

INTERNATIONAL STANDARD

**IEC
60826**

Third edition
2003-10

Design criteria of overhead transmission lines

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

IEC 60826:2003

<https://standards.iteh.ai/en/standards/iec/57698c3d-ed9d-4caa-b929-44f0bfe6499f/iec-60826-2003>

*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*



Reference number
IEC 60826:2003(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site** (www.iec.ch)

- **Catalogue of IEC publications**

The on-line catalogue on the IEC web site (www.iec.ch/searchpub) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

This summary of recently issued publications (www.iec.ch/online_news/justpub) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

Email: custserv@iec.ch
Tel: +41 22 919 02 11
Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 60826

Third edition
2003-10

Design criteria of overhead transmission lines

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

IEC 60826:2003

<https://standards.iteh.ai/catalog/standards/iec/60826-2003>

© IEC 2003 Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE

XF

For price, see current catalogue

CONTENTS

FOREWORD	11
1 Scope	15
2 Normative references.....	15
3 Terms, definitions, symbols and abbreviations	17
3.1 Terms and definitions	17
3.2 Symbols and abbreviations	21
4 General	27
4.1 Objective	27
4.2 System design	29
4.3 System reliability	29
5 General design criteria.....	31
5.1 Methodology.....	31
5.2 Climatic load-strength requirements.....	37
6 Loadings.....	41
6.1 Description	41
6.2 Climatic loads, wind and associated temperatures	43
6.3 Climatic loads, ice without wind	61
6.4 Climatic loads, combined wind and ice loadings	71
6.5 Loads for construction and maintenance (safety loads).....	79
6.6 Loads for failure containment (security requirements).....	83
7 Strength of components and limit states	87
7.1 Generalities	87
7.2 General equations for the strength of components	89
7.3 Data related to the calculation of components.....	93
Annex A (informative) Technical information	103
A.1 Relations between load and strength.....	103
A.2 Strength of line components.....	143
A.3 Temperature measurements and their interpretation	145
A.4 Determination of the meteorological reference wind speed.....	149
A.5 Atmospheric icing.....	167
A.6 Combined wind and ice loadings	181
Annex B (informative) Application of statistical distribution functions to load and strength of overhead lines.....	185
B.1 General.....	185
B.2 Climatic loads	185
B.3 Strength of components	197
B.4 Effect of span variation on load-strength relationship – Calculation of span use factor	201

Annex C (informative) Statistical distribution and their application in probabilistic design of transmission lines	215
C.1 Classical statistical distributions.....	215
C.2 Normal distribution (Gaussian distribution).....	215
C.3 Log-normal distribution.....	219
C.4 Gumbel distribution	223
C.5 Weibull distribution.....	227
C.6 Gamma distribution	231
C.7 Beta distribution, first type	237
C.8 Gamma function and its relationships.....	241
Figure 1 – Diagram of a transmission line	29
Figure 2 – Transmission line design methodology	33
Figure 3 – Combined wind factor G_C for conductors for various terrain categories and heights above ground.....	51
Figure 4 – Span factor G_L	51
Figure 5 – combined wind factor G_t applicable to supports and insulator strings	53
Figure 6 – Definition of the angle of incidence of wind.....	57
Figure 7 – Drag coefficient C_{xt} for lattice supports made of flat sided members	57
Figure 8 – Drag coefficient C_{xt} for lattice supports made of rounded members.....	59
Figure 9 – Drag coefficient C_{xtc} of cylindrical elements having a large diameter	61
Figure 10 – Factor K_d related to the conductor diameter	65
Figure 11 – Factor K_h related to the conductor height.....	67
Figure 12 – Typical support types.....	69
Figure 13 – Equivalent cylindrical shape of ice deposit.....	77
Figure 14 – Simulated longitudinal conductor load (case of a single circuit support).....	87
Figure 15 – Diagram of limit states of line components.....	89
Figure A.1 – Relations between load and strength.....	105
Figure A.2 – Relations between loads and strengths	119
Figure A.3 – Failure probability $P_f = (1 - P_s)$ for various distributions of Q and R , for $T = 50$ years.....	121
Figure A.4 – Failure probability $P_f = (1 - P_s)$ for various distributions of Q and R , for $T = 150$ years.....	121
Figure A.5 – Failure probability $P_f = (1 - P_s)$ for various distributions of Q and R , for $T = 500$ years.....	123
Figure A.6 – Coordination of strength by using different exclusion limits	133
Figure A.7 – Relationship between meteorological wind velocities at a height of 10 m depending on terrain category and on averaging period	153
Figure A.8 – Wind action on conductors and resultant wind load on support.....	161

