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CONSOLIDATED VERSION

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Short-circuit temperature limits of electric cables with rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)

Limites de température de court-circuit des câbles électriques de tensions assignées de 6 kV (U_m = 7,2 kV) à 30 kV (U_m = 36 kV)

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IEC 60986 edition 2.1 contains the second edition (2000) [documents 20/398/FDIS and 20/417/RVD] and its amendment 1 (2008) [documents 20/952/FDIS and 20/975/RVD].

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

International Standard IEC 60986 has been prepared by IEC technical committee 20: Electric cables.

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- withdrawn,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.

INTRODUCTION

Editorially, this second edition of IEC 60986 is brought into line with IEC 60724, third edition, and IEC 61443, first edition.

The following four aspects may be applicable when selecting the short-circuit rating of a cable system:

a) the permissible maximum temperature limits for cable components (e.g. conductor, insulation, screen or metallic sheath, bedding, armour and oversheath). For the range of voltages covered by this standard, dielectric integrity is a major limitation. For practical purposes, the energy producing the temperature rise is usually expressed by an equivalent (I^2t) value so that the permitted maximum duration for a given short-circuit current can be calculated;

b) the maximum value of current which will not cause mechanical failure (such as bursting) due to electromagnetic forces. Irrespective of any temperature limitations, this determines a maximum current which should not be exceeded;

c) the thermal performance of joints and terminations at the limits of current and duration specified for the associated cable. Accessories should also withstand the thermo-mechanical and electromagnetic forces produced by the short-circuit current in the cable;

d) the influence of installation conditions on the above three aspects.

Aspect a) is dealt with in detail in this standard, and the limits given are based on a consideration of the cable only. A single short-circuit application is not expected to produce any significant damage to the cable, but repeated short-circuits may cause cumulative damage. Guidance is given, where appropriate, on aspects c) and d), mainly as they concern thermo-mechanical forces in the conductors and metallic sheath. Aspect b) is not covered in this standard.

The limits recommended in this standard should be used for guidance only. There is little scientific evidence available on the behaviour of actual cables under short-circuit conditions, most of the information being based on the tests on the constituent material themselves. It has been necessary to exercise considerable judgement in setting these recommended limits, and in general, especially for the dielectric, the best average of present usage has been suggested.

It is not possible to provide complete limits for joints and terminations because their construction is not standardized and performance varies. Where the full short-circuit capability of the cable is needed the accessories should be designed appropriately, but this is not always economically justified and the short-circuit capability of a cable system may be determined by the performance of its joints and terminations. Where possible, guidance has been included on the performance of accessories when they are installed on cables subject to the short-circuit limits given in this standard.

SHORT-CIRCUIT TEMPERATURE LIMITS OF ELECTRIC CABLES WITH RATED VOLTAGES FROM 6 kV (U_m = 7,2 kV) UP TO 30 kV (U_m = 36 kV)

1 Scope

This International Standard gives guidance on the short-circuit maximum temperature limits of electric cables having rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV), with regard to the following:

– insulating materials;

– oversheath and bedding materials;

– conductor and metallic sheath materials and methods of connection.

The design of accessories and the influence of the installation conditions on the temperature limits are taken into consideration.

The calculation of the permissible short-circuit current in the current-carrying components of the cable should be carried out in accordance with IEC 60949.

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 60055 (all parts), *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)*

IEC 60141 (all parts), *Tests on oil-filled and gas-pressure cables and their accessories*

IEC 60502-2:1998, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1,2 kV) up to 30 kV (U_m = 36 kV) – Part 2: Cables for rated voltages from 6 kV (U_m = 7,2 kV) up to 30 kV (U_m = 36 kV)*

IEC 60949:1988, *Calculation of thermally permissible short-circuit currents, taking into account the non-adiabatic heating effects*

3 Factors governing the application of the temperature limits

3.1 General

The short-circuit temperatures given in clause 4 are the actual temperatures of the current-carrying component as limited by the adjacent material in the cable and are valid for short-circuit durations of up to 5 s. When calculating the allowable short-circuit current, these temperatures will be obtained if heat loss into the insulation during the short-circuit is taken into account (non-adiabatic heating). If heat loss during the short-circuit is neglected (adiabatic heating), the calculations give short-circuit currents that are on the safe side.

NOTE The temperature limits given in clause 4 should also not be exceeded with repeated short-circuits occurring in a short time.

The 5 s time period mentioned is the limit for the temperatures quoted to be valid and not for the application of the adiabatic calculation method. The time limit for the use of the adiabatic method has a different definition, being a function of both the short-circuit duration and the cross-sectional area of the current-carrying component. This is dealt with in IEC 60949.

The short-circuit temperature limits recommended in this standard are based on the consideration of the range of limits used by various authorities. They are not necessarily the ideal values as very little applicable experimental data are available on actual cables. The values are, however, considered to be on the safe side.

