



BSI Standards Publication

## Impulse tests on cables and their accessories

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—The text of this standard is the identical text of EN 60230:2018.

## National foreword

This British Standard is the UK implementation of EN IEC 60230:2018. It is identical to IEC 60230:2018. It supersedes BS EN 60230:2002, which will be withdrawn on 14 February 2021.

The UK participation in its preparation was entrusted to Technical Committee GEL/20/16, Electric Cables - Medium/high voltage.

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

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Date	Text affected
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EUROPEAN STANDARD

**EN IEC 60230**

NORME EUROPÉENNE

EUROPÄISCHE NORM

March 2018

ICS 29.060.20

Supersedes EN 60230:2002

English Version

**Impulse tests on cables and their accessories  
(IEC 60230:2018)**Essais de choc des câbles et de leurs accessoires  
(IEC 60230:2018)Stoßspannungsprüfungen an Kabeln und deren Garnituren  
(IEC 60230:2018)

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## European foreword

The text of document 20/1769A/FDIS, future edition 2 of IEC 60230, prepared by IEC/TC 20 "Electric cables" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60230:2018.

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) 2018-11-14
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2021-02-14

This document supersedes EN 60230:2002.

## Endorsement notice

The text of the International Standard IEC 60230:2018 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 60060-2      NOTE      Harmonized as EN 60060-2.

**Annex ZA**  
(normative)

**Normative references to international publications  
with their corresponding European publications**

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NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: [www.cenelec.eu](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60060-1	2010	High-voltage test techniques -- Part 1: General definitions and test requirements	EN 60060-1	2010

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## IMPULSE TESTS ON CABLES AND THEIR ACCESSORIES

## FOREWORD

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International Standard IEC 60230 has been prepared by IEC technical committee 20: Electric cables.

This second edition cancels and replaces the first edition published in 1966. This edition constitutes a technical revision.

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

- a) the structure of the standard takes into account the current style of IEC standards;
- b) this document is no longer a "Recommendation" but an "International Standard";
- c) the test installation is no longer related to gas-pressure and oil-filled cables only;
- d) switching-impulse voltage and superimposed impulse voltage tests have been included;
- e) for the measuring system the reference to IEC 60060-2 has been added. The reference to the sphere gap method has been moved to Annex B.

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

FDIS	Report on voting
20/1769A/FDIS	20/1779/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.

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.

A bilingual version of this publication may be issued at a later date.

## IMPULSE TESTS ON CABLES AND THEIR ACCESSORIES

### 1 Scope

This document defines the procedure for carrying out withstand lightning and switching impulse tests and withstand superimposed impulse test on cables and their accessories.

This document applies solely to the methods of carrying out the tests as such, independently of the problem of selecting the test levels to be specified. The voltages pertaining to the system on which cables and accessories are to be used are given in IEC 60183 or in the relevant product standard.

This document specifies the following requirements:

- the characteristics and state of the test installation and those parts of the procedure which are common to withstand tests and tests above the withstand level;
- the procedure for carrying out withstand lightning and switching impulse tests and superimposed impulse test;
- the procedure for carrying out tests above the withstand level which is intended for research purposes.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in the relevant product standards and the following 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

##### **superimposed impulse voltage**

impulse voltage applied to a test object which is at the same time energized by a DC voltage

Note 1 to entry: The superimposed impulse voltage falls under the definition of composite voltage given in IEC 60060-1:2010, 9.2.

### 4 Characteristics of the test object to be subjected to the tests

The test object shall have been previously subjected to the test protocol as required by the relevant IEC product standards.

If not specified in the reference IEC product standards, the following conditions shall be maintained:

- If the test object is not intended to include any other accessory, the length of the sample taken shall be such that the length of free cable between the terminations is at least 5 m.
- Where one joint is included in the test object, the minimum length of free cable, between the joint and terminations shall be 5 m. Where more than one joint is included, the same requirement shall be observed and in addition there shall be a minimum length of 3 m of free cable between successive joints.

## 5 State of the test object to be subjected to the test

The test object shall be maintained under the following conditions.

