

Surge arresters —

Part 1: Non-linear resistor type gapped surge arresters for a.c. systems

The European Standard EN 60099-1:1994 with the incorporation of amendment A1:1999 has the status of a British Standard

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National foreword

This British Standard has been prepared under the direction of the Electrotechnical Sector Board and is the English language version of EN 60099-1:1994 *Surge arresters — Part 1: Non-linear resistor type gapped surge arresters for a.c. systems* including amendment A1:1999, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 60099-1:1991 including amendment 1:1999 published by the International Electrotechnical Commission (IEC).

This British Standard replaces BS 2914:1972, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index” or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 48, an inside back cover and a back cover.

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Surge arresters — Part 1: Non-linear resistor type gapped surge arresters for a.c. systems

(including amendment A1:1999)
(IEC 60099-1:1991 + A1:1999)

Parafoudres —

Partie 1: Parafoudres à résistance variable avec
éclateurs pour réseaux à courant alternatif

(inclut l'amendement A1:1999)
(CEI 60099-1:1991 + A1:1999)

Überspannungsableiter —

Teil 1: Überspannungsableiter mit
nichtlinearen Widerständen und
Funkenstrecken für Wechselspannungsnetze

(enthält Änderung A1:1999)
(IEC 60099-1:1991 + A1:1999)

This European Standard was approved by CENELEC on 1993-12-08. Amendment A1 was approved by CENELEC on 1999-12-01. 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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 99-1:1991 could be accepted without textual changes, has shown that no common modifications were necessary for acceptance as a European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 60099-1 on 8 December 1993.

NOTE Finland, Norway and Switzerland have no obligation to implement this European Standard.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1994-12-01
- latest date of withdrawal of conflicting national standards (dow) 1994-12-01

For products which have complied with the relevant national standard before 1994-12-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1999-12-01.

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given only for information. In this standard, Annex A and Annex ZA are normative and Annex B, Annex C, Annex D and Annex E are informative.

Foreword to amendment A1

The text of document 37/223/FDIS, future amendment 1 to IEC 60099-1, prepared by IEC TC 37, Surge arresters, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60099-1:1994 on 2002-12-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2000-09-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2002-12-01

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Annex A (normative) Abnormal service conditions	41	The major changes to the previous edition affect the following subjects:
Annex B (informative) Typical information given with enquiries and tenders	41	— measurement of residual voltage;
Annex C (informative) Selection of the long-duration discharge class of heavy-duty arresters	43	— operating-duty test;
Annex D (informative) Typical circuit for a distributed-constant impulse generator for the long-duration current impulse test according to 8.5.3	43	— pressure-relief test;
Annex E (informative) Typical circuit for operating-duty test according to 8.6	44	— standardized sparkover and residual voltages;
Annex ZA (normative) Other international publications quoted in this standard with the references of the relevant European publications	45	— addition of annex for information to be given on enquiries and tenders.
Figure 1 — Front-of-wave voltage sparkover test	44	The changes introduced are limited to the agreed upon subjects. Additional work was not considered due to the changing technology and the present limited use of gapped surge arresters.
Figure D.1 — Typical circuit for a distributed-constant impulse generator for the long-duration impulse test	45	Appendix D of the second edition of this standard has been deleted and issued as a separate Report, IEC 99-3.
Figure E.1 — Typical test-circuit diagram for operating-duty test	47	The present developing gapless surge arresters using metal oxide resistors will be the subject of the future IEC 99-4.
Table 1 — Standard voltage ratings (kV r.m.s.)	25	An application guide is under revision and will be published as IEC 99-5. It will supersede IEC 99-1A.
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Table 9 — Required currents for short-circuit tests

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Table C.1 — Transmission line characteristics

Section 1. General

1.1 Scope

This part of International Standard IEC 99 applies to surge protective devices designed for repeated operation to limit voltage surges on a.c. power circuits and to interrupt power-follow current. In particular, it applies to surge arresters consisting of single or multiple spark gaps in series with one or more non-linear resistors.

1.2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of International Standard IEC 99. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60, *High-voltage test techniques*.

IEC 71-2:1976, *Insulation co-ordination — Part 2: Application guide*.

IEC 99-3:1990, *Surge arresters — Part 3: Artificial pollution testing of surge arresters*.

Section 2. Definitions

For the purpose of this part, the following definitions apply.

2.1

surge arrester¹⁾

a device designed to protect electrical apparatus from high transient voltage and to limit the duration and frequently the amplitude of follow-current. The term “surge arrester” includes any external series gap which is essential for the proper functioning of the device as installed for service, regardless of whether or not it is supplied as an integral part of the device

NOTE Surge arresters are usually connected between the electrical conductors of a network and earth although they may sometimes be connected across the windings of apparatus or between electrical conductors.

