



BSI Standards Publication

Power installations exceeding 1 kV AC and 1,5 kV DC

Part 1: AC

National foreword

This British Standard is the UK implementation of EN IEC 61936-1:2021. It is identical to IEC 61936-1:2021. It supersedes BS EN 61936-1:2010+A1:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/99, Erection and operation of power installations.

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Amendments/corrigenda issued since publication

Date	Text affected
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English Version

Power installations exceeding 1 kV AC and 1,5 kV DC - Part 1:
AC
(IEC 61936-1:2021)

Installations électriques de puissance de tension supérieure
à 1 kV en courant alternatif et 1,5 kV en courant continu -
Partie 1: Courant alternatif
(IEC 61936-1:2021)

Starkstromanlagen mit Nennwechselspannungen über 1 kV
AC und 1,5 kV DC - Teil 1: Wechselstrom
(IEC 61936-1:2021)

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 99/311/FDIS, future edition 3 of IEC 61936-1, prepared by IEC/TC 99 “Insulation co-ordination and system engineering of high voltage electrical power installations above 1,0 kV AC and 1,5 kV DC” was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61936-1:2021.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2022-05-11 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2024-08-11 document have to be withdrawn

This document supersedes EN 61936-1:2010 and all of its amendments and corrigenda (if any).

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The text of the International Standard IEC 61936-1:2021 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60034-3	NOTE	Harmonized as EN IEC 60034-3
IEC 60038	NOTE	Harmonized as EN 60038
IEC 60068 (series)	NOTE	Harmonized as EN 60068 (series)
IEC 60076-13	NOTE	Harmonized as EN 60076-13
IEC 60092 (series)	NOTE	Harmonized as EN 60092 (series)
IEC 60282-1	NOTE	Harmonized as EN IEC 60282-1
IEC 60364-4-41	NOTE	Harmonized as HD 60364-4-41
IEC 60364-7-729	NOTE	Harmonized as HD 60364-7-729
IEC 60376	NOTE	Harmonized as EN IEC 60376
IEC 60480	NOTE	Harmonized as EN IEC 60480
IEC 60664-1	NOTE	Harmonized as EN IEC 60664-1
IEC 60721 (series)	NOTE	Harmonized as EN 60721 (series)
IEC 60721-2-2	NOTE	Harmonized as EN 60721-2-2

IEC 60721-2-3	NOTE	Harmonized as EN 60721-2-3
IEC 60721-2-4	NOTE	Harmonized as EN IEC 60721-2-4
IEC 60721-2-7	NOTE	Harmonized as EN IEC 60721-2-7
IEC 60721-3-1	NOTE	Harmonized as EN IEC 60721-3-1
IEC 60721-3-2	NOTE	Harmonized as EN IEC 60721-3-2
IEC 60832 (series)	NOTE	Harmonized as EN 60832 (series)
IEC 60855-1	NOTE	Harmonized as EN 60855-1
IEC 60865-1	NOTE	Harmonized as EN 60865-1
IEC 60909 (series)	NOTE	Harmonized as EN 60909 (series)
IEC 61000 (series)	NOTE	Harmonized as EN IEC 61000 (series)
IEC 61039	NOTE	Harmonized as EN 61039
IEC 61082-1	NOTE	Harmonized as EN 61082-1
IEC 61243 (series)	NOTE	Harmonized as EN 61243 (series)
IEC 61355-1	NOTE	Harmonized as EN 61355-1
IEC 61869 (series)	NOTE	Harmonized as EN IEC 61869 (series)
IEC 62271-4	NOTE	Harmonized as EN 62271-4
IEC 62271-100	NOTE	Harmonized as EN 62271-100
IEC 62271-102	NOTE	Harmonized as EN IEC 62271-102
IEC 62271-103	NOTE	Harmonized as EN 62271-103
IEC 62271-104	NOTE	Harmonized as EN IEC 62271-104
IEC 62271-105	NOTE	Harmonized as EN 62271-105
IEC 62271-206	NOTE	Harmonized as EN 62271-206
IEC 62305 (series)	NOTE	Harmonized as EN 62305 (series)
IEC 81346 (series)	NOTE	Harmonized as EN IEC 81346 (series)
ISO 26800	NOTE	Harmonized as EN ISO 26800

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60034-1	-	Rotating electrical machines - Part 1: Rating and performance	-	-
IEC 60060-1	-	High-voltage test techniques - Part 1: General definitions and test requirements	EN 60060-1	-
IEC 60071-1	2019	Insulation co-ordination - Part 1: Definitions, principles and rules	EN IEC 60071-1	2019
IEC 60071-2	-	Insulation co-ordination – Part 2: Application guidelines	EN IEC 60071-2	-
IEC 60076	series	Power transformers	EN 60076	series
IEC 60079-0	-	Explosive atmospheres - Part 0: Equipment - General requirements	EN IEC 60079-0	-
IEC 60079-10-1	-	Explosive atmospheres - Part 10–1: Classification of areas - Explosive gas atmospheres	EN IEC 60079-10-1	-
IEC 60079-10-2	-	Explosive atmospheres - Part 10–2: Classification of areas - Explosive dust atmospheres	EN 60079-10-2	-
IEC 60255	series	Measuring relays and protection equipment	EN 60255	series
IEC 60331-1	-	Tests for electric cables under fire conditions - Circuit integrity - Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm	EN IEC 60331-1	-
IEC 60331-21	-	Tests for electric cables under fire conditions - Circuit integrity - Part 21: Procedures and requirements - Cables of rated voltage up to and including 0,6/1,0 kV	-	-
IEC 60332	series	Tests on electric cables under fire conditions	EN 60332	series

