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OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
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TITLE:

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

PROPOSED STABILITY DATE: 2030

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 1: General requirements

FOREWORD

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This part of International Standard IEC 60227-1 has been prepared by Working Group 17: Low-voltage cables, of IEC technical committee 20: Electric cables.

This fourth edition of IEC 60227-1 cancels and replaces the third edition, issued in 2007.

The technical content is therefore identical to the base edition, only editorial modifications have been conducted

It bears the edition number 4.0.

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

Part 1: General requirements

Part 2 - test methods has been withdrawn and replaced by the IEC 63294

Part 3: Non-sheathed cables for fixed wiring

Part 4: Sheathed cables for fixed wiring

Part 5: Flexible cables (cords)

Part 6: Lift cables and cables for flexible connections

Part 7: Flexible cables screened and unscreened with two or more conductors for rated voltages up to and including 300/500 V only.

This part 1, in conjunction with each other parts, forms the complete standard for each described cables in the other parts

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

Draft	Report on voting
20/XX/FDIS	20/XX/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/standardsdev/publications.

A list of all the 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 (300/500 V exclusively for part 7)*, can be found on the IEC website.

The major change is that the part 2 has been withdrawn and replaced by IEC 63294.

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,
- replaced by a revised edition, or
- amended.

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

Part 1: General requirements

1 General

1.1 Scope

This part of International Standard 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 the part 3 to 7 of IEC 60227. The code designations of these types of cables are given in Annex A.

The test methods specified in Parts 1, 3, 4, etc. are given in IEC 63294, IEC 60332-1-2 and in the relevant parts of IEC 60811.

1.2 Normative references

The following referenced documents are indispensable for the application of this document. In all cases reference to an International Standard implies the latest edition of that document (including any amendments).

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

IEC 60227-4, *Polyvinyl chloride insulated cables of rated voltage 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 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 series Electric and optical fibre cables – Test methods for non-metallic materials:

- IEC 60811-401, *Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*

- IEC 60811-404, *Miscellaneous tests – Mineral oil immersion tests for sheaths*

- IEC 60811-405, *Miscellaneous tests – Thermal stability test for PVC insulations and PVC sheaths*

- IEC 60811-409, *Miscellaneous tests – Loss of mass test for thermoplastic insulations and sheaths*

- IEC 60811-501, *Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

- IEC 60811-504, *Mechanical tests – Bending tests at low temperature for insulation and sheaths*

- IEC 60811-505, *Mechanical tests – Elongation at low temperature for insulations and sheaths*

- IEC 60811-506, *Mechanical tests – Impact test at low temperature for insulations and sheaths*

- IEC 60811-508, *Mechanical tests – Pressure test at high temperature for insulation and sheaths*

- IEC 60811-509, *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, *Test methods for electric cables with rated voltage up to and including 450/750 V.*

2 Definitions

For the purpose of this standard the following definitions shall apply.

2.1 Definitions relating to insulating and sheathing materials

2.1.1 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. The same term also designates compounds containing both polyvinyl chloride and certain of its polymers.

2.1.2 Type of compound

The category in which a compound is placed according to its properties, as determined by specific tests. The type designation is not directly related to the composition of the compound.

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.

Note 1 : Type 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 to verify that the finished product meets the design specifications.

2.3 Rated voltage

The rated voltage of a cable is the reference voltage for which the cable is designed and which serves to define the electrical tests.

The rated voltage is expressed by the combination of two values U_0/U, expressed in volts:

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

U being the r.m.s. 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_0 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 Uo

NOTE The operating voltage of a system may 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 Marking

3.1 Indication of origin and cable identification

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 trade-mark.

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

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

3.1.1 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.

3.2 Durability

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

3.3 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.

4 Core identification

Each core shall be identified as follows:

– in cables having up to and including five cores by colour, see 4.1;
– in cables having more than five cores by number, see 4.2.

