °C to 125 °C
D	−40 °C to 150 °C
E	−40 °C to 175 °C
F	−40 °C to 200 °C

4.3 Conductors

The conductors shall consist of annealed or annealed compressed/compacted aluminium, aluminium alloy, or copper-cladded aluminium strands. The specifications for the conductors shall be according to Table 2 and shall be completed by material specifications. Elongation requirements shall be established by the agreement between the customer and the supplier. The finished cable shall meet the resistance requirements of Table 5 for all conductors.

The individual strands of the aluminium conductor shall be manufactured per 1 000 series aluminium, pursuant to EN 573-1. The chemical composition shall follow EN 573-3:2009, Table 1.

NOTE Examples of strandings are shown in Table A.1. These strandings highlight examples of conceptual configurations and are not intended to reflect any preferred constructions. Other stranding configurations may be used provided they meet the requirements specified and are agreed upon by the customer and the supplier.

Table 2 — Characteristics of individual single strand wire after annealing

Tensile strength[a,b] **Rm** MPa	**Elongation at break**[a] A_C %	**Conductivity** κ_{20} Sm/mm^2
70 to 120	≥16	≥35,5
90 to 140[c,d]	≥8[c,d]	≥33,5[d]

a Determined pursuant to ISO 6892-1, (Reference [2]).

b Measured at clamping length of 200 mm.

c Not applicable for compressed conductors. The tensile strength, elongation, and chemical composition requirements shall be established by the agreement between the customer and the supplier.

d Additional aluminium alloys may be used. The conductivity, tensile strength, elongation requirements, and chemical composition shall be established by the agreement between the customer and the supplier.

4.4 Tests

The cables shall be submitted to tests as specified in Table 3.

Unintended direct contact of aluminium wire with any other metal shall not occur with any of the test methods.

4.5 General test conditions

If not otherwise specified, the device under test (DUT) shall be preconditioned for at least 16 h at a room temperature (RT) of (23 ± 5) °C and a relative humidity (RH) of 45 % to 75 %. Unless otherwise specified, all tests other than “in-process” tests shall be conducted at these conditions.

Where no tolerance is specified, all values shall be considered to be approximate.

When a.c. tests are performed, these shall be carried out at 50 Hz or 60 Hz. Applications at higher frequencies may require additional testing.

4.6 Ovens

An oven with air exchange, either natural or by pressure, should be used. The air shall enter the oven in such a way that it flows over the surface of the test pieces and leaves near the top of the oven. The oven shall have not less than 8 and not more than 20 complete air changes per hour at the specified ageing temperature.

Forced air circulation, e.g. by a fan, inside the oven may be used. However, in case of dispute, an oven without forced air circulation shall be used.

Table 3 — Tests

Subclause	Test description	Mandatory			If required[c]	
		In-process[a]	Initial	Periodic[b]	Initial	Periodic[b]
	Dimensions					
5.1	Outside cable diameter	–	X	X	–	–
5.2	Insulation thickness	–	X	X	–	–
5.3	Conductor diameter and cross-sectional area	–	X	X	X	X
	Electrical characteristics					
5.4	Conductor resistance	–	X	X	–	–
5.5	Withstand voltage	–	X[d]	X[d]	–	–
5.6	Insulation faults	X[d]	–	–	–	–
5.7	Insulation volume resistivity	–	–	–	X	X
	Mechanical characteristics					
5.8	Pressure test at high temperature	–	X	X	–	–
5.9	Strip force	–	–	–	X	X
	Low temperature characteristics					
5.10	Winding	–	X	X	–	–
5.11	Impact	–	–	–	X	X
5.12	Resistance to abrasion	–	X[e]	X[e]	–	–
	Heat ageing					
5.13	Long term ageing, 3 000 h	–	X	–	–	–
5.14	Short-term ageing, 240 h	–	X	X	–	–
5.15	Thermal overload	–	–	–	X	X
5.16	Shrinkage by heat	–	X	X	–	–
	Resistance to chemicals					
5.17	Fluid compatibility	–	X[f,g]	–	X[f,g]	–

Table 3 *(continued)*

Subclause	Test description	Mandatory			If required[c]	
		In-process[a]	Initial	Periodic[b]	Initial	Periodic[b]
5.18	Durability of cable marking	–	–	–	X[g]	X[g]
5.19	Resistance to ozone	–	–	–	X[g]	–
5.20	Resistance to hot water	–	X[g]	–	–	–
5.21	Temperature and humidity cycling	–	–	–	X[g]	–
5.22	Resistance to flame propagation	–	X	X	–	–

X applicable test

– not applicable

[a] A test made on entire cable length during or after manufacture.

