IEC 62440

Edition 1.0 2008-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Câbles électriques avec une tension assignée n'excédant pas 450/750 V – Guide d'emploi

IEC 62440:2008

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

T

ICS 29.060.20

ISBN 2-8318-9570-7

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CONTENTS

FOREWORD 4
INTRODUCTION 6

1 Scope 7
2 Normative references 7
3 Terms and definitions 7
4 Safety 8
4.1 General 8
4.2 Selection and installation 8
4.3 Fixed cables 9
4.4 Flexible cables or cords 9
5 Limiting conditions 11
5.1 General 11
5.2 Voltage 11
5.3 Current-carrying capacity 11
5.4 Thermal effects 12
5.5 Fire characteristics 13
5.6 Mechanical stress 14
5.6.1 General 14
5.6.2 Tension 14
5.6.3 Bending 14
5.6.4 Compression 16
5.6.5 Twisting/torsion 16
5.7 Compatibility 17
5.8 Dynamic stresses (electromechanical stress) 17
6 Initial and periodic verifications 17
7 Packaging, storage and handling/transportation 17
7.1 Packaging 17
7.2 Storage 18
7.2.1 Risk of moisture 18
7.2.2 Temperature conditions 18
7.3 Handling/transportation 18

Annex A (informative) Classes of external influence (environmental conditions) 19
Annex B (informative) Types of usage 21
Annex C (informative) Classes of duty 22

Bibliography 24

Figure 1 – Definition of internal bending radius 15

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Full document details: IEC 62440 2008

Table 1 – Spacing of supports for non-armoured cables in accessible positions 9
Table 2 – Examples of maximum permitted voltages against rated voltage of cable 11
Table 3 – Minimum recommended bending radii at cable temperatures of (20 ± 10) °C 16
Table A.1 – Classes of external influence (environmental conditions)..... 19

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ELECTRIC CABLES WITH A RATED VOLTAGE NOT EXCEEDING 450/750 V – GUIDE TO USE

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

FDIS	Report on voting
20/919/FDIS	20/929/RVD

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

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

In some countries legislation may limit the use of certain cable types, and may define additional requirements for cable installation practice.

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INTRODUCTION

This International Standard provides guidance for equipment manufacturers, installers and end-users on the properties of low-voltage electric cables, and the limitations that are deemed to be necessary in order to safeguard life, buildings and goods.

The information is given in the form of limiting values and is illustrated by examples which are not exhaustive but which indicate ways in which safety can be obtained.

Additional information on installation practice is given in the IEC 60364 series.

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ELECTRIC CABLES WITH A RATED VOLTAGE NOT EXCEEDING 450/750 V – GUIDE TO USE

1 Scope

This International Standard provides general guidance for the safe use of electric cables with a rated voltage not exceeding 450/750 V. It is applicable to those cables that are specified in IEC 60227 and IEC 60245.

The guidance given in this standard can also be applicable to low-voltage cables of a similar type to those specified in IEC 60227 and IEC 60245 but not specifically mentioned in those standards. In such cases, it is advisable to seek additional advice from the cable manufacturer.

NOTE Whilst this International Standard, which offers guidelines to the user, is a voluntary standard, those who choose to use it, or who claim conformance to it, must follow the advice contained therein, e.g. with regard to certain bending radii or certain clip spacings, etc. Notwithstanding this, national laws and regulations (especially those relating to selection and installation of cables via IEC 60364), will always take priority.

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 60050-461, *International Electrotechnical Vocabulary – Part 461: Electric cables*

IEC 60245-6, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 6: Arc welding electrode cables*

IEC 60287(all parts), *Electric cables – Calculation of the current rating*

IEC 60335-1, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-5-52, *Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-461 and in the IEC 60364 series, as well as the following, apply.

3.1
internal wiring
wiring mechanically protected by being enclosed within a casing of equipment or by other equivalent means

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4 Safety

4.1 General

Safety of a cable means that the product does not present an unacceptable risk of danger to life or property whilst being used in its intended manner.

The duration of acceptable performance of a particular type of cable depends upon:

– the type of use,
– installation, or
– electrical apparatus,

and on the particular combination of influences that the above might incur. For example, the duration of acceptable performance considered as reasonable for a cable used in a fixed installation for the distribution of electricity in a building is more than that for a flexible cord.

Cables shall not be buried directly in the ground, and unless otherwise stated, shall not be used for any purpose other than the transmission and distribution of electricity.

The test methods and test parameters described in the IEC standards referred to in Clause 1 are only for the purposes of checking design with respect to safety and quality assurance. They do not necessarily indicate that the cables are suitable for service under conditions equivalent to the test conditions.

4.2 Selection and installation

4.2.1 All conductors and cables shall be selected so as to be suitable for the voltages and currents likely to occur, and under all conditions which are anticipated in the equipment or installations or for the part in which they are to be used.

