IEC 60227-1

Edition 4.0 2024-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V –
Part 1: General requirements

IEC 60227-1:2024-02 RLV(en)

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CONTENTS

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POLYVINYL CHLORIDE INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750 V –

Part 1: General requirements

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60227-1:2017. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60227-1 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2007. This edition constitutes a technical revision.

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

a) the reference to tests according to IEC 60227-2 has been withdrawn and replaced with a reference to IEC 63294;
b) normative references have been updated.

The text of this International Standard is based on the following documents:

Draft	Report on voting
20/2145/FDIS	20/2153/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60227 series, published under the general title *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The IEC 60227 series, published under the general title *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V,* consists of the following parts:

IEC 60227-1: General requirements;

IEC 60227-2: Test methods (withdrawn and replaced by IEC 63294);

IEC 60227-3: Non-sheathed cables for fixed wiring;

IEC 60227-4: Sheathed cables for fixed wiring;

IEC 60227-5: Flexible cables (cords);

IEC 60227-6: Lift cables and cables for flexible connections;

IEC 60227-7: Flexible cables screened and unscreened with two or more conductors and of rated voltages up to and including 300/500 V.

This part of IEC 60227, when used in conjunction with each of the other parts of the IEC 60227 series, forms the complete standard for the type of cable specified in the specific part.

POLYVINYL CHLORIDE INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750 V –

Part 1: General requirements

~~1 General~~

1 Scope

This part of IEC 60227 applies to rigid and flexible cables with insulation, and sheath if any, based on polyvinyl chloride, of rated voltages U_0/U up to and including 450/750 V used in power installations of nominal voltage not exceeding 450/750 V AC.

NOTE For some types of flexible cables the term "cord" is used.

The particular types of cables are specified in IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6 and IEC 60227-7. The code designations of these types of cables are provided in this document.

The test methods specified in this document, IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6 and IEC 60227-7 are given in ~~IEC 60227-2~~ IEC 63294, IEC 60332-1-2 and in the relevant parts of the IEC 60811 series.

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.

~~IEC 60173, *Colours of the cores of flexible cables and cords*~~

~~IEC 60227-2, *Polyvinyl chloride insulated cables of rated voltage up to and including 450/750 V – Part 2: Test methods*~~

IEC 60227-3, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 3: Non-sheathed cables for fixed wiring*

IEC 60227-4, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 4: Sheathed cables for fixed wiring*

IEC 60227-5, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (cords)*

IEC 60227-6, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 6: Lift cables and cables for flexible connections*

IEC 60227-7, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 7: Flexible cables screened and unscreened with two or more conductors and of rated voltages up to and including 300/500 V*

IEC 60228, *Conductors of insulated cables*

IEC 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*

~~IEC 60811-1-1, *Common test methods for insulating and sheathing materials of electric cables and optical cables – Part 1: Methods for general application – Measuring of thickness and overall dimensions – Tests for determining the mechanical properties*~~

~~IEC 60811-1-2, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Two: Thermal ageing methods*~~

~~IEC 60811-1-4, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Four: Tests at low temperature*~~

~~IEC 60811-3-1, *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section One: Pressure test at high temperature – Tests for resistance to cracking*~~

~~IEC 60811-3-2, *Common test methods for insulating and sheathing materials of electric cables – Part 3: Methods specific to PVC compounds – Section Two: Loss of mass test – Thermal stability tests*~~

IEC 60811-401:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*
IEC 60811-401:2012/AMD1:2017

IEC 60811-404, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 404: Miscellaneous tests – Mineral oil immersion tests for sheaths*

IEC 60811-405, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 405: Miscellaneous tests – Thermal stability test for PVC insulations and PVC sheaths*

IEC 60811-409, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 409: Miscellaneous tests – Loss of mass test for thermoplastic insulations and sheaths*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-504, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 504: Mechanical tests – Bending tests at low temperature for insulation and sheaths*

IEC 60811-505, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 505: Mechanical tests – Elongation at low temperature for insulations and sheaths*

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 506: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-508, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-509, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*

IEC 62440, *Electric cables with a rated voltage not exceeding 450/750 V – Guide to use ~~for cables with a rated voltage not exceeding 450/750V~~*[1]

IEC 63294:2021, *Test methods for electric cables with rated voltages up to and including 450/750 V*

3 Terms and definitions

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

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

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

~~**2.1 Definitions relating to insulating and sheathing materials**~~

3.1
polyvinyl chloride compound
PVC
combination of materials suitably selected, proportioned and treated, of which the characteristic constituent is the plastomer polyvinyl chloride or one of its copolymers

Note 1 to entry: PVC also designates compounds containing both polyvinyl chloride and certain of its polymers.

3.2
type of compound
category in which a compound is placed according to its properties, as determined by specific tests

Note 1 to entry: The type designation is not directly related to the composition of the compound.

3.3
rated voltage
reference voltage for which the cable is designed and which serves to define the electrical tests

Note 1 to entry: The rated voltage is expressed by the combination of two values U_o/U, expressed in volts:

U_o being the RMS value between any insulated conductor and "earth" (metal covering of the cable or the surrounding medium);

U being the RMS value between any two-phase conductors of a multicore cable or of a system of single-core cables.

In an alternating current system, the rated voltage of a cable shall be at least equal to the nominal voltage of the system for which it is intended.

This condition applies both to the value U_o and to the value U.

In a direct current system, the rated nominal voltage ~~of the system~~ between conductor and "earth" shall be not higher than 1,5 times the rated ~~voltage~~ AC value of ~~the cable~~ U_o.

Note 2 to entry: The operating voltage of a system ~~may~~ can permanently exceed the nominal voltage of such a system by 10 %. A cable can be used at a 10 % higher operating voltage than its rated voltage if the latter is at least equal to the nominal voltage of the system.

~~[1] In preparation.~~

3.4
code designation
code used to designate a specific type of cable

Note 1 to entry: The code designations for the cables specified in the IEC 60227 series are listed in Annex A.

~~**2.2 Definitions relating to the tests**~~

~~**2.2.1 Type tests (symbol *T*)**~~

~~Tests required to be made before supplying a type of cable covered by this standard on a general commercial basis in order to demonstrate satisfactory performance characteristics to meet the intended application. These tests are of such a nature that, after they have been made, they need not be repeated unless changes are made in the cable materials or design which might change the performance characteristics.~~

~~**2.2.2 Sample tests (symbol *S*)**~~

~~Tests made on samples of completed cable or components taken from a completed cable, adequate to verify that the finished product meets the design specifications.~~

4 Marking

4.1 Indication of origin and cable identification

4.1.1 General

Cables shall be provided with an indication of the manufacturer, which shall be either an identification thread or a repetitive marking of the manufacturer's name or trademark.