Figure A.9 – Type of accreted in-cloud icing as a function of wind speed and temperature	173
Figure A.10 – Strategy flow chart for utilizing meteorological data, icing models and field measurements of ice loads	177
Figure B.1 – Fitting of Gumbel distribution with wind data histogram	187
Figure B.2 – Fitting of Gumbel distribution with yearly minimum temperature histogram	193
Figure B.3 – Fitting of Gamma distribution with ice load histogram	195
Figure B.4 – Fitting data from in-cloud icing with Gumbel distribution	197
Figure B.5 – Fitting of Weibull distribution with strength data of lattice supports	199
Figure C.1 – Probability density function of standardized normal distribution	219
Figure C.2 – Probability density function of standardized log-normal distribution	223
Figure C.3 – Probability density function of standardized Gumbel distribution	227
Figure C.4 – Probability density function of standardized Weibull distribution for parameter $p_3 = 0,5; 1,0$ and $2,0$	231
Figure C.5 – Probability density function of standardized Gamma distribution for parameter $p_3 = 0,5; 1,0$ and $2,0$	235
Figure C.6 – Probability density function of standardized beta distribution for parameters $r = 5,0$, $t = 5,5; 6,0$ and $7,0$	239
Table 1 – Reliability levels for transmission lines	35
Table 2 – Default γ_T factors for adjustment of climatic loads in relation to return period T vs. 50 years	39
Table 3 – Design requirements for the system	39
Table 4 – Classification of terrain categories	45
Table 5 – Correction factor τ of dynamic reference wind pressure q_0 due to altitude and temperatures	47
Table 6 – Non-uniform ice loading conditions	71
Table 7 – Return period of combined ice and wind load	73
Table 8 – Drag coefficients of ice-covered conductors	77
Table 9 – Additional security measures	87
Table 10 – Number of supports subjected to maximum load intensity during any single occurrence of a climatic event	89
Table 11 – Strength factor ϕ_N related to the number N of components or elements subjected to the critical load intensity	91
Table 12 – Values of ϕ_{S2}	91
Table 13 – Typical strength coordination of line components	93
Table 14 – Damage and failure limits of supports	93
Table 15 – Damage and failure limits of foundations	95
Table 16 – Damage and failure limits of conductors and ground wires	95
Table 17 – Damage and failure limit of interface components	97

Table 18 – Default values for strength coefficients of variation (COV)	97
Table 19 – u factors for log-normal distribution function for $e = 10\%$	99
Table 20 – Value of quality factor ϕ_Q for lattice towers	99
Table A.1 – Yearly reliability corresponding to various assumptions of load and strength ...	117
Table A.2 – Relationship between reliability levels and return periods of limit loads	125
Table A.3 – Typical strength coordination	129
Table A.4 – Values of central safety factor α and strength coordination factor ϕ_S required to insure that component R_2 will fail after component R_1 with a 90 % probability	137
Table A.5 – Strength factor ϕ_N related to N components in series subjected to the critical load	143
Table A.6 – Values of u_e associated to exclusion limits	145
Table A.7 – Definition of terrain category	151
Table A.8 – Factors describing wind action depending on terrain category	153
Table A.9 – Values of reference wind speed V_R	157
Table A.10 – Physical properties of ice	171
Table A.11 – Meteorological parameters controlling ice accretion	173
Table A.12 – Statistical parameters of ice loads	179
Table A.13 – Combined wind and ice loading conditions	183
Table A.14 – Drag coefficients and density of ice-covered conductors	183
Table B.1 – Ratios of x / \bar{x} for a Gumbel distribution function, T return period in years of loading event, n number of years with observations, v_x coefficient of variation	193
Table B.2 – Parameters of Weibull distribution	199
Table B.3 – Statistical parameters \bar{U} and σ_U of wind span variation	203
Table B.4 – Statistical parameters \bar{U} and σ_U of weight span variation	205
Table B.5 – Values of use factor coefficient γ_U as a function of U and N for $v_R = 0,10$	209
Table B.6 – Use factor coefficient γ_U for different strength coefficients of variation	211
Table C.1 – Parameters C_1 and C_2 of Gumbel distribution	227
Table C.2 – Values of u_1 for given values of function $F_{(u_1)} = I(u_1, p_3-1)$	235

INTERNATIONAL ELECTROTECHNICAL COMMISSION

DESIGN CRITERIA OF OVERHEAD TRANSMISSION LINES

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60826 has been prepared by IEC technical committee 11: Overhead lines.