[b] The frequency of periodic testing shall be established by the agreement between the customer and the supplier.

[c] The usage of "if required" tests shall be established by the agreement between the customer and the supplier.

[d] Some cables are rated at 60 V and others at 600 V. See ISO 6722-1 for details.

[e] See ISO 6722-1 for details.

[f] Some fluids are for "certification" and others are "if required". See ISO 6722-1 for details.

[g] Compliance for a cable family may be demonstrated by testing the examples of large and small conductor sizes only (see 4.7).

4.7 Representative conductor sizes for testing

When a test is required, all combinations of conductor size, wall thickness, and insulation formulation shall meet the appropriate requirements. However, if the testing of representative conductor sizes is permitted (see Table 3), compliance for a cable family may be demonstrated by testing the examples of large and small conductor sizes only. Permission to show compliance for a cable family by testing "representative conductor sizes" shall be established by the agreement between the customer and the supplier.

4.8 Recommended colours

For a list of recommended colours, see ISO 6722-1.

5 Tests

5.1 Outside cable diameter

5.1.1 Purpose, test sample, and test

ISO 6722-1 applies.

5.1.2 Requirement

No single value shall be larger than the appropriate values specified in Table 4.

NOTE See Table A.2 for the minimum outside cable diameters.

5.2 Insulation thickness

5.2.1 Purpose, test sample, and test

ISO 6722-1 applies.

5.2.2 Requirement

No single value shall be less than the appropriate minimum insulation thickness specified in Table 4.

Table 4 — Dimensions

ISO conductor[a]		Thick wall			Thin wall			Ultrathin wall		
Size mm²	Diameter mm	Insulation thickness mm		Outside cable diameter mm	Insulation thickness mm		Outside cable diameter mm	Insulation thickness mm		Outside cable diameter mm
	max.	nominal	min.	max.	nominal	min.	max.	nominal	min.	max.
0,75	1,30	0,60	0,48	2,50	0,30	0,24	1,90	0,20	0,16	1,60
1	1,50	0,60	0,48	2,70	0,30	0,24	2,10	0,20	0,16	1,75
1,25	1,70	0,60	0,48	2,95	0,30	0,24	2,30	0,20	0,16	2,00
1,5	1,80	0,60	0,48	3,00	0,30	0,24	2,40	0,20	0,16	2,10
2	2,00	0,60	0,48	3,30	0,35	0,28	2,80	0,25	0,20	2,40
2,5	2,20	0,70	0,56	3,60	0,35	0,28	3,00	0,25	0,20	2,70
3	2,40	0,70	0,56	4,10	0,40	0,32	3,40			
4	2,80	0,80	0,64	4,40	0,40	0,32	3,70			
5	3,10	0,80	0,64	4,90	0,40	0,32	4,20			
6	3,40	0,80	0,64	5,00	0,40	0,32	4,30			
8	4,30	0,80	0,64	5,90	0,40	0,32	5,00			
10	4,50	1,00	0,80	6,50	0,60	0,48	6,00			
12	5,40	1,00	0,80	7,40	0,60	0,48	6,50			
16	5,80	1,00	0,80	8,30	0,65	0,52	7,20			
20	6,90	1,10	0,88	9,10	0,65	0,52	7,80			
25	7,20	1,30	1,04	10,40	0,65	0,52	8,70			
30	8,30	1,30	1,04	10,90	0,80	0,64	9,60			
35	8,50	1,30	1,04	11,60	0,80	0,64	10,40			
40	9,60	1,40	1,12	12,40	0,90	0,71	11,10			
50	10,50	1,50	1,20	13,50	0,90	0,71	12,20			
60	11,60	1,50	1,20	14,60	1,00	0,80	13,30			
70	12,50	1,50	1,20	15,50	1,00	0,80	14,40			
85	13,60	1,60	1,28	16,80	1,10	0,90	15,80			
95	14,80	1,60	1,28	18,00	1,10	0,90	16,70			
120	16,50	1,60	1,28	19,70						
160	19,00	1,60	1,28	22,50						