IEC 60364	series	Low-voltage electrical installations	HD 60364	series
IEC 60479-1	2018	Effects of current on human beings and livestock - Part 1: General aspects	-	-
IEC 60529	-	Degrees of protection provided by enclosures (IP Code)	-	-
IEC 60754	series	Test on gases evolved during combustion of materials from cables	EN 60754	series
IEC 61034-1	-	Measurement of smoke density of cables burning under defined conditions - Part 1: Test apparatus	EN 61034-1	-
IEC 61219	-	Live working - Earthing or earthing and short-circuiting equipment using lances as a short-circuiting device - Lance earthing	EN 61219	-
IEC 61230	-	Live working - Portable equipment for earthing or earthing and short-circuiting	EN 61230	-
IEC 62271-1	2017	High-voltage switchgear and controlgear - Part 1: Common specifications for alternating current switchgear and controlgear	EN 62271-1	2017
IEC 62271-200	-	High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	EN IEC 62271-200	-
IEC 62271-201	-	High-voltage switchgear and controlgear - Part 201: AC solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	EN 62271-201	-
IEC 62271-202	-	High-voltage switchgear and controlgear - Part 202: High-voltage/ low-voltage prefabricated substation	EN 62271-202	-
IEC 62271-203	-	High-voltage switchgear and controlgear - Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV	EN 62271-203	-
IEC 62271-207	-	High-voltage switchgear and controlgear - Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV	EN 62271-207	-
IEC 62305	series	Protection against lightning	EN 62305	series
IEC/TR 61000-5-2	-	Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 2: Earthing and cabling	-	-
IEC/TR 62271-300	-	High-voltage switchgear and controlgear - Part 300: Seismic qualification of alternating current circuit-breakers	-	-
IEC/TS 60815-1	-	Selection and dimensioning of high-voltage-insulators intended for use in polluted conditions - Part 1: Definitions, information and general principles	-	-

EN IEC 61936-1:2021 (E)

IEC/TS 60815-2	-	Selection and dimensioning of high-voltage - insulators intended for use in polluted conditions - Part 2: Ceramic and glass insulators for a.c. systems	-
IEC/TS 60815-3	-	Selection and dimensioning of high-voltage - insulators intended for use in polluted conditions - Part 3: Polymer insulators for a.c. systems	-
IEC/TS 61463	-	Bushings - Seismic qualification	-
IEC/IEEE 82079-1	-	Preparation of information for use (instructions for use) of products - Part 1: Principles and general requirements	EN IEC/IEEE 82079-1

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based on current practice in some countries 100

INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER INSTALLATIONS EXCEEDING 1 kV AC AND 1,5 kV DC –

Part 1: AC

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.
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International Standard IEC 61936-1 has been prepared by IEC technical committee 99: Insulation co-ordination and system engineering of high voltage electrical power installations above 1,0 kV AC and 1,5 kV DC.

This third edition cancels and replaces the second edition published in 2010 and Amendment 1:2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) introduction has been rewritten to reflect the status when this document is produced;
- b) the scope has been improved to clarify the application of this document;
- c) missing and obsolete terms and definitions have been updated including improvement of existing terms;
- d) Table 1 has been updated where agreements between supplier and user are needed;
- e) requirements of electromagnetic compatibility have been clarified;

- f) insulation coordination clause (Clause 5) has improved wording for better clarity and the technical content has an updated coordination to the latest versions of the insulation coordination standards;
- g) wording regarding electrical equipment has been improved and made clearer;
- h) subclause for fuses has been improved and reworded;
- i) requirements have been added for labelling when multiple sources are required to be disconnected;
- j) missing requirements for GIS have been reintroduced;
- k) subclause regarding ventilation (HVAC) has been improved;
- l) figures in Clause 7 have been updated and moved to the corresponding subclause;
- m) requirements for transformer installations have been improved including adjustment of editorial typing-errors;
- n) clause on protection, automation and auxiliary systems has been restructured and improved;
- o) protection against lightning strokes has been extended;
- p) clarification of content due to the distinction between erection (and providing electrical safety for the intended use of the electrical power installation) and subsequent activities such as maintenance and repair with safe working procedures;
- q) where no provincial, national or regional regulations are available for safe working procedures, an informative guideline is provided in Annex F. This replaces the former parts of Figure 3 in Clause 7.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
99/311/FDIS	99/316/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 61936 series, published under the general title *Power installations exceeding 1 kV AC and 1,5 kV DC*, can be found on the IEC website.

A document on principles to be observed in the preparation of safety publications regarding high voltage installations is currently under development (IEC TS 61936-0).

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

The reader's attention is drawn to the fact that Annex G lists all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this document.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 61936 contains the minimum requirements for the design, erection, and verification of high voltage power installations greater than 1 kV AC. The rules are intended to provide for the safety of persons, livestock and property against dangers and damage which may arise in the reasonable use of such electrical installations and to provide for the proper functioning of those installations.

There are many provincial, national and regional laws, standards and internal rules dealing with the matter coming within the scope of this document regarding high voltage power installations. These practices have been taken as a basis for this work.

This third edition of IEC 61936-1, first published in 2001, follows worldwide feedback to improve clarity. It continues the effort to towards the alignment all over the world of practices concerning the design and erection of high voltage power installations.

Particular requirements for transmission and distribution installations, as well as particular requirements for power generation and industrial installations, are included in this document.

While national standards and regulations take precedence, jurisdictions may elect to adopt the requirements of this document.

POWER INSTALLATIONS EXCEEDING 1 kV AC AND 1,5 kV DC –

Part 1: AC

1 Scope

This part of IEC 61936 provides requirements for the design and the erection of electrical power installations in systems with nominal voltages exceeding 1 kV AC and nominal frequency up to and including 60 Hz, so as to provide safety and proper functioning for the use intended.

