SLOVENSKI STANDARD
SIST HD 558 S1:1998

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Economic optimisation of power cable size (IEC 1059:1991)

Economic optimisation of power cable size

Wirtschaftliche Optimierung der Leiterquerschnitte von Kabeln

Optimisation économique des sections d'âme de câbles

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ENGLISH VERSION

ECONOMIC OPTIMISATION OF POWER CABLE SIZE
(IEC 1059:1991)

Optimisation économique des
sections d'âme de câbles
(CEI 1059:1991)

Wirtschaftliche Optimierung der
Leiterquerschnitte von Kabeln
(IEC 1059:1991)

This Harmonization Document was approved by CENELEC on 1990-06-11.
CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations
which stipulate the conditions for implementation of this Harmonization Document
on a national level.

Up-to-date lists and bibliographical references concerning national implementation
may be obtained on application to the Central Secretariat or to any CENELEC member.

This Harmonization Document exists in three official versions (English, French,
German).

CENELEC members are the national electrotechnical committees of Austria, Belgium,
Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg,
Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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SIST............HD 558 S1

PREVZET PO METODI RAZGLASITVE   -02- 1998

FOREWORD

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 1059:1991 (enquiry based on IEC 20A(C.O.)131) could be accepted without textual changes, has shown that no CENELEC common modifications were necessary for the acceptance as Harmonization Document.
The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as HD 558 S1 on 11 June 1990.

The following dates were fixed:

- latest date of announcement
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- latest date of publication of
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- latest date of withdrawal of
  conflicting national standards   (dow)   1992-03-01

ENDORSEMENT NOTICE

The text of the International Standard IEC 1059:1991 was approved by CENELEC as a Harmonization Document without any modification.

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1059

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Optimisation économique des sections
d'âme de câbles électriques de puissance

Economic optimization of power
cable size

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ECONOMIC OPTIMIZATION OF POWER CABLE SIZE

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.

iTeh STANDARD PREVIEW

This International Standard has been prepared by Sub-Committee 20A: High-voltage cables, of IEC Technical Committee No. 20: Electric cables.

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

DIS	Report on Voting
20A(CO)131	20A(CO)139

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

Annexes A and B are for information only.

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INTRODUCTION

1 General part

The procedure generally used for the selection of a cable size leads to the minimum admissible cross-sectional area, which also minimizes the initial investment cost of the cable. It does not take into account the cost of the losses that will occur during the life of the cable.

The increasing cost of energy, together with the high energy losses which follow from the operating temperatures possible with the newer insulating materials (e.g. 90 °C for XLPE and EPR), now requires that cable size selection be considered on wider economic grounds. Rather than minimizing the initial cost only, the sum of the initial cost and the cost of the losses over the economic life of the cable should also be minimized. For this latter condition a larger size of conductor than would be chosen based on minimum initial cost will lead to a lower power loss for the same current and will, when considered over its economic life, be much less expensive.

The future costs of energy losses during the economic life of the cable can be calculated by making suitable estimates of load growth and cost of energy. The most economical size of conductor is achieved when the sum of the future costs of energy losses and the initial cost of purchase and installation are minimized.

The saving in overall cost, when a conductor size larger than that determined by thermal constraints is chosen, is due to the considerable reduction in the cost of the joule losses compared with the increase in cost of purchase. For the values of the financial and electrical parameters used in this standard, which are not exceptional, the saving in the combined cost of purchase and operation is of the order of 50 % (see clause A.6 in annex A). Calculations for much shorter financial periods can show a similar pattern.

A further important feature, which is demonstrated by examples, is that the savings possible are not critically dependent on the conductor size when it is in the region of the economic value, see figure A.3. This has two implications:

a) The impact of errors in financial data, particularly those which determine future costs, is small. While it is advantageous to seek data having the best practicable accuracy, considerable savings can be achieved using data based on reasonable estimates.

b) Other considerations with regard to the choice of conductor size which feature in the overall economics of an installation, such as fault currents, voltage drop and size rationalization, can all be given appropriate emphasis without losing too many of the benefits arising from the choice of an economic size.

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2 Economic aspects

In order to combine the purchase and installation costs with costs of energy losses arising during the economic life of a cable, it is necessary to express them in comparable economic values, that is values which relate to the same point in time. It is convenient to use the date of purchase of the installation as this point and to refer to it as the "present". The "future" costs of the energy losses are then converted to their equivalent "present values". This is done by the process of discounting, the discounting rate being linked to the cost of borrowing money.

In the procedure given here inflation has been omitted on the grounds that it will affect both the cost of borrowing money and the cost of energy. If these items are considered over the same period of time and the effect of inflation is approximately the same for both, the choice of an economic size can be made satisfactorily without introducing the added complication of inflation.