This third edition cancels and replaces the second edition which was issued as a technical report in 1999. It constitutes a technical revision and now have the status of an International Standard.

This revision consists mainly of splitting the standard into two sections, normative and informative, in addition to simplifying its contents and improving some specific design requirements in accordance with recent technical advances.

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

FDIS	Report on voting
11/175/FDIS	11/177/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.

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

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

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

IEC 60826:2003

<https://standards.iteh.ai/catalog/standards/iec/57898c3d-ed9d-4caa-b929-44f0bfe6499f/iec-60826-2003>

DESIGN CRITERIA OF OVERHEAD TRANSMISSION LINES

1 Scope

This International Standard specifies the loading and strength requirements of overhead lines derived from reliability based design principles. These requirements apply to lines 45 kV and above, but can also be applied to lines with a lower nominal voltage.

This standard also provides a framework for the preparation of national standards dealing with overhead transmission lines, using reliability concepts and employing probabilistic or semi-probabilistic methods. These national standards will need to establish the local climatic data for the use and application of this standard, in addition to other data that are country specific.

Although the design criteria in this standard apply to new lines, many concepts can be used to address the reliability requirements for refurbishment and uprating of existing lines.

This standard does not cover the detailed design of line components such as towers, foundations, conductors or insulators.

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 60652:2002, *Loading tests on overhead line structures*

IEC 61089:1991, *Round wire concentric lay overhead electrical stranded conductors*

IEC 61773:1996, *Overhead lines – Testing of foundations for structures*

IEC 61774:1997, *Overhead lines – Meteorological data for assessing climatic loads*

IEC 61284:1997, *Overhead lines – Requirements and tests for fittings*

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the following terms, definitions, symbols and abbreviations apply.

3.1 Terms and definitions

3.1.1

characteristic strength

guaranteed strength, minimum strength, minimum failing load

R_c

value guaranteed in appropriate standards

NOTE This value usually corresponds to an exclusion limit, from 2 % to 5 %, with 10 % being an upper practical (and conservative) limit.

3.1.2

coefficient of variation

COV

ratio of the standard deviation to the mean value

NOTE The COV of load and strength are respectively denoted by v_Q and v_R .

3.1.3

components

different parts of a transmission line system having a specified purpose

NOTE Typical components are towers, foundations, conductors and insulator strings.

3.1.4

damage limit (of a component)

serviceability limit state

strength limit of a component corresponding to a defined limit of permanent (or inelastic) deformation of this component which leads to damage to the system if it is exceeded

NOTE This limit is also called the serviceability limit state in building codes based on limit states design.

3.1.5

damage state (of the system)

state where the system needs repairing because one of its components has exceeded its damage limit

NOTE The system needs repairing because it is not capable of fulfilling its task under design loads or because design clearances may be reduced (e.g. conductor to ground).

3.1.6

elements

different parts of a component

NOTE For example, the elements of a steel lattice tower are steel angles, plates and bolts.

3.1.7

exclusion limit

e %

value of a variable taken from its distribution function and corresponding to a probability of e % of not being exceeded

3.1.8**failure limit (of a component)**

ultimate limit state

strength limit of a component which leads to the failure of the system if this limit is exceeded.

NOTE If this strength limit is exceeded, the system will reach a state called “ultimate limit state” as defined in building codes based on limit states design.

3.1.9**failure state (of the system)**

state of a system in which a major component has failed because one of its components has reached its failure limit (such as by rupture, buckling, overturning)

NOTE This state leads to the termination of the ability of the line to transmit power and needs to be repaired.

3.1.10**intact state**

state in which a system can accomplish its required function and can sustain limit loads

3.1.11**limit loads**climatic loads corresponding to a return period, T , used for design purposes without additional load factors

NOTE Refer to 5.2.1.

3.1.12**load factor** γ

factor to be multiplied by limit loads in order to design line components

3.1.13**operating period**

general measure of useful (or economical) life

NOTE Typical operating periods of transmission lines vary from 30 years to 80 years.