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

4.1 Core identification by colours

4.1.1 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 a combination of the colours 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 preferably be avoided.

4.1.2 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 6.1 of IEC 63294.

4.1.3 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, one of these colours 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.

4.2 Core identification by numbers

4.2.1 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 4.1.3 and shall be in the outer layer.

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

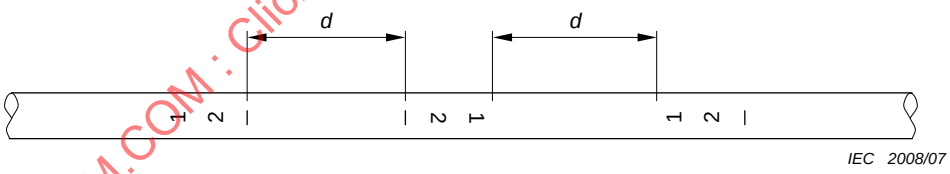
The numbers shall be printed in arabic numerals on the outer surfaces of the cores. All the numbers shall be of the same colour, which shall contrast with the colour of the insulation. The numerals shall be legible.

4.2.2 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 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 the figure below.



4.2.3 Durability

Printed numerals shall be durable. Compliance with this requirement shall be checked by the test given 6.1 of IEC 63294.

5 General requirements for the construction of cables

5.1 Conductors

5.1.1 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.

5.1.2 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 specifications (see IEC 60227-3, IEC 60227-4, etc.).

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.

5.1.3 Check on construction

Compliance with the requirements of 5.1.1 and 5.1.2, including the requirements of IEC 60228, shall be checked by inspection and by measurement.

5.1.4 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 5.1 of IEC 63294.

5.2 Insulation

5.2.1 Material

The insulation shall be polyvinyl chloride compound of the type specified for each type of cable in the particular specifications (see IEC 60227-3, IEC 60227-4, etc.).

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 specifications (see IEC 60227-3, IEC 60227-4, etc.) are given in those publications.

5.2.2 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.

5.2.3 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, etc.).

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 6.2 of IEC 63294.

5.2.4 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	IEC	Part
1	*Tensile strength and elongation at break*					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	10,0	15,0		
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	401 & 501
1.2.1	Ageing conditions: – temperature – duration of treatment	°C h	80 ± 2 7 × 24	80 ± 2 7 × 24	135 ± 2 10 × 24		
1.2.2	Values to be obtained for the tensile strength: – median, min. – variation [1], max.	N/mm^2 %	12,5 ±20	10,0 ±20	15,0 ±25		
1.2.3	Values to be obtained for the elongation at break: – median, min. – variation [1], max.	% %	125 ±20	150 ±20	150 ±25		
2	*Loss of mass test*					60811	409
2.1	Ageing conditions: – temperature – duration of treatment	°C h	80 ± 2 7 × 24	80 ± 2 7 × 24	115 ± 2 10 × 24		
2.2	Values to be obtained for the loss of mass, max.	mg/cm^2	2,0	2,0	2,0		
3	*Compatibility test* [2]					60811	401
3.1	Ageing conditions	°C h	80 ± 2 7 × 24	80 ± 2 7 × 24	100 ± 2 10 × 24		
3.2	Mechanical properties after ageing Values to be obtained		As in references Nos. 1.2.2 and 1.2.3				
4	Heat shock test					60811	509
4.1	Test conditions: – temperature – duration of treatment	°C h	150 ± 2 1	150 ± 2 1	150 ± 2 1		
4.2	Results to be obtained		Absence of cracks				

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

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

[2] If applicable, see 5.3.1.

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

[4] If specified in the particular specifications (IEC 60227-3, IEC 60227-4, etc.).

5.3 Filler

5.3.1 Material

Unless otherwise specified in the particular specifications (IEC 60227-3, IEC 60227-4, etc.), the fillers shall be composed of one of the following or of any combination of the following:

– 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 the insulation and/or the sheath. Compliance with this requirement shall be checked by the test given in IEC 60811-401 annex A.