[a] The maximum cable diameter listed in the table is calculated for bunched conductors. Different maximum conductor diameters for rope and other strandings may be allowed as agreed upon by the customer and the supplier. This change may affect the maximum outside cable diameters dimensions in the table.

5.3 Conductor diameter and cross-sectional area

5.3.1 Conductor diameter

5.3.1.1 Purpose, test sample, and test

ISO 6722-1 applies.

5.3.1.2 Requirement

No single value shall exceed the maximum value specified in Table 4.

NOTE See Table A.2 for the minimum outside cable diameters.

5.3.2 Cross-sectional area (CSA)

5.3.2.1 Purpose

This test is intended to verify that the cable conductor CSA fulfils the specified requirements.

5.3.2.2 Test of cross-sectional area

5.3.2.2.1 Method 1

In case of dispute, Method 2 (weight method) will be the referee method to determine the CSA.

By using the obtained resistance value $R_{L,20}$ according to 5.4.3, the CSA is calculated using Formula (1).

$$A = \frac{1\,000 \times (1 + f_b)}{\kappa \times R_{L,20}} \quad (1)$$

where

A is the cross-sectional area in mm^2;

$R_{L,20}$ is the conductor resistance at 20 °C (Ω);

κ is the conductivity of the used conductor material in Sm/mm^2,

for aluminium, use a conductivity of 35,5 Sm/mm^2,

for aluminium alloy, use a conductivity of 33,5 Sm/mm^2,

for other aluminium alloys with different conductivity, values can be used based on the agreement between the customer and the supplier;

f_b is the bunching loss, depends on strand construction.

5.3.2.2.2 Method 2

1 m ± 5 mm of the cable under test is carefully stripped of all insulation. The conductor is weighed with a scale capable of measurement to 1 mg accuracy. From the result, the CSA is calculated using Formula (2).

$$A = \frac{m}{\gamma} \tag{2}$$

where

A is the cross-sectional area in mm^2;

m is the conductor mass in g;

γ is the density of the used conductor material in g/mm^3,

for aluminium, use a density of 2,70 g/mm^3,

a different density may be used for aluminium alloy.

5.3.2.3 Requirement

The value, measured according to Method 1 or 2, shall fulfil the requirements specified in Table 5.

Table 5 — Conductor resistance and cross-sectional area

ISO conductor size	Cross-sectional area mm^2		Maximum conductor resistance mΩ/m at 20 °C[a]	
mm^2	max.[b]	min.	**Aluminium[c]**	**Aluminium alloy[d]**
0,75	0,754	0,698	41,2	43,6
1	1,01	0,932	30,8	32,7
1,25	1,25	1,16	24,8	26,3
1,5	1,47	1,36	21,2	22,4
2	1,98	1,83	15,7	16,6
2,5	2,45	2,27	12,7	13,4
3	3,03	2,80	10,2	10,9
4	3,95	3,66	7,85	8,32
5	4,73	4,38	6,57	6,96
6	5,93	5,49	5,23	5,55
8	7,82	7,24	3,97	4,20
10	10,2	9,47	3,03	3,21
12	12,3	11,3	2,53	2,68
16	16,1	14,9	1,93	2,05
20	19,5	18,1	1,59	1,69
25	25,1	23,2	1,24	1,31

[a] For other alloys, other values for the maximum resistance may be used. Maximum resistance requirements shall be established by the agreement between the customer and the supplier.

[b] Additional maximum cross-sectional areas may be used. Maximum cross-sectional area requirements shall be established by the agreement between the customer and the supplier.

[c] Calculated from minimum CSA with a conductivity of 35,5 Sm/mm^2.