2.2

non-linear resistor type gapped arrester

an arrester having a single or a multiple spark-gap connected in series with one or more non-linear resistors

2.3

series gap of an arrester

an intentional gap or gaps between spaced electrodes in series with the non-linear series resistor or resistors of the arrester

2.4

non-linear series resistor of an arrester

the part of the surge arrester which, by its non-linear voltage-current characteristics, acts as a low resistance to the flow of high discharge currents thus limiting the voltage across the arrester terminals, and as a high resistance at normal power-frequency voltage thus limiting the magnitude of follow-current

2.5

section of an arrester

a complete, suitably housed part of an arrester including series gaps and non-linear series resistors in such a proportion as is necessary to represent the behaviour of a complete arrester with respect to a particular test

2.6

unit of an arrester

a completely housed part of an arrester which may be connected in series with other units to construct an arrester of higher voltage rating. A unit of an arrester is not necessarily a section of an arrester

2.7

pressure-relief device of an arrester

a means for relieving internal pressure in an arrester and preventing explosive shattering of the housing following prolonged passage of follow-current or internal flashover of the arrester

2.8

rated voltage of an arrester

the designated maximum permissible r.m.s. value of power-frequency voltage between its terminals at which it is designated to operate correctly. This voltage may be applied to the arrester continuously without changing its operating characteristics

2.9

rated frequency of an arrester

the frequency of the power system on which the arrester is designed to be used

¹⁾ This type of equipment may be called “surge diverter” in some countries.

2.10**disruptive discharge**

the phenomena associated with the failure of insulation under electrical stress which include a collapse of voltage and the passage of current; the term applies to electrical breakdown in solid, liquid and gaseous dielectrics and combinations of these

NOTE A disruptive discharge in a solid dielectric produces permanent loss of electrical strength; in a liquid or gaseous dielectric the loss may be only temporary.

2.11**puncture**

a disruptive discharge through a solid

2.12**flashover**

a disruptive discharge over a solid surface

2.13**sparkover of an arrester**

a disruptive discharge between the electrodes of the gaps of an arrester

2.14**impulse**

a unidirectional wave of voltage or current which, without appreciable oscillations, rises rapidly to a maximum value and falls, usually less rapidly, to zero with small, if any, loops of opposite polarity

The parameters which define a voltage or current impulse are polarity, peak value, front time, and time to half value on the tail.

2.15**rectangular impulse**

an impulse which rises rapidly to a maximum value, remains substantially constant for a specified period, and then falls rapidly to zero

The parameters which define a rectangular impulse are polarity, peak value, virtual duration of the peak, and virtual total duration.

2.16**peak (crest) value of an impulse**

the maximum value of voltage or current in an impulse. In case of superimposed oscillations see 8.3.2, 8.5.2e) and 8.5.3.2c)

2.17**front of an impulse**

that part of an impulse which occurs prior to the peak

2.18**tail of an impulse**

that part of an impulse which occurs after the peak

2.19**full-wave voltage impulse**

a voltage impulse which is not interrupted by sparkover, flashover, or puncture

2.20**chopped voltage impulse**

a voltage impulse which is interrupted on the front, peak, or tail by sparkover, flashover or puncture causing a sudden drop in the voltage

2.21**prospective peak (crest) value of a chopped voltage impulse**

the peak (crest) value of the full-wave voltage impulse from which a chopped voltage impulse is derived

2.22**virtual origin of an impulse**

the point on a graph of voltage versus time or current versus time determined by the intersection between the time axis at zero voltage or zero current and a straight line drawn through two reference points on the front of the impulse

- a) For voltage impulses with virtual front times equal to or less than 30 μs , the reference points are at 30 % and 90 % of the peak value.
- b) For voltage impulses with virtual front times greater than 30 μs , the origin is generally well defined and needs no artificial definition.
- c) For current impulses, the reference points are 10 % and 90 % of the peak value.

NOTE This definition applies only when scales of both ordinate and abscissa are linear. See also note to 2.23.

2.23**virtual front time of an impulse (T_1)**

the time, in microseconds, equal to

- a) for voltage impulses with front durations equal to or less than 30 μs , 1,67 times the time taken by the voltage to increase from 30 % to 90 % of its peak value;
- b) for voltage impulses with front durations greater than 30 μs , 1,05 times the time taken by the voltage to increase from 0 % to 95 % of its peak value;
- c) for current impulses, 1,25 times the time taken by the current to increase from 10 % to 90 % of its peak value.

NOTE If oscillations are present on the front, the reference points at 10 %, 30 %, 90 % and 95 % should be taken on the mean curve drawn through the oscillations.

