PD IEC TS 63471:2023

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DC voltages for HVDC grids

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee GEL/8/4.

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Published by BSI Standards Limited 2023

ISBN 978 0 539 29028 8

ICS 29.200; 29.240.01

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 December 2023.

Amendments/corrigenda issued since publication

Date	Text affected

IEC TS 63471

Edition 1.0 2023-12

TECHNICAL SPECIFICATION

DC voltages for HVDC grids

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.200; 29.240.01

ISBN 978-2-8322-7998-4

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FOREWORD

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IEC TS 64571 has been prepared by IEC technical committee 115: High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV. It is a Technical Specification.

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

Draft	Report on voting
115/343/DTS	115/358/RVDTS

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 Technical Specification 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/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- withdrawn, or
- revised.

INTRODUCTION

While high voltage direct current (HVDC) solutions for bulk power transmission have been developed and implemented commercially since 1954, recent years have seen a strong increase in the number of HVDC projects. There were about 80 commercial projects rated above 50 kV in the five decades until the year 2000. Since then, the use of HVDC technology has rapidly grown to around 200 HVDC systems at the time of writing. This development was accompanied by increasing both the HVDC system voltage and current ratings. While in the 20th century, almost all electrical transmission was performed in AC, at present, network planning activities all over the world are increasingly considering HVDC transmission the technology of choice. This is mainly driven by the response to the climate change and the political commitment, such as European Union's Green Deal and others to reduce the carbon-dioxide footprint of societies.

HVDC power transmission, especially voltage-sourced converter (VSC) HVDC power transmission, provide feasible solutions for the large-scale integration of renewable generation, and electrification of platforms in offshore grids. HVDC systems strengthen the power systems by increasing their power transmission capacity, improving stability and controllability as well as enabling the integration of different electricity markets.

VSC HVDC is put forward as the technology for a DC grid, as it supports multiterminal operation with fixed voltage polarity. The current flow direction in an VSC HVDC transmission line or cable can be easily changed by adjusting the voltage difference between two DC substations without polarity reversal. Utilisation of a standardised DC voltage is useful for DC side equipment manufacturing, DC grid design and operation.

For many stand-alone HVDC projects with a DC voltage above 100 kV (not part of any grid), DC voltage is normally selected by optimising total cost of the project considering cost of initial capital investment and cost of losses over entire lifespan. Considering recommended DC voltage levels for HVDC grids could be very beneficial, for anyone planning HVDC projects, which might potentially become part of a future HVDC grid. However, whilst adopting such standardized DC voltages would facilitate future extensions towards HVDC grids, they would preclude the optimization of DC voltage levels in individual projects, thereby leading to potentially higher investment costs. Thus, the DC voltage series is not mandatory for the DC voltage selection of stand-alone (not forming part of DC Grid) HVDC projects, e.g. a point-to-point HVDC power transmission and distribution system.

Although this DC voltage series is preferable in the conversion of segments of AC grids to DC grids the selected DC voltage should take the ratings of transmission lines or cables into account and thus, should not been limited by levels of this DC voltage series.

Over the last few decades, HVDC technology has matured, and significant work is being done towards development and maturing of the medium voltage DC (MVDC) technology. Modularity, easy compliance with standard voltage and power levels and feasibility of cost reduction indicate high potential for medium voltage DC systems. MVDC collection and distribution grids will be key for the grid integration of renewable energies and the connection of, for example, electrical vehicle charging infrastructure, energy storage systems, data centres, distribution for congested urban areas, city infeed and future smart homes. Interconnected MVDC systems can provide high efficiency, avoid overload conditions, limit short circuit currents, and improve overall system cost. Major cost savings can be realized in DC distribution systems because additional AC/DC conversion steps for home appliances with internal DC use can be eliminated and grid side power factor correction is not needed. In addition, the use of MVDC grids allows power flow control between multiple AC substations. This would enable more stable MVAC grids, increased utilization of the AC infrastructure, higher redundancy, and the support of existing weak AC grids. Considering the aspects summarized above the recommended DC voltage series includes medium DC voltage levels above 1,5 kV. Such medium DC voltage levels could also be considered for the design of the DC neutral, dedicated metallic return (DMR) of HVDC systems taking also other requirements such as the insulation levels into account.

The work should be understood as an initial contribution for standardized DC voltages, to be further elaborated by the respective Technical Committees (e.g. TC 8).

DC VOLTAGES FOR HVDC GRIDS

1 Scope

This document provides a recommended DC voltage series for HVDC grids with a DC voltage above 1,5 kV. It concerns the selection of a nominal DC voltage of multi-terminal HVDC power transmission and distribution systems and meshed HVDC networks, grids, rather than a rated DC voltage or highest DC voltage.

There is no stringent requirement to consider this DC voltage series for the DC voltage selection for any stand-alone (not forming part of DC Grid) HVDC projects, e.g. a point-to-point HVDC power transmission and distribution system. However, in order to facilitate the later progression towards larger HVDC systems in the future the use of standardized DC voltages is very useful. At later stages, with multi-terminal systems and meshed HVDC grids, the use of harmonized voltages will indeed become essential in order to optimize both capital and operational costs. Also, for entirely new projects, system planning should include this outlook and can benefit from the use of the recommended DC voltage series.

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 terminology 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
HVDC grid
high voltage direct current transmission and distribution network connecting more than two AC/DC converter stations transferring energy in the form of high voltage direct current, including related transmission lines, switching stations, DC/DC converter stations, if any, as well as other equipment and sub-systems needed for operation

3.2
nominal DC voltage
value of DC voltage used to designate or identify a system or grid

Note 1 to entry: In HVDC grids, the nominal DC voltage is defined as pole-to-earth or pole-to-neutral. The nominal value is generally a rounded value.

3.3
highest DC voltage
highest value of DC voltage for which the equipment and system is designed to operate continuously, in respect of its insulation as well as other characteristics

Note 1 to entry: Rated DC voltage is defined elsewhere for equipment design purposes.