INTERNATIONAL STANDARD

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2007-05

Low-frequency cables and wires with PVC insulation and PVC sheath –

Part 3: Equipment wires with solid or stranded conductor wires, PVC insulated, in singles, pairs and triples

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FOREWORD

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International Standard IEC 60189-3 has been prepared by subcommittee 46C: Wires and symmetrical cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors, r.f. and microwave passive components and accessories.

This fourth edition cancels and replaces the third edition published in 1988 and amendment 1 (1989). This edition constitutes a technical revision.

This edition includes an update of the technical characteristics.

The text of this standard is based on the following documents:

FDIS	Report on voting
46C/822/FDIS	46C/830/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The list of all the parts of the IEC 60189 series, under the general title *Low-frequency cables and wires with PVC insulation and PVC sheath*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

LOW-FREQUENCY CABLES AND WIRES WITH PVC INSULATION AND PVC SHEATH –

Part 3: Equipment wires with solid or stranded conductor wires, PVC insulated, in singles, pairs and triples

1 Scope

This part of IEC 60189 is applicable to equipment wires with solid or stranded conductor, polyvinyl chloride (PVC) insulated, in singles, pairs and triples to be used for internal wiring of telecommunication equipment, industrial and consumer electronic equipment.

NOTE It is the responsibility of the manufacturer to establish quality assurance by quality control procedures which will ensure that the product will meet the requirements of this standard. It is not intended that a complete testing programme must be carried out on every length of conductor. When the purchaser wishes to specify acceptance tests or other quality procedures, it is essential that agreement be reached between the purchaser and the manufacturer by the time of ordering.

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.

IEC 60028, *International standard of resistance for copper*

IEC 60189-1:2007, *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods*

IEC 60304, *Standard colours for insulation for low-frequency cables and wires*

IEC 60344, *Guide to the calculation of resistance of plain and coated copper conductors of low-frequency cables and wires*

IEC 60649, *Calculation of maximum external diameter of cables for indoor installations*

ISO 105 (all parts), *A and B textiles – Tests for colour fastness*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60189-1 apply.

4 Wire construction and dimensions

4.1 Conductor

4.1.1 Conductor material

The conductor shall consist of annealed copper, uniform in quality and free from defects. The properties of the copper shall be in accordance with IEC 60028.

The three smallest conductors (0,12 mm and 0,15 mm diameter and 0,035 mm^2 cross-sectional area) shall consist of copper alloy, uniform in quality and free from defects. Copper alloy may also be used for other small conductor gauges.

4.1.2 Type of conductor

The conductor may be either solid or stranded.

The solid conductor shall consist of a single strand circular in section.

This stranded conductor shall consist of several strands of circular cross-section assembled either by concentric layer stranding or by bunching, and without insulation between them.

4.1.3 Conductor finish

The conductor may be either plain or tinned.

4.1.4 Conductor dimensions

The solid conductor is designated by its nominal diameter.

This stranded conductor is designated by its nominal cross-sectional area, the number of strands, and maximum diameter of strands.

Dimensions are given in Annexes A and B.

4.1.5 Continuity of conductor

Normally the conductor shall be drawn in one piece. In cases of necessity, joints in the conductor are permitted provided that the breaking strength of a joint is not less than 85 % of the breaking strength of the unjointed conductor. Joints in a complete stranded conductor are not permitted.

4.2 Insulation

4.2.1 insulation material

The insulation shall consist of PVC.

NOTE The initials "PVC" denote a plasticized compound of polyvinyl chloride or vinylchloride-vinylacetate copolymers.

4.2.2 Insulation thickness

The insulation shall be continuous having a thickness as uniform as possible and not less than the value specified in Annex A.

The maximum diameter of the wire shall be calculated in accordance with the method given in Annex C.

The minimum thickness of the insulation shall be measured in accordance with the method specified in 5.2.1.1 of IEC 60189-1.

4.2.3 Application of the insulation

The insulation shall be applied to fit closely to the conductor without adhering to it.

The stripping properties of the insulation shall be checked in accordance with the method specified in 6.4.2 of IEC 60189-1.

It shall be possible to strip the insulation from the conductor easily and without damage to the insulation, to the conductor, or to the tinning, if any.

4.2.4 Colour of insulation

The insulated conductors shall be coloured by one colour or by two different colours.

Colours shall correspond reasonably with the standard colours shown in IEC 60304.

Colour fastness to daylight, checked according to ISO 105, shall be rated at not less than standard 4, prolonging the exposure until the contrast is equivalent to grade 4 on the grey scale. When two colours are used, the following conditions shall be fulfilled:

– markings shall be rings or helices; if helices, single helices are preferred, double helices, however, are allowed;
– markings may be made by helical bicolour extrusion;
– markings printed or painted on the insulation shall adhere satisfactorily;
– markings shall be easily identifiable within any 15 mm length of the insulated conductor;
– the distance of repetition of the markings shall be not less than 4 mm, measured from centre to centre parallel to the axis;
– the width of the rings or helices and the width of their spacing shall be not less than 1,5 mm, measured parallel to the axis; the widths shall be approximately constant along the insulated conductor;
– the width of the rings or helices need not be the same as that of the spacing.