For the purpose of interpreting this document, an electrical power installation is considered to be one of the following:

- a) substation, including substation for railway power supply;
- b) electrical power installations on mast, pole and tower, switchgear and/or transformers located outside a closed electrical operating area;
- c) one (or more) power station(s) located on a single site, the electrical power installation includes generators and transformers with all associated switchgear and all electrical auxiliary systems. Connections between generating stations located on different sites are excluded;
- d) the electrical system of a factory, industrial plant or other industrial, agricultural, commercial or public premises;
- e) electrical power installations on offshore facilities for the purpose of generation, transmission, distribution and/or storage of electricity;
- f) transition towers/poles (between overhead lines and underground lines).

The electrical power installation includes, among others, the following equipment:

- rotating electrical machines;
- switchgear;
- transformers and reactors;
- converters;
- cables;
- wiring systems;
- batteries;
- capacitors;
- earthing systems;
- buildings and fences which are part of a closed electrical operating area;
- associated protection, control and auxiliary systems;
- large air core reactor.

NOTE 1 In general, equipment standards take precedence over the requirements of this document.

This document does not apply to the design and erection of any of the following:

- overhead and underground lines between separate electrical power installations;
- electrified railway tracks and rolling stock;
- mining equipment and installations;

- fluorescent lamp installations;
- installations on ships according to IEC 60092 (all parts) and offshore units according to IEC 61892 (all parts), which are used in the offshore petroleum industry for drilling, processing and storage purposes;
- electrostatic equipment (e.g. electrostatic precipitators, spray-painting units);
- test sites;
- medical equipment, e.g. medical X-ray equipment.

This document does not apply to the design of prefabricated, type-tested switchgear and high voltage/low voltage prefabricated substation, for which separate IEC standards exist.

NOTE 2 The scope of this document does not include the requirements for carrying out live working on electrical power installations.

NOTE 3 The scope of this document considers safety requirements for HV installations and the influences of HV installations on LV installations. For electrical installations up to 1 kV, IEC 60364 (all parts) applies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60071-1:2019, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60071-2, *Insulation co-ordination – Part 2: Application guidelines*

IEC 60076 (all parts), *Power transformers*

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC 60079-10-2, *Explosive atmospheres – Part 10-2: Classification of areas – Explosive dust atmospheres*

IEC 60255 (all parts), *Measuring relays and protection equipment*

IEC 60331-1, *Tests for electric cables under fire conditions – Circuit integrity – Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm*

IEC 60331-21, *Tests for electric cables under fire conditions – Circuit integrity – Part 21: Procedures and requirements – Cables of rated voltage up to and including 0,6/1,0 kV*

IEC 60332 (all parts), *Tests on electric and optical fibre cables under fire conditions*

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

IEC 60479-1:2018, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60754 (all parts), *Test on gases evolved during combustion of materials from cables*

IEC TS 60815-1, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC TS 60815-2, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC TS 60815-3, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems*

IEC TR 61000-5-2, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling*

IEC 61034-1, *Measurement of smoke density of cables burning under defined conditions – Part 1: Test apparatus*

IEC 61219, *Live working – Earthing or earthing and short-circuiting equipment using lances as a short-circuiting device – Lance earthing*

IEC 61230, *Live working – Portable equipment for earthing or earthing and short-circuiting*

IEC TS 61463, *Bushings – Seismic qualification*

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-200, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-201, *High-voltage switchgear and controlgear – Part 201: AC solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-202, *High-voltage switchgear and controlgear – Part 202: High-voltage/low-voltage prefabricated substation*

IEC 62271-203, *High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

IEC 62271-207, *High-voltage switchgear and controlgear – Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV*

IEC TR 62271-300, *High-voltage switchgear and controlgear – Part 300: Seismic qualification of alternating current circuit-breakers*

IEC 62305 (all parts), *Protection against lightning*

IEC/IEEE 82079-1, *Preparation of information for use (instructions for use) of products – Part 1: Principles and general requirements*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 General definitions

3.1.1

electrical equipment

item used for such purposes as generation, conversion, transmission, distribution or utilization of electric energy, such as electric machines, transformers, switchgear and controlgear, measuring instruments, protective devices, wiring systems, current-using equipment

[SOURCE: IEC 60050-826:2004, 826-16-01, modified – In the term, "electric" has been replaced by "electrical".]

3.1.2

nominal value

value of a quantity used to designate and identify a component, device, equipment or system

[SOURCE: IEC 60050-151:2001, 151-16-09, modified – The note has been removed.]

3.1.3

rated value

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system

[SOURCE: IEC 60050-151:2001, 151-16-08]

3.1.4

highest voltage for installation

U_m

highest RMS value of phase-to-phase voltage for which the installation is designed in respect of its insulation

Note 1 to entry: For the purpose of this document, "highest voltage for installation U_m " is equal to "highest voltage for equipment U_m " according to IEC 60071-1.

3.1.5

tested connection zone

zone in the vicinity of equipment terminals which has passed a dielectric type test with the appropriate withstand value(s), the applicable conductors being connected to the terminals in a manner specified by the manufacturer of the equipment

3.1.6

isolating distance

<of a pole of a mechanical switching device> clearance between open contacts meeting the safety requirements specified for disconnectors

[SOURCE: IEC 60050-441:2000, 441-17-35]

3.1.7

isolation

switching off or disconnection of an electrical power installation, a part of an electrical power installation or an equipment from all non-earthed conductors by creating isolating gaps or distances

3.1.8

live part

conductor or conductive part intended to be energized in normal operation, including the isolated neutral point

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-195:2021, 195-02-19, modified – "conductor or " has been added at the start of the definition. "neutral conductor and mid-point conductor" has been replaced with "isolated neutral point". LV terms and relation not included.]