Cables for use at a conductor temperature exceeding 70 °C shall also be marked either with the code designation according to Annex A or with the maximum conductor temperature.

Marking may be by printing or by reproduction in relief on or in the insulation or sheath.

4.1.2 Continuity of marks

Each specified mark shall be regarded as continuous if the distance between the end of the mark and the beginning of the next identical mark does not exceed

– 550 mm if the marking is on the outer sheath of the cable;
– 275 mm if the marking is
  a) on the insulation of an unsheathed cable;
  b) on the insulation of a sheathed cable;
  c) on a tape within a sheathed cable.

4.2 Durability

Printed markings shall be durable. Compliance with this requirement shall be checked by the test given in ~~1.8 of IEC 60227-2~~ IEC 63294:2021, 6.1.

4.3 Legibility

All markings shall be legible.

The colours of the identification threads shall be easy to recognize or easily made recognizable, if necessary, by cleaning with petrol or other suitable solvent.

5 Core identification

5.1 General

Each core shall be identified as follows:

– in cables having up to and including five cores by colour, see 5.2;

– in cables having more than five cores by number, see 5.3.

NOTE The colour scheme, and in particular the scheme for rigid multicore cables, is under consideration.

5.2 Core identification by colours

5.2.1 General requirements

Identification of the cores of a cable shall be achieved by the use of coloured insulation or other suitable method.

Each core of a cable shall have only one colour, except the core identified by the colour combination green-and-yellow.

The colours green and yellow, when not in combination, shall not be used for any multicore cable.

NOTE The colours red and white ~~should~~ are preferably ~~be~~ avoided.

5.2.2 Colour scheme

The preferred colour scheme for flexible cables and single-core cables is:

– single-core cable: no preferred colour scheme;

– two-core cable: no preferred colour scheme;

– three-core cable: either green-and-yellow, blue, brown, or, brown, black, grey;

– four-core cable: either green-and-yellow, brown, black, grey,
or blue, brown, black, grey;

– five-core cable: either green-and-yellow, blue, brown, black, grey,
or blue, brown, black, grey, black.

The colours shall be clearly identifiable and durable. Durability shall be checked by the test given in ~~1.8 of IEC 60227-2~~ IEC 63294:2021, 6.1.

5.2.3 Colour combination green-and-yellow

The distribution of the colours for the core coloured green-and-yellow shall comply with the following condition ~~(which is in accordance with IEC 60173)~~: for every 15 mm length of core, either one of ~~these~~ the colours green and yellow shall cover at least 30 % and not more than 70 % of the surface of the core, the other colour covering the remainder.

NOTE Information on the use of the colours green-and-yellow and blue: It is understood that the colours green and yellow, when they are combined as specified above, are recognized exclusively as a means of identification of the core intended for use as earth connection or similar protection, and that the colour blue is intended for the identification of the core intended to be connected to neutral. If, however, there is no neutral, blue can be used to identify any core except the earthing or protective conductor.

5.3 Core identification by numbers

5.3.1 General requirements

The insulation of the cores shall be of the same colour and numbered sequentially, except for the core coloured green-and-yellow, if one is included.

The green-and-yellow core, if any, shall comply with the requirement of 5.2.3 and shall be in the outer layer.

The numbering shall start with number 1 in the inner layer.

The numbers shall be printed in Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of the insulation. The numerals shall be legible.

5.3.2 Preferred arrangement of marking

The numbers shall be repeated, at regular intervals along the core, consecutive numbers being inverted in relation to each other.

When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be ~~disposed~~ positioned one below the other and a dash placed below the lower numeral. The spacing d between consecutive numbers shall not exceed 50 mm.

The arrangement of the marks is shown in Figure 1 below.

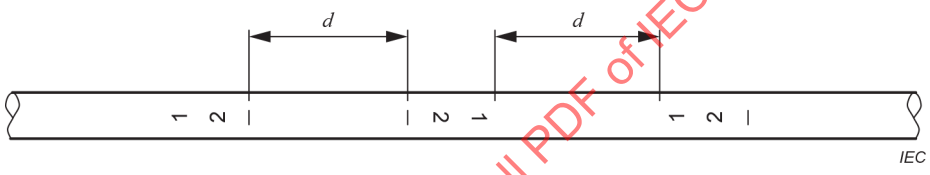

Figure 1 – Arrangement of marking by numbers

5.3.3 Durability

Printed numerals shall be durable. Compliance with this requirement shall be checked by the test given in ~~1.8 of IEC 60227-2~~ IEC 63294:2021, 6.1.

6 General requirements for the construction of cables

6.1 Conductors

6.1.1 Material

The conductors shall consist of annealed copper, except for the wires of tinsel cords, for which a copper alloy may be used. The wires may be plain or tinned.

6.1.2 Construction

The maximum diameters of the wires of flexible conductors – other than the conductors of tinsel cords – and the minimum number of the wires of rigid conductors shall be in accordance with IEC 60228.

The classes of the conductors relevant to the various types of cables are given in the particular standards (see IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

Conductors of cables for fixed installations shall be circular solid, circular stranded or compacted circular stranded conductors.

For tinsel cords each conductor shall comprise a number of strands or groups of strands, twisted together, each strand being composed of one or more flattened wires of copper or copper alloy, helically wound on a thread of cotton, polyamide or similar material.

6.1.3 Check on construction

Compliance with the requirements of 6.1.1 and 6.1.2, including the requirements of IEC 60228, shall be checked by inspection and by measurement.

6.1.4 Electrical resistance

For cables – other than tinsel cords – the resistance of each conductor at 20 °C shall be in accordance with the requirements of IEC 60228 for the given class of the conductor.

Compliance shall be checked by the test given in ~~2.1 of IEC 60227-2~~ IEC 63294:2021, 5.1.

6.2 Insulation

6.2.1 Material

The insulation shall be polyvinyl chloride compound of the type specified for each type of cable in the particular standards (see IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7):

– type PVC/C in the case of cables for fixed installation;
– type PVC/D in the case of flexible cables;
– type PVC/E in the case of heat-resistant cables for internal wiring.

The test requirements for these compounds are specified in Table 1.

