

INTERNATIONAL STANDARD

IEC 60183

Second edition
1984

Guide to the selection of high-voltage cables

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDE TO THE SELECTION OF HIGH-VOLTAGE CABLES

FOREWORD

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by Sub-Committee 20A: High-voltage Cables, of Technical Committee No. 20: Electric Cables.

It forms the second edition of IEC Publication 183.

Drafts were discussed at the meeting held in Florence in 1980. As a result of this meeting, a draft was circulated to the National Committees under the Accelerated Procedure in February 1981 and, as Document 20A(Central Office)82, was submitted to the National Committees for approval under the Six Months' Rule in December 1981.

The National Committees of the following countries voted explicitly in favour of publication:

Austria	Egypt	South Africa (Republic of)
Belgium	France	Sweden
Brazil	Netherlands	Switzerland
Bulgaria	New Zealand	Union of Soviet
Canada	Norway	Socialist Republics
China	Poland	United Kingdom
Denmark	Romania	United States of America

Amendments, Document 20A(Central Office)89, were submitted to the National Committees for approval under the Two Months' Procedure in October 1982.

The National Committees of the following countries voted explicitly in favour of publication:

Australia	German Democratic Republic	Sweden
Austria	Germany	Switzerland
Belgium	Italy	Union of Soviet
Brazil	Netherlands	Socialist Republics
Canada	New Zealand	United Kingdom
Egypt	Norway	United States of America
Finland	Poland	
France	Romania	

Other IEC publications quoted in this standard:

Publications Nos. 55:	Paper-insulated Metal-sheathed Cables for Rated Voltages up to 18/30 kV (with Copper or Aluminium Conductors and Excluding Gas-pressure and Oil-filled Cables).
71:	Insulation Co-ordination.
71-1:	Part 1: Terms, Definitions, Principles and Rules.
228:	Conductors of Insulated Cables.
287:	Calculation of the Continuous Current Rating of Cables (100% Load Factor).
502:	Extruded Solid Dielectric Insulated Power Cables for Rated Voltages from 1 kV up to 30 kV.

GUIDE TO THE SELECTION OF HIGH-VOLTAGE CABLES

1. Scope

This standard is applicable to high-voltage cables. It is intended to give guidance in the selection of the conductor size, insulation level and construction of cable to be used on three-phase alternating current systems operating at voltages exceeding 1 kV. It also summarizes the information which is necessary to enable the appropriate selection to be made.

Unless explicitly mentioned in particular clauses, the contents are applicable to cables of any type. For the time being, only alternating current systems are dealt with; direct current systems may be considered in a future publication.

2. Definitions

The following definitions have been adopted for the purposes of this standard.

2.1 *Voltages pertaining to the cable and its accessories*

U_0 = the rated r.m.s. power-frequency voltage between each conductor and screen or sheath for which cables and accessories are designed

U = the rated r.m.s. power-frequency voltage between any two conductors for which cables and accessories are designed

Note. — This quantity only affects the design of non-radial field cables and accessories.

U_m = the maximum r.m.s. power-frequency voltage between any two conductors for which cables and accessories are designed. It is the highest voltage that can be sustained under normal operating conditions at any time and at any point in a system. It excludes temporary voltage variations due to fault conditions and the sudden disconnection of large loads

U_p = the peak value of the lightning impulse withstand voltage between each conductor and screen or sheath for which cables and accessories are designed

Cables will henceforth be designated by $U_0/U (U_m)$ to provide guidance on compatibility with switchgear and transformers. Table I gives this information.

2.2 *Voltages pertaining to the system on which cables and accessories are to be used*

Nominal voltage of system

The r.m.s. phase-to-phase voltage by which the system is designated and to which certain operating characteristics of the system are related.

Highest voltage of three-phase system

The highest r.m.s. phase-to-phase voltage which occurs under normal operating conditions at any time and at any point in the system. It excludes voltage transients (such as those due to system switching) and temporary voltage variation due to abnormal system conditions (such as those due to fault conditions or sudden disconnection of large loads).

