IEC GUIDE 111-1

Edition 1.0 2023-01

GUIDE

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Electric equipment for high-voltage substations – Common recommendations for product and system standards – Part 1: AC (alternating current)

Matériels électriques pour postes haute tension – Recommandations communes pour les normes de produits et de réseaux – Partie 1: AC (courant alternatif)

IEC GUIDE 111-1:2023-01(en-fr)

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ELECTRIC EQUIPMENT FOR HIGH-VOLTAGE SUBSTATIONS – COMMON RECOMMENDATIONS FOR PRODUCT AND SYSTEM STANDARDS –

Part 1: AC (alternating current)

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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This first edition of IEC Guide 111-1 has been prepared, in accordance with ISO/IEC Directives, Part 1, Annex A, by the IEC Advisory Committee on Transmission and Distribution (ACTAD).

This first edition of IEC Guide 111-1, together with IEC Guide 111-2, cancels and replaces the second edition of IEC Guide 111 published in 2004.

The main changes with respect to the previous edition are as follows:

a) IEC Guide 111 is revised into two parts – Part 1 for AC and Part 2 for DC (Part 2 to be prepared);
b) the scope of the document has been expanded to cover electric equipment in AC high-voltage substations;
c) new definitions have been included;
d) normal conditions have been revised;

e) a general revision of other clauses.

The text of this IEC Guide is based on the following documents:

Draft	Report on voting
SMBNC/25/DV	SMBNC/28/RV

Full information on the voting for the approval of this IEC Guide can be found in the report on voting indicated in the above table.

The language used for the development of this Guide 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.

INTRODUCTION

This document is for use by IEC technical committees (TCs) involved in high-voltage (HV) substation systems, such as:

TC 8, TC 13, TC 14, TC 17, TC 20, TC 22, TC 32, TC 33, TC 36, TC 37, TC 38, TC 57, TC 95, TC 99, TC 115, TC 122, TC 123.

It is of paramount importance that the IEC, through this document, ensures consistency and avoids discrepancies between standards within one system. A few discrepancies can be justified in certain cases according to the specificity of a given product or situation.

The cost of over-standardization of a component compared to utilization of the nearest linked under-standardized component should be considered. The supplementary cost does not in any way increase the reliability of the system as a whole.

Since the same external stresses (climatic, electrical, and mechanical) apply to all the components of the substations, the consistency of their technical features is vital.

The same essential requirements for safety, environmental impact, end of life, availability and integration of systems are applicable. All product standards for a single system need to fulfil these requirements with the same degree of responsibility.

The aim of this document is to provide common rules for HV substation equipment.

ELECTRIC EQUIPMENT FOR HIGH-VOLTAGE SUBSTATIONS – COMMON RECOMMENDATIONS FOR PRODUCT AND SYSTEM STANDARDS –

Part 1: AC (alternating current)

1 Scope

This part of IEC Guide 111 is a horizontal publication which gives guidance for the harmonization of product and system standards for HV substations (higher than 1 kV). It addresses AC equipment which is found in high-voltage (HV) substations in most cases.

This document contains recommendations for common specifications for all HV substation product and system standards, each of which is augmented by the technical background specific to each technical committee, which naturally retains freedom in its technical choices.

This document is applicable when developing product and systems standards for HV power electronic equipment for the AC part of the substation.

NOTE 1 IEC Guide 111-2 relating to DC (direct current) is under development. Once published, IEC Guide 111-2 will be applicable when developing product and systems standards for the HVDC part of the substation.

NOTE 2 The IEC Standardization Management Board (SMB) has decided that Guides such as this one can have mandatory requirements which shall be followed by all IEC committees developing technical work that falls within the scope of the Guide, as well as guidance which may or may not be followed. The mandatory requirements in this Guide are identified by the use of "shall". Statements that are only for guidance are identified by using the verb "should". (See ISO/IEC Directives, IEC Supplement Part 1, A.1.1.)

2 Normative references

There are no normative references in this document.

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 https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
highest voltage of a system
U_s
highest value of operating voltage which occurs under normal operating conditions at any time and at any point in the system

Note 1 to entry: Transient overvoltages, due e.g. to switching operations, and abnormal temporary variations of voltage, are not taken into account.

Note 2 to entry: The highest voltage of a system is considered as the phase-to-phase operating voltage (RMS value).

[SOURCE: IEC 60050-601:1985, 601-01-23, modified – The symbol U_s and Note 2 to entry have been added.]

3.2
highest voltage for equipment
U_m
greatest value of line-to-line voltage (RMS value) for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment standards under normal service conditions

[SOURCE: IEC 60050-614:2016, 614-03-01, modified – The symbol U_m has been added.]