NOTE For wires identified by ring marking, neither the registration of the two half-bands nor the complete encirclement of the wire is critical.

The choice of colours or combinations of colours shall be made in the following order of preference:

– the 12 standard colours shown in IEC 60304;
– the following 19 easily identifiable combinations of two standard colours:

RED-black	YELLOW-violet
RED-blue	GREEN-black
ORANGE-green	GREEN-red
ORANGE-blue	BLUE-black
ORANGE-violet	GREY-red
YELLOW-black	GREY-blue
YELLOW-red	WH ITE-black
YELLOW-green	WHITE-red
YELLOW-blue	WHITE-green
	WHITE-blue

– the following 20 less easily identifiable combinations of two standard colours:

BROWN-black	GREY-black	GREEN-brown
BROWN-blue	GREY-violet	WHITE-brown
ORANGE-black	GREY-brown	WHITE-orange
ORANGE-grey	RED-brown	WHITE-violet
ORANGE-brown	GREEN-grey	WHITE-grey
ORANGE-red	GREEN-violet	WHITE-yellow
VIOLET-black	GREEN-blue	

NOTE 1 The colour combination YELLOW-green is reserved for protectional earth wires exclusively.

NOTE 2 Except in the case of bicolour extrusion, the colour printed in capitals should be known as the "base colour"; it should be

a) the extruded colour;

b) it should have the greater area of exposure on the finished wire.

4.3 Twisting of insulated conductors

The construction shall be (see Figure 1):

– a single insulated conductor, or

– a pair of two insulated conductors twisted together and designated “wire a” and “wire b” respectively or

– a triple of three insulated conductors twisted together and designated “wire a”, “wire b” and “wire c” respectively.

The maximum lay length shall not exceed 120 mm

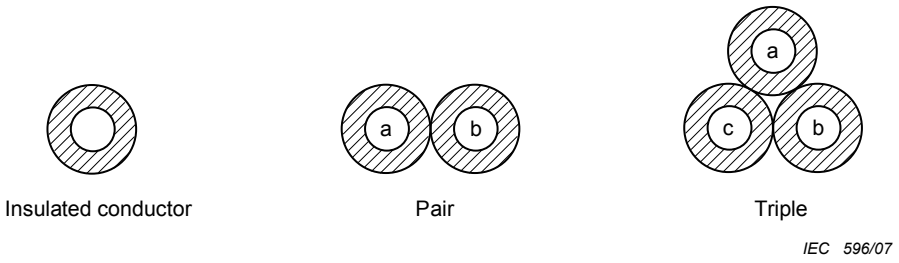

Figure 1 – Construction

4.4 Identification of insulated conductors

The colour combinations for the identification of pairs and triples are not specified in this standard.

4.5 Delivery

Delivery shall be made on reels or in coils protected in a suitable manner.

5 Mechanical requirements

5.1 Conductor

Elongation at break of the bare conductor shall be not less than the value specified in Table 1.

Table 1 – Mechanical requirements of the conductor

Nominal diameter of wire		Minimum elongation	
Above	Up to	Copper	Copper alloy
mm	mm	%	%
–	0,12	–	6,0
0,12	0,2	8,0	6,0
0,2	0,4	10,0	8,0
0,4	–	15,0	–

Compliance shall be checked by measuring the elongation at break in accordance with the method specified in 6.3 of IEC 60189-1.

If the conductor is tinned, the amount of tin per unit area shall be adequate for soldering the conductor to the terminals without difficulty.

Compliance shall be checked by means of the solder test on samples of the conductors in accordance with the method specified in 7.7 of IEC 60189-1.

Good tinning shall be evidenced by free flowing of the solder with wetting of the conductor ends.

5.2 Insulation

The insulation shall have adequate mechanical strength and elasticity. These properties shall remain sufficiently constant during normal use.

Compliance shall be checked before and after accelerated ageing by measuring the tensile strength and the elongation a t break on samples of the insulation in accordance with the method specified in 6.3 of IEC 60189-1.

The accelerated ageing conditioning is specified in 7.1 of IEC 60189-1.

The median of the measured values of tensile strength shall be not less than 12,5 N/mm^2 (12,5 MPa) (see Notes 1 and 2).

The median of the measured values of elongation at break shall be not less than 100 %.

Moreover, the difference between the median values for tensile strength and elongation obtained before and after accelerated ageing shall not exceed 20 % of the median values before ageing.

NOTE 1 The values specified for tensile strength and for elongation at break are independent and non-concomitant minima. An insulation with one characteristic of near-minimum value should present a value well above the minimum for the other characteristic.

NOTE 2 The median value is the middle value if an odd number of values is obtained or the average of the two middle values if an even number of values is obtained. The test results should have been arranged in sequence of increasing values.