Lightning overvoltage

A phase-to-earth or a phase-to-phase overvoltage at a given location in a system due to a lightning discharge or other cause, the wave-shape of which can be regarded, for insulation co-ordination purpose, as similar to the standard impulse (see Clause 51 of IEC Publication 71-1: Insulation Co-ordination, Part 1: Terms, Definitions, Principles and Rules) used for lightning impulse withstand tests. Such overvoltages are usually unidirectional and of very short duration.

3. Service conditions

To determine the appropriate design of cable for a particular project, the following information with regard to service conditions is required. Reference should be made to the relevant IEC publications which deal with many of the following service conditions.

3.1 *Operating conditions*

- a) Nominal voltage of the system.
- b) Highest voltage of the three-phase system.
- c) Lightning overvoltage.
- d) System frequency.
- e) Type of earthing and, where the neutral is not effectively earthed, the maximum permitted duration of earth fault conditions on any one occasion and the total duration per year.
- f) Where terminals are specified, the environmental conditions shall be given, for example:
 - the altitude above sea level, if above 1 000 m;
 - indoor or outdoor installation;
 - whether excessive atmospheric pollution is expected;
 - termination in SF₆ switchgear;
 - design clearance and insulation used in the method for connecting cable to equipment, for example transformers, switchgear, motors, etc. For example, clearance and surrounding insulation should be specified.
- g) Maximum rated current
 - 1) For continuous operation.
 - 2) For cyclic operation.
 - 3) For emergency or overload operation, if any.

Note. — A load curve is essential if cyclic loading is considered when determining conductor size.

- h) The expected symmetrical and asymmetrical short-circuit currents which may flow in case of short circuits, both between phases and to earth.
- j) Maximum time for which short-circuit currents may flow.

3.2 *Installation data*

3.2.1 *General*

- a) Length and profile of route.
- b) Details of laying arrangements (e.g. flat or trefoil arrangement) and how the metallic coverings are connected to each other and to earth.
- c) Special laying conditions, for example cables in water. Individual installations require special consideration.

3.2.2 *Underground cables*

- a) Details of installation conditions (e.g. direct burial, in ducts, etc.) to enable decisions to be taken on composition of metallic sheath, type of armour (if required) and type of serving, for example anti-corrosion, flame-retarding, or anti-termite.
- b) Depth of laying.
- c) Thermal resistivities and kinds of soil along the route (e.g. sand, clay, made-up ground), and whether this information is based on measurement and inspection or only assumed.
- d) Minimum, maximum and average ground temperature at the depth of burial.
- e) Proximity of other load-carrying cables, or of other heat sources, with details.
- f) Lengths of troughs, ducts or pipe lines, with spacing of manholes, if any.
- g) Number of ducts or pipes.
- h) Internal diameter of ducts and pipes.
- j) Spacing between individual ducts and pipes, if more than one.
- k) Material of ducts or pipes.

3.2.3 *Cables in air*

- a) Minimum, maximum and average ambient air temperature to be assumed.
- b) Type of installation (e.g. direct laying on walls, racks, etc. grouping of cables, dimensions of the tunnels, ducts, etc.).
- c) Details of ventilation (for cables indoors, in tunnels or ducts).
- d) Whether exposed to direct sunlight.
- e) Special condition, for example fire risk.

4. Cable insulation levels

4.1 Introduction

For many years two categories of insulation level (1 and 2) have been adequate for accommodating different voltage systems encountered throughout the world. Modern practice, however, shall now take into account various cable dielectrics having different overvoltage performances, coupled with the increasing likelihood of extended overvoltage operation in new systems under earth fault conditions. It has, therefore, become necessary to have three categories of system.

4.2 System categories

Category A: Where earth faults are cleared as rapidly as possible but in any case within 1 min.

