

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

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

<p>See Eesti standard EVS-EN IEC 62836:2024 sisaldab Euroopa standardi EN IEC 62836:2024 ingliskeelset teksti.</p> <p>Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas.</p> <p>Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 05.04.2024.</p> <p>Standard on kättesaadav Eesti Standardimis-ja Akrediteerimiskeskusest.</p>	<p>This Estonian standard EVS-EN IEC 62836:2024 consists of the English text of the European standard EN IEC 62836:2024.</p> <p>This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation and Accreditation.</p> <p>Date of Availability of the European standard is 05.04.2024.</p> <p>The standard is available from the Estonian Centre for Standardisation and Accreditation.</p>
---	---

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile [standardiosakond@evs.ee](mailto:standardiosakond@evs.ee).

ICS 17.220.99, 29.035.01

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardimis- ja Akrediteerimiskeskusele. Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardimis-ja Akrediteerimiskeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardimis-ja Akrediteerimiskeskusega: Koduleht [www.evs.ee](http://www.evs.ee); telefon 605 5050; e-post [info@evs.ee](mailto:info@evs.ee)

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation and Accreditation. No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation and Accreditation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation and Accreditation: Homepage [www.evs.ee](http://www.evs.ee); phone +372 605 5050; e-mail [info@evs.ee](mailto:info@evs.ee)

ICS 17.220.99; 29.035.01

English Version

Measurement of internal electric field in insulating materials -  
Pressure wave propagation method  
(IEC 62836:2024)

Mesurage du champ électrique interne dans les matériaux  
isolants - Méthode de l'onde de pression  
(IEC 62836:2024)

Messung des inneren elektrischen Feldes in  
Isoliermaterialien - Methode der Druckwellenausbreitung  
(IEC 62836:2024)

This European Standard was approved by CENELEC on 2024-04-03. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.



European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

## European foreword

The text of document 112/627/FDIS, future edition 1 of IEC 62836, prepared by IEC/TC 112 "Evaluation and qualification of electrical insulating materials and systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62836:2024.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2025-01-03
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2027-04-03

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

## Endorsement notice

The text of the International Standard IEC 62836:2024 was approved by CENELEC as a European Standard without any modification.

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



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

**Mesurage du champ électrique interne dans les matériaux isolants – Méthode de l'onde de pression**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2024 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

#### IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Recherche de publications IEC -

[webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [sales@iec.ch](mailto:sales@iec.ch).

#### IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications, symboles graphiques et le glossaire. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 500 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 25 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



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

**Mesurage du champ électrique interne dans les matériaux isolants – Méthode de l'onde de pression**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 17.220.99, 29.035.01

ISBN 978-2-8322-8338-7

**Warning! Make sure that you obtained this publication from an authorized distributor.**  
**Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references .....	8
3 Terms, definitions and abbreviated terms .....	8
3.1 Terms and definitions.....	8
3.2 Abbreviated terms.....	8
4 Principle of the method.....	9
5 Samples .....	12
6 Electrode materials.....	12
7 Pressure pulse wave generation .....	12
8 Set-up of the measurement.....	13
9 Calibrating the electric field .....	14
10 Measurement procedure .....	14
11 Data processing for experimental measurement .....	15
12 Space charge distribution measurement .....	16
13 Impact of coaxial geometry .....	16
13.1 Measuring set-up of pressure wave propagation method for the coaxial geometry sample .....	16
13.2 Physical model in coaxial geometry .....	17
13.3 Measuring conditions .....	18
13.4 Calibration of electric field for a coaxial sample .....	19
13.4.1 Summary .....	19
13.4.2 Linearity verification .....	19
13.4.3 Validity verification of the ratio between two current peaks .....	19
13.4.4 Method for retrieving internal electric field from the measured current signal .....	20
Annex A (informative) Preconditional method of the original signal for the PWP method on a planar sample.....	22
A.1 Simple integration limitation .....	22
A.2 Analysis of the resiliency effect and correction procedure .....	23
A.3 Example of the correction procedure on a PE sample .....	24
A.4 Estimation of the correction coefficients .....	25
A.5 MATLAB® code .....	27
Annex B (informative) Linearity verification of the measuring system .....	29
B.1 Linearity verification.....	29
B.2 Sample conditions.....	29
B.3 Linearity verification procedure .....	29
B.4 Example of linearity verification.....	29
Annex C (informative) Measurement examples for planar plaque samples .....	32
C.1 Samples.....	32
C.2 Pressure pulse generation .....	32
C.3 Calibration of sample and signal .....	32
C.4 Testing sample and experimental results .....	33
C.4.1 Measurement results .....	33



