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TECHNICAL SPECIFICATION

colour inside

High voltage direct current (HVDC) power transmission – System requirements for DC-side equipment
Part 1: Using line-commutated converters

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

IEC TS 63014, which is a Technical Specification, has been prepared by IEC technical committee 115: High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV.

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

Enquiry draft	Report on voting
115/167/DTS	115/178/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.

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- withdrawn,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.

HIGH VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION – SYSTEM REQUIREMENTS FOR DC-SIDE EQUIPMENT

Part 1: Using line-commutated converters

1 Scope

This Technical Specification is intended to provide an overall and consistent set of guidelines to facilitate the specification of equipment for the DC-side of a high-voltage direct current (HVDC) system using line-commutated converters. For point-to-point HVDC transmission systems, this document covers all DC-side equipment located between the converter valves and the DC overhead line or cable termination, excluding the converter valves themselves. For back-to-back HVDC systems, this document covers all DC-side equipment excluding the converter valves themselves. Throughout this publication, the terms 'direct voltage' and 'DC voltage' are used interchangeably, as are 'direct current' and 'DC current'.

Traditionally, the largest items of such equipment, such as the DC smoothing reactor and DC harmonic filters, have generally been located outdoors but increasingly the trend is to locate such equipment indoors (although not in the valve hall itself) to provide protection from pollution. Although product standards exist for some DC-side equipment types, many such items of equipment have only standards written for AC applications and, in such cases, the purpose of this document is to provide guidance as to how to specify the additional requirements (particularly with regard to testing) for such equipment to cover their use in DC conditions.

The converter itself is excluded from this scope, being covered by IEC 60700-1 [1][1] and IEC 60700-2 [2].

Although this document includes requirements for DC disconnectors and certain types of specialised DC switching devices (such as the Metallic Return Transfer Switch (MRTS)), it excludes any type of DC circuit-breaker designed to interrupt fault currents.

DC-side equipment for HVDC systems based on voltage-sourced converter (VSC) technology is excluded from this document and will be covered in a future Part 2 of IEC 63014.

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 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

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

IEC 60071-5, *Insulation co-ordination – Part 5: Procedures for high-voltage direct current (HVDC) converter stations*

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1 Numbers in square brackets refer to the Bibliography.

IEC 60076-6:2007, *Power transformers – Part 6: Reactors*

IEC 60099-9:2014, *Surge arresters – Part 9: Metal-oxide surge arresters without gaps for HVDC converter stations*

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

IEC 60353, *Line traps for a.c. power systems*

IEC 60358-1, *Coupling capacitors and capacitor dividers – Part 1: General rules*

IEC 60383 (all parts), *Insulators for overhead lines with a nominal voltage above 1 000 V*

IEC 60437, *Radio interference test on high-voltage insulators*

IEC 60633, *Terminology for high-voltage direct current (HVDC) transmission*

IEC TS 60815-4, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 4: Insulators for d.c. systems*

IEC 60871-1:2014, *Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V – Part 1: General*

IEC 60871-4:2014, *Shunt capacitors for AC power systems having a rated voltage above 1 000 V – Part 4: Internal fuses*

IEC TS 61245, *Artificial pollution tests on high-voltage ceramic and glass insulators to be used on d.c. systems*

IEC 61462, *Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V – Definitions, test methods, acceptance criteria and design recommendations*

IEC 61466 (all parts), *Composite string insulator units for overhead lines with a nominal voltage greater than 1 000 V*

IEC 61850-9-2, *Communication networks and systems for power utility automation – Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

IEC 61869-9, *Instrument transformers – Part 9: Digital interface for instrument transformers*

IEC 61869-14, *Instrument transformers – Part 14: Specific requirements for DC current transformers* [2]

IEC 61869-15, *Instrument transformers – Part 15: Specific requirements for DC voltage transformers* [3]

IEC TS 61936-2, *Power installations exceeding 1 kV AC and 1,5 kV DC – Part 2: DC*

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2 Under preparation. Stage at the time of publication: IEC/FDIS 61869-14:2017.

3 Under preparation. Stage at the time of publication: IEC/FDIS 61869-15:2017.

IEC 62217, *Polymeric HV insulators for indoor and outdoor use – General definitions, test methods and acceptance criteria*

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

IEC 62271-1, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-100:2008, *High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*

IEC 62271-102:2001, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC 62271-109:2008, *High-voltage switchgear and controlgear – Part 109: Alternating-current series capacitor by-pass switches*

IEC 62772, *Composite hollow core station post insulators for substations with a.c. voltage greater than 1 000 V and d.c. voltage greater than 1 500 V – Definitions, test methods and acceptance criteria*

IEC TS 62896, *Hybrid insulators for AC and DC for high-voltage applications – Definitions, test methods and acceptance criteria*

IEC Guide No. 111, *Electrical high-voltage equipment in high-voltage substations – Common recommendations for product standards*

IEC/IEEE 65700-19-03:2014, *Bushings for DC application*

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in IEC 60633 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

3.1 DC switching devices

3.1.1 Types of DC switching device

3.1.1.1
high-speed DC switch
type of switching device used on an HVDC scheme, required to open or close rapidly (<1 second), including in some cases the need to commutate load current into a parallel conducting path, but with no requirement to interrupt fault or load current

Note 1 to entry: DC switching devices are usually based on a single-phase unit of an AC circuit-breaker, appropriately modified for their DC applications. Their capabilities to perform faster opening and closing than disconnect switches are used but the function of breaking short-circuit currents is not required.