2.24**virtual steepness of the front of an impulse**

the quotient of the peak value and the virtual front time of an impulse

2.25**virtual time to half value on the tail of an impulse (T_2)**

the time interval between the virtual origin and the instant when the voltage or current has decreased to half its peak value. This time is expressed in microseconds

2.26**designation of an impulse shape**

a combination of two numbers, the first representing the virtual front time (T_1) and the second the virtual time to half value of the tail (T_2). It is written as T_1/T_2 , both in microseconds, the sign “/” having no mathematical meaning

2.27**standard lightning voltage impulse**

an impulse voltage having a waveshape designation of 1,2/50

2.28**switching voltage impulse**

an impulse having a virtual front time greater than 30 μs

2.29**virtual duration of the peak of a rectangular impulse**

the time during which the amplitude of the impulse is greater than 90 % of its peak value

2.30**virtual total duration of a rectangular impulse**

the time during which the amplitude of the impulse is greater than 10 % of its peak value. If small oscillations are present on the front, a mean curve should be drawn in order to determine the time at which the 10 % value is reached

2.31**peak (crest) value of opposite polarity of an impulse**

the maximum amplitude of opposite polarity reached by a voltage or current impulse when it oscillates about zero before attaining a permanent zero value

2.32**discharge current of an arrester**

the surge or impulse current which flows through the arrester after a sparkover of the series gaps

2.33**nominal discharge current of an arrester**

the peak value of discharge current, having an 8/20 waveshape, which is used to classify an arrester. It is also the discharge current which is used to initiate follow-current in the operating duty test

2.34**follow-current of an arrester**

the current from the connected power source which flows through an arrester following the passage of discharge current

2.35**residual voltage (discharge voltage) of an arrester**

the voltage that appears between the terminals of an arrester during the passage of discharge current

2.36**power-frequency sparkover voltage of an arrester**

the value of the power-frequency voltage measured as the peak value divided by $\sqrt{2}$ applied between the terminals of an arrester, which causes sparkover of all the series gaps

2.37**impulse sparkover voltage of an arrester**

the highest value of voltage attained before sparkover during an impulse of given waveshape and polarity applied between the terminals of an arrester

2.38**front-of-wave impulse sparkover of an arrester**

the impulse sparkover voltage obtained on the wavefront the voltage of which increases linearly with time

2.39**standard lightning impulse sparkover voltage of an arrester**

the lowest prospective peak value of a standard lightning voltage impulse which, when applied to an arrester, causes sparkover on every application

2.40**time to sparkover of an arrester**

the time interval between virtual origin and the instant of sparkover of the arrester. The time is expressed in microseconds

2.41**impulse sparkover-voltage/time curve**

a curve which relates the impulse sparkover voltage to the time to sparkover

2.42**prospective current**

the current which would flow at a given location in a circuit if it were short-circuited at that location by a link of negligible impedance

2.43**type tests (design tests)**

tests which are made upon the completion of the development of a new arrester design to establish representative performance and to demonstrate compliance with this part of the standard. Once made, these tests need not be repeated unless the design is so changed as to modify its performance

2.44**routine tests**

tests made on each arrester or on parts and materials as required to ensure that the product meets the design specifications

2.45**acceptance tests**

selected tests which are made when it has been agreed between the manufacturer and the purchaser that the arresters or representative samples of an order are to be tested

2.46**protective characteristics of an arrester**

the combination of the following:

- a) lightning impulse sparkover-voltage/time curve as determined in 8.3.3;
- b) the residual-voltage/discharge-current curve as determined in clause 8.4;
- c) for 10 000 A arresters rated 100 kV and higher, the switching-voltage impulse sparkover-voltage/time curve as determined in 8.3.5.

2.47**arrester disconnecter**

a device for disconnecting an arrester from the system in the event of arrester failure to prevent a persistent fault on the system and to give visible indication of the failed arrester

NOTE Clearing of the fault current through the arrester during disconnection generally is not a function of the device, and it may not prevent explosive shattering of the housing following internal flashover of the arrester on high fault currents.

Section 3. Identification and classification

3.1 Arrester identification

Surge arresters shall be identified by the following minimum information which shall appear on the rating plate (nameplate):

- rated voltage;
- rated frequency, if other than one of the standard frequencies, see 4.2;
- nominal discharge current (specifying for the 5 000 A arrester whether series A or series B²⁾, and for the 10 000 A arrester, whether light or heavy duty);
- long-duration discharge class (for 10 000 A heavy-duty arresters), see 8.5.3.2;
- I_{A1} the rated short-circuit withstand current in kiloamperes shall be stated on the nameplate of the surge arrester. Arresters without a claimed short-circuit withstand capability shall have this indicated on the nameplate, see 8.7; I_{A1}
- manufacturer's name or trademark, type and identification;
- year of manufacture.

NOTE 1 Information to be given by inquiry or tender may be guided by Annex B.

NOTE 2 In some countries, it is customary to classify arresters as:

- station for 10 000 A arresters;
- intermediate (series A) or distribution (series B) for 5 000 A arresters²⁾;
- secondary for 1 500 A arresters.

3.2 Arrester classification

Surge arresters are classified by their standard nominal discharge currents and they shall meet at least the test requirements and performance characteristics listed in Table 3. Arresters having more favorable performance characteristics or lower protective levels than those required in this part shall be considered to have met this standard.

²⁾ Series A arresters are based on performance characteristics in practice in all countries. Series B arresters are based on performance characteristics in Canada and the United States of America and other countries.