C.4.2	Internal electric field distribution in the testing sample .....	34
C.4.3	Distribution of space charge density in the testing sample .....	36
Annex D (informative)	Measurement examples for coaxial geometry samples .....	38
D.1	Example of linearity verification of coaxial geometry .....	38
D.1.1	Sample conditions .....	38
D.1.2	Linearity verification procedure .....	38
D.1.3	Example of linearity verification .....	38
D.2	Verification of the current peak area ratio between the outer and inner electrodes .....	39
D.2.1	Verification principle .....	39
D.2.2	Example of verification of the current peak area ratio .....	40
D.3	Testing sample and experimental results .....	40
D.3.1	Raw results of measurements .....	40
D.3.2	Electric field distribution in the coaxial sample .....	42
D.3.3	Space charge distribution in the coaxial sample .....	44
Bibliography	.....	46
Figure 1	– Principle of the PWP method .....	11
Figure 2	– Measurement set-up for the PWP method .....	13
Figure 3	– Sample of circuit to protect the amplifier from damage by a small discharge on the sample .....	13
Figure 4	– Diagram of the pressure wave propagation method set-up for a coaxial sample .....	17
Figure 5	– Diagram of wave propagation of PWP for a coaxial geometry sample .....	17
Figure 6	– Diagram of the propagation of pressure wave on the section of a cylinder .....	19
Figure 7	– Flowchart for the computation of the electric field in a coaxial sample from PWP measured currents .....	21
Figure A.1	– Comparison between practical and ideal pressure pulses .....	22
Figure A.2	– Original signal of the sample free of charge under moderate voltage .....	23
Figure A.3	– Comparison between original and corrected reference signals with a sample free of charge under moderate voltage .....	24
Figure A.4	– Electric field in a sample under voltage with space charge calculated from original and corrected signals .....	25
Figure A.5	– Geometrical characteristics of the reference signal for the correction coefficient estimation .....	26
Figure A.6	– Reference signal corrected with coefficients graphically obtained and adjusted .....	26
Figure A.7	– Electric field in a sample under voltage with space charge calculated with graphically obtained coefficient and adjusted coefficient .....	27
Figure B.1	– Voltage signals obtained from the oscilloscope by the amplifier with different amplifications .....	30
Figure B.2	– Current signals induced by the sample, considering the input impedance and the amplification of the amplifier .....	30
Figure B.3	– Relationship between the measured current peak of the first electrode and applied voltage .....	31
Figure C.1	– Measured current signal under –5,8 kV .....	32
Figure C.2	– First measured current signal (< 1 min) .....	33
Figure C.3	– Measured current signal after 1,5 h under –46,4 kV .....	33

Figure C.4 – Measured current signal without applied voltage after 1,5 h under –46,4 kV .....	34
Figure C.5 – Internal electric field distribution under –5,8 kV .....	34
Figure C.6 – Internal electric field distribution under –46,4 kV, at the initial state .....	35
Figure C.7 – Internal electric field distribution after 1,5 h under –46,4 kV .....	35
Figure C.8 – Internal electric field distribution without applied voltage after 1,5 h under –46,4 kV .....	36
Figure C.9 – Space charge distribution after 1,5 h under –46,4 kV .....	37
Figure C.10 – Space charge distribution without applied voltage after 1,5 h under –46,4 kV .....	37
Figure D.1 – Measured currents from the LDPE coaxial sample under different applied voltages in a few minutes .....	39
Figure D.2 – Relationships between the peak amplitude of the measured current at outer and inner electrodes and applied voltage .....	39
Figure D.3 – First measured current signal (< 1 min) for the coaxial sample .....	40
Figure D.4 – Measured current signals for the coaxial sample at beginning and after 2 h under –90,0 kV .....	41
Figure D.5 – Measured current signals for the coaxial sample after 2 h under –90,0 kV, and without applied voltage after 2 h under high voltage .....	41
Figure D.6 – Internal electric field distribution under –22,5 kV for the coaxial sample .....	42
Figure D.7 – Internal electric field distribution under –90,0 kV for the coaxial sample, at the initial state .....	43
Figure D.8 – Internal electric field distribution after 2 h under –90,0 kV .....	43
Figure D.9 – Internal electric field distribution without applied voltage after 2 h under –90,0 kV .....	44
Figure D.10 – Space charge distribution with and without applied voltage after 2 h under –90,0 kV .....	45
Table A.1 – Variants of symbols used in the text .....	27
Table D.2 – Analysis of ratio between theoretical and measured peak area for measured current signal .....	40

## 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)”). Their 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 liaising 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 of, 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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62836 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems. It is an International Standard.

This first edition cancels and replaces IEC TS 62836 published in 2020.

This edition includes the following significant technical changes with respect to IEC TS 62836:

- a) addition of Clause 12 for the measurement of space charge distribution in a planar sample;
- b) addition of Clause 13 for coaxial geometry samples;
- c) addition of Annex D with measurement examples for coaxial geometry samples;
- d) addition of a Bibliography;
- e) measurement examples for a planar sample have been moved from Clause 12 in IEC TS 62836 to Annex C.

The text of this International Standard is based on the following documents:

Draft	Report on voting
112/627/FDIS	112/632/RVD

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 International Standard 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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://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](http://webstore.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

**IMPORTANT – The "colour inside" logo on the cover page of this document 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 structures, especially high-voltage DC cables and capacitors etc., are subjected to charge accumulation and this can 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, a standardized procedure for testing how the internal electric field can be characterized has become essential for the materials used for the cables, and even the structure of these cables when considering electrodes or the junction between cables. The measurement of the internal electric field provides a tool for comparing materials and helps to establish thresholds on the internal electric field for high-voltage applications in order to avoid risks of breakdown 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 document provides a reliable point of comparison between different test results carried out by different laboratories in order to avoid interpretation errors. The method is suitable for a planar plaque sample as well as for a coaxial sample, with homogeneous insulating materials of thickness from 0,5 mm to 5 mm.

# 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, by using the pressure wave propagation (PWP) method. It is suitable for a planar and coaxial geometry sample with homogeneous insulating materials of thickness larger or equal to 0,5 mm 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

### 3.1 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>

#### 3.1.1

##### **pressure wave propagation**

procedure where a pressure wave is propagated in a material containing electric charges and the induced electric signal from electrodes is measured.

#### 3.1.2

##### **interface charge**

net layer of charges between two different materials, either two different insulators or a conductor and an insulator

#### 3.1.3

##### **space charge**

net charge inside an insulating dielectric material

### 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