The maximum operating temperatures for cables insulated with any of the above types of compound and covered by the particular standards (see IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7) are given in those publications.

6.2.2 Application to the conductor

The insulation shall be so applied that it fits closely on the conductor, but for cables other than tinsel cords, it shall be possible to remove it without damage to the insulation itself, to the conductor or to the tin coating if any. Compliance shall be checked by inspection and by manual test.

6.2.3 Thickness

The mean value of the thickness of insulation shall be not less than the specified value for each type and size of cable shown in the tables of the particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

However, the thickness at any ~~place~~ point may be less than the specified value provided that the difference does not exceed 0,1 mm + 10 % of the specified value.

Compliance shall be checked by the test given in ~~1.9 of IEC 60227-2~~ IEC 63294:2021, 6.2.

6.2.4 Mechanical properties before and after ageing

The insulation shall have adequate mechanical strength and elasticity within the temperature limits to which it may be exposed in normal use.

Compliance shall be checked by carrying out the tests specified in Table 1.

The applicable test methods and the results to be obtained are specified in Table 1.

Table 1 – Requirements for the non-electrical tests for polyvinyl chloride (PVC) insulation

1	2	3	4	5	6	7
Reference No.	Test	Unit	Type of component			Test method described in
			PVC/C	PVC/D	PVC/E	
1	Tensile strength and elongation at break					~~60811-1-1~~ IEC 60811-501
1.1	Properties in the state as delivered					
1.1.1	Values to be obtained for the tensile strength:					
	– median, min.	N/mm^2	12,5	10	15	
1.1.2	Values to be obtained for the elongation at break:					
	– median, min.	%	125	150	150	
1.2	Properties after ageing in air oven					~~60811-1-2 and 60811-1-1~~ IEC 60811-401 and IEC 60811-501
1.2.1	Ageing conditions:					
	– temperature	°C	80 ± 2	80 ± 2	135 ± 2	
	– duration of treatment	h	7 × 24	7 × 24	10 × 24	
1.2.2	Values to be obtained for the tensile strength:					
	– median, min.	N/mm^2	12,5	10	15	
	– variation[a], max.	%	±20	±20	±25	
1.2.3	Values to be obtained for the elongation at break:					
	– median, min.	%	125	150	150	
	– variation[a], max.	%	±20	±20	±25	
2	Loss of mass test					~~60811-3-2~~ IEC 60811-409
2.1	Ageing conditions:					
	– temperature	°C	80 ± 2	80 ± 2	115 ± 2	
	– duration of treatment	h	7 × 24	7 × 24	10 × 24	
2.2	Values to be obtained for the loss of mass, max.	mg/cm^2	2	2	2	
3	Compatibility test[b]					~~60811-1-2~~ IEC 60811-401
3.1	Ageing conditions	°C	80 ± 2	80 ± 2	100 ± 2	
		h	7 × 24	7 × 24	10 × 24	
3.2	Mechanical properties after ageing Values to be obtained		As in reference Nos. 1.2.2 and 1.2.3			
4	Heat shock test					~~60811-3-1~~ IEC 60811-509
4.1	Test conditions:					
	– temperature	°C	150 ± 2	150 ± 2	150 ± 2	
	– duration of treatment	h	1	1	1	

1	2	3	4	5	6	7
Reference No.	**Test**	**Unit**	**Type of component**			**Test method described in**
			PVC/C	**PVC/D**	**PVC/E**	
4.2	Results to be obtained		Absence of cracks			
5	Pressure test at high temperature					~~60811-3-1~~ IEC 60811-508
5.1	Test conditions:					
	– force exercised by the blade		See ~~IEC 60811-3-1~~ IEC 60811-508			
	– duration of heating under load		See ~~IEC 60811-3-1~~ IEC 60811-508			
	– temperature	°C	80 ± 2	70 ± 2	90 ± 2	
5.2	Results to be obtained:					
	– median of the depth of penetration, max.	%	50	50	50	
6	Bending test at low temperature					~~60811-1-4~~ IEC 60811-504
6.1	Test conditions:					
	– temperature~~[1)]~~	°C	–15 ± 2	–15 ± 2	–15 ± 2	
	– period of application of low temperature		See ~~IEC 60811-1-4~~ IEC 60811-504			
6.2	Results to be obtained		Absence of cracks			
7	Elongation test at low temperature					~~60811-1-4~~ IEC 60811-505
7.1	Test conditions:					
	– temperature~~[1)]~~	°C	–15 ± 2	–15 ± 2	–	
	– period of application of low temperature		See ~~IEC 60811-1-4~~ IEC 60811-505			
7.2	Result to be obtained:					
	– elongation without break, min.	%	20	20	–	
8	Impact test at low temperature[c]					~~60811-1-4~~ IEC 60811-506
8.1	Test conditions:					
	– temperature~~[1)]~~	°C	–15 ± 2	–15 ± 2	–	
	– period of application of low temperature		See ~~IEC 60811-1-4~~ IEC 60811-506			
	– mass of hammer		See ~~IEC 60811-1-4~~ IEC 60811-506			
8.2	Results to be obtained		See ~~IEC 60811-1-4~~ IEC 60811-506			
9	Thermal stability test					~~60811-3-2~~ IEC 60811-405
9.1	Test conditions:					
	– temperature	°C	–	–	200 ± 0,5	
9.2	Results to be obtained:					
	– mean value of the thermal stability time, min.	min	–	–	180	

~~[1)] Due to climatic conditions, national standards may require a lower test temperature to be used.~~

[a] Variation: difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.

[b] If applicable, see 6.3.1.

[c] If specified in the particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

6.3 Filler

6.3.1 Material

The fillers shall be composed of one of the following or of any combination of the following, unless otherwise specified in the particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7):

– a compound based on unvulcanized rubber or plastics; or

– natural or synthetic textiles; or

– paper.

When the filler is composed of unvulcanized rubber, there shall be no harmful interactions between its constituents and either insulation or sheath or both. Compliance with this requirement shall be checked by the test given in ~~8.1.4 of IEC 60811-1-2~~ IEC 60811-401:2012, Annex C and IEC 60811-401:2012/AMD1:2017, Annex C.

6.3.2 Application

For each type of cable, the particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7) specify whether that cable includes fillers or whether the sheath or inner covering may penetrate between the cores, thus forming a filling.

The fillers shall fill the spaces between the cores giving the assembly a practically circular shape. The fillers shall not adhere to the cores. The assembly of cores and fillers may be held together by a film or tape.

