IEC®

IEC 60885-3

Edition 2.0 2015-04
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

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

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
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 It also gives information on projects, replaced and withdrawn publications.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
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
More than 60 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - 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: csc@iec.ch.

IEC 60885-3

Edition 2.0 2015-04
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.060.20

ISBN 978-2-8322-2617-9

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

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

ELECTRICAL TEST METHODS FOR ELECTRIC CABLES –

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

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) 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.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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.

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 publication using a colour printer.

ELECTRICAL TEST METHODS FOR ELECTRIC CABLES –

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

1 SECTION ONE – GENERAL

1 Scope

This part of IEC 60885 specifies the essential requirements 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. The first edition of IEC 60270 appeared in 1968. All references in this standard apply to the second edition (1981).

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*

2 SECTION TWO – PARTIAL DISCHARGE TESTS

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 ~~with~~ and a ~~given~~ 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.

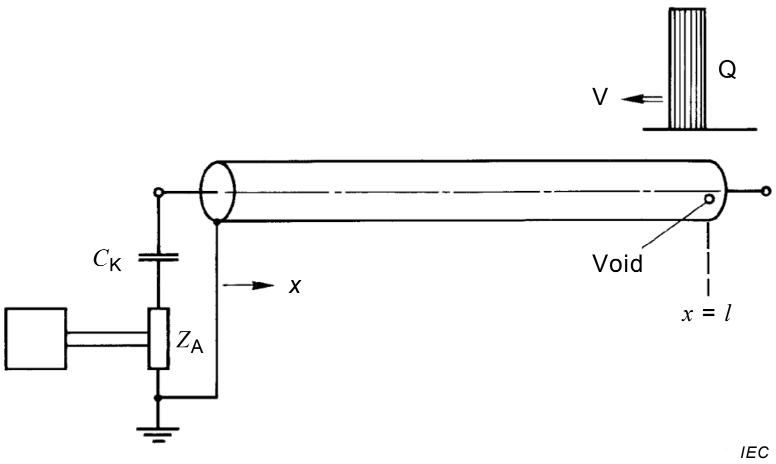

Figure 1 – Discharge site exactly at the cable end remote from the detector ($x = l$)

