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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Part 1: General requirements

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.060.20

ISBN 978-2-8322-8368-4

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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.

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a) the reference to tests according to IEC 60227-2 has been withdrawn and replaced with a reference to IEC 63294;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

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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.

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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*

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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)*

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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.~~

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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.

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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.

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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.

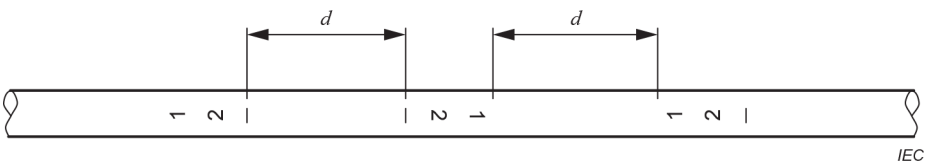

Figure 1 – Arrangement of marking by numbers

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.

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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.

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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	

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