IEC 60885-3

Edition 2.0 2015-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electrical test methods for electric cables –
Part 3: Test methods for partial discharge measurements on lengths of extruded power cables

Méthodes d'essais électriques pour les câbles électriques –
Partie 3: Méthodes d'essais pour la mesure des décharges partielles sur des longueurs de câbles de puissance extrudés

IEC 60885-3:2015-04(en-fr)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.060.20

ISBN 978-2-8322-2582-0

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CONTENTS

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ELECTRICAL TEST METHODS FOR ELECTRIC CABLES –

Part 3: Test methods for partial discharge measurements on lengths of extruded power cables

FOREWORD

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International Standard IEC 60885-3 has been prepared by IEC technical committee 20: Electric cables.

This second edition of IEC 60885-3 cancels and replaces the first edition, published in 1988 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- The definition of sensitivity as twice the background noise level has been removed and replaced by a practical assessment of sensitivity based on the minimum level of detectable discharge.
- References to measurements of pulse heights in mm on an oscilloscope have been replaced by measurements of partial discharge magnitude in pC.

- The order of the clauses has been revised in line with the general numbering scheme of IEC standards and to provide clarity in order to facilitate its practical use. Section 3 of the first edition (Application guide) has been removed as it is considered that background information is better obtained from the original references as listed in the bibliography.

The text of this standard is based on the following documents:

FDIS	Report on voting
20/1560/FDIS	20/1587/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60885 series, published under the general title *Electrical test methods for electric cables*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

ELECTRICAL TEST METHODS FOR ELECTRIC CABLES –

Part 3: Test methods for partial discharge measurements on lengths of extruded power cables

1 Scope

This part of IEC 60885 specifies the test methods for partial discharge (PD) measurements on lengths of extruded power cable, but does not include measurements made on installed cable systems.

Reference is made to IEC 60270 which gives the techniques and considerations applicable to partial discharge measurements in general.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60270 apply.

3.2 Symbols used in Figures 1 to 14

a_1 discharge magnitude measured with the calibrator at the end near to the detector

a_2 discharge magnitude measured with the calibrator at the end remote from the detector

C_{cal} calibrator

C_K coupling capacitor

C_x power cable

D detector

I double pulse generator

l length of the power cable

M coaxial signal cable

Q discharge magnitude

$R_1 R_2$ matching resistors

RS reflection suppressor

v propagation velocity of partial discharge

V voltage indicator

W power supply

Z impedance/filter

Z_A input unit

Z_W terminal impedance

4 Overview

4.1 General

Partial discharge measurements shall be carried out using the test techniques specified in IEC 60270.

4.2 Object

The object of the test is to determine the discharge magnitude, or to check that the discharge magnitude does not exceed a specified value, at a specified voltage and a declared minimum sensitivity.

4.3 Problem of superposition of travelling waves for long lengths

Short lengths of cable behave in the same way as a single capacitor in that the discharge magnitude can be measured directly by considering the cable as a single capacitor. However longer cables behave like a transmission line and PD pulses travel away from their source in both directions along the cable, in the form of a wave. On reaching the remote end from the measuring equipment, the pulse will be reflected with the same polarity if the end is open circuit. The reflected pulse will then travel back along the length of cable and arrive at the detector at a time after the directly received pulse. If the time between the arrival of the two pulses is short (the time difference depending on the length of the cable) then the detection instrument may give a false response, indicating either a larger or smaller magnitude of discharge than was actually the case. The methods detailed in this standard allow correct measurement of partial discharges under these conditions.

Figures 1 to 4 illustrate the behaviour of travelling waves and possible superposition effects.

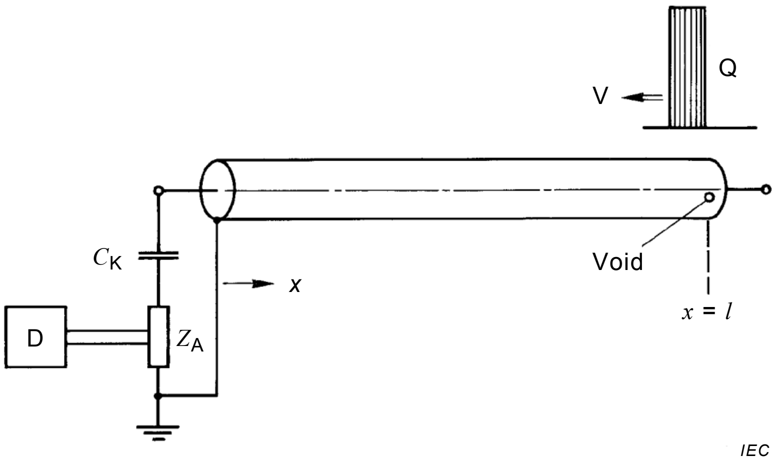

Figure 1 – Discharge site exactly at the cable end remote from the detector ($x = l$)

