IEC 60245-1

Edition 4.1 2008-01
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Rubber insulated cables – Rated voltages up to and including 450/750 V –
Part 1: General requirements

Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V –
Partie 1: Exigences générales

IEC 60245-1:2003-12+AMD1:2008-01 CSV(en-fr)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 25.160.20; 29.060.20

ISBN 2-8318-9450-6

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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RUBBER INSULATED CABLES – RATED VOLTAGES UP TO AND INCLUDING 450/750 V –

Part 1: General requirements

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60245-1 edition 4.1 contains the fourth edition (2003-12) [documents 20/659/FDIS and 20/679/RVD] and its amendment 1 (2007-10) [documents 20/902/FDIS and 20/909/RVD].

A vertical line in the margin shows where the base publication has been modified by amendment 1.

International Standard IEC 60245-1 has been prepared by IEC technical committee 20: Electric cables.

The principal change with respect to the previous edition is the replacement of insulation IE 1 with IE 4. This fourth edition does not constitute a full technical revision.

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

IEC 60245 consists of the following parts, under the general title *Rubber insulated cables – Rated voltages up to and including 450/750 V:*

Part 1: General requirements

Part 2: Test methods

Part 3: Heat resistant silicone insulated cables

Part 4: Cords and flexible cables

Part 5: Lift cables

Part 6: Arc welding electrode cables

Part 7: Heat resistant ethylene-vinyl-acetate rubber insulated cables

Part 8: Cords for applications requiring high flexibility

Parts 3 to 8 are for particular types of cable and should be read in conjunction with Part 1 and Part 2. Further parts may be added as other types are standardized.

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

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

RUBBER INSULATED CABLES – RATED VOLTAGES UP TO AND INCLUDING 450/750 V –

Part 1: General requirements

1 General

1.1 Scope

This part of IEC 60245 applies to rigid and flexible cables with insulation, and sheath if any, based on vulcanized rubber 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 a.c.

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

The particular types of cables are specified in IEC 60245-3, IEC 60245-4, etc. The code designations of these types of cables are given in Annex A.

The test methods specified in Parts 1 to 8 are given in IEC 60245-2, IEC 60332-1 and in the relevant parts of IEC 60811.

1.2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60173:1964, *Colours of the cores of flexible cables and cords*

IEC 60228:1978, *Conductors of insulated cables*

IEC 60245-2:1994, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 2: Test methods*

IEC 60245-3:1994, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 3: Heat resistant silicone insulated cables*

IEC 60245-4:1994, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 4: Cords and flexible cables*

IEC 60245-7:1994, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 7: Heat resistant ethylene-vinyl-acetate rubber insulated cables*

IEC 60332-1:1993, *Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable*

IEC 60811-1-1:1993, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties*

IEC 60811-1-2:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Two: Thermal ageing methods*

IEC 60811-1-4:1985, *Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Four: Tests at low temperature*

IEC 60811-2-1:1998, *Insulating and sheathing materials of electric and optical cables – Common test methods – Part 2-1: Methods specific to elastomeric compounds – Ozone resistance, hot set andmineral oil immersion tests*

IEC 60811-3-1:1985, *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 62440, *Electric cables – Guide to use for cables with a rated voltage not exceeding 450/750V*[1]

2 Terms and definitions

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

2.1 Definitions relating to insulating and sheathing materials

2.1.1
type of compound
category in which a compound is placed according to its properties, as determined by specific tests

NOTE The type designation is not directly related to the composition of the compound.

2.1.2
rubber compound
combination of materials suitably selected, proportioned, treated and vulcanized, of which the characteristic constituent is a rubber and/or synthetic elastomer

NOTE Vulcanization is defined as a post-application treatment taking place after the insulation and/or sheath has been applied in order to induce permanent cross-linking of the elastomer.

2.1.3
polychloroprene compound (PCP) or other equivalent synthetic elastomer
vulcanized compound in which the elastomer is polychloroprene or other equivalent synthetic elastomer providing a compound with properties similar to PCP

2.1.4
ethylene-vinyl acetate rubber compound (EVA) or other equivalent synthetic elastomer
cross-linked compound in which the elastomer is ethylene-vinyl acetate or other equivalent synthetic elastomer providing a compound with properties similar to EVA

2.1.5
ethylene-propylene rubber compound (EPR) or equivalent synthetic elastomer
cross-linked compound in which the elastomer is ethylene-propylene or equivalent synthetic elastomer providing a compound with properties similar to EPR

2.1.6
cross-linked polyvinyl chloride (XLPVC)
combinations of materials of which polyvinyl chloride is the characteristic constituent, including adequate cross-linking agents, suitably selected, proportioned and treated which, when cross-linked, meet the requirements given in the particular specification

1 In preparation.

2.2 Definitions relating to the tests

2.2.1
type tests
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 These tests are of such a nature that, after they have been made, they need not be repeated, unless changes have been made in the cable materials or design which might change the performance characteristics.

2.2.2
sample tests
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

2.3
rated voltage
reference voltage for which the cable is designed, and which serves to define the electrical tests

NOTE 1 The rated voltage is expressed by the combination of two values: U_0/U expressed in volts (V):

U_0 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 is 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 nominal voltage of the system is not higher than 1,5 times the rated voltage of the cable.

NOTE 2 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 trademark.

Marking may be by printing or by reproduction in relief on, or in, the insulation or sheath, or by printing on a proofed tape or a separate marker tape.

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

– on the insulation of an unsheathed cable, or
– on the insulation of a sheathed cable, or
– 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 1.8 of IEC 60245-2.

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 colour or by number; see 4.1 and 4.2.

