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Method for spark testing of cablesEssai diélectrique au défilement à sec
des câbles électriquesDurchlaufspannungsprüfung an
elektrischen Kabeln und Leitungen

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CENELECEuropean Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 20, Electric cables.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50356 on 2002-03-01.

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Contents

Introduction.....	4
1 Scope.....	5
2 Types of voltage waveform	5
3 Procedure.....	5
4 Equipment.....	5
5 Test voltages.....	8
6 Sensitivity.....	8
7 Calibration.....	9
Annex A (informative) Recommended minimum voltage levels	14
Annex B (informative) Example of an artificial fault device	16
Annex C (informative) Notes on the use of spark testing machines	17
Bibliography	18
Figure 1 — Requirements for pulsed waveforms – Rise time	11
Figure 2 — Requirements for pulsed waveforms – Fluctuation of peak value and pulse repetition rate	12
Figure 3 — Requirements for pulsed waveforms – Pulse duration	13
Figure B.1 — Needle for use in the artificial fault device	16

<https://standards.iteh.ai/catalog/standards/sist/55083e21-10c9-4ddc-929f-4e05bbbf57/sist-en-50356-2002>

Introduction

The practice of using spark-testers to detect defects in the insulation or sheathing layers of electric cables has been developed over many years of practical experience.

The operation of the equipment using the verification method described in this document has proved to be satisfactory. This method employs an artificial fault simulator and its performance has been shown to be comparable to that using operational efficacy tests involving the detection of artificially prepared defects (i.e. faults in the insulation/sheathing material) in lengths of cable.

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1 Scope

The spark-test method specified in this standard is intended for the detection of defects in the insulation or sheathing layers of electric cables. For single core cables with no outer metallic layer, the general process is accepted as being equivalent to subjecting samples of those cables to a voltage test in water.

This standard specifies the operational requirements for the spark-test equipment, as well as the principal characteristics, functional parameters and calibration procedures for each type of test equipment.

2 Types of voltage waveform

For the purposes of this standard, the types of voltage waveform used for spark-testing are divided into the following groups:

- a.c.** an alternating current (a.c.) voltage of approximately sine-wave form, at the industrial frequency of 40 Hz to 62 Hz;
- d.c.** a direct current (d.c.) voltage;
- h.f.** an alternating current (a.c.) voltage of approximately sine-wave form, at frequencies between 500 Hz and 1 MHz;

pulsed a voltage waveform comprising a fast rise time and highly damped wave-tail, as defined in 4.2.

NOTE Provided the manufacturer can demonstrate equivalent effectiveness, h.f. voltages at frequencies below 500 Hz may be used.

3 Procedure

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The insulated conductor or sheathed cable shall be passed through an electrode energised at the test voltage. The method detailed in this standard provides for the application of a.c., d.c., h.f. and pulsed voltages.

The requirements for voltage waveform, frequency and test voltage are given in 4.2 and clause 5. The maximum speed at which the cable shall pass through the electrode is determined by the minimum residence time specified in 4.6.

When used as an alternative to a voltage test in water, it is recommended that the test be restricted to layer thicknesses not greater than 2,0 mm and to a.c. and d.c. test voltages.

The requirements are not applicable to cable insulation having a rated voltage (U_0) greater than 3 kV.

Annex A provides recommended voltages for each voltage waveform, to be used in the absence of any alternative voltages in the relevant cable standard.

4 Equipment

4.1 Safety

To limit the effect of electrical shock to personnel, for all types of voltage source, the equipment shall be constructed such that the short-circuit current is limited to less than 10 mA r.m.s. or equivalent.

This requirement is additional to, or may be superseded by, any national regulation that prevails at the time.

NOTE Guidance on the limiting of shock currents can be found in IEC 60479-1 and IEC 60479-2.

Further aspects of operational safety are given in Annex C.

4.2 High voltage source

The high voltage electrode shall be supplied in one of the following forms, as defined in clause 2: a.c., d.c., h.f. or pulsed.

For a d.c. test, connection to the test electrode shall be by means of a low capacitance unscreened lead. For d.c. and pulsed voltage testing, the test electrode may be either positive or negative polarity, the other pole being earthed.

The requirements for pulsed waveforms are presented in Figures 1, 2 and 3.

For pulsed waveforms, the rise time of the wave front shall reach 90 % of the specified peak value in less than 75 μs – see Figure 1. Fluctuations of the actual peak value, due to variations of input power into the generator, shall not exceed $\pm 2\%$ of the specified peak value – see Figure 2. The peak value shall not show more than 5 % reduction in the event of an increase of capacitive load of 50 pF, during the operation, from an initial load of 25 pF between electrode and instrument ground. The time that each pulse remains at a voltage greater than 80 % of the specified peak voltage shall be between 20 μs and 100 μs – see Figure 3. The pulse repetition frequency shall be greater than 170 per second and less than 500 per second. This corresponds to pulse separations between 2 000 μs and 5 880 μs . Visible or audible corona shall be evident in the electrode structure when operating at the specified voltage.