- Pressure conditions, if any:  
For gas-pressure and oil-filled cables, the pressure shall be adjusted in accordance with the relevant IEC standard.
- Temperature conditions:  
The temperature conditions and the method of temperature measurement shall be as described in the relevant IEC standard, but other methods of temperature measurement may be used by agreement between the purchaser and the manufacturer.

## 6 Lightning impulse voltage

The peak voltage level of the lightning impulse is specified in the relevant product standard or contractual agreements. The lightning impulse voltage to be applied shall be a standard lightning-impulse voltage as specified in IEC 60060-1 with the exception that the front time  $T_1$  shall be between 1  $\mu$ s and 5  $\mu$ s.

## 7 Switching impulse voltage

The peak voltage level of the switching impulse is specified in the relevant product standard.

The switching impulse voltage to be applied shall be a standard switching impulse voltage as specified in IEC 60060-1.

## 8 Superimposed impulse voltage test

### 8.1 General

The superimposed impulse voltage test shall be carried out on HVDC cable systems. The peak voltage level of the switching impulse is specified in the relevant product standard.

When a superimposed impulse voltage test is required, Clause 8 shall be applied in addition to the other clauses of this document.

### 8.2 Test setup

Some possibilities are given to apply an impulse voltage to a test object which is at the same time energized by a DC voltage; Annex C illustrates the possible superimposed impulse test circuit arrangements.

### 8.3 Time parameters

The time parameters shall meet the requirements of Clause 6 or Clause 7 and shall be determined with the DC voltage source set to zero output or disconnected, i.e. without energizing the test object by a DC voltage and with the spark gap (as applicable) short-circuited. Once the time parameters have been determined, there shall be no changes to the test setup other than connecting the DC voltage source and removing the short-circuit across the spark gap.

The time parameters are to be determined in this way because a base level around 0 kV is required by IEC 60060-1.

### 8.4 Application of the DC voltage

Before the impulses are applied to the test object, if required, the test object shall be energized by a DC voltage with a level and duration and polarity as specified in the product standard.

The application of the impulses is given in Clause 10.

## 9 Measuring system

The preferred method to measure the impulse voltage is by using an approved measuring system according to IEC 60060-2.

Alternatively, the method described in Annex B may be used at the discretion of the manufacturer.

## 10 Application of the impulses

Both ends of the test object shall be connected to the impulse generator (via the spark gap or blocking capacitor in the case of a superimposed impulse test).

For an impulse test, the test object shall be subjected to a series of 10 positive impulses and 10 negative impulses at the voltage and shape as specified. For a superimposed impulse test the polarity, method of application of impulses and rest periods between DC polarity changes shall be as given in the relevant product standard.

As a means of conditioning the test object when using an approved measuring system, each series of 10 impulses may be preceded by one or more impulses of the same polarity at a level of approximately 50 %, 65 % and 80 % of the voltage and shape specified.

At least the first and tenth impulses at the voltage and shape specified shall be recorded, in each series.

The impulses at the lower level may be recorded.

The ambient temperature, the cable temperature and, where applicable, the gas or oil pressure shall be recorded.

When, for research purposes, lightning-impulse tests to levels above the withstand level are made, the procedure according to Annex A is recommended.

## **Annex A** **(informative)**

### **Tests above the withstand level**

#### **A.1 General**

Annex A deals with the application of lightning-impulse test above the specified withstand level and the omission of power-frequency test.

When, for research purposes, lightning-impulse tests to levels above the withstand level are made, the procedure given below is recommended.

In this case, the power-frequency test at ambient temperature, specified in the relevant product standard or contractual agreements may be omitted, provided that there is no doubt that the test object has successfully passed the lightning-impulse withstand voltage test. If the last oscillogram does not show this clearly, further lightning-impulse voltages may be applied at withstand level to obtain a good oscillogram.

#### **A.2 Procedure for tests above the withstand level**

##### **A.2.1 General sequence of lightning-impulse tests**

With the temperature conditions as specified, lightning-impulses shall be applied in the following sequence:

- 1) 10 negative lightning-impulses at withstand voltage plus approximately 5 %;
- 2) 5 positive lightning-impulses, the first at 50 % of the value used for 1) and the remainder at progressively increasing values up to 85 % of the value used for 1);
- 3) 10 positive lightning-impulses at withstand voltage plus approximately 5 %;
- 4) 10 positive lightning-impulses at withstand voltage plus approximately 10 %;
- 5) 5 negative lightning-impulses, the first at 50 % of the value used for 4) and the remainder at progressively increasing values up to 85 % of the value used for 4);
- 6) 10 negative lightning-impulses at withstand voltage plus approximately 10 %.

