

INTERNATIONAL STANDARD

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High voltage direct current (HVDC) power transmission – Cables with extruded insulation and their accessories for rated voltages up to 320 kV for land applications – Test methods and requirements

Câbles haute tension en courant continu (CCHT) – Câbles d'énergie à isolation extrudée et leurs accessoires pour des tensions assignées jusqu'à 320 kV pour les applications terrestres – Méthodes et exigences d'essai



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**HIGH VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION –
CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR
RATED VOLTAGES UP TO 320 kV FOR LAND APPLICATIONS –
TEST METHODS AND REQUIREMENTS**

FOREWORD

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FDIS	Report on voting
20/1708A/FDIS	20/1726/RVD

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INTRODUCTION

As a result of major developments in cable systems with extruded insulation for high voltage DC (HVDC) applications, CIGRE study committee B1 set up working group (WG) B1.32 in 2008 with the aim to prepare recommendations for testing DC extruded cable systems for power transmission at a rated voltage of up to 500 kV.

The recommendations of WG B1.32 were published in TB 496 in April 2012. At the time of preparing the CIGRE recommendation there was laboratory experience at voltages up to and including 500 kV, but operating experience was limited to 200 kV. At the time of preparation of this standard several projects up to 320 kV are in progress and many others are planned for the near future.

A list of relevant references is given in the Bibliography.

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HIGH VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION – CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR RATED VOLTAGES UP TO 320 kV FOR LAND APPLICATIONS – TEST METHODS AND REQUIREMENTS

1 Scope

This International Standard specifies test methods and requirements for HVDC transmission power cable systems, employing cables with extruded insulation and their accessories, for fixed land installations, for rated voltages up to and including 320 kV.

Within the scope of this standard “extruded insulation” means insulation manufactured by extrusion of either thermoplastic (e.g. polyethylene) or crosslinked (e.g. crosslinked polyethylene, ethylene propylene rubber, etc.) material. The insulation material may be either unfilled or filled (e.g. with mineral or carbon).

The requirements apply to single-core cables in combination with their accessories, outdoor and terminations for gas insulated systems, joints, and asymmetric joints for usual conditions of installation and operation, but not to special cables and their accessories, such as submarine cables, for which modifications to the standard tests may be necessary or special test conditions may need to be devised.

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 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60228, *Conductors of insulated cables*

IEC 60229, *Electric cables – Tests on extruded oversheaths with a special protective function*

IEC 60230, *Impulse tests on cables and their accessories*

IEC 60287-1-1:2006, *Electric cables – Calculation of the current rating – Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General*

IEC 60287-1-1:2006/AMD1:2014

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60502-2:2014, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV) – Part 2: Cables for rated voltages from 6 kV ($U_m = 7,2$ kV) up to 30 kV ($U_m = 36$ kV)*

IEC 60502-4, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV) – Part 4: Test requirements on accessories for cables with rated voltages from 6 kV ($U_m = 7,2$ kV) up to 30 kV ($U_m = 36$ kV)*

IEC 60811-201, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 201: General tests – Measurement of insulation thickness*

IEC 60811-202, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 202: General tests – Measurement of thickness of non-metallic sheath*

IEC 60811-203, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 203: General tests – Measurement of overall dimensions*

IEC 60811-401, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 401: Miscellaneous tests – Thermal ageing methods – Ageing in an air oven*

IEC 60811-403, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 403: Miscellaneous tests – Ozone resistance test on cross-linked compounds*

IEC 60811-409, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 409: Miscellaneous tests – Loss of mass test for thermoplastic insulations and sheaths*

IEC 60811-412, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 412: Miscellaneous tests – Thermal ageing methods – Ageing in an air bomb*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 60811-505, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 505: Mechanical tests – Elongation at low temperature for insulations and sheaths*

IEC 60811-506, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 506: Mechanical tests – Impact test at low temperature for insulations and sheaths*

IEC 60811-507, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 507: Mechanical tests – Hot set test for crosslinked materials*

IEC 60811-508, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 508: Mechanical tests – Pressure test at high temperature for insulation and sheaths*

IEC 60811-509, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 509: Mechanical tests – Test for resistance of insulations and sheaths to cracking (heat shock test)*

IEC 60811-605, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 605: Physical tests – Measurement of carbon black and/or mineral filler in polyethylene compounds*

IEC 60811-606, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 606: Physical tests – Methods for determining the density*

IEC 62067, *Power cables with extruded insulation and their accessories for rated voltages above 150 kV ($U_m = 170$ kV) up to 500 kV ($U_m = 550$ kV) – Test methods and requirements*

3 Terms and definitions

For the purposes of this document the following terms and definitions apply.

