INTERNATIONAL STANDARD

ISO 6722-1

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

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

Véhicules routiers — Câbles monoconducteurs de 60 V et 600 V — Partie 1: Dimensions, méthodes d'essai et exigences pour les câbles conducteurs en cuivre

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 6722-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This fourth edition of ISO 6722-1 cancels and replaces ISO 6722:2006, which has been technically revised.

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*[1)]

1) To be published.

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

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

WARNING — The use of this International Standard may involve hazardous materials, operations, and equipment. This International Standard 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 International Standard 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 greater than > (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 copper conductor cables.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 6931-1, *Stainless steels for springs — Part 1: Wire*

IEC 60811-2-1, *Common test methods for insulating and sheathing materials of electric and optical cables — Part 2-1: Methods specific to elastomeric compounds — Ozone resistance, hot set and mineral oil immersion tests*

ASTM B1, *Standard Specification for Hard Drawn Copper Wire*

ASTM B3, *Standard Specification for Soft or Annealed Copper Wire*

ASTM B33, *Standard Specification for Tin Coated Soft or Annealed Copper Wire for Electrical Purposes*

ASTM B298, *Standard Specification for Silver Coated Soft or Annealed Copper Wire*

ASTM B355, *Standard Specification for Nickel Coated Soft or Annealed Copper Wire*

EN 13602, *Copper and copper alloys — Drawn, round copper wire for the manufacture of electrical conductors*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

3.1
60 volt (V) cable
cable intended for use in road vehicle applications where the nominal system voltage is equal to or less than (60 V d.c. or 25 V a.c.)

3.2
600 volt (V) cable
cable intended for use in road vehicle applications where the nominal system voltage is greater than (60 V d.c. or 25 V a.c.) and less than or equal to (600 V d.c. or 600 V a.c.)

3.3
cable family
group with multiple conductor sizes having the same conductor strand coating, insulation formulation, and wall thickness type

3.4
nominal (value)
suitable approximate value used to designate or identify a component

4 General

4.1 Safety concerns

See the “Warning” notice at the beginning of this International Standard.

4.2 Temperature classes

Eight 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
G	–40 °C to 225 °C
H	–40 °C to 250 °C

4.3 Conductors

The conductors shall consist of plain or coated copper strands as shown in Table 2. Conductor sizes $\geq 0{,}5\ mm^2$ shall consist of soft annealed copper or annealed compressed/compacted wires. Conductor sizes $< 0{,}5\ mm^2$ shall consist of soft annealed copper, soft annealed compressed/compacted copper, hard unannealed copper, or a copper alloy. The specifications for the conductors shall be completed by material specifications. Elongation requirements shall be established by agreement between customer and supplier. The finished cable shall meet the resistance requirements of Table 5 for all conductors except alloys. When an alloy is used, the resistance requirement shall be established by agreement between customer and supplier.

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

Table 2 — Conductor specifications

ASTM B1	Hard-drawn copper wire
ASTM B3 or EN 13602	Soft or annealed copper wire
ASTM B33 or EN 13602	Tin-coated soft or annealed copper wire
ASTM B298	Silver-coated soft or annealed copper wire
ASTM B355	Nickel-coated soft or annealed copper wire
NOTE Silver and Nickel coated conductors are intended for use with high "temperature class ratings".	

4.4 Tests

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

NOTE A special set of requirements for trucks is intended to be added to the next revision of this International Standard.

Table 3 — Tests

Sub-clause	Test description	Mandatory			If required[c]	
		In progress[a]	Initial	Periodic[b]	Initial	Periodic
5.1	Outside cable diameter	—	X	X	—	—
5.2	Insulation thickness	—	X	X	—	—
5.3	Conductor diameter	—	—	—	X	X
5.4	Conductor resistance	—	X	X	—	—
5.5	Withstand voltage	—	Note 1	Note 1	—	—
5.6	Insulation faults	Note 1	—	—	—	—
5.7	Insulation volume resistivity	—	—	—	X	X
5.8	Pressure test at high temperature	—	X	X	—	—
5.9	Strip force	—	—	—	X	X
5.10	Low temperature winding	—	X	X	—	—
5.11	Cold impact	—	—	—	X	X
5.12	Abrasion test	—	Note 2	Note 2	—	—
5.13	Long term heat ageing, 3 000 h	—	X	—	—	—
5.14	Short term heat ageing, 240 h	—	X	X	—	—
5.15	Thermal overload	—	—	—	X	X
5.16	Shrinkage by heat	—	X	X	—	—
5.17	Fluid compatibility	—	Notes 3 and 4	—	Notes 3 and 4	—
5.18	Durability of cable marking	—	—	—	Note 4	Note 4
5.19	Resistance to ozone	—	—	—	Note 4	—
5.20	Resistance to hot water	—	—	—	Note 4	—
5.21	Temperature and humidity cycling	—	—	—	Note 4	—
5.22	Resistance to flame propagation	—	X	X	—	—

