

TECHNICAL SPECIFICATION



**UHV AC transmission systems –
Part 201: UHV AC substation design**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2018 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.

IEC Central Office
3, rue de Varembe
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

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 It also gives information on projects, replaced and withdrawn publications.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 also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

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.

generated by EVS



TECHNICAL SPECIFICATION



**UHV AC transmission systems –
Part 201: UHV AC substation design**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.240.01; 29.240.10

ISBN 978-2-8322-6330-3

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	6
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	9
4 UHV AC substation requirement	10
4.1 General requirement.....	10
4.2 System demands	10
4.3 Operation and maintenance requirements.....	11
4.4 Construction requirements	11
4.5 Site condition.....	11
4.6 Environmental impact.....	12
4.7 Economy.....	12
5 Bus scheme and feeder connection	12
5.1 General.....	12
5.2 Scheme at high-voltage side of main transformer.....	13
5.3 Scheme at intermedium-voltage side of main transformer	14
5.4 Scheme at low-voltage side of main transformer	14
5.5 System neutral earthing mode of a UHV AC substation.....	15
6 Selection of equipment and conductors	16
6.1 General.....	16
6.1.1 Voltage.....	16
6.1.2 Rated current.....	16
6.1.3 Rated frequency	16
6.2 Basic requirements	16
6.2.1 Electrical requirements	16
6.2.2 Mechanical requirements.....	17
6.2.3 Environmental conditions.....	17
6.3 Transformer	18
6.4 UHV shunt reactor and neutral-earthing reactor	19
6.5 UHV switchgear	19
6.6 UHV circuit breaker.....	20
6.7 UHV disconnecter	20
6.8 UHV earthing switch for maintenance	21
6.9 High-speed earthing switch	22
6.10 UHV current transformer	22
6.11 UHV voltage transformer.....	22
6.12 UHV surge arrester	23
6.13 Reactive power compensation device for low voltage side of UHV transformer	23
6.14 UHV bushing.....	23
6.15 UHV insulator	24
6.16 UHV conductor.....	24
6.16.1 General	24
6.16.2 Conductor type	24
6.16.3 Selection of current-carrying capacity (cross-section).....	25
6.16.4 Corona and radio interference	25
6.16.5 Mechanical strength.....	26

7	Equipment layout.....	26
7.1	General requirement of equipment layout.....	26
7.1.1	General	26
7.1.2	Optimization of substation layout	26
7.1.3	Seismic performance	26
7.1.4	Construction, serviceability and reliability and failure response ability.....	26
7.2	Minimum clearances	27
7.2.1	Normal environmental conditions	27
7.2.2	Minimum clearances in air-voltage range	27
7.3	Electromagnetic environment.....	27
7.3.1	Electrostatic induction mitigation design	27
7.3.2	Magnetic induction mitigation design	28
7.3.3	Audible noise mitigation design	28
7.4	Selection of switchgear equipment.....	29
7.5	Switchgear Installations layout.....	29
7.5.1	General	29
7.5.2	Location arrangement of switchgear	29
7.5.3	Basic arrangement of surge arresters	30
7.5.4	Optimal gas-insulated busbar (GIB) layout and length	30
7.5.5	Utilization of working space for substations	30
7.6	Protection against direct lightning strike.....	31
7.7	Earthing systems	31
7.7.1	General considerations	31
7.7.2	Multiple point earthing method for GIS.....	32
7.8	Seismic design.....	33
7.8.1	General	33
7.8.2	Basic seismic design	33
7.8.3	Special seismic performance for UHV AC substation equipment	34
8	Control, protection and communication	35
8.1	General.....	35
8.2	Control system.....	35
8.3	Relay protection.....	36
8.3.1	General	36
8.3.2	Duplicated configuration of UHV AC equipment relay protection	36
8.3.3	UHV transformer protection	36
8.4	Communication	37
8.5	Electromagnetic compatibility requirements for control and protection equipment.....	37
9	DC and AC auxiliary power supply system	38
9.1	General.....	38
9.2	DC power supply system.....	38
9.3	AC auxiliary power supply system	38
9.4	AC uninterruptible power supply (UPS) system	39
10	UHV gantry, support and foundation design	39
10.1	UHV gantry and support design	39
10.1.1	General	39
10.1.2	Load and combination of loads	39
10.1.3	Detailing requirements.....	40
10.2	GIS or MTS foundation design	41