[d] Calculated from minimum CSA with a conductivity of 33,5 Sm/mm^2.

Table 5 *(continued)*

ISO conductor size	Cross-sectional area mm2		Maximum conductor resistance mΩ/m at 20 °C[a]	
mm2	max.[b]	min.	**Aluminium**[c]	**Aluminium alloy**[d]
30	28,8	26,6	1,08	1,14
35	35,3	32,7	0,878	0,931
40	39,4	36,5	0,788	0,835
50	50,6	46,9	0,613	0,650
60	59,1	54,7	0,525	0,556
70	71,9	66,6	0,432	0,457
85	85,0	78,7	0,365	0,387
95	95,0	88,0	0,327	0,346
120	122	113	0,255	0,270
160	159	147	0,195	0,207

[a] For other alloys, other values for the maximum resistance may be used. Maximum resistance requirements shall be established by the agreement between the customer and the supplier.

[b] Additional maximum cross-sectional areas may be used. Maximum cross-sectional area requirements shall be established by the agreement between the customer and the supplier.

[c] Calculated from minimum CSA with a conductivity of 35,5 Sm/mm^2.

[d] Calculated from minimum CSA with a conductivity of 33,5 Sm/mm^2.

5.4 Conductor resistance

5.4.1 General

This test is intended to verify that cable conductor resistance does not exceed the maximum permitted value.

5.4.2 Test sample

5.4.2.1 General

Prepare a test sample of 1,1 m length, including the length necessary for connections. The current has to be supplied to the device under test with extra terminals situated outside the voltage probes. The thickness of the blades for the voltage measurement shall be smaller than 0,5 mm. The distance between the inner edges of the voltage probes shall be (1 000 ± 5) mm.

The oxide film on the aluminium surface is removed before carrying out the measurement following one of the two methods mentioned below.

5.4.2.2 Method for removing the oxide film on the aluminium surface by soldering

Remove the insulation from the wire, apply a soldering fluid on the aluminium surface, and dip the aluminium wire into the solder bath.

In case of doubt, for example, the resistance requirements are not met, the soldering fluid might not be applicable and the following referee soldering fluid shall be used.

The referee soldering fluid consists of the following components:

— diethanolamine, 45 % to 65 %;

— fluoroboric acid, 11 % to 13 %;

— diethylenetriamine, 14 % to 17 %.

The solder bath consists of the following components:

— tin, 80 % to 90 %;

— zinc, 10 % to 20 %;

— other metals, 1 %.

5.4.2.3 Method for removing the oxide film on the aluminium surface by pickling

Remove the insulation and immerse the aluminium conductor in 3,5 % hydrochloric acid solution in water for 1 min. Remove the wire from the hydrochloric acid solution, rinse the immersed part with distilled water, and dry. Perform the conductor measurement immediately after drying.

5.4.3 Conductor measurement

The measurement shall be carried out according to ISO 6722-1.

5.4.4 Calculation method for conductor resistance at 20 °C

The calculation method for the conductor resistance at 20 °C is as given in ISO 6722-1, but using a temperature coefficient factor of $4{,}03 \times 10^{-3}$ 1/K.

The temperature coefficient factor for converting the measured resistance to the value at 20 °C may vary depending on the composition of the aluminium. For soft aluminium, the temperature coefficient is $4{,}03 \times 10^{-3}$ 1/K. For other types of aluminium conductor, e.g. alloyed aluminium, CCA, etc., this may be different.

The applied temperature coefficient shall be measured according to Annex B and be reported. Another material-specific temperature coefficient may also be used if agreed upon by the customer and the supplier.

5.4.5 Requirement

The corrected value shall not exceed the appropriate maximum resistance specified in Table 5.

5.5 Withstand voltage

ISO 6722-1 applies.

5.6 Insulation faults

ISO 6722-1 applies.

5.7 Insulation volume resistivity

5.7.1 Purpose

This test is intended to ensure limitation of leakage current by verifying that the volume resistivity meets the requirements as specified.