6 Thermal stability and climatic requirements

6.1 Measurement of insulation shrinkage after over-heating of conductor

The measured shrinkage shall be not more than 4 % when tested according to 7.6 of IEC 60189-1.

6.2 Resistance to flame propagation

Resistance to flame propagation shall be checked in accordance with the method specified in 7.3.2 of IEC 60189-1.

6.3 Cold bend test

The insulation shall show no cracks when tested according to 7.4.1 of IEC 60189-1.

6.4 Heat shock test

The insulation shall show no cracks when tested according to 7.5.1 of IEC 60189-1.

7 Electrical requirements

7.1 Electrical resistance of conductor

The electrical resistance of the conductor measured at, or corrected to, a temperature of 20 °C, shall not exceed the value specified in Annexes A and B.

Calculation of these values is based on IEC 60344, using the k_1 value for tinned conductors, the k_2 value for stranded conductors and, in the case of pairs and triples, the k_3 value for a twisting factor greater than 16. The same resistance values may also be applied to plain conductors.

The method for measuring the resistance and also for correcting the measured values for length and temperature are specified in 8.1 of IEC 60189-1.

7.2 Dielectric strength

The insulation shall withstand the application for 1 min without breakdown of the voltage specified in Annexes A and B.

The method for checking the dielectric strength is specified in 8.2 of IEC 60189-1.

7.3 Insulation resistance

Insulation resistance measured at, or corrected to, a temperature of 20 °C shall be not less than the value specified in Annexes A and B.

The method for measuring the insulation resistance is specified in 8.3 of IEC 60189-1.

Annex A
(normative)

Single equipment wires

Conductor					Insulation		Test requirements		
Nominal diameter	Nominal section	Number of strands	Maximum diameter of strands	Maximum resistance	Minimum thickness	Maximum diameter	Dielectric strength test voltage	Minimum insulation resistance for	
								General purposes	Telecommunication equipment
mm	mm²		mm	Ω/km[c]	mm	mm[d]	V	MΩ.km	MΩ.km
0,12[a]				1 646		0,55			
0,15[a]				1 054		0,55			
0,20				593		0,60			
	0,035[a]	7	0,09	571		0,65	500 a.c.		
0,25				379	0,12	0,65	or	10	50
	0,055	7	0,11	365		0,70	750 d.c.		
	0,079	7	0,13	242		0,80			
0,32				225		0,75			
	0,124	7	0,16	155		0,90			
0,40				144		0,90	1 000 a.c.		
0,50				92,2		1,00	or		
	0,22	7	0,21	87,2	0,15	1,10	1 500 d.c.	10	200
0,60				64,0		1,10			
	0,50	28	0,16	38,8		1,80			
		16	0,21	38,2			1 500 a.c.		
0,8				36,0		1,60	or	10	200
	0,75	42	0,16	25,8	0,25	2,00	2 250 d.c.		
		24	0,21	25,4					
1,0				22,8		1,85			
	1,00	32	0,21	19,1		2,55	2 000 a.c.		
	1,50	30	0,26	13,0	0,40	2,90	or	10	200
1,40				12,0[b]		2,65	3 000 d.c.		

[a] These conductors are only in copper alloy.

[b] This value is based on a solid conductor size of 1,38 mm nominal diameter.

[c] Add 20 % to these values for copper alloy conductors.

[d] For engineering calculation purposes.

Annex B
(normative)

Equipment wires in pairs and triples

Conductor					Insulation		Test requirements		
Nominal diameter	**Nominal section**	**Number of strands**	**Maximum diameter of strands**	**Maximum resistance**	**Minimum thickness**	**Maximum diameter**	**Dielectric strength test voltage**	**General purposes**	**Minimum insulation resistance for telecommunication equipment**
Mm	mm²		mm	Ω/km[b]	mm	mm[c]	V	MΩ.km	MΩ.km
0,12[a]				1 712		0,55			
0,15[a]				1 096		0,55			
0,20				616		0,60			
	0,035[a]	7	0,09	594		0,65	500 a.c		
0,25				394	0,12	0,65	or	10	50
	0,055	7	0,11	380		0,70	750 d.c.		
	0,079	7	0,13	252		0,80			
0,32				234		0,75			
	0,124	7	0,16	161		0,90			
0,40				148		0,90	1 000 a.c.		
0,50				95,0		1,00	or		
	0,22	7	0,21	89,9	0,15	1,10	1 500 d.c.	10	200
0,60				65,9		1,10			

[a] These conductors are only in copper alloy.

[b] Add 20 % to these values for copper alloy conductors.

[c] For engineering calculation purposes.

Annex C
(normative)

Calculation of the maximum diameter of insulated conductors

The nominal diameter, d_i, is calculated in accordance with IEC 60649.

The value (d_i + 10 %) is calculated and rounded to the nearest two decimal places, that is to say, X,XX.

The second decimal place figure (0,0X) is then rounded up in steps of 0,05, for example: 1,81 rounded to 1,85, 1,86 rounded to 1,90.

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