Category B: This category comprises those systems, which, under fault conditions, are operated for a short time only with one phase earthed. This period should, in general, not exceed 1 h, but a longer period can be tolerated as specified in the relevant cable standard.

Note. — It should be realized that in a system where an earth fault is not automatically and promptly eliminated, the extra stresses on the insulation of cables during the earth fault reduce the life of the cables to a certain degree. If the system is expected to be operated fairly often with a permanent earth fault, it may be economical to classify the system into the next Category C.

Category C: This category comprises all systems which do not fall into Category A or B.

Reference should be made to the relevant cable standards, for example IEC Publication 502: Extruded Solid Dielectric Insulated Power Cables for Rated Voltages from 1 kV up to 30 kV, and IEC Publication 55: Paper-insulated Metal-sheathed Cables for Rated Voltages up to 18/30 kV (with Copper and Aluminium Conductors and Excluding Gas-pressure and Oil-filled Cables), for recommendations applicable to each type of cable.

4.3 Selection of U_m

U_m should be chosen to be equal to or greater than the highest voltage of the three-phase system as defined in Sub-clause 2.2.

4.4 Selection of U_p

The value of U_p chosen should be equal to or greater than the lightning impulse withstand voltage selected from IEC Publication 71 in accordance with the line insulation levels, the system protective levels, the surge impedance of the overhead lines and the cables, the length of cables and the distance of the flashover point from terminal.

5. Selection of the conductor size

The conductor size should be chosen from one of the standard sizes given in the relevant standard for cable construction. Where a standard does not exist for the type of cable to be used, the conductor size should be selected from one of the standard sizes for class 2 conductors given in IEC Publication 228: Conductors of Insulated Cables.

In the selection of conductor size, the following factors should be taken into account:

- a) The maximum temperature occurring in the cable under the specified continuous load, cyclic load, emergency load and short-circuit conditions.

Note. — IEC Publication 287: Calculation of the Continuous Current Rating of Cables (100% Load Factor), gives details of calculation procedures for continuous load conditions.

- b) Mechanical loads imposed on the cable during installation and in service.
- c) The electrical stress in the insulation. A small diameter conductor arising from the use of a small cross-sectional area may result in unacceptably high electric stress in the insulation.

6. Terminations

The design of terminations depends upon the values of the required power-frequency and impulse withstand voltages (which may be different from those required for the cable), the degree of exposure to atmospheric pollution, and the altitude at the position of the termination.

6.1 *Insulating levels for power-frequency and impulse voltages*

These will be chosen after consideration of the factors given in Clause 4 and Sub-clauses 6.2 and 6.3.

6.2 *Atmospheric pollution*

The degree of exposure to atmospheric pollution determines the minimum creepage distances and the type of insulators to be used for cable sealing ends.

6.3 *Altitude*

The air density at high altitude is lower than at sea level. The electric strength of the air is thus reduced, and air clearances which are adequate at sea level may be insufficient at higher altitudes. The puncture strength and oil flashover values of terminations are not affected by altitude. Terminations capable of complying with the required impulse withstand test under standard atmospheric conditions are suitable for use at any altitude below 1 000 m. In order to ensure that the requirement is met at higher altitudes, the air clearances normally specified should be increased by a suitable amount.

TABLE I

Relationship between U_0/U and (U_m)

Rated voltage of cables and accessories (U_0/U kV)	Highest voltage for equipment (U_m kV)
1.8/3 and 3/3; 1.9/3.3 and 3.3/3.3	3.6
3.6/6 and 6/6; 3.8/6.6 and 6.6/6.6	7.2
6/10 and 8.7/10; 6.35/11 and 8.7/11	12
8.7/15	17.5
12/20; 12.7/22	24
18/30; 19/33	36
26/45; 27/47	52
38/66; 40/69	72.5
63.5/110; 66/115	123
76/132; 80/138	145
87/150; 93/161	170
127/220; 133/230	245
159/275; 166/287	300
190/330; 200/345	362
220/380; 230/400	420
290/500	525
405/700; 430/750	765

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