3.3
rated voltage
U_r
<of equipment> voltage value assigned by a manufacturer or other entity for a specified operating condition of a component, device or equipment

Note 1 to entry: The value for the rated voltage of high-voltage equipment is generally assigned from the list of highest voltages for equipment in Tables 3, 4 and 5 of IEC 60038:2009.

Note 2 to entry: The value for the rated voltage of low voltage equipment is generally assigned from the list of nominal voltages in Tables 1 and 6 of IEC 60038:2009.

Note 3 to entry: Equipment may have more than one rated voltage value or may have a rated voltage range.

[SOURCE: IEC 60050-614:2016, 614-03-09, modified – The symbol U_r has been added.]

3.4
electric 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]

3.5
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]

3.6
rated insulation level
test voltages, under specified conditions, that the insulation is designed to withstand

Note 1 to entry: These test voltages can be for instance:

a) rated lightning impulse and short duration power frequency withstand voltages;

b) rated lightning and switching impulse withstand voltages (phase-to-earth).

[SOURCE: IEC 60050-421:1990, 421-09-02]

3.7
rated frequency
f_r
frequency at which the equipment is designed to operate

Note 1 to entry: The standard values of the rated frequency are 50 Hz and 60 Hz.

[SOURCE: IEC 60050-421:1990, 421-04-03, modified – "transformer or reactor" has been replaced with "equipment", the symbol f_r and Note 1 to entry have been added.]

3.8
rated current
I_r
RMS value of the current which equipment is designed to carry continuously under specified conditions of use and behaviour

Note 1 to entry: Rated currents for temporary or for intermittent duty are subject to agreement between manufacturer and user.

Note 2 to entry: In the area of transformers, rated power is used and not rated current.

3.9
high voltage
HV
<general> set of voltage levels in excess of low voltage

Note 1 to entry: High voltage (HV) covers nominal voltages above low voltage (1,0 kV AC and 1,5 kV DC nominal) and includes medium voltage (MV), extra high voltage (EHV) and ultra high voltage (UHV).

3.10
high voltage
<upper voltage> set of upper voltage levels used in power systems for bulk transmission of electricity

3.11
high voltage
<apparatus or installation> highest of two or more voltages in an apparatus or installation

3.12
low voltage
LV
<general> set of voltage levels used for the distribution of electricity where the nominal voltage is generally accepted to be up to 1 000 V for alternating current and 1 500 V for direct current

3.13
low voltage
<apparatus or installation> lowest of two or more voltages in an apparatus or installation

3.14
medium voltage
MV
subcategory of high voltage applicable to electricity distribution in the voltage range in excess of low voltage to the upper range of electricity distribution voltages, typically up to 52 kV AC

Note 1 to entry: The upper value of distribution voltage depends on local circumstances and history or common usage.

3.15
extra high voltage
EHV
subcategory of high voltage applicable to electricity transmission having a highest voltage for equipment exceeding 245 kV AC and up to 800 kV AC

3.16
ultra high voltage
UHV
subcategory of high voltage applicable to electricity transmission having a highest voltage for equipment exceeding 800 kV AC

3.17
earthing circuit
<of an assembly> conductors, connections, and the conducting parts of earthing devices or of the metal frame, intended to connect the high-voltage conductive parts of an assembly to the earthing point provided

Note 1 to entry: The earthing circuit can include short-circuiting circuits between poles and phase-to-earth circuits from each pole to the earthing point and/or from the short-circuiting point of phase-to-earth circuits to the earthing point provided.

[SOURCE: IEC 62271-200:2021, 3.5.107]

3.18
earthing system
grounding system (US)
arrangement of electric connections and devices involved necessary to earth equipment or a system separately or jointly

[SOURCE: IEC 61936-1:2021, 3.7.6]

3.19
required withstand voltage
U_{rw}
test voltage that the insulation must withstand in a standard withstand voltage test to ensure that the insulation will meet the performance criterion when subjected to a given class of overvoltages in actual service conditions and for the whole service duration

Note 1 to entry: The required withstand voltage has the shape of the co-ordination withstand voltage, and is specified with reference to all the conditions of the standard withstand voltage test selected to verify it.

[SOURCE: IEC 60071-1:2019, 3.28]

3.20
withstand voltage
U_w
test voltage suitably selected equal to or above the required withstand voltage (U_{rw})

Note 1 to entry: For AC equipment, values of withstand voltages U_w are standardized as per IEC 60071-1.

Note 2 to entry: The standard impulse shapes used for withstand tests on equipment as well as the test procedures are defined in IEC 60060-1 and IEC 60071-1.

[SOURCE: IEC 60071-5:2014, 3.8, modified – The second sentence has been deleted in Notes 1 and 2 to entry.]