4.2.2 Cables shall be so constructed, installed, protected, used and maintained as to prevent danger so far as it is reasonably practicable.

4.2.3 Cables shall be selected so that they are suitable for the intended operating conditions and equipment classification. Examples of operation conditions include:

a) voltage;
b) current;
c) protective measures;
d) grouping of cables;
e) method of installation;
f) accessibility.

4.2.4 Cables shall be selected so that they are suitable for any external influences which might exist. Cables should not be installed under any of these conditions unless they are of a type specifically designed to withstand such conditions. Examples of external influences include:

a) ambient temperature;
b) presence of rain, steam or accumulation of water;
c) presence of corrosive, chemical or polluting substances;
d) mechanical stresses (such as through holes or sharp edges in metal work);
e) fauna (such as rodents);
f) flora (such as mould);

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g) radiation (such as sunlight).

The colour of the cable is an important factor with regard to solar radiation. Black gives a higher degree of protection against solar radiation than a light colour.

Classes of external influence are shown in Annex A.

Annex B gives an explanation of the different types of usage (i.e. indoor/outdoor).

4.3 Fixed cables

4.3.1 Cables shall not be installed in contact with, or close to, hot surfaces, unless they are of a type intended for such conditions.

4.3.2 Cables shall be supported adequately. The recommended maximum spacing of supports is given in Table 1. In deciding the actual spacing, the mass of the cable between the supports shall be taken into account so that the limiting value of tension (see 5.6.2) is not exceeded. The cable shall not be damaged by any mechanical restraint used for its support.

In the case of single-core cables, the spacing also depends on the dynamic forces due to a short-circuit current; the manufacturer's recommendations shall be observed (see 5.8).

Cables which have been in use can be damaged if they are disturbed. This can arise from the effect of natural ageing on the physical properties of the materials used for cable insulation and sheathing which can ultimately result in hardening of these materials.

Table 1 – Spacing of supports for non-armoured cables in accessible positions

Overall diameter (D) of cable[a] mm	Maximum spacing of supports[b] mm			
	General		In caravans	
	Horizontal	Vertical	Horizontal	Vertical
D ≤9	250	400	150	150
9 <D ≤ 15	300	400	150	150
15 <D ≤ 20	350	450	150	150
20 <D ≤ 40[c]	400	550	–	–

[a] For flat cables this is taken as the measurement of the major axis.

[b] The spacings stated for horizontal runs may also be applied to runs at an angle of more than 30° from the vertical. For runs at an angle of 30° or less than the vertical, the vertical spacings are applicable.

[c] For the spacing of supports for cables of overall diameter exceeding 40 mm, and for single core cables having conductors of cross-sectional area 300 mm^2 and larger, the manufacturer's recommendations shall be observed.

4.4 Flexible cables or cords

4.4.1 Flexible cables or cords shall be used for connections to all mobile equipment. The length of such cables should not be so great as to prevent the short-circuit protective device from operating correctly (see 5.3). Such cables should also be of a minimum practical length to reduce the risk of mechanical damage.

4.4.2 Flexible cables and cords shall be selected and used with due reference to the appropriate class of duty.

Annex C gives information on classes of duty.

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4.4.3 Where thermoplastic flexible cables and cords are acceptable, consideration shall be given to the use of extensible leads as a means of limiting the length of the connection.

4.4.4 Multicore control cables, if installed so that they are continually flexed, shall be protected in a manner which minimizes the possibility of abrasion, cutting and sharp bends.

4.4.5 Flexible cables and cords shall not be used as fixed wiring unless they are contained in an enclosure affording mechanical protection, with the following two exceptions:

a) final connection to fixed equipment when the duty type of the cable is at least ordinary duty or higher;

b) fixed installations in temporary buildings when the duty type of the cable is heavy duty.

4.4.6 Exposed lengths of flexible cable or flexible cord used as final connections to fixed equipment shall be as short as practicably possible and shall be directly connected to the fixed wiring in a manner that is appropriate to the equipment and the method of termination.

4.4.7 Flexible cables or cords shall not be subject to excessive tension (see 5.6.2), crushing, abrasion, torsion and kinking, particularly at the inlet of the appliance and at the point of connection to the fixed wiring. They shall not be damaged by any strain relief or clamping device.

4.4.8 Flexible cables or cords shall not be placed under carpets or other floor coverings, where there is:

a) any risk of thermal insulating effects, leading to excessive temperature rise (see 5.4,1 point a));

b) any risk of damage due to furniture or equipment resting on them or traffic passing over them.

4.4.9 Flexible cables or cords shall be prevented from being in contact with or close to hot surfaces, unless they are of a type intended for such conditions. Because of the relative low melting temperature of thermoplastic insulated and/or sheathed cables or cords, very careful consideration of the temperatures involved shall be made before using this type of cable. PVC-covered cables shall not be used for welding (this includes both industrial arc welding and hobby welding). Only the cross-linked rubber cables specified in IEC 60245-6 shall be used for such purposes, as they are designed to resist the hot particles that are commonly generated during welding.