6.4 Extruded inner covering

6.4.1 Material

The extruded inner covering shall be composed of a compound based on unvulcanized rubber or plastics, unless otherwise specified in the particular standards (IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

Where the inner covering is composed of unvulcanized rubber, there shall be no harmful interactions between its constituents and either insulation or sheath or both.

Compliance with this requirement shall be checked by the test given in ~~8.1.4 of IEC 60811-1-2~~ IEC 60811-401:2012, Annex C and IEC 60811-401:2012/AMD1:2017, Annex C.

6.4.2 Application

The extruded inner covering shall surround the cores and may penetrate the spaces between them giving the assembly a practical circular shape. The extruded inner covering shall not adhere to the cores.

For each type of cable, the particular standards (IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7) indicate whether that cable includes an extruded inner covering or not, or whether the outer sheath may penetrate between the cores, thus forming a filling.

6.4.3 Thickness

No measurement is required for the extruded inner covering, unless otherwise specified in the particular standards (IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

6.5 Sheath

6.5.1 Material

The sheath shall be polyvinyl chloride compound of the type specified for each type of cable in the particular standards (see IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7):

– type PVC/ST4 in the case of cables for fixed installations;
– type PVC/ST5 in the case of flexible cables;
– type PVC/ST9 in the case of oil-resistant flexible cables;
– type PVC/ST10 in the case of cables sheathed with a 90 °C polyvinyl chloride compound.

The test requirements for these compounds are specified in Table 2.

6.5.2 Application

The sheath shall be extruded in a single layer:

a) on the core, in the case of single-core cables;
b) on the assembly of cores and fillers or inner covering, if any, in the case of other cables.

The sheath shall not adhere to the cores. A separator, consisting of a film or tape, may be placed under the sheath.

In certain cases, indicated in the particular standards (IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7), the sheath may penetrate into the spaces between the cores, thus forming a filling (see 6.4.2).

6.5.3 Thickness

The mean value of the thickness shall not be less than the specified value for each type and size of cable shown in the tables of the particular standards (IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

However, the thickness at any place may be less than the specified value provided that the difference does not exceed 0,1 mm + 15 % of the specified value, unless otherwise specified.

Compliance shall be checked by the test given in ~~1.10 of IEC 60227-2~~ IEC 63294:2021, 6.3.

6.5.4 Mechanical properties before and after ageing

The sheath shall have adequate mechanical strength and elasticity within the temperature limits to which it ~~may~~ can be exposed in normal use.

Compliance shall be checked by carrying out the tests specified in Table 2.

The applicable test values and the results to be obtained are specified in Table 2.

Table 2 – Requirements for the non-electrical test for polyvinyl chloride (PVC) sheaths

1	2	3	4	5	6	7	8
Reference No.	Test	Unit	Type of compound				Test method described in
			PVC/ ST4	PVC/ ST5	PVC/ ST9	PVC/ ST10	
1	Tensile strength and elongation at break						~~60811-1-1~~ IEC 60811-501
1.1	Properties in the state as delivered						
1.1.1	Values to be obtained for the tensile strength:						
	– median, min.	N/mm^2	12,5	10	10	10	
1.1.2	Values to be obtained for the elongation at break						
	– median, min.	%	125	150	150	150	
1.2	Properties after ageing in the air oven						~~60811-1-2~~
1.2.1	Ageing conditions:						~~60811-1-1~~ IEC 60811-401
	– temperature	°C	80 ± 2	80 ± 2	80 ± 2	135 ± 2	
	– duration of treatment	h	7 × 24	7 × 24	7 × 24	7 × 24	
1.2.2	Values to be obtained for the tensile strength:						
	– median, min.	N/ mm^2	12,5	10	10	10	
	– variation[a], max.	%	±20	±20	±20	±25	
1.2.3	Values to be obtained for the elongation at break:						
	– median, min.	%	125	150	150	150	
	– variation[a], max.	%	±20	±20	±20	±25	
2	Loss of mass test						~~60811-3-2~~ IEC 60811-409
2.1	Ageing conditions:						
	– temperature	°C	As in reference No. 1.2.1			115 ± 2	
	– duration of treatment	h				10 × 24	
2.2	Values to be obtained for the loss of mass, max.	mg/cm^2	2	2	2	2	
3	Compatibility test[b]						~~60811-1-2~~ IEC 60811-401
3.1	Ageing conditions:						
	– temperature	°C	As in reference No. 1.2.1			100 ± 2	
	– duration of treatment	h				10 × 24	
3.2	Mechanical properties after ageing Values to be obtained		As in reference Nos. 1.2.2 and 1.2.3				
4	Heat shock test						~~60811-3-1~~ IEC 60811-509
4.1	Test conditions:						
	– temperature	°C	150 ± 2	150 ± 2	150 ± 2	150 ± 2	
	– duration of treatment	h	1	1	1	1	
4.2	Results to be obtained		Absence of cracks				

1	2	3	4	5	6	7	8
Reference No.	**Test**	**Unit**	**Type of compound**				**Test method described in**
			PVC/ ST4	**PVC/ ST5**	**PVC/ ST9**	**PVC/ ST10**	
5	Pressure test at high temperature						~~60811-3-1~~ IEC 60811-508
5.1	Test conditions:						
	– force exercised by the blade						~~60811-3-1~~
	– duration of heating under load	h					
	– temperature	°C	80 ± 2	70 ± 2	70 ± 2	90 ± 2	~~60811-3-1~~
5.2	Results to be obtained:						
	– median of the depth of penetration, max.	%	50	50	50	50	
6	Bending test at low temperature						~~60811-1-4~~ IEC 60811-504
6.1	Test conditions:						~~60811-1-4~~
	– temperature~~1)~~	°C	–15 ± 2	–15 ± 2	–15 ± 2	–15 ± 2	
	– period of application of low temperature	h					
6.2	Results to be obtained		Absence of cracks				~~60811-1-4~~
7	Elongation test at low temperature						~~60811-1-4~~ IEC 60811-505
7.1	Test conditions:						
	– temperature~~1)~~	°C	–15 ± 2	–15 ± 2	–15 ± 2	–15 ± 2	
	– period of application of low temperature						
7.2	Results to be obtained:						
	– elongation without break, min.	%	20	20	20	20	~~60811-1-4~~
8	Impact test at low temperature						~~60811-1-4~~ IEC 60811-505
8.1	Test conditions:						
	– temperature~~1)~~	°C	–15 ± 2	–15 ± 2	–15 ± 2	–15 ± 2	~~60811-1-4~~
	– period of application of low temperature	h					
	– mass of hammer						
8.2	Results to be obtained						~~60811-1-4~~
9	Mechanical properties after immersion in mineral oil						~~60811-2-1~~ IEC 60811-404
9.1	Test conditions:						
	– temperature of oil	°C	-	-	90 ± 2	-	
	– duration of immersion in oil	h	-	-	24	-	
9.1.1	Value to be obtained for the tensile strength:						
	– variation max.[a]	%	-	-	±30		
9.1.2	Value to be obtained for the elongation at break[a]:						
	– variation max.	%	-	-	±30		
10	Minimum thermal stability at 200 °C	min	-	-	-	180	~~60811-3-2~~ IEC 60811-405