3.1.9

feeder

electric line originating at a main substation and supplying one or more secondary substations, or one or more branch lines, or any combination of these two types of installations

[SOURCE: IEC 60050-601:1985, 601-02-08, modified – Branch lines included and the combination of those installations]

3.1.10

ferro-resonance

resonance due to oscillations between the capacitance of an apparatus and the inductance of the saturable magnetic circuit of an adjacent apparatus

[SOURCE: IEC 60050-614:2016, 614-01-19]

3.1.11

transient overvoltage

overvoltage with a duration of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[SOURCE: IEC 60050-614:2016, 614-03-14, modified – The notes to entry have been deleted.]

3.1.12

temporary overvoltage

TOV

power-frequency overvoltage of a relatively long duration

Note 1 to entry: The overvoltage may be undamped or weakly damped. In some cases, its frequency may be several times smaller or higher than power frequency.

[SOURCE: IEC 60071-1:2019, 3.17.1]

3.1.13

high voltage

HV

voltage exceeding 1 000 V AC

[SOURCE: IEC 60050-601:1985, 601-01-27, modified – Fixed limit HV > 1 000 V and synonym to preferred term moved to new line.]

3.1.14**low voltage****LV**

voltage not exceeding 1 000 V AC

[SOURCE: IEC 60050-601:1985, 601-01-26, modified – Fixed limit LV ≤ 1 000 V and synonym to preferred term moved to new line.]

3.1.15**operation**

all activities, including both electrical and non-electrical work activities, necessary to permit the electric power installation to function

Note 1 to entry: These activities include switching, controlling, monitoring and maintenance.

[SOURCE: IEC 60050-151:2001, 151-11-28, modified – Enlarged extent related to electric power installations.]

3.1.16**normal conditions of operation**

all operating conditions frequently encountered

Note 1 to entry: These include rated operating conditions, maximum and minimum operating conditions, partial load, normal transients (start-up, shut-down, load changes) and standby situations.

3.1.17**abnormal conditions of operation**

operating conditions of low occurrence (typically only a few times during equipment lifetime)

Note 1 to entry: These include human errors, loss of power supply, overvoltages, earthquake, etc. After such a condition has occurred, equipment inspection may be required.

3.1.18**electrical work**

work on, with or near an electrical power installation such as testing and measurement, repairing, replacing, modifying, extending, erection and inspection

3.2 Definitions concerning electrical power installations**3.2.1****closed electrical operating area**

room or location for operation of electrical power installations and equipment to which access is intended to be restricted to skilled or instructed persons or to lay ordinary persons under the supervision of skilled or instructed persons

3.2.2**operating area subject to fire hazard**

room, area or location, indoor or outdoor, where there is a danger, due to local or operating conditions, that hazardous quantities of easily flammable materials may come so close to the electrical equipment as to cause a fire hazard resulting from the high temperature of the equipment or due to arcing

3.2.3**sump**

receptacle which is intended to receive the insulating liquid of a transformer or other equipment in case of leakage

3.2.4

catchment tank

collecting tank for the leakage liquids, rain water, etc. for one or more transformers or other equipment

3.2.5

busbar

conductor with associated connections, joints and insulated supports forming a common electrical connection between a number of circuits or individual pieces of apparatus

3.3 Definitions concerning types of electrical power installations

3.3.1

substation

<of a power system> part of a power system, concentrated in a given place, including mainly the terminations of transmission or distribution lines, switchgear and housing and which may also include transformers

Note 1 to entry: It generally includes facilities necessary for system security and control (e.g. the protective devices).

Note 2 to entry: According to the nature of the system within which the substation is included, a prefix may qualify it.

EXAMPLE Transmission substation (of a transmission system), distribution substation, 400 kV substation, 20 kV substation.

[SOURCE: IEC 60050-605:1983, 605-01-01, modified – Supplementary information has been moved from the definition to Note 1 to entry.]

3.3.2

power station

installation whose purpose is to generate electricity and which includes civil engineering works, energy conversion equipment and all the necessary ancillary equipment

[SOURCE: IEC 60050-602:1983, 602-01-01]

3.3.3

installations of open design

installations where the equipment does not have protection against direct contact

3.3.4

switchgear 'bay' or 'cubicle'

each branch of a busbar in an electrical power installation

3.4 Definitions concerning safety measures against electric shock

3.4.1

protection against direct contact

measures which prevent persons coming into hazardous proximity to live parts or those parts which could carry a hazardous voltage, with parts of their bodies or objects (reaching the danger zone)

3.4.2

protection in case of indirect contact

protection of persons from hazards which could arise, in event of fault, from contact with exposed-conductive-parts of electrical equipment or extraneous-conductive-parts

3.4.3**enclosure**

part providing protection of equipment against certain external influences and, in any direction, protection against direct contact

3.4.4**protective barrier**

<electrically> part providing protection against direct contact by a human being or livestock with hazardous-live-parts from any usual direction of access

[SOURCE: IEC 60050-195:2021, 195-06-15, modified – In the definition, "contact" has been replaced with "direct contact".]