5.7.2 Test sample

The sample preparation shall be carried out according to the method specified in 5.4.2. Prepare a test sample of 5 m length and remove 25 mm of insulation from each end.

5.7.3 Test

ISO 6722-1 applies.

5.7.4 Requirement

ISO 6722-1 applies.

5.8 Pressure test at high temperature

ISO 6722-1 applies.

5.9 Strip force

ISO 6722-1 applies.

5.10 Low temperature winding

The test shall be carried out as specified in ISO 6722-1 but using the mandrel diameter A (≤5× the required maximum outside cable diameter).

5.11 Cold impact

ISO 6722-1 applies.

5.12 Abrasion test

ISO 6722-1 applies.

5.13 Long-term heat ageing, 3 000 h

ISO 6722-1 applies.

5.14 Short-term heat ageing, 240 h

ISO 6722-1 applies.

5.15 Thermal overload

ISO 6722-1 applies.

5.16 Shrinkage by heat

ISO 6722-1 applies.

5.17 Resistance to chemicals

ISO 6722-1 applies.

5.18 Durability of cable marking

ISO 6722-1 applies.

5.19 Resistance to ozone

ISO 6722-1 applies.

5.20 Resistance to hot water

5.20.1 Purpose

This test is intended to verify that the cable maintains electrical integrity after exposure to hot water.

5.20.2 Test samples

The sample preparation shall be carried out according to the method specified in 5.4.2. Prepare two test samples, each of (2,5 ± 0,1) m length and remove 25 mm of insulation from each end.

5.20.3 Test

ISO 6722-1 applies.

5.20.4 Requirement

ISO 6722-1 applies.

5.21 Temperature and humidity cycling

ISO 6722-1 applies.

5.22 Resistance to flame propagation

According to ISO 6722-1, for the test procedure and the requirement and in addition, if the conductor breaks during the test, the flame exposure time should be reduced in steps of 1 s until the conductor does not break.

Annex A
(informative)

Conductor sizes and cable dimensions

A.1 ISO conductor sizes, strand diameters, and number of strands

Table A.1 — ISO conductor sizes, diameters, and number of strands

ISO conductor size mm^2	Structure A		Structure B		Structure C	
	Number of strands	Strand diameter max. mm	Number of strands	Strand diameter max. mm	Number of strands	Strand diameter max. mm
0,75	7	0,38	11[a]	0,30[a]	19	0,23
1	7	0,43	16[a]	0,29[a]	19	0,27
1,25	19	0,30	16[a]	0,32[a]	12	0,37
1,5	19	0,32	16[a]	0,35[a]	37	0,23
2	19	0,37	15	0,42	37	0,27
2,5	19	0,43			37	0,30
3	19	0,46	23	0,42	37	0,33
4	37	0,38	30	0,42	47	0,33
5	37	0,41	36	0,42	58	0,33
6	37	0,46	45	0,42	70	0,33
8			59	0,42	98	0,33
10			50	0,52	126	0,33
12			60	0,52	154	0,33
16			78	0,52	209	0,33
20			95	0,52	247	0,33
25			122	0,52	323	0,33
30			141	0,52	361	0,33
35	121	0,62	172	0,52	456	0,33
40	134	0,62	193	0,52	494	0,33
50	172	0,62	247	0,52	646	0,33
60	201	0,62	289	0,52	741	0,33
70	180	0,72	351	0,52	855	0,33
85	213	0,72	420	0,52	1064	0,33
95	238	0,72	463	0,52	1178	0,33
120	234	0,82	305	0,72		
160	243	0,92	398	0,72		

[a] Possible structure for smooth body, compressed conductor. The strand diameter specified is for non-compressed conductors. No strand diameter is specified for compressed conductors.