1	2	3	4	5	6	7	8
Reference No.	**Test**	**Unit**	**Type of compound**				**Test method described in**
			PVC/ ST4	**PVC/ ST5**	**PVC/ ST9**	**PVC/ ST10**	
~~1) Due to climatic conditions, national standards may require the use of a lower test temperature.~~							
[a] Variation: difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.							
[b] Only applicable when called up by the particular cable standard, see also 6.3.1.							

6.6 Tests on completed cables

6.6.1 Electrical properties

The cables shall have adequate dielectric strength and insulation resistance.

Compliance shall be checked by carrying out the tests specified in Table 3.

The test methods and the results to be obtained are specified in Table 3.

Table 3 – Requirements for electrical tests for PVC insulated cables

1	2	3	4	5	6	7
Reference No.	**Test**	**Unit**	**Rated voltage of cables**			**Test method described in**
			300/ 300 V	**300/ 500 V**	**450/ 750 V**	
1	Measurement of the resistance of conductors					~~60227-2~~ IEC 63294:2021, 5.1
1.1	Values to be obtained, max.		See IEC 60228 and particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7)			
2	Voltage test on completed cables					~~60227-2~~ IEC 63294:2021, 5.2
2.1	Test conditions:					
	– minimum length of the sample	m	10	10	10	
	– minimum period of immersion in water	h	1	1	1	
	– temperature of the water	°C	20 ± 5	20 ± 5	20 ± 5	
2.2	Voltage applied (AC)	V	2 000	2 000	2 500	
2.3	Duration of each application of voltage, min.	min	5	5	5	
2.4	Results to be obtained		No breakdown			

1	2	3	4	5	6	7
Reference No.	**Test**	**Unit**	**Rated voltage of cables**			**Test method described in**
			300/ 300 V	**300/ 500 V**	**450/ 750 V**	
3	Voltage test on cores					~~60227-2~~ IEC 63294:2021, 5.3
3.1	Test conditions:					
	– length of sample	m	5	5	5	
	– minimum period of immersion in water	h	1	1	1	
	– temperature of the water	°C	20 ± 5	20 ± 5	20 ± 5	
3.2	Applied voltage (AC) according to specified thickness of insulation:					
	– up to and including 0,6 mm	V	1 500	1 500	–	
	– exceeding 0,6 mm	V	2 000	2 000	2 500	
3.3	Duration of each application of voltage, min.	min	5	5	5	
3.4	Results to be obtained		No breakdown			
4	Measurement of insulation resistance					~~60227-2~~ IEC 63294:2021, 5.4
4.1	Test conditions:					
	– length of sample	m	5	5	5	
	– previous voltage test as in Ref. Nos. 2 or 3					
	– minimum period of immersion in hot water	h	2	2	2	
	– temperature of water		See tables in the particular standards			
4.2	Results to be obtained		(IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7)			

6.6.2 Overall dimensions

The mean overall dimensions of the cables shall be within the limits specified in the tables in the particular standards (see IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

~~The difference between any two values of the overall diameter of sheathed circular cables of the same cross-section (ovality) shall not exceed 15 % of the upper limit specified for the mean overall diameter.~~

Ovality compliance shall be checked by the tests given in ~~1.11 of IEC 60227-2~~ IEC 63294:2021, 6.4.

6.6.3 Mechanical strength of flexible cables

6.6.3.1 General

The flexible cables shall be capable of withstanding bending and other mechanical stresses occurring in normal use.

When specified in the particular standards (see IEC 60227-5, IEC 60227-6, IEC 60227-7), compliance shall be checked by the test given in ~~Clause 3 of IEC 60227-2~~ IEC 63294:2021, Clause 6.

6.6.3.2 Flexing test for flexible cables

See ~~3.1 of IEC 60227-2~~ IEC 63294:2021, 6.6.

During the test with 15 000 backward and forward movements, i.e. 30 000 single strokes, neither interruption of the current nor short circuit between the conductors shall occur.

After the test, the sample shall withstand the voltage test carried out in accordance with ~~2.2 of IEC 60227-2~~ IEC 63294:2021, 5.2.

6.6.3.3 Bending test for tinsel cord

See ~~3.2 of IEC 60227-2~~ IEC 63294:2021, 6.8.

During the test with 60 000 bending cycles, i.e. 120 000 single strokes, interruption of the current shall not occur.

After the test, the sample shall withstand the voltage test carried out in accordance with ~~2.2 of IEC 60227-2~~ IEC 63294:2021, 5.2, the voltage, however, being 1 500 V and applied only between the conductors connected together and the water.

6.6.3.4 ~~Snatch~~ Drop test for tinsel cord

See ~~3.3 of IEC 60227-2~~ IEC 63294:2021, 6.10.

During the test, interruption of the current shall not occur.

6.6.3.5 Test for separation of cores

See ~~3.4 of IEC 60227-2~~ IEC 63294:2021, 6.11.

The force shall be between 3 N and 30 N.

6.6.4 Flame retardance

All the cables shall comply with the test specified in IEC 60332-1-2.

7 Guidance on the use of cables

~~See the future IEC 62440.~~

The use of cables shall comply with IEC 62440, which provides general guidance on the safe use of electric cables with a rated voltage not exceeding 450/750 V.

Annex A
(normative)

Code designations

Cables of the types covered by the IEC 60227 series are designated by two numerals, preceded by the reference number.

The first numeral indicates the basic class of cable; the second numeral indicates the particular type within the basic class.