3.4.5**protective obstacle**

part preventing unintentional direct contact, but not preventing direct contact by deliberate action

[SOURCE: IEC 60050-826:2004, 826-12-24]

3.5 Definitions concerning clearances**3.5.1****clearance**

distance between two conductive parts along a string stretched the shortest way between these conductive parts

[SOURCE: IEC 60050-441:1984, 441-17-31]

3.5.2**minimum clearance**

smallest permissible clearance in air between live parts or between live parts and earth

3.5.3**protective barrier clearance**

smallest permissible clearance between a protective barrier and live parts or those parts which may become subject to a hazardous voltage

3.5.4**protective obstacle clearance**

smallest permissible clearance between a protective obstacle and live parts or those parts which may become subject to a hazardous voltage

3.5.5**danger zone**

in the case of high voltage, area limited by the minimum clearance around hazardous-live-parts without complete protection

Note 1 to entry: Entering the danger zone is considered the same as touching hazardous-live-parts.

[SOURCE: IEC 61140:2016, 3.35]

3.5.6**minimum clearance of danger zone**

N

clearance which describes the area of danger zone around hazardous-live-parts without complete protection against direct contact

Note 1 to entry: The values for minimum clearance of danger zone in Table 2, Table 3 and Annex A are designated as "N".

Note 2 to entry: The safety clearances as given in Clause 7 are based on the minimum clearance of danger zone.

3.5.7

boundary clearance

smallest permissible clearance between an external fence and live parts or those parts which may become subject to a hazardous voltage

3.5.8

minimum height

smallest permissible vertical clearance between accessible surfaces and live parts without protection against direct contact or those parts which may become subject to a hazardous voltage

3.5.9

standard short-duration power-frequency voltage

sinusoidal voltage with frequency between 48 Hz and 62 Hz, and duration of 60 s

[SOURCE: IEC 60071-1:2019, 3.18.1]

3.5.10

standard rated short-duration power-frequency withstand voltage

RMS value standardized as withstand voltage for levels of specified standard short-duration power-frequency voltages

Note 1 to entry: See IEC 60071-1:2019, 5.6 for specified voltage levels.

3.5.11

standard lightning impulse voltage

impulse voltage having a front time of 1,2 µs and a time to half-value of 50 µs

[SOURCE: IEC 60071-1:2019, 3.18.3, modified – "voltage" added to term.]

3.5.12

standard rated lightning impulse withstand voltage

peak value, standardized as withstand voltage of standard lightning impulse voltage

Note 1 to entry: See 60071-1 2019, 5.7 for specified values.

3.5.13

standard switching impulse voltage

impulse voltage having a time to peak of 250 µs and a time to half-value of 2 500 µs

[SOURCE: IEC 60071-1:2019, 3.18.2, modified – "voltage" added to term.]

3.5.14

standard rated switching impulse withstand voltage

peak value, standardized as withstand voltage of standard switching impulse voltage

Note 1 to entry: See 60071-1 2019, 5.7 for specified values.

3.6 Definitions concerning control and protection

3.6.1

interlocking device

device which makes the operation of a switching device dependent upon the position or operation of one or more other pieces of equipment

[SOURCE: IEC 60050-441:1984, 441-16-49]

3.6.2

local control

control of an operation at a point on or adjacent to the controlled switching device

[SOURCE IEC 60050-441:1984, 441-16-06]

3.6.3

remote control

control of operation at a point distant from the controlled switching device

[SOURCE: IEC 60050-441:1984, 441-16-07]

3.6.4

automatic reclosing

reclosing of a circuit-breaker associated with a faulted section of a network by automatic means after a time interval which permits that section to recover from a transient fault

[SOURCE: IEC 60050-614:2016, 614-02-29]

3.7 Definitions concerning earthing

3.7.1

local earth**local ground (US)**

part of the Earth that is in electric contact with an earth electrode and that has an electric potential not necessarily equal to zero

Note 1 to entry: The conductive mass of the Earth, whose electric potential at any point is conventionally taken as equal to zero.

[SOURCE: IEC 60050-195:2021, 195-01-03, modified – Note 1 to entry has been added.]

3.7.2

reference earth**reference ground (US)**

part of the Earth considered as conductive, the electric potential of which is conventionally taken as zero, being outside the zone of influence of the relevant earthing arrangement

Note 1 to entry: The concept "Earth" means the planet and all its physical matter.

[SOURCE: IEC 60050-195:2021, 195-01-01, modified – "any earthing arrangement" has been replaced with "the relevant earthing arrangement".]

3.7.3

earth electrode**ground electrode (US)**

<electrical power installations> conductive part, which may be embedded in a specific conductive medium, e.g. in concrete or coke, in electric contact with the Earth

[SOURCE: IEC 60050-195:1998, 195-02-01, modified – "<electrical power installation>" has been added.]

3.7.4

earthing conductor

grounding conductor (US)

conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode

Note 1 to entry: Where the connection between part of the installation and the earth electrode is made via a disconnecting link, disconnecting switch, surge arrester counter, surge arrester control gap, etc., then only that part of the connection permanently attached to the earth electrode is an earthing conductor.

[SOURCE: IEC 60050-195:2021, 195-02-03, modified – In the definition, "forming a conductive path between a conductive part" has been replaced with "which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment". Note 1 to entry has been added.]

3.7.5

bonding conductor

protective conductor for ensuring equipotential bonding

3.7.6

earthing system

grounding system (US)

arrangement of electric connections and devices involved necessary to earth equipment or a system separately or jointly

[SOURCE: IEC 60050-826:2004, 826-13-04, modified – In the terms, "system" has been replaced by "arrangement". The definition clarifies that involved parts can be separately or jointly earthed.]

3.7.7

structural earth electrode

metal part, which is in conductive contact with the earth or with water directly or via concrete, whose original purpose is not earthing, but which fulfils all requirements of an earth electrode without impairment of the original purpose

Note 1 to entry: Examples of structural earth electrodes are pipelines, sheet piling, concrete reinforcement bars in foundations and the steel structure of buildings, etc.