##### **A.2.2 Tests beyond withstand level**

The sequence specified in A.2.1 shall be repeated, the test voltage being increased in steps of approximately 5 %. Thus, steps 7) to 9) will be at withstand voltage plus approximately 15 %; steps 10) to 12) at withstand voltage plus 20 %; and so on.

The test shall continue until the desired voltage is reached, or until breakdown occurs.

At least the first and tenth impulses of each series of 10 impulses shall be recorded in each series.

The impulses of each series of 5 impulses may be recorded.

##### **A.2.3 Re-calibration of the generator**

In case an approved measuring system is used, A.2.3 is not applicable.

In case an approved measuring system is not used, then, in general, no recalibration of the generator is necessary throughout this series of tests and the voltage can be determined by extrapolation from the original calibration. When, however, the margin between the test voltage and the maximum voltage used for the original calibration is considered too large for accurate results, a fresh calibration as described in Annex B may be necessary.

## **Annex B** (normative)

### **Calibration of impulse generator**

#### **B.1 General**

Annex B is only applicable when an approved measuring system according to IEC 60060-2 is not used.

#### **B.2 Calibration of impulse generator**

Immediately before or during the period when the temperature of the cable is maintained at a constant value, preparatory to the application of the impulses, the generator shall be calibrated, with positive polarity, under the following conditions.

Both ends of the test assembly shall be connected to the impulse generator. A measuring sphere-gap and an oscillograph, with its associated voltage divider, shall be connected in parallel and remain so connected throughout the test.

For every setting of the sphere-gap, the charging voltage of the generator shall be so adjusted as to give 50 % flashover of the gap (see IEC 60060-1:2010, Annex A) and an oscillogram of the impulse voltage shall be taken. This procedure shall be carried out for at least three different settings of the sphere-gap. The settings shall be so selected that their 50 % flashover voltages are approximately 50 %, 65% and 80 % of the test level specified.

A curve showing the charging voltage as a function of the sphere-gap flashover voltage shall be drawn for this positive polarity. This curve, which should be a straight line, shall be extrapolated to determine the charging voltage necessary to obtain the specified level with positive polarity.

The ratio of the voltage divider shall be so selected for this polarity as to take into account the maximum flashover voltages for the sphere-gap and the voltage oscillograms that have to be obtained. This value for the ratio of the voltage divider shall be used for all the oscillograms taken in the course of the series of tests with this polarity.

#### **B.3 Application of the impulses at the level specified**

With the sphere-gap setting increased so that no flashover occurs across the gap, and with the cable maintained at the required temperature, the test installation shall be subjected to a series of 10 positive impulses at the voltage specified. The time interval between two successive impulses shall be just sufficient to ensure that the impulse generator is charged at the correct voltage.

Immediately after the application of the 10 positive impulses, the generator shall be re-calibrated for negative polarity under the conditions specified in Clause B.2 and a series of 10 negative impulses of the same specified voltage shall then be applied to the test assembly.

Oscillograms shall be taken of at least the first and tenth impulses in each series. The oscillograms shall include a timing oscillation.

The ambient temperature, the cable temperature and, where applicable, the gas or oil pressure, shall be recorded during the test.