The classes and types are as follows:

0. Non-sheathed cables for fixed wiring:
   - 01. Single-core non-sheathed cable with rigid conductor for general purposes (60227 IEC 01);
   - 02. Single-core non-sheathed cable with flexible conductor for general purposes (60227 IEC 02);
   - 05. Single-core non-sheathed cable with solid conductor for internal wiring for a conductor temperature of 70 °C (60227 IEC 05);
   - 06. Single-core non-sheathed cable with flexible conductor for internal wiring for a conductor temperature of 70 °C (60227 IEC 06);
   - 07. Single-core non-sheathed cable with solid conductor for internal wiring for a conductor temperature of 90 °C (60227 IEC 07);
   - 08. Single-core non-sheathed cable with flexible conductor for internal wiring for a conductor temperature of 90 °C (60227 IEC 08);
1. Sheathed cables for fixed wiring:
   - 10. Light polyvinyl chloride sheathed cable (60227 IEC 10);
4. Non-sheathed flexible cables for light duty:
   - 41. Flat tinsel cord (60227 IEC 41);
   - 42. Flat non-sheathed cord (60227 IEC 42);
   - 43. Cord for indoor decorative lighting chains (60227 IEC 43);
5. Sheathed flexible cables for normal duty:
   - 52. Light polyvinyl chloride sheathed cord (60227 IEC 52);
   - 53. Ordinary polyvinyl chloride sheathed cord (60227 IEC 53);
   - 56. Heat-resistant light PVC-sheathed cord for a maximum conductor temperature of 90 °C (60227 IEC 56);
   - 57. Heat-resistant ordinary PVC-sheathed cord for a maximum conductor temperature of 90 °C (60227 IEC 57);
7. Sheathed flexible cables for special duty:
   - 71c Circular polyvinyl chloride sheathed ~~lift cable and~~ cable for flexible connections (60227 IEC 71c);
   - 71f Flat polyvinyl chloride sheathed ~~lift~~ cable~~s and cables~~ for flexible connections (60227 IEC 71f).
   - 74. Oil resistant, polyvinyl chloride sheathed, screened flexible cable (60227 IEC 74);
   - 75. Oil resistant, polyvinyl chloride sheathed, unscreened flexible cable (60227 IEC 75).

Bibliography

IEC 60227-2, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods*[2]

2 Withdrawn.

IEC 60227-1

Edition 4.0 2024-02

INTERNATIONAL STANDARD

Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V –
Part 1: General requirements

IEC 60227-1:2024-02(en)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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POLYVINYL CHLORIDE INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750 V –

Part 1: General requirements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 60227-1 has been prepared by IEC technical committee 20: Electric cables. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2007. This edition constitutes a technical revision.

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

a) the reference to tests according to IEC 60227-2 has been withdrawn and replaced with a reference to IEC 63294;
b) normative references have been updated.

The text of this International Standard is based on the following documents:

Draft	Report on voting
20/2145/FDIS	20/2153/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60227 series, published under the general title *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

The IEC 60227 series, published under the general title *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V,* consists of the following parts:

IEC 60227-1: General requirements;

IEC 60227-2: Test methods (withdrawn and replaced by IEC 63294);

IEC 60227-3: Non-sheathed cables for fixed wiring;

IEC 60227-4: Sheathed cables for fixed wiring;

IEC 60227-5: Flexible cables (cords);

IEC 60227-6: Lift cables and cables for flexible connections;

IEC 60227-7: Flexible cables screened and unscreened with two or more conductors and of rated voltages up to and including 300/500 V.

This part of IEC 60227, when used in conjunction with each of the other parts of the IEC 60227 series, forms the complete standard for the type of cable specified in the specific part.

POLYVINYL CHLORIDE INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750 V –

Part 1: General requirements

1 Scope

This part of IEC 60227 applies to rigid and flexible cables with insulation, and sheath if any, based on polyvinyl chloride, of rated voltages U_o/U up to and including 450/750 V used in power installations of nominal voltage not exceeding 450/750 V AC.

NOTE For some types of flexible cables the term "cord" is used.

The particular types of cables are specified in IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6 and IEC 60227-7. The code designations of these types of cables are provided in this document.

The test methods specified in this document, IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6 and IEC 60227-7 are given in IEC 63294, IEC 60332-1-2 and in the relevant parts of the IEC 60811 series.

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.

IEC 60227-3, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 3: Non-sheathed cables for fixed wiring*

IEC 60227-4, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 4: Sheathed cables for fixed wiring*

IEC 60227-5, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (cords)*

IEC 60227-6, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 6: Lift cables and cables for flexible connections*

IEC 60227-7, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 7: Flexible cables screened and unscreened with two or more conductors and of rated voltages up to and including 300/500 V*

IEC 60228, *Conductors of insulated cables*

IEC 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*

IEC 60811-401:2012, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*
IEC 60811-401:2012/AMD1:2017

IEC 60811-404, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 404: Miscellaneous tests – Mineral oil immersion tests for sheaths*

IEC 60811-405, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 405: Miscellaneous tests – Thermal stability test for PVC insulations and PVC sheaths*

IEC 60811-409, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 409: Miscellaneous tests – Loss of mass test for thermoplastic insulations and sheaths*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-504, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 504: Mechanical tests – Bending tests at low temperature for insulation and sheaths*

IEC 60811-505, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 505: Mechanical tests – Elongation at low temperature for insulations and sheaths*

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 506: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-508, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-509, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*

IEC 62440, *Electric cables with a rated voltage not exceeding 450/750 V – Guide to use*

IEC 63294:2021, *Test methods for electric cables with rated voltages up to and including 450/750 V*

3 Terms and definitions

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

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

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

3.1
polyvinyl chloride compound
PVC
combination of materials suitably selected, proportioned and treated, of which the characteristic constituent is the plastomer polyvinyl chloride or one of its copolymers

Note 1 to entry: PVC also designates compounds containing both polyvinyl chloride and certain of its polymers.

3.2
type of compound
category in which a compound is placed according to its properties, as determined by specific tests

Note 1 to entry: The type designation is not directly related to the composition of the compound.

3.3
rated voltage
reference voltage for which the cable is designed and which serves to define the electrical tests

Note 1 to entry: The rated voltage is expressed by the combination of two values U_o/U, expressed in volts:

U_o being the RMS value between any insulated conductor and "earth" (metal covering of the cable or the surrounding medium);

U being the RMS value between any two-phase conductors of a multicore cable or of a system of single-core cables.

In an alternating current system, the rated voltage of a cable shall be at least equal to the nominal voltage of the system for which it is intended.

This condition applies both to the value U_o and to the value U.