NOTE 1 Some cables are rated at 60 V and others at 600 V. See 5.5.3 and 5.6.3 for details.

NOTE 2 See 5.12.

NOTE 3 Some fluids are for “Certification” and others are “If required”. See 5.17 for details.

NOTE 4 Compliance for a cable family may be demonstrated by testing examples of large and small conductor sizes only. See 4.7 for details.

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

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

[c] The usage of “If required” tests shall be established by agreement between customer and supplier.

4.5 General test conditions

Unless specified otherwise, 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 specified otherwise, 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, they shall be 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 exits 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.

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 testing of representative conductor sizes is permitted (see Table 3), compliance for a cable family may be demonstrated by testing 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 agreement between customer and supplier.

4.8 Recommended colours

A list of recommended colours is shown in Table C.1.

5 Tests and requirements

5.1 Outside cable diameter

5.1.1 Purpose

This test is intended to verify that the cable outside diameter is within the required tolerances to fit seal and harness dimension requirements.

5.1.2 Test Sample

Prepare a test sample of 3 m in length.

5.1.3 Test

Use a measuring device which shall not cause deformation. Take three sets of measurements at positions separated by 1 m and record the highest and lowest outside cable diameter at each position.

5.1.4 Requirement

All measurements shall be within the limits of the appropriate maximum and minimum “outside cable diameter” specified in Table 4 and Table B.2. The values in Table 4 are normative. Since the values in Table B.2 are informative, they are not required; however, they may be applied by agreement between customer and supplier.

5.2 Insulation thickness

5.2.1 Purpose

This test is intended to verify that the cable insulation thickness is within the required tolerances to withstand electrical, mechanical and chemical abuse.

5.2.2 Test samples

Prepare three test samples from a cable sample 3 m in length. Take the test samples at 1 m intervals. Strip the insulation from the cable. A test sample consists of a thin cross-section of insulation. Take care not to deform the test sample during the preparation process. If cable marking causes indentation of the insulation, take the first test sample through this indentation.

5.2.3 Test

Use a measuring device which shall not cause deformation.

Place the test sample under the measuring equipment with the plane of the cut perpendicular to the optical axis. Determine the minimum “insulation thickness”.

5.2.4 Requirement

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

Table 4 — Dimensions

ISO conductor		Thick wall			Thin wall			Ultra-thin wall		
Size	Diameter	Insulation thickness		Outside cable diameter	Insulation thickness		Outside cable diameter	Insulation thickness		Outside cable diameter
mm^2	mm	mm		mm	mm		mm	mm		mm
	max.	nominal	min.	max.	nominal	min.	max.	nominal	min.	max.
0,13	0,55				0,25	0,20	1,05	0,20	0,16	0,95
0,22	0,70						1,20			1,05
0,35	0,90						1,40[a]			1,20
0,50	1,10	0,60	0,48	2,30	0,28	0,22	1,60			1,40
0,75	1,30			2,50	0,30	0,24	1,90			1,60
1	1,50			2,70			2,10			1,75
1,25	1,70			2,95			2,30			2,00
1,5	1,80			3,00			2,40			2,10
2	2,00			3,30	0,35	0,28	2,80	0,25	0,20	2,40
2,5	2,20	0,70	0,56	3,60			3,00			2,70
3	2,40			4,10			3,40			
4	2,80	0,80	0,64	4,40	0,40	0,32	3,70			
5	3,10			4,90			4,20			
6	3,40			5,00			4,30			
8	4,30			5,90			5,00			
10	4,50	1,00	0,80	6,50	0,60	0,48	6,00			
12	5,40			7,40			6,50			
16	5,80			8,30	0,65	0,52	7,20			
20	6,90	1,10	0,88	9,10			7,80			
25	7,20	1,30	1,04	10,40			8,70			
30	8,30			10,90	0,80	0,64	9,60			
35	8,50			11,60			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			12,20			
60	11,60			14,60	1,00	0,80	13,30			
70	12,50			15,50			14,40			
95	14,80	1,60	1,28	18,00	1,10	0,90	16,70			
120	16,50			19,70						