4.4.10 When flexible cables or cords are required for use outdoors, whether for intermittent, temporary or permanent usage, they shall only be used when the ambient temperature is in the range of 5 °C to 40 °C. If a cable is required to work outside of this temperature range, the cable manufacturer shall be consulted for guidance. Flexible thermoplastic cables or cords are unsuitable for permanent use outdoors and shall not be used for temporary or intermittent outdoor use, unless the ambient temperature is above 5 °C.

4.4.11 Non-sheathed cords shall not be used for connection to any Class II appliance (as defined in IEC 60335-1), for any extension cord or for the replacement of any sheathed cable type.

4.4.12 Flexible cables shall not be used in deep mining operations, in quarrying, or on moveable equipment such as cranes with spring-loaded reeling devices.

4.4.13 Flexible thermoplastic cables and cords are not necessarily suitable for the manufacture of extensible leads.

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5 Limiting conditions

5.1 General

The influence of all factors as outlined in 5.2 to 5.8 shall be considered in combination, not separately.

5.2 Voltage

The rated voltage of a cable is the reference voltage for which the cable is designed.

The rated voltage in an alternating current system, is expressed by the combination of two values U_0/U, expressed in volts, where:

a) U_0 is the r.m.s. value between any insulated conductor and “earth” (metal covering of the cable or the surrounding medium);

b) U is 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 or cord shall be at least equal to the nominal voltage of the system for which it is intended. This condition applies to the values of both U_0 and U.

In a direct current system, the maximum permanent operating voltage of the system is stated in Table 2.

Table 2 – Examples of maximum permitted voltages against rated voltage of cable

Rated voltage of cable	Maximum permanent permitted operating voltage of the system			
	a.c.	3-phase a.c.	d.c.	
U_0/U	Conductor-earth	Conductor-conductor	Conductor-earth	Conductor-conductor
V	U_0 max (V)	U max (V)	V	V
300/300	320	320[a]	410	410
300/500	320	550	410	820
450/750	480	825	620	1 240

[a] Single phase power system only.

5.3 Current-carrying capacity

5.3.1 The cross-sectional area of every conductor shall be such that its current-carrying capacity is not less than the maximum sustained current which will normally flow through it.

5.3.2 The limiting temperature to which the current-carrying capacity is related shall not exceed that appropriate to the type of cable insulation or sheath concerned.

5.3.3 The current-carrying capacities for flexible cables, cords and fixed wiring shall be in accordance with IEC 60364-5-52 or, where not available, reference shall be made to the cable manufacturer.

The values given in IEC 60364-5-52 for the particular cable type and size have been determined such that the limiting temperatures of the cable are not exceeded, under the

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particular installation conditions given, when the cables are continuously loaded (100 % load factor) with current having an alternating frequency of 50 Hz or 60 Hz.

If current ratings for a particular cable type are not included in IEC 60364-5-52, ratings can be derived from IEC 60287 or reference made to the cable manufacturer.

For arc welding cables, the current-carrying capacities and the associated voltage drop figures shall be obtained from the cable manufacturer.

5.3.4 In the case of soft soldered joints or terminations, the temperature for the conductor under short-circuit conditions shall be not more than 160 °C.

5.3.5 Tinned copper conductors shall not be used at temperatures above 200 °C, even under fault conditions, because of the risk of mutual adhesion.

5.3.6 The method of installation used for the cable affects its current-carrying capacity and due account shall be taken of this. Correction factors for quoted current-carrying capacities are sometimes available for particular conditions such as:

a) ambient temperature;

b) cable grouping;

c) type of overcurrent protection;

d) presence of thermal insulation;

e) reeled/drummed cables;

f) frequency of supply (if different from 50 Hz or 60 Hz, etc.);

g) effect of harmonics.

5.3.7 The selection of the cross-sectional area of any conductor shall not be based on current-carrying capacity alone. Account shall also be taken of:

1) electric shock;

2) thermal effects;

3) overload and short-circuit current;

4) voltage drop;

5) mechanical strength;

taking particular account of influences such as:

– limiting temperatures for terminals of equipment, busbars or bare conductors;

– limiting short-circuit temperatures;

– the carrying of current by the neutral conductor, e.g. as resulting from the presence of significant harmonic current in a three-phase circuit;

– electromagnetic effects;

– reduction of heat dissipation;

– size of the circuit protective conductor under fault conditions;

– solar or infra-red radiation.

This list is not exhaustive. Other influences might arise for particular installations.