## Annex C (normative)

### Test circuits for superimposed impulse voltage test

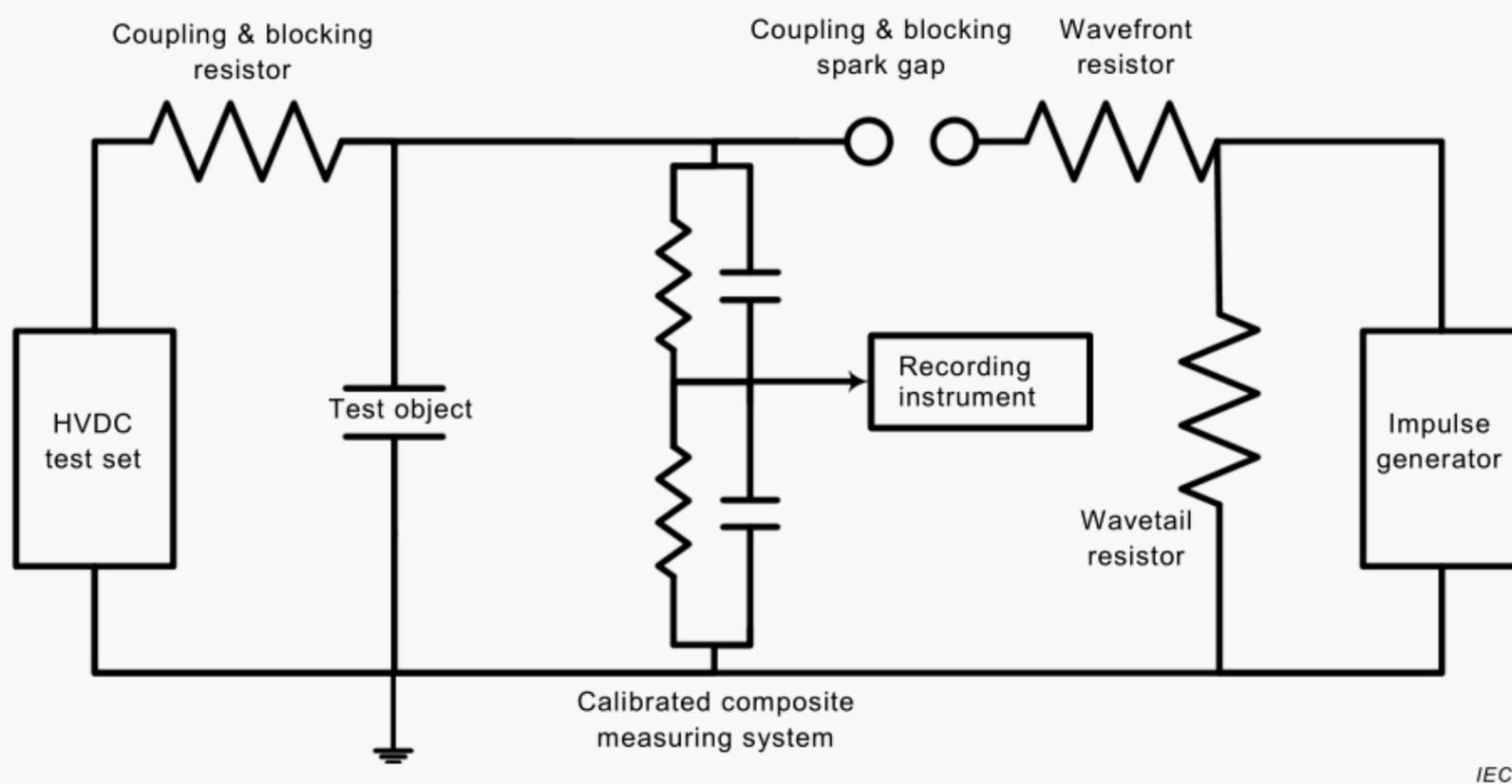
#### C.1 General

Figures C.1 and C.2 indicate possible configurations of the superimposed impulse voltage test circuits.

Circuits using a blocking capacitor will require a higher voltage to be applied from the impulse generator for a given output voltage at the test object than circuits using a spark gap (due to the voltage drop across the blocking capacitor).