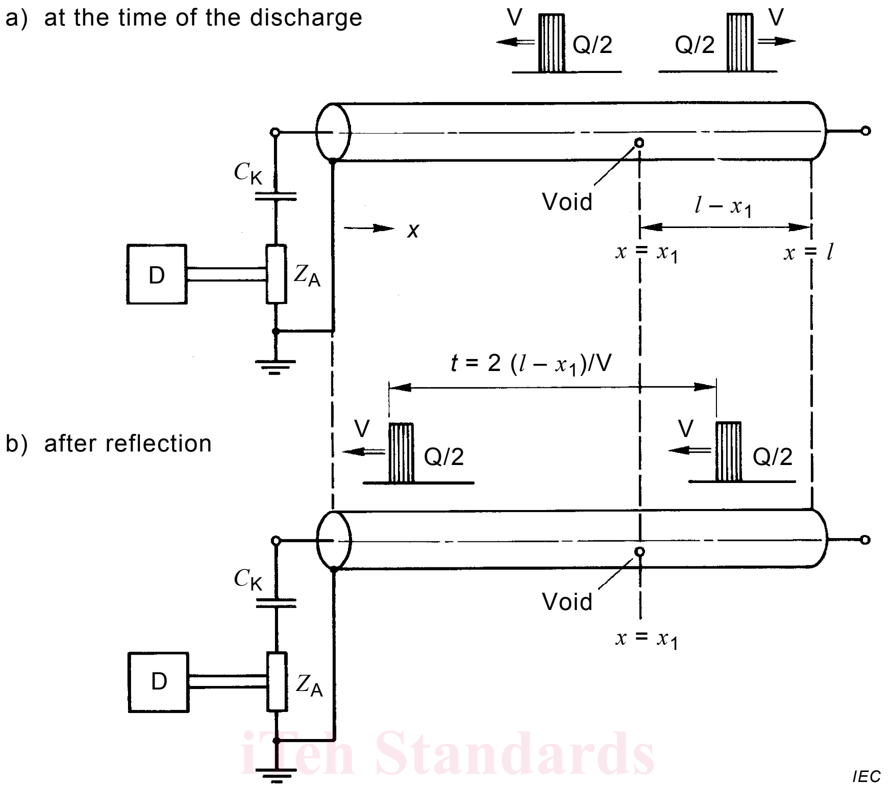

Figure 2 – Discharge site at a distance $x = x_1$ – Travelling waves

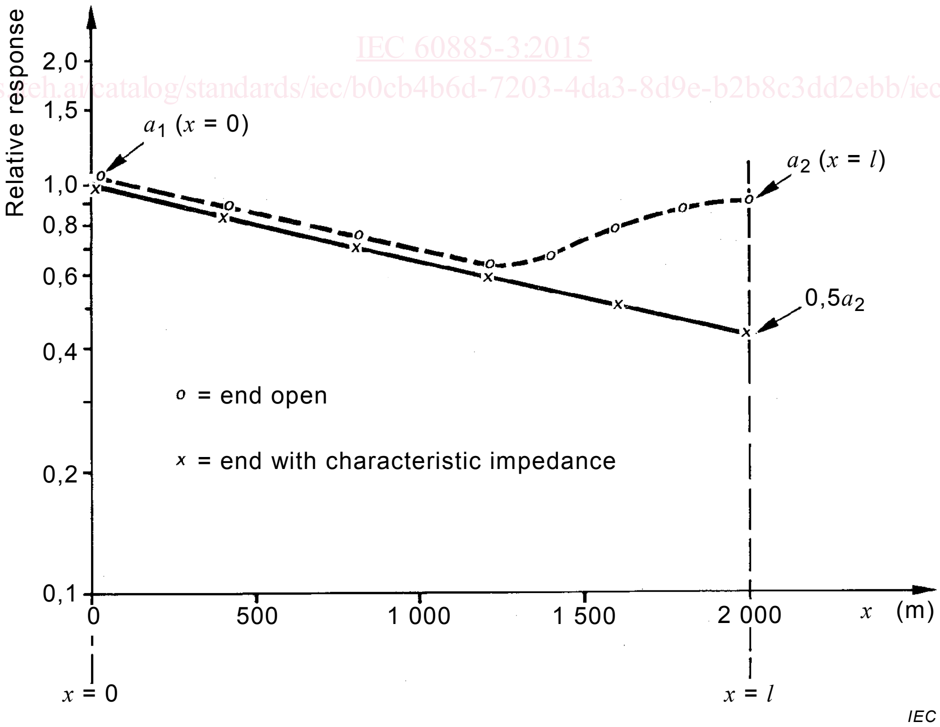

Figure 3 – Attenuation of PD pulses along the cable

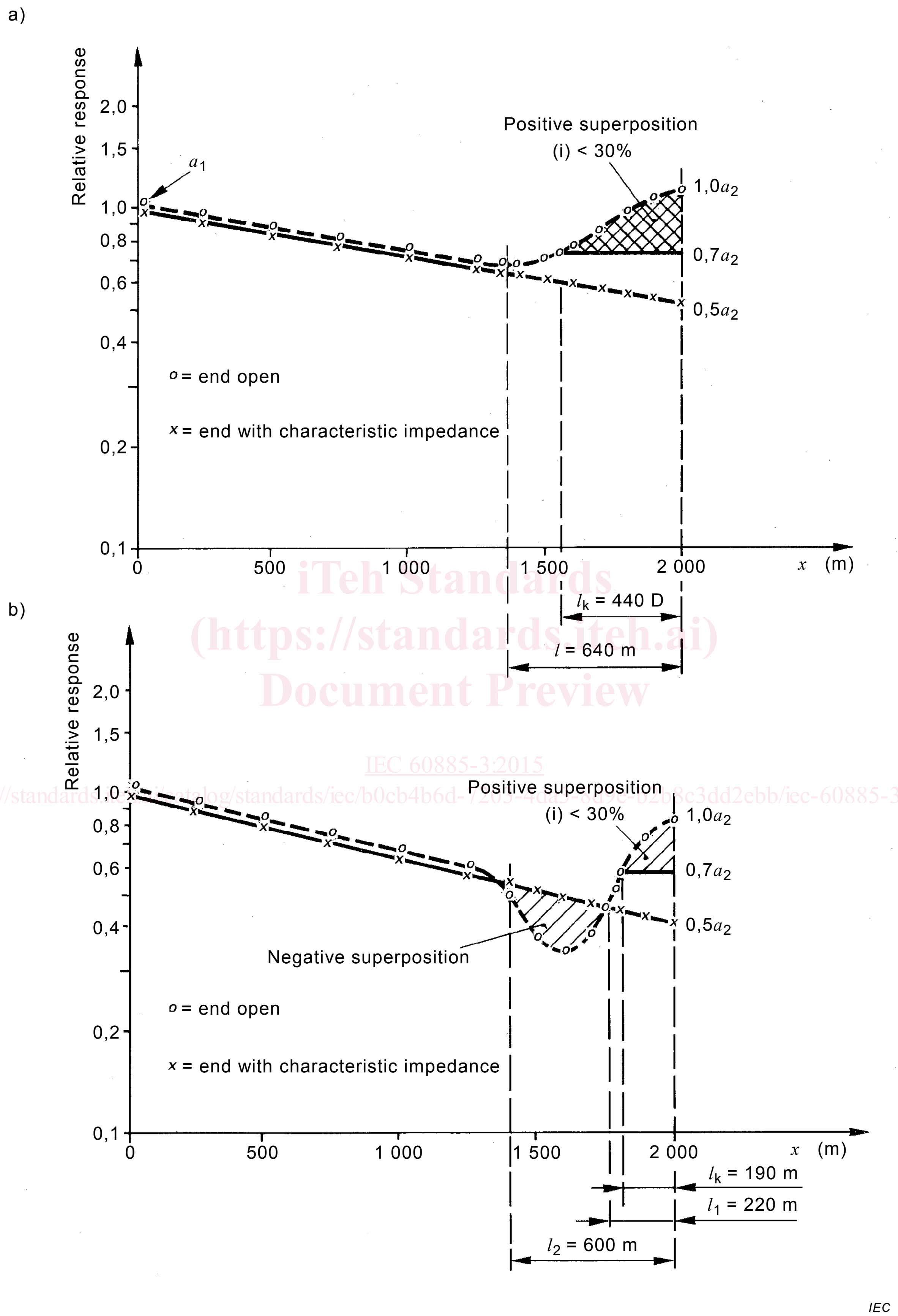

Figure 4 – Superposition and attenuation of PD pulses

5 Partial discharge tests

5.1 Test apparatus

5.1.1 Equipment

The equipment consists of a high-voltage ~~power~~ alternating voltage supply having a ~~kilovolt-ampere capability~~ rating adequate ~~for~~ to energise the length of cable under test, a voltmeter for high voltages, a measuring circuit, a discharge calibrator, a double pulse generator and, ~~if necessary~~ 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 is assumed to be the power frequency a.c. 49 Hz to 61 Hz of approximately sine-wave form, the ratio peak value/r.m.s. being equal to with a tolerance of ±7 %. The main subjects considered in this standard, calibration and attenuation of partial discharge pulses, are not affected by using different frequencies of the power supply. However, the partial discharge characteristics are affected by the test frequency; the measurement procedure should take this fact into consideration.~~

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 ~~circuit~~ 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 ~~and, if desired, an additional~~, 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