5.4 Thermal effects

5.4.1 The maximum continuous operating temperature limits of the individual types of cables are given in IEC 60227 and IEC 60245. The values given shall not be exceeded by any

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combination of the heating effect of current in the conductors and the ambient conditions. Particular account shall be taken of the following.

a) Cables in free air shall be installed so that the natural air convection is not impeded. When cables are covered or embedded in thermal insulation, or when the heat dissipation is impeded by other means, it is essential that the current-carrying capacity is reduced by an appropriate factor. This factor can be as low as 0,5.

b) The temperature of cable sheaths can be significantly higher than the ambient temperatures where the cables are subjected to radiation, e.g. solar or infra-red. Where these situations cannot be avoided, their effect shall be taken into account in assessing the current-carrying capacity or the temperature of the cable relative to the limiting temperature and its service life.

c) Account shall be taken of the temperatures occurring within equipment, appliances, luminaires and at their terminals, in selecting the types of cables to be used in them and connected thereto.

d) Exposure of thermoplastic-insulated cables to temperatures greater than those given in IEC 60364-5-52, even for short periods, can cause the insulation to soften. Account shall be taken of this effect, particularly when mechanical stress is also an influence.

The minimum ambient temperature for all cable types is 5 °C, and if a cable is required to work below this temperature, the cable manufacturer shall be consulted for guidance. All insulation and sheath materials used for cables become progressively stiffer as their temperature is lowered below the normal ambient temperature to the point where they become brittle.

5.4.2 Cables shall be selected, located and installed such that their intended heat dissipation is not inhibited and they do not present a fire hazard to adjacent materials.

5.4.3 Where the surface of the cable is liable to exceed 50 °C, the cable shall be located or guarded in such a way as to prevent contact with persons or animals.

Cable surface temperatures above this temperature can cause involuntary reaction in the event of contact with exposed skin.

5.4.4 Account shall be taken of the effect of heat generated by the passage of current through the conductor on the material of which it is made and on the material used in making joints or terminations.

5.5 Fire characteristics

5.5.1 Cables can provide a source of fuel and means of propagating a fire, and the insulation and sheath materials of burning cables can give rise to smoke and to toxic and corrosive fumes. Where this could constitute a hazard, and particularly where it is necessary to ensure safe evacuation of the premises, e.g. in public buildings, offices, hotels, hospitals, etc., the guidance of the cable manufacturer shall be obtained to select cables to minimize the hazard.

The use of a fire safety engineering approach shall also be considered.

National legislation may exist which specifies the detailed requirements that have to be met.

5.5.2 Guidance shall be sought in selecting cables required to maintain the integrity of electrical circuits when this is necessary for the safety of life and property in the case of fire.

5.5.3 When a cable is to be used in the presence of explosive or flammable atmospheres, guidance shall be sought in selecting suitable cables.

Guidance is available from cable manufacturers; see also IEC 60079.

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5.6 Mechanical stress

5.6.1 General

In assessing the potential risk of mechanical damage to cables, account shall be taken of any mechanical strains likely to be imposed during the normal process of installation of cables.

5.6.2 Tension

The tension applied to a cable shall not exceed the following values of tensile stress per conductor, subject to a total maximum tensile force of 1 000 N, unless otherwise agreed by the cable manufacturer:

a) 50 N/mm^2 for non-flexible cables during installation;

b) 15 N/mm^2 for flexible cables under static tensile stress, and for non-flexible cables in service in fixed circuits.

NOTE A mass of 1 kg is approximately equal to 10 N.

In circumstances where a stress exceeding these values would result, a separate stress-bearing member or device shall be used. The method of attaching such a member or device to the cable shall be such that the cable is not damaged.

In circumstances where flexible cables are under dynamic stress (including those due to inertia, e.g. reeling drums) the permissible tensions or fatigue life shall be agreed between the design engineer and the cable manufacturer.

Where cables are installed vertically, without intermediate support, and are inaccessible and unlikely to be moved or disturbed, they shall be supported at the top of the run such that the internal radius of the resultant bend is not less than the appropriate minimum bending radius for normal use according to Table 3. The unsupported vertical length shall not exceed 5 m.

5.6.3 Bending

The internal bending radii (R) (as shown in Figure 1) for different types of cable shall, under normal circumstances, be not less than those given in Table 3.

Care shall be taken when stripping the insulation to ensure that no damage occurs to the conductor, since this will severely affect the bending radii.

The bending radii (R) recommended are for ambient temperatures of (20 ± 10) °C. For temperatures outside these limits, the cable manufacturer's recommendations shall be followed.

For flexible cables and cords, particularly at terminations and at the point of entry of moveable appliances, it can be necessary to use a device which ensures that the cable is not bent to an internal bend radius less than that recommended in Table 3. It is necessary to prevent the cable being flexed significantly too close to any internal and/or external anchorage point. If a cord guard or other device is used, it shall not prevent internal movement of the cores of the cable within the device.

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