



BSI Standards Publication

Measurement of internal electric field in insulating materials — Pressure wave propagation method

National foreword

This Published Document is the UK implementation of IEC TS 62836:2020.

The UK participation in its preparation was entrusted to Technical Committee GEL/112, Evaluation and qualification of electrical insulating materials and systems.

A list of organizations represented on this committee can be obtained on request to its committee manager.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2020
Published by BSI Standards Limited 2020

ISBN 978 0 580 52224 6

ICS 29.035.01; 17.220.99

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2020.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------



TECHNICAL SPECIFICATION



Measurement of internal electric field in insulating materials – Pressure wave propagation method

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.220.99; 29.035.01

ISBN 978-2-8322-8993-8

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

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms, definitions and abbreviated terms	7
3.1 Terms and definitions.....	7
3.2 Abbreviated terms.....	7
4 Principle of the method.....	8
5 Samples	9
6 Electrode materials.....	10
7 Pressure pulse wave generation.....	10
8 Set-up of the measurement.....	11
9 Calibrating the electric field	12
10 Measurement procedure	12
11 Data processing for the experimental measurement.....	13
12 Measurement examples.....	14
12.1 Samples.....	14
12.2 Pressure pulse generation	14
12.3 Calibration of sample and signal	14
12.4 Testing sample and experimental results.....	15
Annex A (informative) Preconditional method of the original signal for the PWP method.....	19
A.1 Simple integration limitation	19
A.2 Analysis of the resiliency effect and correction procedure	20
A.3 Example of the correction procedure on a PE sample	21
A.4 Estimation of the correction coefficients.....	22
A.5 MATLAB® code	24
Annex B (informative) Linearity verification of the measuring system	26
B.1 Linearity verification.....	26
B.2 Sample conditions.....	26
B.3 Linearity verification procedure	26
B.4 Example of linearity verification.....	26
Figure 1 – Principle of the PWP method.....	9
Figure 2 – Measurement set-up for the PWP method	11
Figure 3 – Sample of circuit to protect the amplifier from damage by a small discharge on the sample.....	11
Figure 4 – Measured current signal under –5,8 kV.....	14
Figure 5 – First measured current signal (< 1 min).....	15
Figure 6 – Measured current signal under –46,4 kV, after 1,5 h under high voltage.....	15
Figure 7 – Measured current signal without applied voltage, after 1,5 h under high voltage.....	16
Figure 8 – Internal electric field distribution under –5,8 kV.....	16
Figure 9 – Internal electric field distribution under –46,4 kV, at the initial state	17

Figure 10 – Internal electric field distribution under –46,4 kV, after 1,5 h under high voltage.....	17
Figure 11 – Internal electric field distribution without applied voltage after 1,5 h under high voltage.....	18
Figure A.1 – Comparison between practical and perfect pressure pulses.....	19
Figure A.2 – Original signal of the sample free of charge under moderate voltage.....	20
Figure A.3 – Comparison between original and corrected reference signals with a sample free of charge under moderate voltage.....	21
Figure A.4 – Electric field in a sample under voltage with space charge calculated from original and corrected signals.....	22
Figure A.5 – Geometrical characteristics of the reference signal for the correction coefficient estimation.....	23
Figure A.6 – Reference signal corrected with coefficients graphically obtained and adjusted.....	23
Figure A.7 – Electric field in a sample under voltage with space charge calculated with graphically obtained coefficient and adjusted coefficient.....	24
Figure B.1 – Voltage signals obtained from the oscilloscope by the amplifier with different amplifications.....	27
Figure B.2 – Current signals induced by the sample, considering the input impedance and the amplification of the amplifier.....	27
Figure B.3 – Relationship between the measured current peak of the first electrode and applied voltage.....	28
Table A.1 – Variants of symbols used in the text.....	24

INTERNATIONAL ELECTROTECHNICAL COMMISSION

MEASUREMENT OF INTERNAL ELECTRIC FIELD IN INSULATING MATERIALS – PRESSURE WAVE PROPAGATION METHOD

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)"); the 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 cooperating 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 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.

IEC TS 62836 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems. It is a Technical Specification

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

Draft	Report on voting
112/472/DTS	112/499/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/standardsdev/publications.

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.

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.

INTRODUCTION

High voltage insulating cables, especially high voltage DC cables, are subject to charge accumulation and this may lead to electrical breakdown if the electric field produced by the charges exceeds the electrical breakdown threshold. With the trend to multiply power plants, especially green power plants such as wind or solar generators, more cables will be used for connecting these power plants to the grid and share the electric energy between countries. Therefore, the materials for the cables, and even the structure of these cables, when considering electrodes or the junction between cables, need a standardized procedure for testing how the internal electric field can be characterized. The measurement of the internal electric field would give a tool for comparing materials and help to establish thresholds on the internal electric field for high voltage applications in order to limit breakdown risks as much as possible. The pressure wave propagation (PWP) method has been used by many researchers to measure the space charge distribution and the internal electric field distribution in insulators. However, since experimental equipment, with slight differences, is developed independently by researchers throughout the world, it is difficult to compare the measurement results between the different equipment.

The procedure outlined in this Technical Specification provides a reliable point of comparison between different test results carried out by different laboratories in order to avoid interpretation errors. The IEC has established a project team to develop a procedure for the measurement of PWP.

MEASUREMENT OF INTERNAL ELECTRIC FIELD IN INSULATING MATERIALS – PRESSURE WAVE PROPAGATION METHOD

1 Scope

This document provides an efficient and reliable procedure to test the internal electric field in the insulating materials used for high-voltage applications, using the pressure wave propagation (PWP) method. It is suitable for a sample with homogeneous insulating materials and an electric field higher than 1 kV/mm, but it is also dependent on the thickness of the sample and the pressure wave generator.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms, definitions and abbreviated terms 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 Terms and definitions

3.1.1

pressure wave propagation

PWP

pressure wave that is propagated in a material containing electric charges and measurement of the induced electric signal from electrodes

3.2 Abbreviated terms

CB	carbon black
EVA	ethylene-vinyl acetate
LDPE	low density polyethylene
LIPP	laser induced pressure pulse
PE	polyethylene
PIPP	piezoelectric induced pressure pulse
PMMA	poly (methyl methacrylate)
PWP	pressure wave propagation
S/N	signal to noise ratio