~~The properties of the partial discharge test circuit shall be checked by means of~~ A double pulse generator is an instrument producing two equal pulses (with the same apparent charge) following each other within a ~~continuously~~ 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 ~~(characteristic impedance)~~

A terminal impedance is an impedance, equal in value to the characteristic impedance of the test object ~~may be~~, which is connected to the open end of the cable remote from the detector. ~~This will suppress the reflection of pulses at this end.~~ 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

~~To avoid superposition effects when testing without a terminal impedance, a reflection suppressor may be used.~~ This is an electronic switch which ~~in most cases can~~ is designed to block the input of the ~~detector~~ measuring instrument from pulses reflected from the open end of the cable. ~~However, when the partial discharge source is located at or near the open end some positive superposition is unavoidable.~~ 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 ~~must~~ shall also be connected together.

5.2.2 Terminal impedance

~~If a terminal impedance is used (see Figure 4) its suitability for the type of cable under test should be demonstrated using the procedure described in 2.7. This check should be carried out at least once a year and also upon request and when any significant circuit component has been repaired or changed.~~

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 ~~Superposition~~ 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 ~~at least once a year and also upon request and when any significant circuit component has been repaired or changed~~ 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 ~~at least once per year and also upon request and when any significant circuit component has been repaired or changed~~ 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 ~~charge~~ of the measuring system in the complete test circuit

~~The "charge transfer" method of calibration shall be used in accordance with 5.2.1 of IEC 60270. Further guidance for the use of discharge calibrators is given in CIGRÉ Report 1968-21-01, Appendix III. In this method, a calibrator is connected directly across one end of the cable being tested to inject short current pulses of predetermined charge magnitude into the test object as detailed in 2.4. The resulting pulse on the oscilloscope should have a height of at least 10 mm.~~

~~Unless the calibrating capacitor is rated for use at the test voltages involved, it is necessary to disconnect it before the high-voltage test transformer is energized. The amplifier gain shall not be re-adjusted after this has been done, unless a means is provided for continuous display of a suitable calibrating signal throughout the test.~~

~~Such a means may be as follows:~~

a) the calibrating capacitor may be full voltage rated and may form part of the test circuit. It need not, in this case, be disconnected before the high-voltage test transformer is energized, or

b) a secondary calibrator can be used additionally. This calibrator is connected to the input of the detector. In this case, the amplitude of the secondary pulse response shall be pre-calibrated against the primary calibrator before the latter is disconnected and the high-voltage test transformer is energized in accordance with CIGRÉ Report 1968-21-01, Appendix III, Section I, Sub-clause 1.2.

The calibration discharge, q_{cal} (in picocoulombs), is equal to the product of the calibration pulse amplitude ΔU (in volts) and the calibrating capacitance C_{cal} (in picofarads), of the calibrator as long as this capacitance is small compared with the capacitance of the test object, C_x.

$$q_{cal} = C_{cal} \cdot \Delta U$$

The characteristics of the calibrating pulse shall comply with 5.2 and 5.3 of IEC 60270 and CIGRÉ Report 1968-21-01, Appendix III, Section III. For long lengths of cable there is an additional requirement that the calibrating capacitance shall be not larger than 150 pF.

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

a) The sensitivity of the test circuit (with the high-voltage supply and the instruments) 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. Individual, clearly identifiable interference pulses may be disregarded. An oscilloscope display is required to monitor noise signal levels since a picocoulomb meter does not identify the source of the signal indicated. In order to be detectable, a discharge pulse shall be of at least twice the apparent noise height, h_n (h_n is the noise reading on the oscilloscope or the picocoulomb meter if this is used additionally).

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:

$$q_{min} = 2\,k \cdot h_n$$

$$q_{min} = x \times k \times h_n$$

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.

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

5.3 Measurement procedures

The test shall be carried out as a type test on short cable samples and as a routine test on production lengths.