5.3.2 Application

For each type of cable, the particular specifications (IEC 60227-3, IEC 60227-4, etc.) 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.

5.4 Extruded inner covering

5.4.1 Material

Unless otherwise specified in the particular specifications (IEC 60227-4, etc.), the extruded inner covering shall be composed of a compound based on unvulcanized rubber or plastics.

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

Compliance with this requirement shall be checked by the test given in IEC 60811-401 annex A.

5.4.2 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 specifications (IEC 60227-4, etc.) 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.

5.4.3 Thickness

Unless otherwise specified in the particular specifications (IEC 60227-4, etc.), no measurement is required for the extruded inner covering.

5.5 Sheath

5.5.1 Material

The sheath shall be polyvinyl chloride compound of the type specified for each type of cable in the particular specifications (see IEC 60227-4, etc.):

– type PVC/ST4 in the case of cables for fixed installations;
– type PVC/ST5 in the case of flexible cables;
– type PVC/ST9 in 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.

5.5.2 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 specifications (IEC 60227-4, etc.), the sheath may penetrate into the spaces between the cores, thus forming a filling (see 5.4.2).

5.5.3 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 specifications (IEC 60227-4, etc.).

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 6.3 of IEC 63294.

5.5.4 Mechanical properties before and after ageing

The sheath shall have adequate mechanical strength and elasticity within the temperature limits to which it may 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.

445 **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	IEC	Part
1	*Tensile strength and elongation at break*						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	10,0	10,0	10,0		
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							
1.2.1	Ageing conditions: – temperature – duration of treatment	°C h	80 ± 2 7 × 24	80 ± 2 7 × 24	80 ± 2 7 × 24	135 ± 2 7 × 24	60811	401
1.2.2	Values to be obtained for the tensile strength: – median, min. – variation[1], max.	N/ mm^2 %	12,5 ±20	10,0 ±20	10,0 ±20	10,0 ±25	60811	501
1.2.3	Values to be obtained for the elongation at break: – median, min. – variation[1], max.	% %	125 ±20	150 ±20	150 ±20	150 ±25	60811	501
2	*Loss of mass test*						60811	409
2.1	Ageing conditions: – temperature – duration of treatment	°C h	As in reference No. 1.2.1			115 ± 2 10 × 24		
2.2	Values to be obtained for the loss of mass, max.	mg/cm^2	2,0	2,0	2,0	2,0		
3	*Compatibility test* [2]						60811	401
3.1	Ageing conditions: – temperature – duration of treatment	°C h	As in reference No. 1.2.1			100 ± 2 10 × 24		
3.2	Mechanical properties after ageing Values to be obtained		As in references Nos. 1.2.2 and 1.2.3					
4	*Heat Shock test*						60811	509
4.1	Test conditions: – temperature – duration of treatment	°C h	150 ± 2 1	150 ± 2 1	150 ± 2 1	150 ± 2 1		
4.2	Result to be obtained		Absence of cracks					
5	*Pressure test at high temperature*						60811	508
5.1	Test conditions: – force exercised by the blade – duration of heating under load – temperature	 h °C	 80 ± 2	 70 ± 2	 70 ± 2	 90 ± 2	60811 60811	508 508
5.2	Results to be obtained: – median of the depth of penetration, max.	%	50	50	50	50		
6	*Bending test at low temperature*						60811	504
6.1	Test conditions: – temperature[3] – period of application of low temperature	°C h	–15 ± 2	–15 ± 2	–15 ± 2	–15 ± 2	 60811	 504
6.2	Results to be obtained		Absence of cracks					
7	*Elongation test at low temperature*						60811	505
7.1	Test conditions: – temperature[3] – period of application of low temperature	°C h	–15 ± 2	–15 ± 2	–15 ± 2	–15 ± 2	 60811	 505