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IEEE Recommended Practice for Space Charge Measurements on High-Voltage Direct-Current Extruded Cables for Rated Voltages up to 550 kV

IEEE Dielectrics and Electrical Insulation Society

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IEEE
3 Park Avenue
New York, NY 10016-5997
USA

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Abstract: The aim of this recommended practice is establishing a protocol for the measurement of space charges in high-voltage direct-current (HVDC) extruded cables having rated voltage up to 550 kV. Such measurements are prescribed to be carried out at the beginning and at the end of load cycle qualification tests (either the long-duration voltage test of prequalification tests or the load cycle test of type tests). The various steps of the protocol for the measurement of space charges in such cables are carefully described. Details are given about the procedure for applying and switching off the voltage, the preparation and conditioning of specimens, the measurement times during poling and depolarization, and the calculations for checking electric field stabilization. The ultimate goal of this recommended practice is not verifying the compliance with any maximum acceptable limit of either space charge or electric field, but rather assessing the variation of the electric field profile in the cable insulation wall during load cycle qualification tests.

Keywords: HVDC extruded insulation, IEEE 1732™, power cables, power cable testing, space charge measurements

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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Participants

At the time this IEEE recommended practice was completed, the DEI/SC/HVDC Cable Systems Working Group had the following membership:

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Massimo Marzinotto, *Vice Chair*

Jerome Castellon
George Chen
John Fothergill
Mingli Fu
Naohiro Hozumi
June-Ho Lee
Jian Li
Frank Mauseth
Peter Morshuis
Clive Reed
Yasuhiro Tanaka
Antonios Tzimas
Kai Wu

The following members of the individual balloting committee voted on this recommended practice. Balloters may have voted for approval, disapproval, or abstention.

Ettore Bartolucci
William Byrd
Jerome Castellon
George Chen
Namal Fernando
John Fothergill
Mingli Fu
Paul Gaberson
Randall Groves
Werner Hoelzl
Alexander Kraetge
Michael Lauxman
Jian Li
Arturo Maldonado
Massimo Marzinotto
Frank Mauseth
Giovanni Mazzanti
Peter Morshuis
Clive Reed
Yasuhiro Tanaka
Antonios Tzimas
Kai Wu

When the IEEE-SA Standards Board approved this recommended practice on 23 March 2017, it had the following membership:

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Annette D. Reilly
Robby Robson
Dorothy Stanley
Adrian Stephens
Mehmet Ulema
Phil Wennblom
Howard Wolfman
Yu Yuan

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 1732-2017, IEEE Recommended Practice for Space Charge Measurements on High-Voltage Direct-Current Extruded Cables for Rated Voltages up to 550 kV.

Recently many high-voltage direct-current (HVDC) cable systems with extruded insulation have been installed all over the world (Mazzanti and Marzinotto [B13]). Since extruded insulation for HVDC cables is strongly affected by trapped space charge, several space charge measurement methods have been developed since the mid-1980s. So far, space charge measurements have mostly been made using thin, small-size plaques and mini-cables. Much less effort has been devoted to cables of size and design comparable or equal to the full-size cables installed in the field. On the other hand, space charge measurements on full-size cables are of great interest for practical cable systems, as such measurements enable actual service conditions of power cables to be evaluated.

Inherent difficulties mainly related to thick insulation make measuring space charge on full-size cables difficult. However, since the 1990s, satisfactory space charge measurements on large HVDC extruded cables have been described in the literature. Furthermore, space charge measurements on full-size HVDC extruded cable loops have been, and are being, used worldwide in qualification tests for HVDC extruded cable link projects. These measurements are based on project-dependent agreements between cable manufacturers and the customers, as there is no agreed standard procedure.

Aiming to fill this gap, in 2015 a position paper prepared by the IEEE DEIS HVDC Cable Systems Technical Committee was published (Mazzanti, et al. [B12]). The paper illustrates a protocol for the measurement of space charge on full-size HVDC extruded cables during load cycle qualification tests (either the long-duration voltage test of prequalification tests or the load cycle test of type tests). The protocol incorporates experience gained in the above-mentioned space charge measurements for HVDC extruded cable system projects.

This recommended practice aims at improving this protocol and establishing it as a reference IEEE best practice for the measurement of space charge on full-size HVDC extruded cables. At the time of writing of this document, the maximum rated voltage of HVDC extruded cable systems commissioned worldwide is 320 kV, but systems with rated voltage up to 525 kV are being qualified. Moreover, in 2012 CIGRÉ issued the Technical Brochure 496 entitled "Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500 kV" (see Clause 2). Aiming at accounting for these recent and/or ongoing developments, an upper limit of 550 kV has been selected for the rated voltage of HVDC extruded cables to which the present recommended practice is applicable.

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IEEE Recommended Practice for Space Charge Measurements on High-Voltage Direct-Current Extruded Cables for Rated Voltages up to 550 kV

1. Overview

1.1 Scope

This standard recommends best practices for the measurement of space charge on high-voltage direct-current (HVDC) extruded cables having rated voltage up to 550 kV. Focus is on poling time, depolarization time, heating and cooling of specimens. Particular reference is made to space charge measurements to be carried out during load cycle qualification tests (either prequalification or type test load cycles). The ultimate goal of this standard is not checking the compliance with any maximum acceptable limit of either space charge or electric field; rather, assessing the variation of the electric field profile in the cable insulation wall during load cycle qualification tests.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

CIGRÉ Technical Brochure 288:2006, Guide for Space Charge Measurement in Dielectrics and Insulating Materials—PEA, PWP, (IPWP & LIPP) and TSM Methods.

CIGRÉ Technical Brochure 496:2012, Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500 kV.

IEC 60060-1:2010, High-Voltage Test Techniques—Part 1: General Definitions and Test Requirements.[1]

[1]IEC publications are available from the International Electrotechnical Commission (http://www.iec.ch/). IEC publications are also available in the United States from the American National Standards Institute (http://www.ansi.org/).