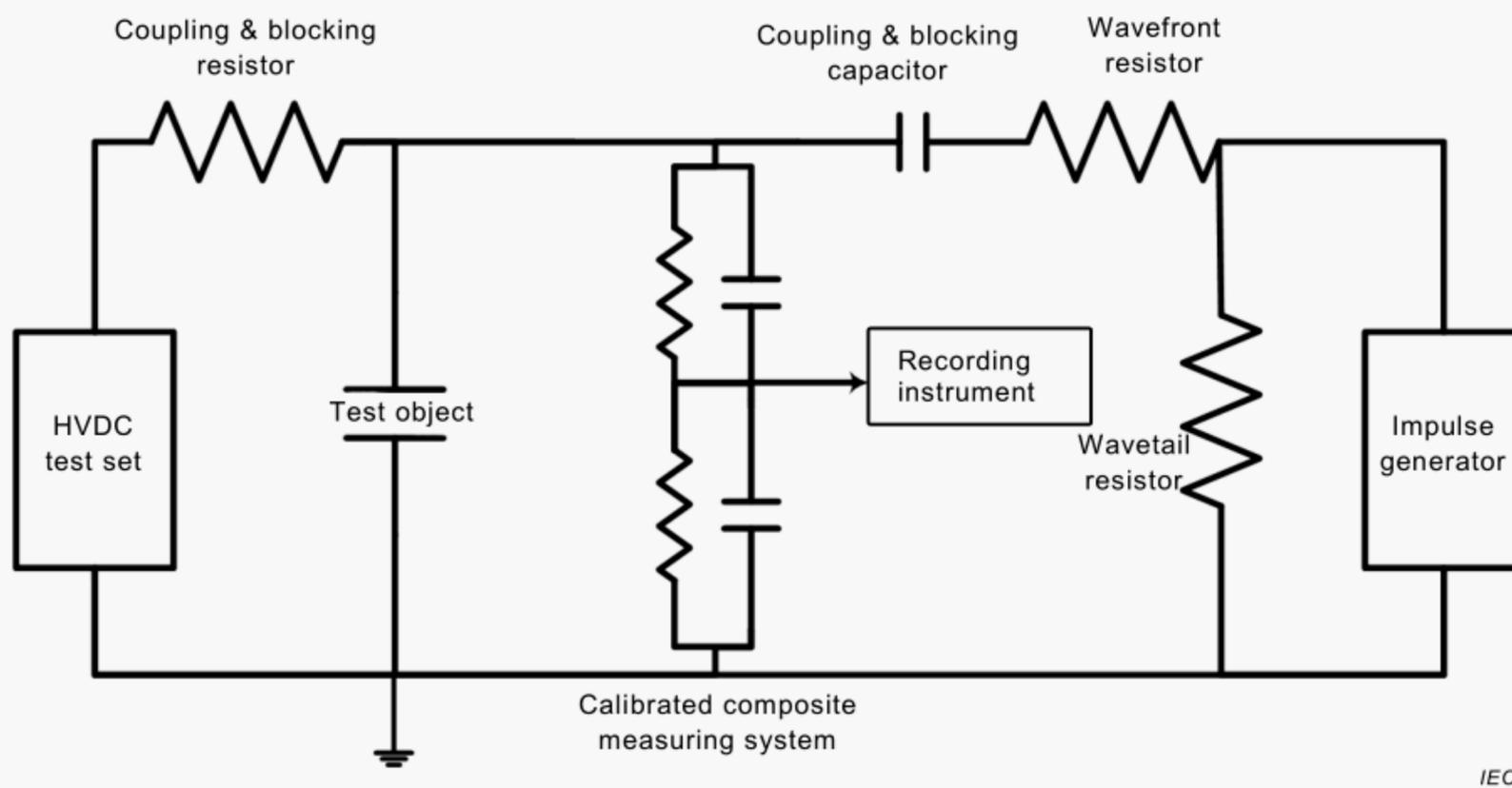
NOTE 1 When using a spark gap circuit (set at the impulse generator) and when the DC and impulse polarities are opposite, the applied impulse voltage is similar to that impulse voltage when no DC voltage were present (measured in 8.3); it is not the difference between the DC level and impulse level of opposite polarity.

NOTE 2 If the DC and impulse voltages are of the same polarity, the careful adjustment of the spark gap avoids flashover under the DC voltage.



IEC

**Figure C.1 – Spark gap setup using calibrated composite measuring system capable of measuring HVDC and impulse**



IEC

**Figure C.2 – Blocking capacitor setup using calibrated composite measuring system capable of measuring HVDC and impulse**

## Bibliography

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60183, *Guidance for the selection of high-voltage A.C. cable systems*

Electra No. 189, *Recommendations for tests of power transmission DC cables for a rated voltage up to 800 kV*, April 2000, pp 38-55

CIGRE TB 496, *Recommendations for testing DC extruded cable systems for power transmission at a rated voltage up to 500 kV*

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