4.3 Voltage monitoring equipment

For a.c., d.c. and h.f. sources, the voltage between electrode and earth shall be displayed on a meter either by connection directly to the output terminal of the high voltage source or by any suitable equivalent arrangement. The measurement system shall have an accuracy of $\pm 5\%$ of the indicated value.

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For a pulse source there shall be a peak reading instrument voltmeter connected directly to the electrode, continually indicating the voltage at the electrode, with or without a grounded test wire in the test chamber. The peak reading voltmeter shall indicate full deflection at a peak value not exceeding 25 kV and with a precision level of $\pm 5\%$ of the indicated value.

NOTE If the spark-tester is to be controlled remotely, it should be noted that the current drawn by the cable under test can cause variation of the test voltage. In this situation, the regulation of the voltage source needs to be sufficient to maintain the voltage within the 5 % accuracy limit.

4.4 Fault indicator

There shall be a detection circuit to provide a visible and/or audible indication of failure of the insulation or sheath to maintain the specified voltage. The fault detector shall be arranged to operate a digital display counter such that one count per discrete fault is registered. It shall also be of a totalizer type and cumulative to the end of the cable run. The counter shall maintain the indication until either the next succeeding fault is registered or until the indication is manually cancelled.

4.5 Electrodes

An appropriate choice of electrode shall be made in order to obtain the maximum effective rate of detection.

Types of cable to be tested (construction, materials, etc.) and the test conditions (linear speed, voltage source mode, etc.) form some of the parameters to be considered.

Examples of electrode types are

- contact types:
 - bead chain, spring loaded hyperbola, brushes (rotating or fixed),
- non-contact types:
 - metallic tube, rings.

4.6 Design of electrodes

4.6.1 Contact type

The electrode shall be of metallic construction and its length shall be such that every point of the insulated conductor or non-metallic sheath under test is in electrical contact with the electrode for times not less than the following:

- a) for a.c. supply to the electrode: 0,05 s

NOTE 1 This time represents a maximum linear throughput speed of 1,2 m/min per millimetre of electrode. The minimum length of the electrode (mm) is therefore given by $0,833 v$, where v is the linear throughput speed in m/min.

- b) for d.c. supply to the electrode : 0,001 s

NOTE 2 This time represents a maximum linear throughput speed of 60 m/min per millimetre of electrode. The minimum length of the electrode (mm) is therefore given by $0,017 v$, where v is the linear throughput speed in m/min.

- c) for h.f. supply to the electrode: $\frac{0,0025}{f}$ s

where f is the supply frequency in kHz.

NOTE 3 This time represents a maximum linear throughput speed of $24 f$ m/min per millimetre of electrode. The minimum length of the electrode (mm) is therefore given by $0,042 v/f$, where v is the linear throughput speed in m/min.

- d) for pulse supply to the electrode: $\frac{2,5}{p}$ s

where p is the pulse repetition rate in pulses per second.

NOTE 4 This time represents a maximum linear throughput speed of $24 p$ m/min per millimetre of electrode. The minimum length of the electrode (mm) is therefore given by $0,042 v/p$, where v is the linear throughput speed in m/min.

4.6.2 Non-contact type (d.c. test only)

The electrode shall consist of a cylindrical metal tube or series of metallic rings. In either case the internal diameter(s) shall not be greater than 15 mm. In the case of the ring type, the number of rings shall be such that a uniform electric field is formed. These electrodes shall only be used with a d.c. source and their length shall be such that every point of the insulated conductor or non-metallic sheath is in the electrode for not less than 0,001 s.

NOTE This time represents a maximum linear throughput speed of 60 m/min per millimetre of electrode. The minimum length of the electrode (mm) is therefore given by $0,017 v$, where v is the linear throughput speed in m/min.

The design of the non-contact electrode shall be such that the cable under test is guided by any suitable means along the central axis and be maintained in that position without undue deviation for the duration of the test run.

The maximum recommended overall diameter of the core or cable to be tested using the non-contact electrode system is 3,0 mm.

The use of this type of electrode shall be restricted to a test voltage of 18 kV.

5 Test voltages

The test voltage depends upon the type of electrode used and the voltage waveform applied.

The voltage is related to the total layer thickness being subjected to the test. This may be an insulation layer, a sheath over a metallic layer, or a combination of insulation and sheath with no intermediate metallic layer.