3.1.1.2
DC commutation switch
type of high-speed DC switch specifically designed to commutate load current into an alternative parallel current path

Note 1 to entry: The metallic return transfer switch (MRTS) and the earth return transfer switch (ERTS) defined in IEC 60633 are well-known examples of DC commutation switch.

3.1.1.3
mechanical switch
mechanical switching device forming part of a high-speed DC switch

3.1.2 Applications of DC switching devices

3.1.2.1
neutral bus switch
NBS
DC commutation switch connected in series with the neutral bus on a bipolar HVDC scheme, designed to commutate current out of the pole conductor or neutral bus and into the electrode line or dedicated metallic return conductor or earth in response to a fault in a converter or neutral bus

3.1.2.2
neutral bus earthing switch
NBES
neutral bus ground switch
NBGS
DC commutation switch connected from the neutral bus to the station earth mat on a bipolar HVDC scheme, designed to provide a temporary earth connection in the event of an open-circuit fault on the electrode line until the imbalance of current between the two poles can be reduced to a safe minimum level or the electrode line connection can be restored

3.1.2.3
bypass switch
BPS
high-speed DC switch connected across each converter valve group in HVDC schemes using more than one independent converter per pole, designed to close rapidly to bypass a converter group that is being taken out of service and commutate the current back into a valve group that is being taken back into service

3.1.2.4
line paralleling switch
LPS
DC commutation switch placed in series with one or more high-voltage pole conductors, allowing two or more lines to be connected in parallel or to revert to single-line operation while conducting load current

3.1.2.5
converter paralleling switch
CPS
high-speed DC switch connected in series with each converter at the high-voltage DC terminal in HVDC schemes where two or more converters are connected in parallel onto a common pole conductor, designed to allow additional converter(s) to be connected in parallel or disconnected without affecting the load current in the other converter

3.2 Filter components

3.2.1 Filter capacitors

3.2.1.1
main DC filter capacitor
high-voltage DC filter capacitor which is exposed to a substantial direct voltage

3.2.1.2
auxiliary capacitor
LV filter capacitor
capacitor in a DC filter not exposed to direct voltage across its terminals (such as C2 in Figure 5)

3.2.1.3
DC neutral bus capacitor
capacitor connected between the DC neutral bus and the substation earth

3.2.1.4
DC surge capacitor
capacitor connected between the DC line and the substation earth (directly or indirectly) to serve the primary function of reducing the amplitude and steepness of lightning surges applied to the substation equipment

3.2.2 Filter resistors

3.2.2.1
resistor
power resistor forming part of some types of harmonic filter bank and connected in parallel and/or series with the LV filter capacitors and/or filter reactors, usually at the neutral side of the filter

3.2.2.2
resistor element
single part of resistor, which is not possible to be divided into smaller parts (such as a grid, a mat, a spring coil, etc. depending on the technology)

3.2.2.3
bank of resistor elements
mechanical assembly of several single elements electrically connected together, plus a mechanical structure, insulating parts, terminals, etc.

3.2.2.4
resistor module
part of the resistor in one enclosure (if applicable)

3.2.3
filter reactors
power reactor forming part of a harmonic filter bank, responsible (sometimes together with the LV filter capacitors, where used) for defining the tuned frequency(ies) of the filter bank and usually connected at the neutral side of the filter

3.3 Surge arresters

3.3.1
continuous operating voltage
COV
maximum continuous voltage characterized by the voltages CCOV, PCOV, DCOV and ECOV where applicable and that may be applied continuously between the arrester terminals

Note 1 to entry: Operation voltages of several arrester types can vary significantly during different operation conditions of the HVDC converters (e.g. depending on firing angles, tap position) as well as in different configuration of the DC system (e.g. metallic return configuration). The specified requirements shall consider the applicable operating conditions accordingly.

3.3.2
crest value of continuous operating voltage
CCOV
highest continuously occurring crest value of the voltage across the arrester excluding commutation overshoots and commutation notches and calculated with a system model valid for up to approximately 5 kHz

3.3.3
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, commutation notches and ripple calculated with a model which takes into account stray capacitances/inductances of converter transformers, valves, buswork, etc. and valid for at least 50 kHz

3.3.4
DC component of continuous operating voltage
DCOV
highest mean or average of the continuous operating voltage across the arrester excluding harmonics and commutation overshoots

3.3.5
equivalent continuous operating voltage
ECOV
RMS value of the sinusoidal power-frequency voltage or direct voltage at a metal-oxide surge arrester stressed by operating voltage of any wave shape that generates the same power losses in the metal-oxide material as the actual operating voltage

3.3.6
switching impulse protective level
SIPL
residual voltage of a surge arrester subjected to a discharge current corresponding to the coordination switching impulse current

3.3.7
lightning-impulse protective level
LIPL
residual voltage of a surge arrester subjected to a discharge current corresponding to the coordination lightning-impulse current

3.3.8
steep-front impulse protective level
SFIPL
STIPL
residual voltage of a surge arrester subjected to a discharge current corresponding to the coordination steep-front impulse current

4 General

4.1 Overview

"DC-side equipment" is the overall name given to a collection of high-voltage equipment located on the DC side of the HVDC converter in a converter station, excluding the converter itself.