3.7.8

electric resistivity of soil

ρ_E

resistivity of a typical sample of soil

[SOURCE: IEC 60050-195:1998, 195-01-19]

3.7.9

resistance to earth

R_E

real part of the impedance to earth

[SOURCE: IEC 60050-195:1998, 195-01-18]

3.7.10**impedance to earth** Z_E

impedance at a given frequency between a specified point in a system or in an installation or in equipment and reference earth

Note 1 to entry: The impedance to earth is determined by the directly connected earth electrodes and also by connected overhead earth wires and wires buried in earth of overhead lines, by connected cables with earth electrode effect and by other earthing systems which are conductively connected to the relevant earthing system by conductive cable sheaths, shields, PEN conductors or in another way. Impedance to earth is composed of the resistance to earth of the substation and connected parallel impedances such as overhead ground wires and cable sheaths.

[SOURCE: IEC 60050-195:2021, 195-01-17, modified – The symbol Z_E and Note 1 to entry have been added.]

3.7.11**earth potential rise****EPR** U_E

voltage between an earthing system and reference earth

3.7.12**touch voltage** U_T

<effective> voltage between conductive parts when touched simultaneously

Note 1 to entry: The value of the effective touch voltage may be appreciably influenced by the impedance of the person in electric contact with these conductive parts.

[SOURCE: IEC 60050-195:2021, 195-05-11, modified – The symbol U_T has been added. In the definition, "by a human being or livestock" has been deleted. In Note 1 to entry, "of the human being or livestock" has been replaced by "of the person".]

3.7.13**permissible touch voltage** U_{Tp}

limit value of touch voltage U_T

3.7.14**prospective touch voltage** U_{vT}

voltage between simultaneously accessible conductive parts when those conductive parts are not being touched

3.7.15**prospective permissible touch voltage** U_{vTp}

limit value of prospective touch voltage U_{vT}

3.7.16**step voltage**

voltage between two points on the Earth's surface that are 1 m distant from each other

Note 1 to entry: 1 m is considered to be the stride length of a person.

[SOURCE: IEC 60050-195:2021, 195-05-12, modified – In the definition, "that are 1 m distant from each other" has been added. Note 1 to entry has been replaced.]

3.7.17**transferred potential**

potential rise of an earthing system caused by a current to earth transferred by means of a connected conductor (for example a metallic cable sheath, PEN conductor, pipeline, rail) into areas with low or no potential rise relative to reference earth, resulting in a potential difference occurring between the conductor and its surroundings

Note 1 to entry: The definition also applies where a conductor, which is connected to reference earth, leads into the area of the potential rise.

3.7.18**stress voltage**

voltage appearing during earth fault conditions between an earthed part or enclosure of equipment or device and any other of its parts and which could affect its normal operation or safety

3.7.19**global earthing system**

equivalent earthing system created by the interconnection of local earthing systems that ensures, by the proximity of the earthing systems, that there are no dangerous touch voltages

Note 1 to entry: Such systems permit the division of the earth fault current in a way that results in a reduction of the earth potential rise at the local earthing system. Such a system could be said to form a quasi-equipotential surface.

Note 2 to entry: The existence of a global earthing system may be determined by sample measurements or calculation for typical systems. Typical examples of global earthing systems are in city centres; urban or industrial areas with distributed low- and high-voltage earthing.

3.7.20**multi-earthed HV neutral conductor****multi-grounded HV neutral conductor (US)**

neutral conductor of a distribution line connected to the earthing system of the source transformer and regularly earthed

3.7.21**exposed-conductive-part**

conductive part of equipment that can be touched and that is not live under normal conditions, but that can become live when basic insulation fails

[SOURCE: IEC 60050-195:2021, 195-06-10]

3.7.22**extraneous-conductive-part**

conductive part not forming part of the electrical power installation and likely to introduce an electric potential, generally the electric potential of a local earth

[SOURCE: IEC 60050-195:2021, 195-06-11, modified – In the definition, "electrical installation" has been replaced with "electrical power installation".]

3.7.23**PEN conductor**

conductor combining the functions of both a protective earthing conductor and a neutral conductor

[SOURCE: IEC 60050-195:2021, 195-02-12]

3.7.24**earth fault****ground fault (US)**

fault caused by a conductor being connected to earth or by the insulation resistance to earth becoming less than a specified value

Note 1 to entry: Earth faults of two or several phase conductors of the same system at different locations are designated as double or multiple earth faults.

3.7.25**earth fault current** I_F

current which flows from the main circuit to earth or earthed parts at the fault location

Note 1 to entry: For single earth faults, this is in systems with:

- isolated neutral, the capacitive earth fault current;
- high resistive earthing, the RC composed earth fault current;
- resonant earthing, the earth fault residual current;
- solid or low impedance neutral earthing, the line-to-earth short-circuit current.

Note 2 to entry: Further earth fault current may result from double earth fault and line to line to earth

4 Fundamental requirements

4.1 General

4.1.1 General requirements

Electrical power installations and equipment shall be capable of withstanding electrical, mechanical, climatic and environmental influences anticipated on site.

Site selection should take into account matters including, but not limited to:

- access to allow for construction, maintenance and operations activities;
- community impact including proximity to sensitive sites, visual, noise, amenity and traffic;
- environmental impact including consideration of pollution, ventilation, fauna and flora;
- impact of topography, earthquake zones, fault lines, flood paths, swamps, avalanches or landslides;
- soil conditions, including thermal and electrical resistivity and soil contamination;
- site dimensions;
- line corridors;
- site security.

