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Surge arresters –

Part 6:
Surge arresters containing both series and parallel gapped structures – Rated 52 kV and less

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International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60099-6 has been prepared by IEC technical committee 37: Surge arresters.

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

FDIS	Report on voting
37/282/FDIS	37/283/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.

Annexes A, B, C and D form an integral part of this standard.

Annexes E and F are for information only.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

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- withdrawn;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

INTRODUCTION

This part of IEC 60099 presents the minimum criteria for the requirements and testing of metal-oxide surge arresters containing gapped structures that are applied to a.c. power systems.

Arresters covered by this standard can be applied to overhead installations in place of the non-linear type arresters covered in IEC 60099-1 and IEC 60099-4.

An accelerated ageing procedure is incorporated in the standard to simulate the long-term effects of voltage and temperature on the arrester. This is necessary since during the arrester's service life the gaps and resistor elements will have portions of the system power frequency voltage continuously applied across them.

SURGE ARRESTERS –

Part 6: Surge arresters containing both series and parallel gapped structures – Rated 52 kV and less

1 General

1.1 Scope

This part of IEC 60099 applies to non-linear metal-oxide resistor type surge arresters with spark gaps designed to limit voltage surges on a.c. power circuits.

This standard basically applies to all metal-oxide surge arresters with gaps and housed in either porcelain or polymeric housings.

This standard specifies requirements and tests for metal-oxide surge arresters with internal series gaps, with rated voltages 52 kV and below.

The following arrester types and ratings are presently under consideration, but are not addressed in this standard. They will not be addressed until more information can be ascertained on the individual subjects:

- series gapped arresters above 54 kV;
- externally gapped arresters, all ratings;
- shunt gapped arresters, all ratings;
- line discharge class 2, 3, 4 and 5.

1.2 Normative references

The following referenced documents are indispensable for the application 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 60060-1:1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60060-2:1994, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60099-1:1991, *Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems*

IEC 60099-3:1990, *Surge arresters – Part 3: Artificial pollution testing of surge arresters*

IEC 60099-4:1991, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*
Amendment 1 (1998)
Amendment 2 (2001)[1]

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

[1] A consolidated edition 1.2 exists (2001) that includes edition 1.0 (1991), its amendment 1 (1998) and amendment 2 (2001).

2 Definitions

For the purposes of this part of IEC 60099, the following definitions apply.

2.1
metal-oxide surge arrester without gaps
arrester having non-linear metal-oxide resistors connected in series and/or in parallel without any integrated series or parallel spark gaps

NOTE See 2.55 for metal-oxide surge arrester with series gapped structures.

2.2
non-linear metal-oxide resistor
part of the surge arrester which by its non-linear voltage versus current characteristics acts as a low resistance to overvoltages, thus limiting the voltage across the arrester terminals, and as a high resistance at normal power frequency voltage

2.3
internal grading system of an arrester
grading impedance, in particular linear/non-linear resistors and/or grading capacitors connected in parallel to one or to a group of non-linear metal-oxide resistors and/or series gap, to control the voltage distribution along the arrester and/or between the metal oxide resistors and gaps

2.4
grading ring of an arrester
metal part usually circular in shape, mounted to modify electrostatically the voltage distribution along the arrester

2.5
section of an arrester
complete, suitably assembled part of an arrester necessary to represent the behaviour of a complete arrester with respect to a particular test

NOTE A section of an arrester is not necessarily a unit of an arrester.

2.6
unit of an arrester
completely housed part of an arrester which may be connected in series and/or in parallel with other units to construct an arrester of higher voltage and/or current rating

NOTE A unit of an arrester is not necessarily a section of an arrester.

2.7
pressure relief device of an arrester
means for relieving internal pressure in an arrester and preventing violent shattering of the housing following prolonged passage of fault current or internal flashover of the arrester

2.8
rated voltage of an arrester, U_r
maximum permissible r.m.s. value of power frequency voltage between its terminals at which it is designed to operate correctly under temporary overvoltage conditions as established in the operating duty tests, see 7.5

NOTE 1 The rated voltage is used as a reference parameter for the specification of operating characteristics.

NOTE 2 The rated voltage as defined in this standard is the 10 s power frequency voltage used in the operating duty test after high current. Tests used to establish the voltage rating in the IEC 60099 series, as well as some national standards, involve the application of repetitive impulses at nominal impulse current with power frequency voltage applied. Attention is drawn to the fact that these two methods used to establish rating do not necessarily produce equivalent values. (A resolution to this discrepancy is under consideration.)

2.9
continuous operating voltage of an arrester, U_c
continuous operating voltage is the designated permissible r.m.s. value of power frequency voltage that may be applied continuously between the arrester terminals in accordance with 7.5

2.10
rated frequency of an arrester
frequency of the power system on which the arrester is designed to be used

2.11
disruptive discharge
phenomena associated with the failure of insulation under electric stress, which include a collapse of voltage and the passage of current

NOTE 1 The term applies to electrical breakdowns in solid, liquid and gaseous dielectric, and combinations of these.