In a direct current system, the rated nominal voltage between conductor and "earth" shall be not higher than 1,5 times the rated AC value of U_o.

Note 2 to entry: The operating voltage of a system can permanently exceed the nominal voltage of such a system by 10 %. A cable can be used at a 10 % higher operating voltage than its rated voltage if the latter is at least equal to the nominal voltage of the system.

3.4
code designation
code used to designate a specific type of cable

Note 1 to entry: The code designations for the cables specified in the IEC 60227 series are listed in Annex A.

4 Marking

4.1 Indication of origin and cable identification

4.1.1 General

Cables shall be provided with an indication of the manufacturer, which shall be either an identification thread or a repetitive marking of the manufacturer's name or trademark.

Cables for use at a conductor temperature exceeding 70 °C shall also be marked either with the code designation according to Annex A or with the maximum conductor temperature.

Marking may be by printing or by reproduction in relief on or in the insulation or sheath.

4.1.2 Continuity of marks

Each specified mark shall be regarded as continuous if the distance between the end of the mark and the beginning of the next identical mark does not exceed

– 550 mm if the marking is on the outer sheath of the cable;
– 275 mm if the marking is
  a) on the insulation of an unsheathed cable;
  b) on the insulation of a sheathed cable;
  c) on a tape within a sheathed cable.

4.2 Durability

Printed markings shall be durable. Compliance with this requirement shall be checked by the test given in IEC 63294:2021, 6.1.

4.3 Legibility

All markings shall be legible.

The colours of the identification threads shall be easy to recognize or easily made recognizable, if necessary, by cleaning with petrol or other suitable solvent.

5 Core identification

5.1 General

Each core shall be identified as follows:

– in cables having up to and including five cores by colour, see 5.2;
– in cables having more than five cores by number, see 5.3.

NOTE The colour scheme, and in particular the scheme for rigid multicore cables, is under consideration.

5.2 Core identification by colours

5.2.1 General requirements

Identification of the cores of a cable shall be achieved by the use of coloured insulation or other suitable method.

Each core of a cable shall have only one colour, except the core identified by the colour combination green-and-yellow.

The colours green and yellow, when not in combination, shall not be used for any multicore cable.

NOTE The colours red and white are preferably avoided.

5.2.2 Colour scheme

The preferred colour scheme for flexible cables and single-core cables is:

– single-core cable: no preferred colour scheme;
– two-core cable: no preferred colour scheme;
– three-core cable: either green-and-yellow, blue, brown, or, brown, black, grey;
– four-core cable: either green-and-yellow, brown, black, grey,
or blue, brown, black, grey;
– five-core cable: either green-and-yellow, blue, brown, black, grey,
or blue, brown, black, grey, black.

The colours shall be clearly identifiable and durable. Durability shall be checked by the test given in IEC 63294:2021, 6.1.

5.2.3 Colour combination green-and-yellow

The distribution of the colours for the core coloured green-and-yellow shall comply with the following condition: for every 15 mm length of core, either one of the colours green and yellow shall cover at least 30 % and not more than 70 % of the surface of the core, the other colour covering the remainder.

NOTE Information on the use of the colours green-and-yellow and blue: It is understood that the colours green and yellow, when they are combined as specified above, are recognized exclusively as a means of identification of the core intended for use as earth connection or similar protection, and that the colour blue is intended for the identification of the core intended to be connected to neutral. If, however, there is no neutral, blue can be used to identify any core except the earthing or protective conductor.

5.3 Core identification by numbers

5.3.1 General requirements

The insulation of the cores shall be of the same colour and numbered sequentially, except for the core coloured green-and-yellow, if one is included.

The green-and-yellow core, if any, shall comply with the requirement of 5.2.3 and shall be in the outer layer.

The numbering shall start with number 1 in the inner layer.

The numbers shall be printed in Arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of the insulation. The numerals shall be legible.

5.3.2 Preferred arrangement of marking

The numbers shall be repeated, at regular intervals along the core, consecutive numbers being inverted in relation to each other.

When the number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be positioned one below the other and a dash placed below the lower numeral. The spacing d between consecutive numbers shall not exceed 50 mm.

The arrangement of the marks is shown in Figure 1 below.

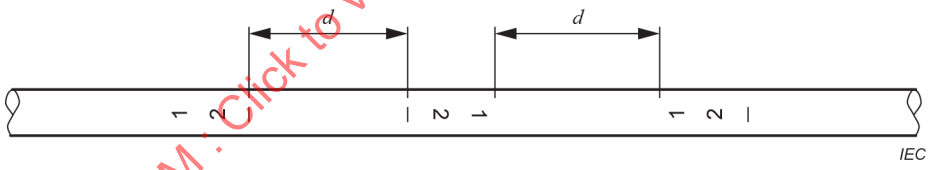

Figure 1 – Arrangement of marking by numbers

5.3.3 Durability

Printed numerals shall be durable. Compliance with this requirement shall be checked by the test given in IEC 63294:2021, 6.1.

6 General requirements for the construction of cables

6.1 Conductors

6.1.1 Material

The conductors shall consist of annealed copper, except for the wires of tinsel cords, for which a copper alloy may be used. The wires may be plain or tinned.

6.1.2 Construction

The maximum diameters of the wires of flexible conductors – other than the conductors of tinsel cords – and the minimum number of the wires of rigid conductors shall be in accordance with IEC 60228.

The classes of the conductors relevant to the various types of cables are given in the particular standards (see IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

Conductors of cables for fixed installations shall be circular solid, circular stranded or compacted circular stranded conductors.

For tinsel cords each conductor shall comprise a number of strands or groups of strands, twisted together, each strand being composed of one or more flattened wires of copper or copper alloy, helically wound on a thread of cotton, polyamide or similar material.

6.1.3 Check on construction

Compliance with the requirements of 6.1.1 and 6.1.2, including the requirements of IEC 60228, shall be checked by inspection and by measurement.

6.1.4 Electrical resistance

For cables – other than tinsel cords – the resistance of each conductor at 20 °C shall be in accordance with the requirements of IEC 60228 for the given class of the conductor.

Compliance shall be checked by the test given in IEC 63294:2021, 5.1.

6.2 Insulation

6.2.1 Material

The insulation shall be polyvinyl chloride compound of the type specified for each type of cable in the particular standards (see IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7):

– type PVC/C in the case of cables for fixed installation;
– type PVC/D in the case of flexible cables;
– type PVC/E in the case of heat-resistant cables for internal wiring.

The test requirements for these compounds are specified in Table 1.