The design shall take into account:

- the purpose of the installation;
- the user requirements such as power quality, reliability, availability, and ability of the electrical network to withstand the effects of transient conditions such as starting of large motors, short power outages and re-energization of the electrical power installation;
- load conditions, design short circuit currents, etc.;
- the safety of the operators and the public;
- the environmental influence;
- the possibility for extension (if required) and maintenance.

The user shall define preferences for specific maintenance features and identify the safety requirements to be met for levels of segregation of the switchgear and controlgear to ensure minimal plant shutdown. Where necessary, the levels of segregation of switchgear shall be such as to minimize the spread of a fault, including a fire, occurring in any defined module into adjacent modules.

There are operating conditions of low occurrence or low cumulative duration which can occur and for which specific design criteria and measures required to maintain safety conditions and to avoid damage to electrical or plant equipment are subject to agreement between the supplier and user.

The generators shall be capable of meeting the requirements for connection to the power system grid or local grid, e.g. for voltage regulation, frequency response, etc.

4.1.2 Agreements between supplier and user

The working procedures of the user shall be taken into account in the design of the electrical power installation.

For design and erection of electric power installations, additional agreements between supplier/manufacturer/contractor/planner and user/orderer/owner (hereinafter denoted as supplier and user) shall be followed, which also may have effects to necessary operational requirements. References can be found in the subclauses as listed in Table 1 below.

Table 1 – References to subclauses where agreement between supplier and user is required

Subclause	Item
4.1.1	General requirements (specific design criteria)
4.2.2	Voltage classification (Nominal values, rated values)
4.3.1	Mechanical requirements, local conditions
4.3.9	Special conditions and requirements for seismic environment
4.4.2.1	Climatic and environmental conditions (for auxiliary equipment: indoor)
4.4.2.2	Climatic and environmental conditions (for auxiliary equipment: outdoor)
4.4.3.1	Conditions different from the normal environmental conditions
4.4.3.5	Special conditions and requirements for vibrations
6.1.1	Compliance with operational and safety procedures
6.2.1	Method of indication (contact position of interrupting or isolating equipment)
6.2.1	Interlocks and/or locking facilities
6.2.1	Switching devices (reduced rating)
6.2.1	Rating of switchgear (specific requirements)
6.2.8	Insulators, level of pollution and wetting conditions
6.2.9.2	Insulated cables (temperatures at special operating conditions)
7.1.1	Higher values for distances, clearances and dimensions
7.1.1	Common requirements (operating procedures)
7.1.3	Documentation (extent of the documentation)
7.1.4	Transport routes (load capacity, height and width)
7.1.6	Lighting (presence and extent of the lighting)
7.5.4	Maintenance and operating areas (distances of the escape route)
8.4.1	Means to protect persons working on electrical power installations (working procedures)
8.4.4	Devices for determining the de-energized state (extent of provisions)
8.4.5	Devices for earthing and short-circuiting (Extent of provision or supply)
8.4.6.2	Insertable insulated partitions
8.4.6.3	Insertable partition walls
8.5	Protection from danger resulting from arc fault (degree of importance of measures)
8.6	Protections against direct lightning strokes (method of analysis)
8.7.1	Requirements for fire extinguishing equipment
8.7.2.2	Reduction of distances G_1 and G_2
8.9	The language of the identification and marking
9.1	Protection systems, protection coordination, settings, backup, etc.
9.3.1.3	Auxiliary systems and battery sizing
9.3.2	Compressed air system (sectionalization for maintenance)
9.3.3	SF ₆ gas handling plants (design and capacity of the plant)
10.2.1	Fundamental requirements for design of the earthing system
11.1	Inspection and testing (extent of the inspection and testing / specification / documentation)
11.2	Verification of specified performances
11.3	Tests during installation and commissioning (requirements / test equipment / schedule of tests)
11.4	Trial running (performance)

4.2 Electrical requirements

4.2.1 Methods of neutral earthing

The method of neutral earthing strongly influences the fault current level and the fault current duration. Furthermore, the neutral earthing method is important with regard to the following:

- selection of insulation level;
- characteristics of overvoltage – limiting devices – such as spark gaps or surge arresters;
- selection of protective relays;
- design of earthing system.

The following are examples of neutral earthing methods:

- isolated neutral;
- resonant earthing;
- high resistive earthing;
- solid (low impedance) earthing.

The choice of the type of neutral earthing is normally based on the following criteria:

- local regulations (if any);
- continuity of supply required for the network;
- limitation of damage to equipment caused by earth faults;
- selective elimination of faulty sections of the network;
- detection of fault location;
- touch and step voltages;
- inductive interference;
- operation and maintenance aspects.

One galvanically connected system has only one method of neutral earthing. Different galvanically independent systems may have different methods of neutral earthing. If different neutral earthing configurations can occur during normal or abnormal operating conditions, equipment and protective system shall be designed to operate under these conditions.

4.2.2 Voltage classification

The user shall define the nominal voltage and the maximum operating voltage of their system. Based on the maximum operating voltage, the highest voltage for installation (U_m) shall be selected either from Table 2, Table 3 or Annex A.

4.2.3 Current in normal operation

Every part of an electrical power installation shall be designed and constructed to withstand currents under defined operating conditions.

4.2.4 Short-circuit current

Electrical power installations shall be designed, constructed and erected to safely withstand the mechanical and thermal effects resulting from short-circuit currents.

NOTE 1 Where an installation has on-site generation, motors or parallel operation with a network (co-generation), fault levels can increase.

For the purpose of this document, all types of short-circuit shall be considered. Examples include:

- three-phase;
- phase-to-phase;
- phase-to-earth;
- double phase-to-earth.

Electrical power installations shall be protected with automatic devices to disconnect three-phase and phase-to-phase short-circuits.