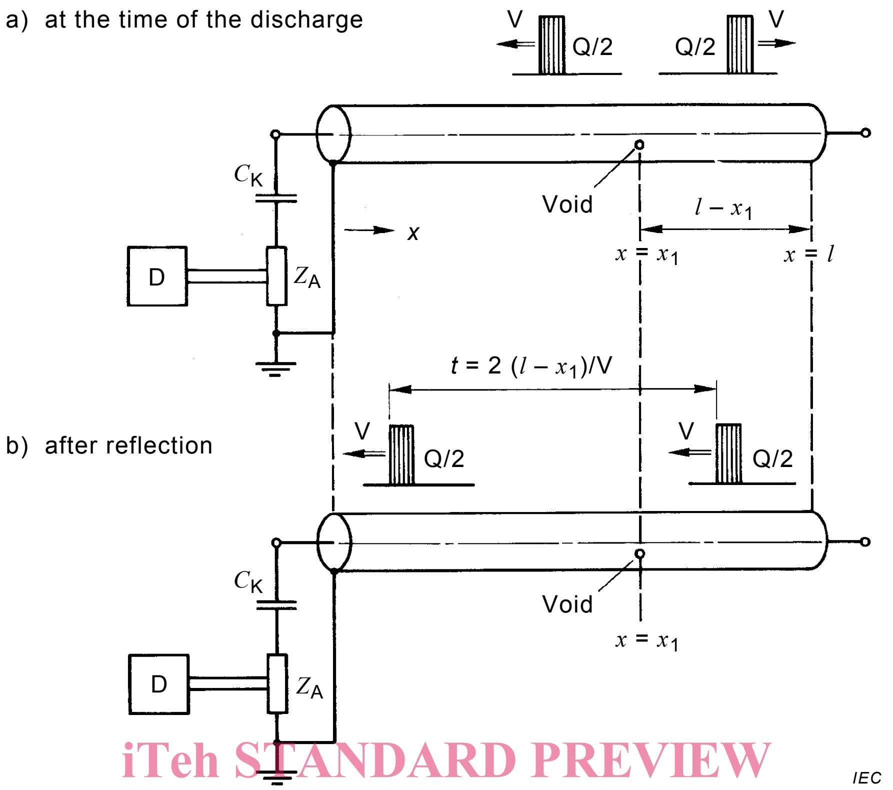

Figure 2 – Discharge site at a distance $x = x_1$ – Travelling waves

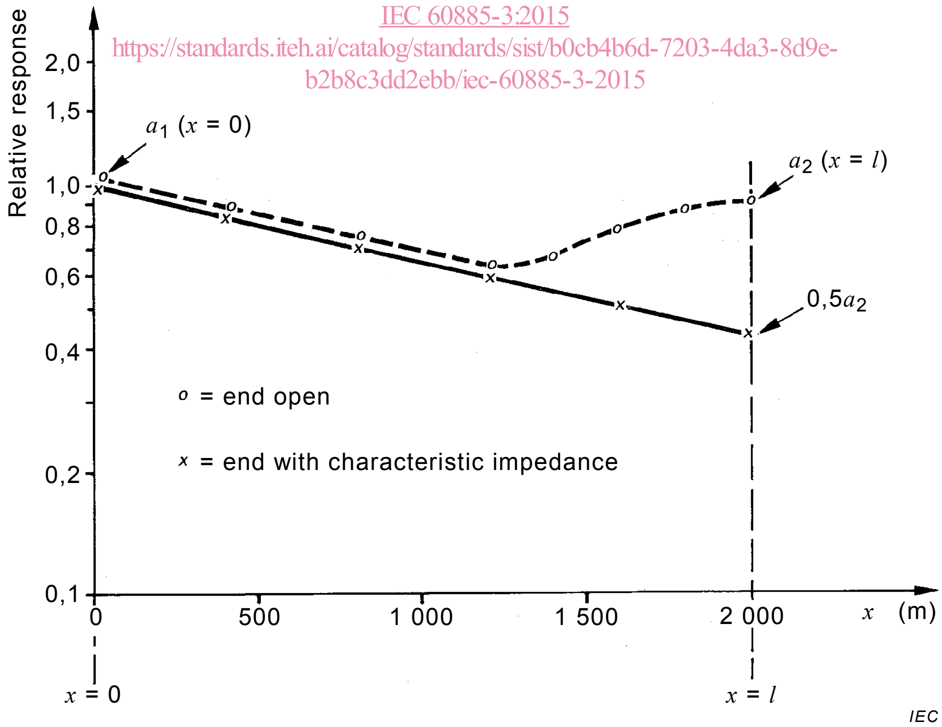

Figure 3 – Attenuation of PD pulses along the cable

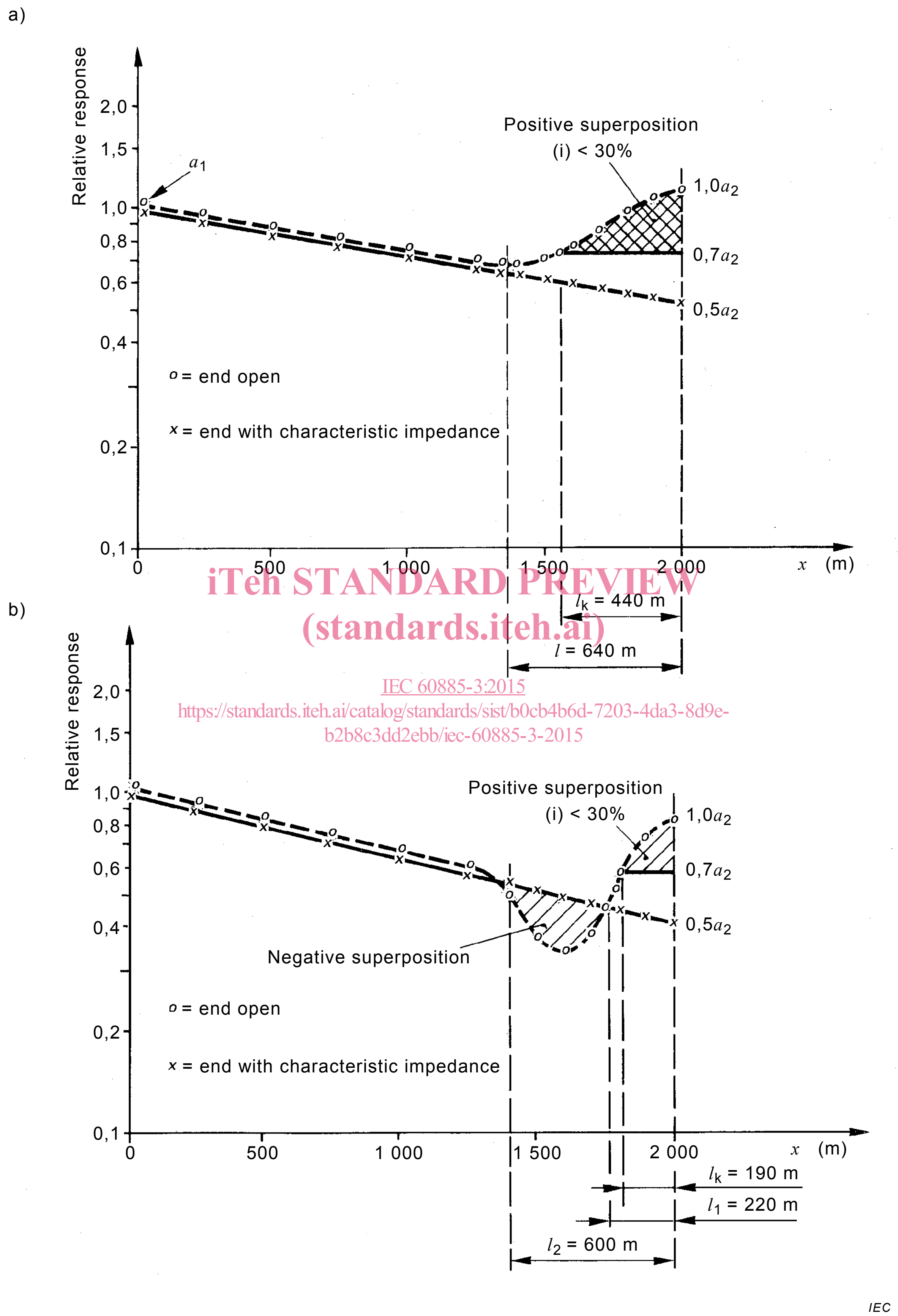

Figure 4 – Superposition and attenuation of PD pulses

5 Partial discharge tests

5.1 Test apparatus

5.1.1 Equipment

The equipment consists of a high-voltage alternating voltage supply having a rating adequate to energise the length of cable under test, a voltmeter for high voltages, a measuring circuit, a discharge calibrator, a double pulse generator and, where applicable, a terminal impedance or reflection suppressor. All components of the test equipment shall have a sufficiently low noise level to achieve the required sensitivity. The frequency of the test supply shall be in the range 45 Hz to 65 Hz with a waveshape approximating to a sinusoid with the ratio of peak to r.m.s. values being equal to √2 with a maximum tolerance of 5 %.