The maximum operating temperatures for cables insulated with any of the above types of compound and covered by the particular standards (see IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7) are given in those publications.

6.2.2 Application to the conductor

The insulation shall be so applied that it fits closely on the conductor, but for cables other than tinsel cords, it shall be possible to remove it without damage to the insulation itself, to the conductor or to the tin coating if any. Compliance shall be checked by inspection and by manual test.

6.2.3 Thickness

The mean value of the thickness of insulation shall be not less than the specified value for each type and size of cable shown in the tables of the particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

However, the thickness at any point may be less than the specified value provided that the difference does not exceed 0,1 mm + 10 % of the specified value.

Compliance shall be checked by the test given in IEC 63294:2021, 6.2.

6.2.4 Mechanical properties before and after ageing

The insulation shall have adequate mechanical strength and elasticity within the temperature limits to which it may be exposed in normal use.

Compliance shall be checked by carrying out the tests specified in Table 1.

The applicable test methods and the results to be obtained are specified in Table 1.

Table 1 – Requirements for the non-electrical tests for polyvinyl chloride (PVC) insulation

1	2	3	4	5	6	7
Reference No.	**Test**	**Unit**	**Type of component**			**Test method described in**
			PVC/C	**PVC/D**	**PVC/E**	
1	Tensile strength and elongation at break					IEC 60811-501
1.1	Properties in the state as delivered					
1.1.1	Values to be obtained for the tensile strength:					
	– median, min.	N/mm^2	12,5	10	15	
1.1.2	Values to be obtained for the elongation at break:					
	– median, min.	%	125	150	150	
1.2	Properties after ageing in air oven					IEC 60811-401 and IEC 60811-501
1.2.1	Ageing conditions:					
	– temperature	°C	80 ± 2	80 ± 2	135 ± 2	
	– duration of treatment	h	7 × 24	7 × 24	10 × 24	
1.2.2	Values to be obtained for the tensile strength:					
	– median, min.	N/mm^2	12,5	10	15	
	– variation[a], max.	%	±20	±20	±25	
1.2.3	Values to be obtained for the elongation at break:					
	– median, min.	%	125	150	150	
	– variation[a], max.	%	±20	±20	±25	
2	Loss of mass test					IEC 60811-409
2.1	Ageing conditions:					
	– temperature	°C	80 ± 2	80 ± 2	115 ± 2	
	– duration of treatment	h	7 × 24	7 × 24	10 × 24	
2.2	Values to be obtained for the loss of mass, max.	mg/cm^2	2	2	2	

1	2	3	4	5	6	7
Reference No.	**Test**	**Unit**	**Type of component**			**Test method described in**
			PVC/C	**PVC/D**	**PVC/E**	
3	Compatibility test[b]					IEC 60811-401
3.1	Ageing conditions	°C	80 ± 2	80 ± 2	100 ± 2	
		h	7 × 24	7 × 24	10 × 24	
3.2	Mechanical properties after ageing Values to be obtained		As in reference Nos. 1.2.2 and 1.2.3			
4	Heat shock test					IEC 60811-509
4.1	Test conditions:					
	– temperature	°C	150 ± 2	150 ± 2	150 ± 2	
	– duration of treatment	h	1	1	1	
4.2	Results to be obtained		Absence of cracks			
5	Pressure test at high temperature					IEC 60811-508
5.1	Test conditions:					
	– force exercised by the blade		See IEC 60811-508			
	– duration of heating under load		See IEC 60811-508			
	– temperature	°C	80 ± 2	70 ± 2	90 ± 2	
5.2	Results to be obtained:					
	– median of the depth of penetration, max.	%	50	50	50	
6	Bending test at low temperature					IEC 60811-504
6.1	Test conditions:					
	– temperature	°C	–15 ± 2	–15 ± 2	–15 ± 2	
	– period of application of low temperature		See IEC 60811-504			
6.2	Results to be obtained		Absence of cracks			
7	Elongation test at low temperature					IEC 60811-505
7.1	Test conditions:					
	– temperature	°C	–15 ± 2	–15 ± 2	–	
	– period of application of low temperature		See IEC 60811-505			
7.2	Result to be obtained:					
	– elongation without break, min.	%	20	20	–	
8	Impact test at low temperature[c]					IEC 60811-506
8.1	Test conditions:					
	– temperature	°C	–15 ± 2	–15 ± 2	–	
	– period of application of low temperature		See IEC 60811-506			
	– mass of hammer		See IEC 60811-506			
8.2	Results to be obtained		See IEC 60811-506			

1	2	3	4	5	6	7
Reference No.	**Test**	**Unit**	**Type of component**			**Test method described in**
			PVC/C	**PVC/D**	**PVC/E**	
9	Thermal stability test					IEC 60811-405
9.1	Test conditions:					
	– temperature	°C	–	–	200 ± 0,5	
9.2	Results to be obtained:					
	– mean value of the thermal stability time, min.	min	–	–	180	

[a] Variation: difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.

[b] If applicable, see 6.3.1.

[c] If specified in the particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

6.3 Filler

6.3.1 Material

The fillers shall be composed of one of the following or of any combination of the following, unless otherwise specified in the particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7):

– a compound based on unvulcanized rubber or plastics; or

– natural or synthetic textiles; or

– paper.

When the filler is composed of unvulcanized rubber, there shall be no harmful interactions between its constituents and either insulation or sheath or both. Compliance with this requirement shall be checked by the test given in IEC 60811-401:2012, Annex C and IEC 60811-401:2012/AMD1:2017, Annex C.

6.3.2 Application

For each type of cable, the particular standards (IEC 60227-3, IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7) specify whether that cable includes fillers or whether the sheath or inner covering may penetrate between the cores, thus forming a filling.

The fillers shall fill the spaces between the cores giving the assembly a practically circular shape. The fillers shall not adhere to the cores. The assembly of cores and fillers may be held together by a film or tape.

6.4 Extruded inner covering

6.4.1 Material

The extruded inner covering shall be composed of a compound based on unvulcanized rubber or plastics, unless otherwise specified in the particular standards (IEC 60227-4, IEC 60227-5, IEC 60227-6, IEC 60227-7).

Where the inner covering is composed of unvulcanized rubber, there shall be no harmful interactions between its constituents and either insulation or sheath or both.

Compliance with this requirement shall be checked by the test given in IEC 60811-401:2012, Annex C and IEC 60811-401:2012/AMD1:2017, Annex C.