Electrical power installations shall be protected either with automatic devices to disconnect earth faults or with devices to indicate the earth fault condition. The selection of the device is dependent upon the method of neutral earthing.

The standard value of rated duration of the short-circuit is 1,0 s.

If a value other than 1 s is appropriate in the design process, recommended values would be 0,5 s, 2,0 s and 3,0 s.

NOTE 2 The rated duration includes the fault clearance time.

Methods for the calculation of short-circuit currents in three-phase AC systems are given in the IEC 60909 (all parts).

Methods for the calculation of the effects of short-circuit current are given in IEC 60865-1 and, for power cables, in IEC 60949.

4.2.5 Rated frequency

Electrical power installations shall be designed for the rated frequency of the system in which they shall operate.

4.2.6 Corona

The design of electrical power installations shall be such that radio interference due to electromagnetic fields, e.g. caused by corona effects, will not exceed a specified level.

NOTE 1 Recommendations for minimizing the radio interference of high-voltage installations are reported in CISPR 18-1, CISPR 18-2 and CISPR 18-3.

NOTE 2 Maximum permissible levels of radio interference can be given by provincial, national or regional authorities.

NOTE 3 Guidance on acceptable levels of radio interference voltage for switchgear and controlgear can be found in IEC 62271-1.

When the acceptable value is exceeded, the corona level may be controlled, for example, by the installation of corona rings or the recessing of fasteners on bus fittings for high-voltage suspension insulator assemblies, bus support assemblies, bus connections and equipment terminals.

4.2.7 Electric and magnetic fields

The design of an electrical power installation shall be such as to limit the electric and magnetic fields generated by energized equipment to an acceptable level for exposed people.

NOTE Provincial, national or regional regulations can specify acceptable levels. Further information is available from International Commission on Non-Ionizing Radiation Protection (ICNIRP) or IEEE.

4.2.8 Overvoltages

Equipment shall be protected against overvoltages resulting from switching operations or lightning that could exceed the withstand values according to IEC 60071-1 and IEC 60071-2.

4.2.9 Harmonics

Consideration should be given to the effect of harmonic currents and harmonic voltages on the electrical power installation, e.g. in industrial installations. Harmonic analyses may be required to determine what corrective measures are needed to meet local regulations and/or to ensure correct operation of the whole electrical system.

4.2.10 Electromagnetic compatibility

Electrical power installations should be designed so that they function properly in their given EMC environment.

NOTE Guidance on ensuring electromagnetic compatibility and to ensuring that electromagnetic fields meet provincial, national or regional authority permissible limits can be found in Clause 9 and Clause 10. As well, guidance can be found in IEC 61000 (all parts), with particular reference to IEC 61000-5 (all parts), IEC 61000-6-5, IEC 62271-1, IEC 62271-208 and CIGRE Technical Brochure 535.

4.3 Mechanical requirements

4.3.1 General

Equipment and structures, including their foundations, shall withstand all the anticipated load combinations.

Due consideration should be given to the ultimate and serviceability limit states of the structures.

The load assumptions related to the local conditions shall be determined in an agreement between the supplier and user.

Two load cases shall be considered, normal and exceptional.

In each of these load cases, several combinations shall be investigated. The most unfavourable combination shall be used to determine the mechanical strength of the structures. In the normal load case, the following loads shall be considered:

- dead load;
- tension load;
- erection load;
- ice load;
- wind load.

Consideration should be given to temporary stresses and loads that may be applied during construction or maintenance procedures. Specific equipment can be affected by cyclic loads (refer to specific equipment standards).

In the exceptional load case, dead load and tension load acting simultaneously with the largest of the following occasional loads shall be considered:

- switching forces;
- short-circuit forces;
- loss of conductor tension;
- seismic loads;

- buoyant force to the foundation at flooding.

4.3.2 Tension load

The tension load shall be calculated from the maximum conductor tension under the most unfavourable local conditions.

NOTE Possible combinations include, for example: –20 °C without ice and without wind; –5 °C with ice and without wind; +5 °C with wind.

4.3.3 Erection load

The erection load is a load of at least 1,0 kN applied at the most critical position of a supporting structure, tensioning portal, etc.

4.3.4 Ice load

In regions where icing can occur, the resulting load on flexible conductors and on rigid busbars and conductors shall be taken into account.

If national standards and regulations, local experience or statistics are not available, ice coatings of 1 mm, 10 mm or 20 mm based on criteria given in IEC 62271-1 may be assumed.

4.3.5 Wind load

Wind loads, which can be very different depending on the local topographic influences and the height of the structures above the surrounding ground, shall be taken into account. The most unfavourable wind direction shall be considered.

IEC 62271-1 contains requirements for wind loading on switchgear and controlgear.

4.3.6 Switching forces

Switching forces shall be considered when designing supports. The forces shall be determined by the designer of the equipment.

4.3.7 Short-circuit forces

The mechanical effects of a short-circuit can be estimated by the methods detailed in IEC 60865-1.

NOTE CIGRE Technical Brochure 214, "The mechanical effects of short-circuit currents in open air substations" gives additional advice.

4.3.8 Loss of conductor tension

A structure with tension insulator strings shall be designed to withstand the loss of conductor tension resulting from breakage of the insulator or conductor which gives the most unfavourable load case.

NOTE 1 General practice is to base the calculation on 0 °C, no ice and no wind load.

NOTE 2 For bundle conductors, only one subconductor is assumed to fail.

4.3.9 Seismic loads

Special conditions and requirements shall be agreed between the supplier and user (see also 4.4.3.5 and IEC 60721-2-6) and have regard to local requirements if any.

Electrical power installations situated in a seismic environment shall be designed to take this into account.