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**Koordinacija izolacije - 12. del: Smernice za uporabo LCC HVDC  
(visokonapetostnih enosmernih) pretvorniških postaj**

Insulation co-ordination - Part 12: Application guidelines for LCC HVDC converter stations

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## Insulation co-ordination - Part 12: Application guidelines for LCC HVDC converter stations (IEC 60071-12:2022)

Coordination de l'isolement - Partie 12: Lignes directrices en matière d'application pour stations de conversion à courant continu haute tension (CCHT) équipées de convertisseurs commutés par le réseau (LCC)  
(IEC 60071-12:2022)

Isolationskoordination für HVDC Systeme - Teil 12: Anwendungsrichtlinien für Stromrichterstationen mit Stromzwischenkreis-Konverter (LCC)  
(IEC 60071-12:2022)

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**EN IEC 60071-12:2022 (E)****European foreword**

The text of document 99/368/FDIS, future edition 1 of IEC 60071-12, 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 60071-12:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2023-08-18
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2025-11-18

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

IEC 60060-1	NOTE	Harmonized as EN 60060-1
IEC 60071-1:2019	NOTE	Harmonized as EN IEC 60071-1:2019 (not modified)
IEC 60071-2:2018	NOTE	Harmonized as EN IEC 60071-2:2018 (not modified)
IEC 60071-5:2014	NOTE	Harmonized as EN 60071-5:2015 (not modified)
IEC 60099-5:2018	NOTE	Harmonized as EN IEC 60099-5:2018 (not modified)
IEC 60099-9:2014	NOTE	Harmonized as EN 60099-9:2014 (not modified)
IEC 60505:2011	NOTE	Harmonized as EN 60505:2011 (not modified)
IEC 60700-1:2015/AMD1:2021	NOTE	Harmonized as EN 60700-1:2015/A1:2021 (not modified)
IEC 60721-3-0:2020	NOTE	Harmonized as EN IEC 60721-3-0:2020 (not modified)

## 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](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60071-11 <sup>1</sup>	-	Insulation co-ordination - Part 11 - Definitions, principles and rules for HVDC system	EN IEC 60071-11 <sup>2</sup>	-
IEC 60099-4	-	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems	EN 60099-4	-
IEC 60633	-	High-voltage direct current (HVDC) transmission - Vocabulary	EN IEC 60633	-

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<sup>1</sup> Under preparation. Stage at the time of publication: IEC/CFDIS 60071-11:2022.

<sup>2</sup> Under preparation. Stage at the time of publication: FprEN IEC 60071-11:2022.





# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

**Insulation co-ordination –  
Part 12: Application guidelines for LCC HVDC converter stations**

**Coordination de l'isolement –  
Partie 12: Lignes directrices en matière d'application pour stations de  
conversion à courant continu haute tension (CCHT) équipées de convertisseurs  
commutés par le réseau (LCC)**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## INSULATION CO-ORDINATION –

## Part 12: Application guidelines for LCC HVDC converter stations

## FOREWORD

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IEC 60071-12 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. It is an International Standard.

On the basis of technical experience gained and the development of HVDC, sufficient consensus has emerged to establish a series insulation co-ordination standard for HVDC system. The standard series for HVDC system belongs to IEC 60071 standard series, and a list of all parts in the IEC 60071 series, published under the general title *Insulation co-ordination*, can be found on the IEC website.

This International Standard replaces, in conjunction with IEC 60071-11<sup>1</sup>, IEC 60071-5 published in 2014. IEC 60071-5 provides basic principles and guidance for insulation coordination of high-voltage direct current (HVDC) converter stations. IEC 60071-11 specifies the principles on the procedures for the determination of the specified withstand voltages, creepage distance and air clearances for the equipment and the installations of these systems. IEC 60071-12 provides guidelines on the procedures for insulation co-ordination of line commutated converter (LCC) stations for high-voltage direct current (HVDC) project, whose aim is to give guidance for the determination of the specified withstand voltages for equipment.

IEC 60071-12 retains the technical content of IEC 60071-5 of the guidelines on the procedures for insulation coordination of LCC converter stations, and there are no essentially technical amendments. An example for LCC HVDC converter station in a pole with two 12-pulse converters in series is provided in annex. Examples of insulation co-ordination for controlled series capacitor converter (CSCC) and capacitor commutated converters (CCC) in IEC 60071-5 are no longer dealt with in this document.

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

Draft	Report on voting
99/368/FDIS	99/379/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

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

<sup>1</sup> Under preparation. Stage at the time of publication: IEC/CFDIS 60071-11:2022.

## INSULATION CO-ORDINATION –

### Part 12: Application guidelines for LCC HVDC converter stations

#### 1 Scope

This part of IEC 60071 applies guidelines on the procedures for insulation co-ordination of line commutated converter (LCC) stations for high-voltage direct current (HVDC) project, whose aim is evaluating the overvoltage stresses on the converter station equipment subjected to combined DC, AC power frequency, harmonic and impulse voltages, and determining the specified withstand voltages for equipment.