5.1.2 Test circuit and instruments

The test circuit includes the high voltage power supply, test object, the coupling capacitor and the HV and PD measuring equipment. The measuring circuit consists of the measuring impedance (input impedance of the measuring instrument and the input unit which is selected to match the cable impedance), the connecting lead and the measuring instrument. The measuring instrument or detector includes a suitable amplifying device, an oscilloscope, or other instrument to indicate the existence of partial discharges and to measure the apparent charge. The measuring system shall comply with IEC 60270.

5.1.3 Double pulse generator

A double pulse generator is an instrument producing two equal pulses (with the same apparent charge) following each other within a time interval which can be varied between 0,2 μs to 100 μs. The rise time of the pulses shall not exceed 20 ns (10 % to 90 % of peak value); the time between 10 % values of the front and the tail shall not exceed 150 ns. The pulses may be synchronized with the power frequency.

5.1.4 Terminal impedance

A terminal impedance is an impedance, equal in value to the characteristic impedance of the test object, which is connected to the open end of the cable remote from the detector. It may be a combination of resistance and capacitance (R & C) or resistance, capacitance and inductance (R, C & L). The components shall be suitable for operation at the test voltage to be applied to the cable under test. Additional requirements are specified in section 5.6.

5.1.5 Reflection suppressor

This is an electronic switch which is designed to block the input of the measuring instrument from pulses reflected from the open end of the cable. This is achieved by blocking the input for a fixed time after the first pulse is received.

5.2 Setting up the test circuit

5.2.1 Determination of characteristic properties of the test circuit

The characteristic properties of the test circuit should be determined under the conditions to be used. The test circuits normally used for connections to a single cable end are those shown in Figures 5, 6, 7, 8 and 9. Similar test circuits are also applicable when both ends of the cable conductor are connected together; in this case the two ends of the metal cable screen shall also be connected together.

5.2.2 Terminal impedance

If a terminal impedance is connected to the remote end of the cable under test, with an impedance value equal to the characteristic impedance of the cable then the cable will behave as if it is of infinite length and there will be no reflected wave. The circuit for connection of a terminal impedance is shown in Figure 8. The values (RC and L where applicable) of the components of the terminal impedance and its suitability for the type of cable under test should be demonstrated using the procedure described in 5.6. This check should be carried out when the test circuit is set up and also when any changes are made to the circuit.

5.2.3 Determination of superposition of travelling waves

If a terminal impedance is not used, it is necessary to determine the properties of the test circuit with respect to superposition of travelling waves. A double pulse generator is connected according to Figure 10 and a double pulse diagram is plotted (see 5.5 and Figures 11, 12 and 13). This check should be carried out when the test circuit is set up and also when any changes are made to the circuit.

5.2.4 Reflection suppressor

The purpose of using a reflection suppressor is to obtain a double pulse diagram of Type 1 corresponding to Figure 11. Using the arrangement shown in Figure 14, the efficiency of the reflection suppressor should be checked by plotting a double pulse diagram (see 5.5 and Figures 11, 12 and 13), when the test circuit is set up and also when any changes are made to the circuit.

5.2.5 Calibration of the measuring system in the complete test circuit

Calibration of the measuring system in the complete test circuit shall be carried out in accordance with Clause 5 of IEC 60270:2000. The calibrator used shall comply with IEC 60270. For long lengths of cable (> 100 m) there is an additional requirement that the calibrating capacitance shall be not greater than 150 pF.

5.2.6 Sensitivity

The sensitivity of the measuring system is defined as the minimum detectable discharge pulse, q_{min} (in picocoulombs – pC) that can be observed in the presence of background noise.

Value of q_{min} shall be determined by evaluation of the background noise level and shall be no more than twice the apparent noise level, h_{n} (h_{n} is the noise reading on the measuring instrument).

Therefore:

$$q_{\text{min}} = x \times k \times h_{\text{n}}$$

where k is the scale factor and x is the ratio of the minimum detectable discharge to the background noise. The maximum allowed value of x is 2. Typically values of x of between 1,25 and 1,5 should be achievable.

The maximum values of sensitivity shall be determined according to 5.4.

5.3 Measurement procedures

5.3.1 General

The selection of the test circuit depends on whether the cable sample may be considered as a short length (see 5.3.2) or a long length (see 5.3.3, 5.3.4 and 5.3.5). The test circuit shall be discharge free in order to achieve the required sensitivity (see 5.2.6). Calibration does not necessarily have to be done with the HV supply on (see 5.2.5). During the partial discharge measurement, individual pulses clearly identifiable as interference may be disregarded.