NOTE Outside cable diameter minimum values for high volume cable constructions are shown in Table B.2. Since the values in Table B.2 are informative, they are not required; however, they may be applied by agreement between customer and supplier.

[a] The outside cable diameter for conductor size 0,35 mm^2 with 7 strands shall be max. 1,30 mm.

5.3 Conductor diameter

5.3.1 Purpose

This test is intended to verify that the cable conductor diameter is within the required tolerances to fit terminal crimps and mechanical demands.

5.3.2 Test samples

Use the test samples as specified in 5.2. In case of disputed results, a referee method is provided below.

Prepare three test samples from a cable sample 3 m in length. Take these samples at 1 m intervals. A sample consists of a 20 mm length of cable. Take care not to deform the test sample. Immerse the samples in a casting resin. After hardening, take a section perpendicular to the axis of the test sample.

5.3.3 Test

Use a measuring device which shall not cause deformation.

Determine the conductor diameter by measuring the inside diameter of the test samples and record the maximum inside diameter for each test sample.

5.3.4 Requirement

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

5.4 Conductor resistance

5.4.1 Purpose

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

5.4.2 Test samples

Prepare a test sample of 1 m length plus the length necessary for connections. Other lengths may be used providing that the resistance reading is adjusted using the method shown in 5.4.3. The ends of the test sample may be soldered.

5.4.3 Test

Use a resistance measuring device with an accuracy of ± 0,5 % of the measured value and a thermometer with an accuracy of ± 0,5 °C.

Measure the temperature of the test sample and the unsoldered length. Take care to ensure that connections are secure. Measure the resistance of the test sample. Correct the measured value using Equation (1):

$$R_{20} = \frac{R_t}{L\left[1 + 0{,}00\ 393\left(t - 20\right)\right]} \tag{1}$$

where

R_{20} is the corrected conductor resistance at the reference temperature of 20 °C, expressed in mΩ/m;

R_t is the conductor resistance measured at the conductor temperature in mΩ;

L is the unsoldered conductor length, expressed in m;

t is the conductor temperature at the time of measuring, expressed in °C.

NOTE The value of 0,00393 is the temperature coefficient for copper with 100 % conductivity at temperatures at 20 °C. For coated wires or alloys, the correction factor shall be established by agreement between customer and supplier.

5.4.4 Requirement

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

Table 5 — Conductor resistance

ISO conductor size mm^2	Maximum conductor resistance per length mΩ/m at 20 °C[a]		
	Plain copper	Sn plated copper	Ni plated copper
0,13	136	140	142
0,22	84,8	86,5	87,9
0,35	54,4	55,5	56,8
0,50	37,1	38,2	38,6
0,75	24,7	25,4	25,7
1	18,5	19,1	19,3
1,25	14,9	15,9	16,0
1,5	12,7	13,0	13,2
2	9,42	9,69	9,82
2,5	7,60	7,82	7,92
3	6,15	6,36	6,41
4	4,71	4,85	4,91
5	3,94	4,02	4,11
6	3,14	3,23	3,27
8	2,38	2,52	2,60
10	1,82	1,85	1,90
12	1,52	1,60	1,66
16	1,16	1,18	1,21
20	0,955	0,999	1,03
25	0,743	0,757	0,774
30	0,647	0,684	0,706
35	0,527	0,538	0,549
40	0,473	0,500	0,516
50	0,368	0,375	0,383
60	0,315	0,333	0,344
70	0,259	0,264	0,270
95	0,196	0,200	0,204
120	0,153	0,156	0,159
Conductors produced from silver coated strands shall not exceed the maximum conductor resistance per length for plain copper.			
[a] Minimum conductor resistance values for high volume cable constructions are shown in Table B.3. Since the values in Table B.3 are informative, they are not required; however, they may be applied by agreement between customer and supplier.			