3.1.14**reference wind speed** V_R wind speed at 10 m in height, corresponding to an averaging period of 10 min and having a return period T

NOTE When this wind speed is taken in a terrain type B, which is the most common case in the industry, the reference wind speed is identified as V_{RB} .

3.1.15**reliability (structural)**

probability that a system performs a given task, under a set of operating conditions, during a specified time

NOTE Reliability is thus a measure of the success of a system in accomplishing its task. The complement to reliability is the probability of failure or unreliability.

3.1.16**return period (of a climatic event)**

average occurrence of a climatic event having a defined intensity

NOTE The inverse of the return period is the yearly frequency which corresponds to the probability of exceeding this climatic event in a given year.

3.1.17**safety**

ability of a system not to cause human injuries or loss of lives

NOTE In this standard, safety relates mainly to protection of workers during construction and maintenance operations. The safety of the public and of the environment in general is covered by national regulations.

3.1.18**security (structural)**

ability of a system to be protected from a major collapse (cascading effect) if a failure is triggered in a given component

NOTE Security is a deterministic concept as opposed to reliability which is a probabilistic concept.

3.1.19**strength factor**

ϕ

factor applied to the characteristic strength of a component

NOTE This factor takes into account the coordination of strength, the number of components subjected to maximum load, quality and statistical parameters of components.

3.1.20**system**

set of components connected together to form the transmission line

3.1.21**task**

function of the system (transmission line), i.e. to transmit power between its two ends

3.1.22**unavailability**

inability of a system to accomplish its task

NOTE Unavailability of transmission lines results from structural unreliability as well as from failure due to other events such as landslides, impact of objects, sabotage, defects in material, etc.

3.1.23**use factor**

ratio of the actual load (as built) to limit load of a component

NOTE For tangent towers, it is virtually equal to the ratio of actual to maximum design spans (wind or weight) and for angle towers, it also includes the ratio of the sines of the half angles of deviation (actual to design angles).

3.2 Symbols and abbreviations

a	Unit action of wind speed on line elements (Pa or N/m ²)
A_c	Wind force on conductors (N)
A_i	Wind force on insulators (N)
A_t	Wind force acting on a tower panel made of steel angles, A_{tc} for cylindrical tower members (N)
B_i	Reduction factor of the reference wind speed for wind and ice combinations

C_x	Drag coefficient (general form)
C_i	Drag coefficient of ice covered conductors (C_{iL} for low probability and C_{iH} for a high probability)
C_{xc}	Drag coefficient of conductors
C_{xi}	Drag coefficient of insulators
C_{xt}	Drag coefficient of supports C_{xt1} , C_{xt2} for each tower face (C_{xtc} on cylindrical tower members)
COV	Coefficient of variation, also identified as v_x (ratio of standard deviation to mean value)
d	Conductor diameter (m)
d_{tc}	Diameter of cylindrical tower members (m)
D	Equivalent diameter of ice covered conductors (D_H for high probability and D_L for low probability) (m)
e	Exclusion limit (%)
e_N	Exclusion limit of N components in series (%)
$f_{(x)}$	Probability density function of variable x
$F_{(x)}$	Cumulative distribution function of variable x
G	Wind factor (general form)
G_c	Combined wind factor of conductors
G_t	Combined wind factor of towers
G_L	Span factor for wind calculations
g	Unit weight of ice (N/m)
\bar{g}	Mean value of yearly maximum ice load (N/m)
g_{max}	Maximum weight of ice per unit length observed during a certain number of years (N/m)
g_R	Reference design ice weight (N/m)
g_H	Ice load having a high probability (N/m)
g_L	Ice load having a low probability (N/m)
h	Height of centre of gravity of a panel in a lattice tower (m)
K_R	Terrain roughness factor
K_d	Factor related to the influence of conductor diameter
K_h	Factor to be multiplied by \bar{g} to account for the influence of height above ground
K_n	Factor to be multiplied by \bar{g} to account for the influence of the number of years with icing observations
l_e	Length of a support member (m)
L	Span length or wind span (m)
L_m	Average span (m)
n	Number of years of observation of a climatic event
N	Number of components subjected to maximum loading intensity
P_f	Probability of failure (%)
P_{fi}	Probability of failure of component i (%)
P_s	Probability of survival (%)
P_{si}	Probability of survival of component i (%)