A.2 Minimum outside cable diameter

Table A.2 — Minimum outside cable diameter

ISO conductor size mm2	Minimum outside cable diameter mm		
	Thick wall	**Thin wall**	**Ultrathin wall**
0,75	2,20	1,70	1,45[a]
1	2,40	1,90	1,55[a]
1,25	2,40	2,10	1,70[a]
1,5	2,70	2,20	1,90[a]
2	3,00	2,50	2,20
2,5	3,30	2,70	2,50
3	3,80	3,10	
4	4,00	3,40	
5	4,50	3,90	
6	4,60	4,00	
8	5,00	4,60	
10	5,90	5,30	
12	6,60	5,80	
16	7,70	6,40	
20	8,10	7,00	
25	9,40	7,90	
30	9,70	8,70	
35	9,60	9,40	
40	11,20	10,00	
50	11,50	11,00	
60	13,40	12,00	
70	13,50	13,00	
85	14,80	14,40	
95	16,00	15,30	
120	17,70		

NOTE 1 The minimum outside cable diameter values in this table may be used for certification requirements.

NOTE 2 The maximum outside cable diameter values are shown in Table 4.

[a] The minimum outside cable diameters do not apply to smooth body, compressed conductors according to structure B in Table A.1.

Annex B
(normative)

Determination of temperature coefficients

B.1 Principle

The resistance of a cable under test is determined while its temperature is varied from room temperature up to 50 °C. The resistance is calculated from a measurement of the potential difference across the cable and a measurement of the current passing through the cable. The current is supplied by a constant-current source (d.c. power supply).

B.2 Calibration graph

The cable under test (see 5.4) is submitted to a temperature range from 20 °C to 50 °C in a silicone oil bath. At least 80 % of the cable length is submersed in the oil. Alternatively, the test can be performed in a suitable heating chamber.

Table B.1 — Length of cable sample

Nominal cross-sectional area mm^2	Length m
<2,5	10
≥2,5 to <10	5
≥10	2

B.3 4-point measurement

The applied measurement current is kept constant. The current shall not cause a warming of the conductor (see Table B.2).

Table B.2 — Maximum permissible current

Nominal cross-sectional area mm^2	Maximum permissible current mA
<2,5	10
≥2,5 to <10	50
≥10	200

The contact points for voltage measurement shall be below the oil surface in the oil bath to ensure that the part of the cable between the voltage measurement points has a uniform temperature.

For the voltage measurement, a gauge with an input impedance >1 MΩ shall be used.

The resistance of the cable is determined at each predefined temperature point by the measurement of the current and voltage drop.

B.4 Procedure

The temperature of the oil bath shall be measured and controlled. The oil bath temperature measurement shall be better than ± 0,2 °C. The temperature of the oil bath shall be homogeneous throughout the bath.

Starting at room temperature but ≤25 °C, the oil is heated up to 30 °C and subsequently in steps of 10 °C up to 50 °C.

After each temperature step, wait until the change in oil temperature is less than ± 0,2 °C and the change in the measured resistance value is lower than 0,04 % for 60 s.

Calculate the resistance at each temperature from the measured current, voltage, and length between the voltage measurement terminals.

B.5 Analysis of test results

B.5.1 Linear approximation

The determined resistance values R' (Ω/m) versus the temperature increase ΔT (oil bath temperature, T – 20 °C) represent the calibration graph $R'(\Delta T)$.

The data pairs $R'(\Delta T)$ and ΔT from 30 °C up to and including 50 °C are fitted by linear interpolation to determine the parameters a and b in Formula (B.1).

$$R'\left(\Delta T\right) = a \cdot \Delta T + b \qquad \text{(B.1)}$$

where

$R'(\Delta T)$ is the determined resistance at the increased temperature ΔT;

ΔT is the increased oil bath temperature (T – 20) °C.

For calculating the resistance temperature coefficient, α_ρ, Formula (B.1) can be expressed as Formula (B.2).

$$R'\left(\Delta T\right) = \alpha_\rho \cdot R'_{20} \cdot \Delta T + R'_{20} \qquad \text{(B.2)}$$

where

R'_{20} is the electrical resistance per unit length at 20 °C in Ω/m;

α_ρ is the linear temperature coefficient of material-specific resistivity in 1/K.

The constants R'_{20} and α_ρ are calculated using Formulae (B.3) and (B.4).

$$R'_{20} = \mathrm{b} \qquad \text{(B.3)}$$

$$\alpha_\rho = \frac{a}{b} \qquad \text{(B.4)}$$

Bibliography

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