Annex A (informative) Load combination of UHV AC equipment	43
Annex B (informative) Specification of UHV AC equipment and conductor	44
Annex C (informative) 1 000 kV outdoor overhead flexible conductor for UHV AC substations in China	46
C.1 General.....	46
C.2 Environmental conditions	46
C.3 Current-carrying capacity and thermal stability check.....	46
C.3.1 Current-carrying capacity check.....	46
C.3.2 Thermal stability check	47
C.4 Determination of bundle spacing	48
C.4.1 General	48
C.4.2 Calculation of maximum electric field strength around conductor	48
C.5 Corona inception voltage	49
C.6 Electric field strength on ground caused by electrostatic induction	50
Annex D (informative) Corona noise reduction measures of a UHV AC substation conductor under the rainy condition in Japan	52
D.1 Basic concept of corona noise reduction	52
D.2 Structure design of UHV AC substation conductor	52
D.3 Design criteria of partial discharge on UHV AC substation conductor	54
D.4 Corona noise measurement of the entrance in UHV AC test station	54
Annex E (informative) Typical examples of items to be considered to select switchgear type	56
Annex F (informative) Standards related to seismic design	58
F.1 Typical seismic guide and standards.....	58
F.2 Comparison of main items among the seismic standards	58
Bibliography.....	59
Figure 1 – Birds eye view of a typical UHV AC substation.....	10
Figure 2 – Double busbar (DB) with or without bus section connection.....	13
Figure 3 – One-and-a-half circuit breaker (OHCB)	14
Figure 4 – Two-circuit breaker (2CB)	14
Figure 5 – Example diagram of a bus scheme and feeder connection	15
Figure 6 – Typical configuration of UHV gas-insulated switchgear and crane location	31
Figure 7 – Earthing methods	33
Figure 8 – Flow chart for seismic qualification.....	34
Figure 9 – Example of continuous UHV gantry and independent gantry.....	41
Figure 10 – GIS foundation forms	42
Figure C.1 – Relationship between maximum electric field strength and bundle spacing	49
Figure C.1 – Layout plan of main transformer incoming lines	51
Figure D.1 – Conductor design of UHV AC substation.....	53
Table 1 – Comparison of a four-legged reactor and HSES	22
Table 2 – Comparison of conductors.....	25
Table A.1 – Example of load combination for UHV AC equipment	43
Table B.1 – UHV voltage specification	44
Table B.2 – Specification of UHV short-circuit current.....	44

Table B.3 – Noise specification 44

Table B.4 – Surge arrester specification applied in different countries 45

Table C.1 – Current-carrying capacity of bundle conductor 47

Table C.2 – Corona inception voltage of conductor 50

Table D.1 – Estimated values of corona noise of UHV AC transmission line..... 53

Table D.2 – Design criteria of partial discharge on UHV AC substation conductor 54

Table D.3 – Results of corona noise measurements and average value of corona noise 55

Table E.1 – The principal technology designs for substations (CIGRE TB 570) 56

Table E.2 – Typical examples of items to be considered to select switchgear type 57

Table F.1 – Typical seismic guide and standards 58

Table F.2 – Comparison of main items among seismic standards..... 58

This document is a preview generated by EVS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

UHV AC TRANSMISSION SYSTEMS –

Part 201: UHV AC substation design

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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 63042-201, which is a technical specification, has been prepared by IEC technical committee 122: UHV AC transmission systems.

The text of this Technical Specification is based on the following documents:

Enquiry draft	Report on voting
122/64/DTS	122/71A/RVDTS

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 63042 series, published under the general title *UHV AC transmission systems*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://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.

A bilingual version of this publication may be issued at a later date.

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.

UHV AC TRANSMISSION SYSTEMS –

Part 201: UHV AC substation design

1 Scope

This part of 63042, which is a Technical Specification, provides common rules for the design of substations with the highest voltages of AC transmission systems exceeding 800 kV, so as to provide safety and proper functioning for the intended use.

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 60038:2009, *IEC standard voltages*

IEC 60044 (all parts), *Instrument transformers*

IEC 60059:1999, *IEC standard current ratings*
IEC 60059:1999/AMD1:2009

IEC 60071-1:2006, *Insulation co-ordination – Part 1: Definitions, principles and rules*
IEC 60071-1:2006/AMD1:2010

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

IEC 60076 (all parts), *Power transformers*

IEC 60068-3-3, *Environmental testing – Part 3: Guidance – Seismic test methods for equipments*

IEC 60137, *Insulated bushings for alternating voltages above 1000 V*

IEC 60168, *Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V*

IEC 60196:2009, *IEC standard frequencies*

IEC 60255-26, *Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements*

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

IEC 60721-2-4, *Classification of environmental conditions – Part 2-4: Environmental conditions appearing in nature – Solar radiation and temperature*

IEC TS 60815 (all parts), *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions*

IEC 60865 (all parts), *Short-circuit currents*

IEC 60871 (all parts), *Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V*

IEC 60909 (all parts), *Short-circuit currents in three-phase a.c. systems*

IEC TS 61463, *Bushings – Seismic qualification*

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

IEC 61936-1:2010, *Power installations exceeding 1 kV a.c. – Part 1: Common rules*

IEC 61936-1:2010/AMD1:2014

IEC 62231, *Composite station post insulators for substations with AC voltages greater than 1 000 V up to 245 kV – Definitions, test methods and acceptance criteria*

IEC 62271-100, *High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*

IEC 62271-102, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

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*

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

UHV AC

highest voltage of AC transmission system exceeding 800 kV

Note 1 to entry: UHV stands for "ultra high voltage".

3.2

high-voltage side of transformer

highest voltage among two or three voltages on each side of the main transformer

3.3

intermedium voltage side of transformer

second highest voltage among three voltages on each side of the main transformer

3.4

low-voltage side of transformer

lowest voltage among two or three voltages in the apparatus or installation

Note 1 to entry: In this document, the definition is modified as the lowest voltage among two or more voltages on each side of main transformer.