The limits for cables in this standard are selected so that the dielectric properties are not impaired. The impairment of dielectric properties will be very dependent on the type of cable, for example adhesion of the semi-conducting screens will most likely set the limits for polymeric insulated cables, whereas the properties of the dielectric itself are of more importance in paper cables (both oil-filled and mass-impregnated cables).

Caution may be needed when using the conductor temperatures specified when the cables are sheathed with a lower temperature material, especially for cables with conductor cross-sectional areas of 1 000 mm^2 and above. This is because the high thermal time constant of these cables will cause the oversheath to attain high temperatures for longer times. In addition, the high mechanical forces could result in insulation deformation. Nevertheless, it should be stressed that for conductor cross-sectional areas above 1 000 mm^2, the permissible short-circuit current is so high that it is not normally attained in common systems.

Where other temperature limits are known with certainty to be more appropriate for the materials or the cable design, then these may be used.

3.2 Cables

3.2.1 Paper insulated cables (both oil-filled cables according to IEC 60141 and mass-impregnated cables according to IEC 60055)

The temperature limits for paper insulated cables impregnated with oil/resin or non-draining compound are imposed by the tendency to compound migration and void formations. All paper insulated cables are also limited by thermal degradation of the cable components and by possible tearing of paper tapes due to movement of the cores.

3.2.2 Polymeric insulated cables (according to IEC 60502-2)

The temperature limits for polymeric insulated cables are imposed by the dielectric properties of the insulation. The high temperatures, electromagnetic forces and expansion forces produced under short-circuit conditions could have a marked effect on the physical condition of the cable Thus, the integrity of the bond between the semi-conducting screens and the insulation and deformation of the insulation are two important considerations for polymeric insulated cables. In addition, the high temperatures may change the properties of the semi-conducting and sheathing materials.

For thermoplastic insulating materials, the temperature limits should be applied with caution when the cables are either directly buried or securely clamped when in air. Local pressure due to clamping or the use of an installation radius less than that specified for the cable, especially for cables that are rigidly restrained, can lead to high deforming forces under short-circuit conditions. Where these conditions cannot be avoided, it is suggested that the limit be reduced by 10 °C.

3.3 Accessories

Attention should be given to the design and installation of joints and terminations if the short-circuit limits set out in this standard are to be safely used. The following aspects are not exclusive and are provided for guidance only. It is desirable that the performance of an accessory be considered in the context of the particular installation.

a) Longitudinal thrust in cable conductors can be considerable, depending on the degree of lateral restraint imposed on the cable. Conductor stresses as high as 50 N/mm^2 can easily occur. These forces may cause buckling of conductors and other damage in a joint or termination.

b) Longitudinal tension in cable conductors is also to be expected after a short-circuit. This tension may exist for a very long period, particularly if the cable is only partly loaded after the short-circuit. A minimum conductor stress of 40 N/mm^2 should be used for design purposes.

c) With mass-impregnated paper cables, compound expansion can give rise to considerable fluid pressure. If compound leaks out at joints and terminations, it could cause softening of the bitumen filling. Moisture may also be drawn back into the accessory and cable in a sufficient quantity to affect the performance of the insulation.

d) The use of a temperature limit only implies that any combination of current and time which produces temperatures not exceeding that limit is permissible. For short-circuit currents this is not sufficient. An additional limit should be set for the peak value of the current in order to avoid excessive electromagnetic forces. These forces are of particular importance at terminations, and proper support is necessary to avoid undesirable movement and damage.

e) Soldered joints should not be used if conductor temperatures greater than 160 °C are contemplated.

f) Attention is drawn to the need to examine the design for short-circuit stability of the electrical contact of all connectors used for jointing conductors and connecting armour and metallic sheath bonds.

g) Screen and/or armour wires, when gathered together at a joint or termination, may have a lower short-circuit performance than when in the cable. At such connections, the expected temperature rise should not be excessive for the materials involved, and adequate mechanical support should be provided.

h) Account should be taken of the risk of longitudinal shrinkage of polymeric components at the cut ends of cables at short-circuit temperatures.

3.4 Installation conditions

When it is intended to make full use of the short-circuit limit of a cable, consideration should be given to the influence of the installation conditions. An important aspect concerns the extent and nature of the mechanical restraint imposed on the cable. Longitudinal expansion of the cable during a short-circuit can be significant, and when this expansion is restrained the resultant forces are considerable.

For cables in air, it is advisable to install them so that expansion is absorbed uniformly along the cable length. When snaking, fixings should be spaced sufficiently far apart to permit lateral movement of cables.

Where cables are installed directly in the ground, or must be restrained by frequent fixing, then provision should be made to accommodate the resulting longitudinal forces on accessories. Sharp bends should be avoided because the longitudinal forces are translated into radial pressures at bends in the cable route and these may damage thermoplastic components of the cable. Attention is drawn to the minimum radius of installed bend recommended by the appropriate installation regulations.