To calculate the present value of the costs of the losses it is necessary to choose appropriate values for the future development of the load, annual increases in kWh price and annual discounting rates over the economic life of the cable, which could be 25 years or more. It is not possible to give guidance on these aspects in this standard because they are dependent on the conditions and financial constraints of individual installations. Only the appropriate formulae are given: it is the responsibility of the designer and the user to agree on the economic factors to be used.

The formulae proposed in this standard are straightforward, but in their application due regard should be taken of the assumption that the financial parameters are assumed to remain unchanged during the economic life of the cable. Nevertheless, the above comments on the effect of the accuracy of these parameters is relevant here also.

There are two approaches to the calculation of the economic size, based on the same financial concepts. The first, where a series of conductor sizes is being considered, is to calculate a range of economic currents for each of the conductor sizes envisaged for particular installation conditions and then to select that size whose economic range contains the required value of the load. This approach is appropriate where several similar installations are under consideration. The second method, which may be more suitable where only one installation is involved, is to calculate the optimum cross-sectional area for the required load and then to select the closest standard conductor size.

3 Other criteria

Other criteria, for example short-circuit current and its duration, voltage drop and cable size rationalization, must be considered also. However, a cable chosen to have an economical size of conductor may well be satisfactory also from these other points of view, so that when sizing a cable the following sequence may be advantageous:

a) calculate the economic cross-sectional area;

b) check by the methods given in IEC 287 and IEC 853 that the size indicated by a) is adequate to carry the maximum load expected to occur at the end of the economic period without its conductor temperature exceeding the maximum permitted value;

c) check that the size of cable selected can safely withstand the prospective short-circuit and earth fault currents for the corresponding durations;

d) check that the voltage drop at the end of the cable remains within acceptable limits;

e) check against other criteria appropriate to the installation.

To complete the field of economic selection, proper weight should be given to the consequences of interruption of supply. It may be necessary to use a larger cross-section of conductor than the normal load conditions require and/or the economic choice would suggest, or to adapt the network accordingly.

A further cost component may be recognized in the financial consequence of making a faulty decision weighted by its probability. However, in doing so one enters the field of decision theory which is outside the scope of this standard.

Thus, economic cable sizing is only a part of the total economic consideration of a system and may give way to other important economic factors.

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ECONOMIC OPTIMIZATION OF POWER CABLE SIZE

1 Scope

This International Standard deals solely with the economic choice of conductor size based on joule losses. Voltage dependent losses have not been considered.

NOTES

1   It is recommended that the method given in this standard should not be used for cables operating on system voltages equal to or greater than the following (see IEC 287):

Type of cable	System voltage U_o kV
Cables insulated with impregnated paper:	
solid type	38
oil-filled and gas pressure	63,5
Cables with other types of insulation:	
butyl rubber	18
EPR	63,5
PVC	6
PE (HD and LD)	127
XLPE (unfilled)	127
XLPE (filled)	63,5

2   Modifications to the method given in this standard in order to take dielectric losses into account are under consideration.

Likewise, matters such as maintenance, energy losses in forced cooling systems and time of day energy costs have not been included in this standard.

An example of the application of the method to a hypothetical supply system is given in annex A.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 228: 1978, *Conductors of insulated cables*.

IEC 287: 1982, *Calculation of the continuous current rating of cables (100 % load factor)*.

IEC 853, *Calculation of the cyclic and emergency current rating of cables*.

3   Symbols

A	= variable component of cost per unit length related to conductor size	cu/m.mm²
B	= auxiliary quantity defined by equation (16)	–
C	= constant component of cost per unit length related to laying conditions etc.	cu/m
CT	= total cost of a system	cu
D	= demand charge each year	cu/W.year
F	= auxiliary quantity defined by equation (10)	cu/W
I_{max}	= maximum load in first year i.e. the highest hourly mean value	A
$I(t)$	= load as a function of time	A
l	= cable length	m
CJ	= present value of the cost of joule losses during N years	cu
N	= period covered by financial calculations, also referred to as "economic life"	year
N_p	= number of phase conductors per circuit	–
N_c	= number of circuits carrying the same type and value of load	–
P	= cost of one watt-hour at relevant voltage level	cu/W.h
CI	= installed cost of the length of cable being considered	cu
CI_2	= installed cost of the next larger standard size of conductor	cu
CI_1	= installed cost of the next smaller standard size of conductor	cu
$CI(S)$	= installed cost of a cable as a function of its cross-sectional area	cu
Q	= auxiliary quantity defined by equation (8)	–
R	= cable a.c. resistance per unit length, including the effect of y_p, y_s, λ_1, λ_2,(considered to be a constant value at an average operating temperature, see clause 4)	Ω/m
R_2	= a.c. resistance per unit length of next larger standard conductor size	Ω/m