

STN	Koordinácia izolácie Časť 12: Aplikačné pokyny pre meniče HVDC LCC	STN EN IEC 60071-12 33 0400
------------	---	---

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

Táto norma obsahuje anglickú verziu európskej normy.
This standard includes the English version of the European Standard.

Táto norma bola oznámená vo Vestníku ÚNMS SR č. 03/23

Táto STN čiastočne nahrádza STN EN 60071-5 z júna 2015.

Obsahuje: EN IEC 60071-12:2022, IEC 60071-12:2022

136585

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN IEC 60071-12

November 2022

ICS 29.080.30

Supersedes EN 60071-5:2015 (partially)

English Version

**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)

This European Standard was approved by CENELEC on 2022-11-18. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.



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

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

This document partially supersedes EN 60071-5:2015 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 60071-12:2022 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 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.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60071-11 ¹	-	Insulation co-ordination - Part 11 - Definitions, principles and rules for HVDC system	EN IEC 60071-11 ²	-
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	-

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

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



IEC 60071-12

Edition 1.0 2022-10

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)**





THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2022 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, 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 either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.



IEC 60071-12

Edition 1.0 2022-10

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)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.080.30

ISBN 978-2-8322-5845-3

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms, definitions, symbols and abbreviated terms.....	7
3.1 Terms and definition	7
3.2 Symbols and abbreviated terms	8
3.2.1 General	8
3.2.2 Subscripts	8
3.2.3 Letter symbols	8
3.2.4 Abbreviated terms	9
4 Typical LCC HVDC converter station schemes	9
5 Voltages and overvoltages in service.....	12
5.1 Continuous operating voltages at various locations in the converter station	12
5.2 Peak continuous operating voltage (PCOV) and crest continuous operating voltage (CCOV)	16
5.3 Sources and types of overvoltages	18
5.4 Temporary overvoltage	18
5.4.1 General	18
5.4.2 Temporary overvoltage on the AC side	18
5.4.3 Temporary overvoltages on the DC side	19
5.5 Slow-front overvoltages	19
5.5.1 General	19
5.5.2 Slow-front overvoltages on the AC side	19
5.5.3 Slow-front overvoltages on the DC side	20
5.6 Fast-front, very-fast-front and steep-front overvoltages	20
6 Arrester characteristics and stresses	21
6.1 Arrester characteristics	21
6.2 Arrester specification	22
6.3 Arrester stresses.....	23
6.3.1 General	23
6.3.2 AC bus arrester (A).....	24
6.3.3 AC filter arrester (FA)	24
6.3.4 Transformer valve winding arresters (T).....	25
6.3.5 Valve arrester (V)	25
6.3.6 Bridge arrester (B).....	28
6.3.7 Converter unit arrester (C).....	28
6.3.8 Mid-point DC bus arrester (M).....	29
6.3.9 Converter unit DC bus arrester (CB)	29
6.3.10 DC bus and DC line/cable arrester (DB and DL/DC)	30
6.3.11 Neutral bus arrester (E, EL, EM in Figure 3, EB, E1, EL, EM in Figure 1)	30
6.3.12 DC reactor arrester (DR)	31
6.3.13 DC filter arrester (FD).....	32
6.3.14 Earth electrode station arrester.....	32
6.4 Protection strategy.....	32
6.4.1 General	32
6.4.2 Insulation directly protected by a single arrester	32
6.4.3 Insulation protected by more than one arrester in series	32

6.4.4	Valve side neutral point of transformers.....	33
6.4.5	Insulation between phase conductors of the converter transformer	33
6.4.6	Summary of protection strategy	33
6.5	Summary of events and stresses	36
7	Design procedure of insulation co-ordination	37
7.1	General.....	37
7.2	Arrester requirements	38
7.3	Representative overvoltages (U_{rp}).....	38
7.4	Determination of the co-ordination withstand voltages (U_{cw}).....	40
7.5	Determination of the required withstand voltages (U_{rw})	40
7.6	Determination of the specified withstand voltage (U_w)	40
8	Study tools and system modelling.....	40
8.1	General.....	40
8.2	Study approach and tools	40
8.3	System details	41
8.3.1	Modelling and system representation.....	41
8.3.2	AC network and AC side of the LCC HVDC converter station.....	43
8.3.3	DC overhead line/cable and earth electrode line details.....	44
8.3.4	DC side of an LCC HVDC converter station details	44
Annex A	(informative) Example of insulation co-ordination for LCC HVDC converter stations.....	45
A.1	General.....	45
A.2	Example for LCC HVDC converter station in a pole with one 12-pulse converter	45
A.2.1	Arrester protective scheme	45
A.2.2	Arrester stresses, protection and insulation levels	45
A.2.3	Transformer valve side withstand voltages.....	50
A.2.4	Air-insulated smoothing reactors withstand voltages	50
A.2.5	Results	52
A.3	Example for LCC HVDC converter station in a pole with two 12-pulse converters in series.....	54
A.3.1	Arrester protective scheme	54
A.3.2	Arrester stresses, protection and insulation levels	55
A.3.3	Transformer valve side withstand voltages.....	59
A.3.4	Smoothing reactor withstand voltages.....	61
A.3.5	Results	62
Bibliography	64
Figure 1	– Possible arrester locations in a pole with two 12-pulse converters in series	11
Figure 2	– Possible arrester locations for a back-to-back converter station	12
Figure 3	– LCC HVDC converter station in a pole with one 12-pulse converter.....	13
Figure 4	– Continuous operating voltages at various locations (location identification according to Figure 3).....	15
Figure 5	– Operating voltage of a valve arrester (V), rectifier operation and definition of PCOV and CCOV.....	17
Figure 6	– Operating voltage of a mid-point arrester (M), rectifier operation	17
Figure 7	– Operating voltage of a converter bus arrester (CB), rectifier operation	17
Figure 8	– One pole of an LCC HVDC converter station	43

Figure A.1 – AC and DC arresters (LCC HVDC converter station in a pole with one 12-pulse converter).....	52
Figure A.2 – Valve arrester stresses for slow-front overvoltages from AC side	53
Figure A.3 – Arrester V2 stress for slow-front overvoltage from AC side	53
Figure A.4 – Valve arrester stresses for earth fault between valve and upper bridge transformer bushing	54
Figure A.5 – Arrester V1 stress for earth fault between valve and upper bridge transformer bushing	54
Figure A.6 – AC and DC arresters (LCC HVDC converter station in a pole with two 12-pulse converters in series).....	63
Table 1 – Symbol description	12
Table 2 – Arrester protection on the DC side: one 12-pulse converter (Figure 3).....	34
Table 3 – Arrester protection on the DC side: two 12-pulse converters in series (Figure 1).....	35
Table 4 – Events stressing arresters: one 12-pulse converter (Figure 3).....	36
Table 5 – Types of arrester stresses for different events: one 12-pulse converter (Figure 3).....	37
Table 6 – Arrester requirements.....	38
Table 7 – Representative overvoltages and required withstand voltages	39
Table 8 – Origin of overvoltages and associated frequency ranges	42

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSULATION CO-ORDINATION –

Part 12: Application guidelines for LCC HVDC converter stations

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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 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.

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 60071-11¹, 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. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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.

¹ 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 60071-11², *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*

koniec náhľadu – text ďalej pokračuje v platenej verzii STN