3.21
lightning impulse withstand voltage
LIWV
withstand voltage of insulation with the shape of the standard lightning impulse

[SOURCE: IEC 60071-5:2014, 3.8.2]

3.22
switching impulse withstand voltage
SIWV
withstand voltage of insulation with the shape of the standard switching impulse

[SOURCE: IEC 60071-5:2014, 3.8.1]

4 Guidance in referencing IEC documents

4.1 "Normative references" clause in product standards

The use of horizontal publications is of the utmost importance for the harmonization process.

Strong reasons are needed to depart from the recommendations of horizontal publications and, in all cases, it is necessary to explain the reason for any discrepancy.

Within the fields concerned, the essential horizontal documents to be taken into account and to be mentioned in the normative references clause of each standard are the following:

- field of definitions: International Electrotechnical Vocabulary (IEV) – IEC 60050 series;
- field of voltage: IEC 60038;
- field of current: IEC 60059;
- field of insulation: IEC 60060 series, IEC 60071 series, IEC TS 60815 series and IEC 61180;
- field of temperature rise: IEC 60216 series and IEC TR 60943;
- field of degrees of protection: IEC 60529 – although IEC 60529 defines its scope as being limited to voltages not exceeding 72,5 kV, the use of IP classification and testing methods according to IEC 60529 may be extended to be used also for voltages exceeding 72,5 kV;
- field of environmental conditions affecting the equipment: IEC 60664 series, IEC 60721 series, IEC 60376, IEC 60296, IEC 60867 and IEC TR 62271-300;
- field of environmental aspects if any affected by the equipment: IEC Guide 109, IEC 62474 and IEC 62271-4;
- field of electromagnetic compatibility (EMC): IEC Guide 107; horizontal publications in the IEC 61000 series; CISPR 11, CISPR TR 18 series, CISPR 32 and CISPR 35;
- field of safety: IEC 61936-1, IEC Guide 104, IEC Guide 117, ISO/IEC Guide 51, IEC 60695 series;
- field of mechanical stresses: IEC 60865 series, IEC 62155 and IEC 62262;
- field of dependability: IEC 60300-3 series, IEC 62308;
- field of information communication: IEC/IEEE 82079-1 and IEC 62271-3.

4.2 "Terms and definitions" clause in product standards

Definitions already in the IEV should be used. If a definition already in the IEV is not satisfactory or not clear enough, the difficulty should be referred to TC 1 and solved in cooperation. New definitions should not be used unless absolutely necessary, i.e. no similar definition exists in publications on a similar subject. A similar definition may be modified with a reference to the original.

5 Environmental conditions

5.1 General

This clause should be the same for all TCs active in the area of substations. Installations, including all devices and auxiliary equipment which form an integral part of them, should be designed for operation under the climatic and environmental conditions listed below. Equipment product standards should be taken into account.

Normal environmental conditions shown in Table 1 are the environmental conditions defined for indoor and outdoor conditions in order to coordinate the application of a wide range of diverse equipment types within a single operating environment such as an electrical substation. The values chosen address the needs of the majority of applications worldwide and provide a basis for the design, specification and application of standardized equipment and installations.

Normal environmental conditions shown in Table 2 are particular environmental conditions defined for indoor conditions or enclosed conditions associated with power electronic equipment and other associated equipment. This range is defined in order to coordinate the application of power electronic equipment and other associated equipment within a single operating environment.

Technical committees may define ratings of equipment in accordance with Table 1 for general application and Table 2 for power electronic, electronic and associated applications.

Installations shall take into account the constructive provisions to find the standardized values in Table 1 and Table 2.

There are many cases where specification of values outside the conditions defined in Table 1 and Table 2 is necessary and justified. These are referred to as special environmental conditions. These cases can relate to extremes of the natural environment such as higher or lower temperatures for outdoor installations, or to the specific requirements of equipment or sub-systems such as the need to avoid sub-zero temperatures for certain equipment. The effects of enclosures or other factors that alter the environment within which equipment designed for the normal environment is situated shall be considered separately.

Special environmental conditions associated with extremes of the natural environment are summarized in Table 3 and these provide a basis for user specification of appropriate special environmental conditions for their application(s).

Special environmental conditions associated directly with the requirements of specific equipment types, such as a further-restricted operating temperature range, are detailed in the appropriate equipment standards. These equipment-specific requirements typically supersede the more general requirements for the entire electrical installation on the basis that a specifically controlled operating environment (such as a room, building or enclosure) can be provided. Whilst these conditions are considered special in the context of this document, they may be considered "normal" in the context of the specific equipment under consideration. It is common for sub-systems requiring special environmental conditions as defined in this document, to be installed within a controlled environment within an electrical installation which itself is defined as having normal environmental conditions.

TCs should use the phrase "environmental conditions" in preference to "service conditions".