NOTE The colour scheme 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 is as follows:

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.
cables having more than five cores:	either in the outer layer one core green-and-yellow, one core blue, and the other cores of one and the same colour, however not green, yellow, blue or brown; in the other layers one core brown and the other cores of one and the same colour, however not green, yellow, blue or brown; or in the outer layer one core blue, one core brown and the other cores of one and the same colour, however not green, yellow, blue or brown; in the other layers one core brown and the other cores of one and the same colour, however not green, yellow, blue or brown.

The colours shall be clearly identifiable and durable. Durability shall be checked by the test given in 1.8 of IEC 60245-2.

4.1.3 Colour combination green/yellow

The distribution of the colours for the core coloured green/yellow shall comply with the following condition (which is in accordance with IEC 60173): 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/yellow, if one is included.

The green/yellow core, if any, shall comply with the requirement of 4.1.3 and shall be in the outer layer.

The numbering shall start with the 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 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.

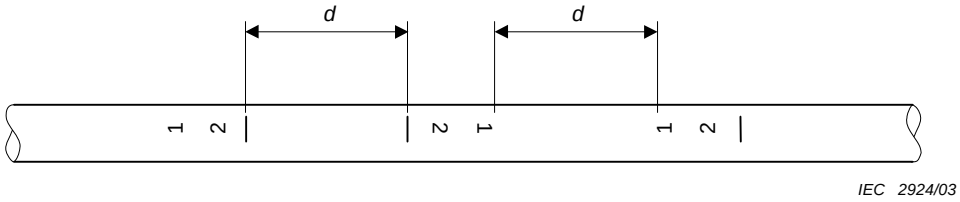

Figure 1 – Arrangement of marking by numbers

4.2.3 Durability

Printed numerals shall be durable. Compliance with this requirement shall be checked by the test given in 1.8 of IEC 60245-2.

5 General requirements for the construction of cables

5.1 Conductors

5.1.1 Material

The conductors shall consist of annealed copper. Unless otherwise specified in the particular specifications (IEC 60245-3, IEC 60245-4, etc.), the wires of conductors may be plain or tinned. Tinned wires shall be covered with an effective layer of tin.

5.1.2 Construction

The maximum diameters of the wires of the conductors shall be in accordance with IEC 60228, unless otherwise specified in the particular cable specifications.

The classes of conductors relevant to the various types of cables are given in the particular specifications (IEC 60245-3, IEC 60245-4, etc.).

5.1.3 Separator between conductor and insulation

An optional separating tape made of suitable material may be placed between the plain or tinned conductor and the insulation.

5.1.4 Construction verification

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.

5.1.5 Electrical resistance

Unless otherwise specified in the particular specifications (IEC 60245-3, IEC 60245-4, etc.), the resistance of each conductor at 20 °C shall be in accordance with the requirements of IEC 60228 for the given class of conductor.

Compliance shall be checked by the test given in 2.1 of IEC 60245-2.

5.2 Insulation

5.2.1 Material

The insulation shall be a cross-linked material of the type specified for each type of cable in the particular specification (IEC 60245-3, IEC 60245-4, etc.).

Type IE 2 in the case of cables insulated with silicone rubber compound.

Type IE 3 in the case of cables insulated with rubber compound based on ethylene vinyl-acetate or equivalent materials.

Type IE 4 in the case of cables insulated with ordinary ethylene-propylene rubber compound or equivalent materials.

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

NOTE For some cables belonging to IEC 60245-8, insulation type XP1 is given in that particular specification.

The maximum operating temperatures for cables insulated with any of the above types of compound and covered by the particular specifications (IEC 60245-3, IEC 60245-4, etc.) are given in those publications.

5.2.2 Application to the conductor

The insulation shall be closely applied to the conductor or separator. In the particular specifications (IEC 60245-3, IEC 60245-4, etc.) it is stated, for each type of cable, whether the insulation shall be applied in a single layer or in a number of layers, and whether it shall or shall not be covered with a proofed tape. It shall be possible to remove the insulation, without damage to the insulation itself, to the conductor, or to the tin or metal 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 specifications (IEC 60245-3, IEC 60245-4, etc.). However, the thickness at any one place 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 60245-2.

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 non-electrical tests for cross-linked rubber insulation

1	2	3	4	5	6	7	
Ref. No.	Test	Unit	Type of compound			Test method described in	
			IE 2	IE 3	IE 4	IEC	Subclause
1	*Tensile strength and elongation at break*					60811-1-1	9.1
1.1	Properties in the state as delivered						
1.1.1	Values to be obtained for the tensile strength:						
	- median, min.	N/mm^2	5,0	6,5	5,0		
1.1.2	Values to be obtained for the elongation at break:						
	- median, min.	%	150	200	200		
1.2	Properties after ageing in air oven					60811-1-1 and 60811-1-2	9.1 and 8.1
1.2.1	Ageing conditions [a, b] :						
	- temperature	°C	200 ± 2	150 ± 2	100 ± 2		
	- duration of treatment	h	10 × 24	7 × 24	7 × 24		
1.2.2	Values to be obtained for the tensile strength:						
	- median, min.	N/mm^2	4,0	-	4,2		
	- variation [c], max.	%	-	± 30	± 25		
1.2.3	Values to be obtained for the elongation-at-break:						
	- median, min.	%	120	-	200		
	- variation [c], max.	%	-	± 30	± 25		
1.3	Spare						
1.4	Properties after ageing in an air bomb					60811-1-2	8.2
1.4.1	Ageing conditions [a] :						
	- temperature	°C	-	150 ± 3	127 ± 2		
	- duration of treatment	h	-	7 × 24	40		
1.4.2	Values to be obtained for the tensile strength:						
	- median, min.	N/mm^2	-	6,0	-		
	- variation [c], max.	%	-	-	±30		
1.4.3	Values to be obtained for the elongation-at-break:						
	- variation [c], max.	%	-	–30 [d]	±30		