This document deals only with metal-oxide surge arresters, without gaps, which are used in modern HVDC converter stations. The criteria for determining the protective levels of series and/or parallel combinations of surge arresters used to ensure optimal protection are also presented. Typical arrester protection schemes and stresses of arresters are presented.

Annex A contains examples of insulation co-ordination for LCC HVDC converters which support the concepts described in the main text, and the basic analytical techniques used.

#### 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 60071-11<sup>2</sup>, *Insulation co-ordination – Part 11 : Definitions, principles and rules for HVDC system*

IEC 60099-4, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*

IEC 60633, *High-voltage direct current (HVDC) transmission – Vocabulary*

#### 3 Terms, definitions, symbols and abbreviated terms

##### 3.1 Terms and definition

For the purposes of this document, the terms and definitions given in IEC 60071-11 and the following 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>

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<sup>2</sup> Under preparation. Stage at the time of publication: IEC/CFDIS 60071-11:2022.

**3.1.1****crest value of continuous operating voltage**

CCOV

highest continuously occurring crest value of the voltage at the equipment on the DC side of the converter station excluding commutation overshoots

**3.1.2****peak value of continuous operating voltage**

PCOV

highest continuously occurring crest value of the voltage at the equipment on the DC side of the converter station including commutation overshoots and commutation notches

**3.1.3****valve protective firing**

means of protecting the thyristors from excessive forward voltage, rate of change of voltage or forward voltage applied during the reverse recovery time, by firing the thyristors into conduction

**3.2 Symbols and abbreviated terms****3.2.1 General**

The list covers only the most frequently used symbols and abbreviated terms, some of which are illustrated graphically in the single-line diagram of Figure 1 and Figure 2. For a more complete list of symbols which has been adopted for LCC HVDC converter stations, and also for insulation co-ordination, refer to the standards listed in the normative references (Clause 2) and to the Bibliography.

**3.2.2 Subscripts**

0(zero)	at no load (IEC 60633)
d	direct current or voltage (IEC 60633)
i	ideal (IEC 60633)
max	maximum (IEC 60633)
n	pertaining to harmonic component of order n (IEC 60633)

**3.2.3 Letter symbols**

$K_a$	altitude correction factor (IEC 60071-1)
$K_c$	co-ordination factor (IEC 60071-1)
$K_s$	safety factor (IEC 60071-1)
$U_c$	continuous operating voltage of an arrester
$U_{ccov}$	crest value of continuous operating voltage
$U_{ch}$	continuous operating voltage of an arrester including harmonics
$U_{di0}$	ideal no-load direct voltage (IEC 60633)
$U_{di0max}$	maximum value of $U_{di0}$ taking into account AC voltage measuring tolerances, and transformer tap-changer offset by one step
$U_s$	highest voltage of an AC system (IEC 60071-1 and IEC 60071-2)
$U_m$	highest voltage for the equipment
$U_{v0}$	no-load phase-to-phase voltage on the valve side of converter transformer, r.m.s. value excluding harmonics

$U_{rp}$	representative overvoltage
$U_{cw}$	co-ordination withstand voltage
$U_{rw}$	required withstand voltage
$U_w$	specified withstand voltage (standard withstand voltage in alternating current)
$\alpha$	delay angle (IEC 60633); “firing angle” also used in this standard
$\beta$	advance angle (IEC 60633)
$\gamma$	extinction angle (IEC 60633)
$\mu$	overlap angle (IEC 60633)

### 3.2.4 Abbreviated terms

LCC	line commutated converter
VSC	voltage sourced converter
HVDC	high voltage direct current
HV	high voltage
LV	low voltage
CCOV	crest value of continuous operating voltage
GIS	gas-insulated switchgear
PCOV	peak continuous operating voltage
ECOV	equivalent continuous operating voltage
RSFO	representative slow-front overvoltage (the maximum voltage stress value)
RFFO	representative fast-front overvoltage (the maximum voltage stress value)
RSTO	representative steep-front overvoltage (the maximum voltage stress value)
RSIWV	required switching impulse withstand voltage
RLIWV	required lightning impulse withstand voltage
RSTIWV	required steep-front impulse withstand voltage
SIPL	switching impulse protective level
LIPL	lightning impulse protective level
STIPL	steep-front impulse protective level
SIWV	switching impulse withstand voltage
LIWV	lightning impulse withstand voltage
STIWV	steep-front impulse withstand voltage
p.u.	per unit

## 4 Typical LCC HVDC converter station schemes

Figure 1 shows the single line diagram of typical LCC HVDC converter stations equipped with two 12-pulse converters in series. It can be noted that Figure 1 shows possible arrester locations covered in this document. Some of these arresters can be redundant and could be excluded depending on the specific design.

Figure 2 shows an example for a single line diagram and arrester arrangement of a back-to-back converter station. Other arrangements with different earthing connections are also common, e.g., earthing at the mid-point between the two six-pulse bridges. The location of the smoothing reactor, if applicable, can change accordingly.