3.1 Definitions of dimensional values (thicknesses, cross-sections, etc.)

3.1.1

nominal value

value by which a quantity is designated and which is often used in tables

Note 1 to entry: In this standard, nominal values usually give rise to values to be checked by measurements taking into account specified tolerances.

3.1.2

median value

value which is, when several test results have been obtained and ordered in an increasing (or decreasing) succession, the middle value if the number of available values is odd, and the mean of the two middle values if the number is even

3.2 Definitions concerning tests

3.2.1

routine test

test carried out by the manufacturer on each manufactured component (length of cable or accessory) to check that the component meets the specified requirements

3.2.2

sample test

test carried out by the manufacturer on samples of complete cable, or components taken from a complete cable or accessory, at a specified frequency, so as to verify that the finished product meets the specified requirements

3.2.3

type test

test carried out before supplying, on a general commercial basis, a type of cable system, in order to demonstrate satisfactory performance characteristics to meet the intended application

Note 1 to entry: Once successfully completed, these tests need not be repeated, unless changes are made in the cable or accessory with respect to materials, manufacturing process, design or design electrical stress levels, which might adversely change the performance characteristics.

3.2.4

prequalification test

PQ test

test carried out before supplying, on a general commercial basis, a type of cable system, in order to demonstrate satisfactory long term performance of the complete cable system

Note 1 to entry: The PQ test need only be carried out once unless there is a substantial change in the cable system with respect to material, manufacturing process, design or design electrical stress levels.

Note 2 to entry: A substantial change is defined as that which might adversely affect the performance of the cable system. The supplier should provide a detailed case, including test evidence, if modifications are introduced, which are claimed not to constitute a substantial change.

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3.2.5

electrical test after installation

test carried out to demonstrate the integrity of the cable system as installed

3.2.6

development test

test carried out on test objects to characterize the properties and performance of elements of the cable system or of selected materials and material combinations

3.3 Other definitions

3.3.1

cable system

cable with installed accessories including components used for thermo-mechanical restraint of systems limited to those used for terminations and joints only

3.3.2

nominal electrical stress

electrical stress calculated at U_0 using nominal dimensions and constant material characteristics

Note 1 to entry: See 4.1.

3.3.3

test object

object which is a cable length or an accessory to be subjected to testing

3.3.4

return cable

cable, which is typically a low/medium voltage DC cable used for the return current in monopolar operation of HVDC schemes.

Note 1 to entry: A return cable can either be connected over the full length between the converters or can only be connected for part of the length connecting a converter to an electrode station

3.3.5

transmission cable

cable which is a high voltage cable of a monopolar or bipolar scheme, and which is connected to the HV terminal at the DC side of the converter

3.3.6

test loop

cable loop which is a combination of series connected test objects simultaneously under test

SEE: Figure 1.

3.3.7

line commutated converter

LCC

converter system that has the feature of changing voltage polarity on the cable system when the direction of power flow is reversed

Note 1 to entry: See IEC 60633.

Note 2 to entry: This note 2 only applies to the French language.

3.3.8

voltage source converter

VSC

converter system that does not change the voltage polarity of the cable system when the direction of power flow is reversed

Note 1 to entry: This note only applies to the French language.

3.3.9

extrusion length

length of cable conductor with the insulation and semiconducting layers continuously extruded in the same non-interrupted extrusion operation

3.3.10

manufacturing length

whole extrusion length (or parts thereof if cut), where construction elements (outside the outer semiconducting layer) have been applied

3.3.11

delivery length

typically the completed cable length on a drum for a cable

3.3.12

field joint

joint between two cables that is completed with all construction elements and in a state as installed in the field in the actual cable system

3.3.13

asymmetric joint

joint, which connects two cables with the same insulation system, but of different design

Note 1 to entry: An asymmetric joint is for instance a joint between cables of different conductor, insulation or screen dimension

4 Voltage designations and materials

4.1 Rated voltage

U_0 is the rated DC voltage between conductor and metal screen/sheath for which the cable system is designed. It is used to determine the DC test voltages U_T , U_{TP1} and U_{TP2} .