The conductor of the cable under test, or the metallic layer underlying the sheath under test, shall be continuously earthed throughout the test, such that the full test voltage is applied between the test electrode and this earthed component of the cable.

The magnitude of the test voltages are to be found in the cable standard. In the absence of such specified voltages, use can be made of the recommended test voltages given in Annex A.

6 Sensitivity

6.1 a.c., d.c. and h.f. voltages

The sensitivity of the spark test equipment shall be such that the fault detector will operate when an artificial fault is connected between the electrode and earth. The method is given in 6.3.

The performance requirement for each type of voltage source is given below:

a.c. and h.f.

The typical fault is defined as a fault current

- a) between 0,5 mA and 10 mA in conformity with the technical characteristics of the test equipment,
- b) at a minimum repetition frequency of 1 pulse per second,
- c) with a minimum current duration of 0,025 s,
- d) with a minimum series of 20 pulses.

d.c.

The typical fault is defined as a fault current as above for a.c. and h.f. conditions except that the minimum current duration shall be 0,000 5 s and at a level between 0,1 mA and 10 mA.

6.2 Pulsed voltages

The sensitivity shall be such that the fault detector will operate when a typical fault is present between electrode and earth.

The typical fault is defined as that generated through a 0,5 M Ω resistor by one pulse over its operating voltage range.

6.3 Method of assessment

NOTE 1 To check the absence of interference on fault detection through the corona effect it is necessary to test a number of lengths of fault free cable at the maximum voltage. No single fault should be detected.

The no-load electrode voltage shall be set initially at 3 kV r.m.s. (a.c. and h.f. systems) or 5 kV for d.c. systems or the minimum test level if greater. When the artificial fault device is connected to the electrode, with the spark gap temporarily short circuited, the steady state current shall not exceed 600 μ A. In order to limit the current to a suitable value an impedance may be added in series with the artificial fault device.

NOTE 2 Where the test is to be used as an in-process check in addition to the final voltage test on the cable, the sensitivity test at 3 kV r.m.s. or 5 kV d.c. may be carried out at a steady state current of 1,5 mA. This would be appropriate if the normal operating conditions are such that a sensitivity setting of less than 1,5 mA during production would lead to spurious tripping of the detector.

The artificial fault device shall be set to produce a spark having a maximum duration of 0,025 s for a.c. and h.f., or 0,000 5 s for d.c., for each simulated fault.

A succession of not less than 20 sparks (as specified above) shall be effected, with consecutive sparks being no more than 1 s apart and, if required, with the current-limiting impedance in series with the gap. The fault indicator shall register neither more nor less than one count per spark.

The current-limiting impedance, if any, shall then be short circuited. A fault-free length of cable, presenting the largest capacitive load with which the spark tester is to be used, shall be inserted into the electrode. Alternatively, a high voltage capacitor having the equivalent capacitance shall be connected across the gap. The electrode voltage shall be increased to the maximum required test voltage.

The test shall then be repeated in order to establish that 20 further sparks (no more than 1 s apart) cause the fault indicator to register neither more nor less than one count per spark.

NOTE 3 Separate artificial fault devices may be used for the two tests, in order to limit damage caused by the high energy sparks, for example by erosion of spark gaps.

NOTE 4 Details of one common type of artificial fault device are given in Annex B.

7 Calibration

7.1 General

Verification of the performance of the equipment for a.c., d.c. and h.f. voltage sources shall be carried out using the sensitivity determination specified in 6.3 for a.c., d.c. and h.f. voltage sources.

The pulse type equipment shall be calibrated by means of a peak detecting electronic voltmeter connected directly between the electrode head and ground. The pulse generator shall be energized and the voltage control of the pulse generator shall be adjusted until the reading on the calibration voltmeter is the specified voltage, at which point the reading on the instrument voltmeter shall be observed and recorded. This calibration shall be repeated at each specified peak voltage. The pulse waveform shall be monitored by means of an oscilloscope connected to the electrode head at suitable test points.

NOTE Calibration may be accomplished without a test cable in the electrode, in which case the voltage control on the pulse generator may require a different setting for each cable size in order to give the desired reading on the instrument voltmeter; or the calibration may be made with a load of 20 pF to 60 pF. The equipment may also be calibrated against an oscilloscope with a calibrated and compensated attenuator. The chosen method should have an accuracy of ± 2 %.

7.2 Verification frequency

The test system may be demonstrated to be effective by carrying out the sensitivity assessment in clause 6. It is recommended that the verification is carried out at least once a year, upon initial installation and after any repairs or major adjustments to the equipment.