NOTE 2 A disruptive discharge in a solid dielectric produces permanent loss of electric strength. In a liquid or gaseous dielectric the loss may be only temporary.

2.12
puncture (breakdown)
disruptive discharge through a solid

2.13
flashover
disruptive discharge over a solid surface

2.14
impulse
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, excursions of opposite polarity

NOTE 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
designation of an impulse shape
combination of two numbers, the first representing the virtual front time (T_1) and the second the virtual time to half value on the tail (T_2), written as T_1/T_2, both in μs, the sign "/" having no mathematical meaning

2.16
steep current impulse
current impulse with a virtual front time of 1 μs with limits in the adjustment of equipment such that the measured values are from 0,9 μs to 1,1 μs and the virtual time to half value on the tail not longer than 20 μs

NOTE The time to half value on the tail is not critical and may have any tolerance during the residual voltage type tests, see 7.3.1.

2.17
lightning current impulse
an 8/20 current impulse with limits on the adjustment of equipment such that the measured values are from 7 μs to 9 μs for the virtual front time and from 18 μs to 22 μs for the time to half value on the tail

NOTE The time to half value on the tail is not critical and may have any tolerance during the residual voltage type tests, see 7.3.1.

2.18
long duration current impulse
rectangular impulse which rises rapidly to 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.

2.19
peak (crest) value of an impulse
maximum value of a voltage or current impulse

NOTE Superimposed oscillations may be disregarded, see 7.4.2 c) and 7.5.3.2 e).

2.20
front of an impulse
part of an impulse which occurs prior to the peak

2.21
tail of an impulse
part of an impulse which occurs after the peak

2.22
virtual origin of an impulse
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 the straight line drawn through two reference points on the front of the impulse

NOTE 1 For current impulses the reference points are 10 % and 90 % of the peak value.

NOTE 2 This definition applies only when scales of both ordinate and abscissa are linear.

NOTE 3 If oscillations are present on the front, the reference points at 10 % and 90 % should be taken on the mean curve drawn through the oscillations.

2.23
virtual front time of a current impulse, T_1
time in µs equal to 1,25 multiplied by the time in µs for 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 % and 90 % should be taken on the mean curve drawn through the oscillations.

2.24
virtual steepness of the front of an impulse
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
time interval between the virtual origin and the instant when the voltage or current has decreased to half its peak value, expressed in µs

2.26
virtual duration of the peak of a rectangular impulse
time during which the amplitude of the impulse is greater than 90 % of its peak value

2.27
virtual total duration of a rectangular impulse
time during which the amplitude of the impulse is greater than 10 % of its peak value

NOTE 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.

2.28
peak (crest) value of opposite polarity of an impulse
maximum amplitude of opposite polarity reached by a voltage or current impulse when it oscillates about zero before attaining a permanent zero value

2.29
discharge current of an arrester
impulse current which flows through the arrester

2.30
nominal discharge current of an arrester, I_n
peak value of lightning current impulse (see 2.17 and table 1) which is used to classify an arrester

2.31
high current impulse of an arrester
peak value of discharge current having a 4/10 impulse shape which is used to test the stability of the arrester on direct lightning strokes

2.32
switching current impulse of an arrester
peak value of discharge current having a virtual front time greater than 30 µs but less than 100 µs and a virtual time to half value on the tail of roughly twice the virtual front time

2.33
continuous current of an arrester
continuous current is the current flowing through the arrester when energized at the continuous operating voltage, expressed either by its r.m.s. or peak value

NOTE The continuous current, which consists of a resistive and a capacitive component, may vary with temperature, stray capacitance and external pollution effects. The continuous current of a test sample may, therefore, not be the same as the continuous current of a complete arrester.

2.34
reference current of an arrester
peak value (the higher peak value of the two polarities if the current is asymmetrical) of the resistive component of a power frequency current used to determine the reference voltage of the arrester

NOTE 1 The reference current should be high enough to make the effects of stray capacitance at the measured reference voltage of the arrester units (with designed grading system) negligible and should be specified by the manufacturer.

NOTE 2 Depending on the nominal discharge current and/or line discharge class of the arrester, the reference current will be typically in the range of 0,05 mA to 1,0 mA per square centimetre of disc area for single column arresters.

2.35
reference voltage of the main series metal-oxide resistors
peak value of power frequency voltage divided by $\sqrt{2}$ applied to the main series metal-oxide resistors of arrester to obtain the reference current

NOTE The reference voltage of a multi-unit arrester is the sum of the reference voltages of the main series metal-oxide resistors of the individual units.

2.36
residual voltage of an arrester, U_{res}
peak value of voltage that appears between the terminals of an arrester during the passage of discharge current

NOTE The term “discharge voltage” is used in some countries.

2.37
power frequency withstand voltage versus time characteristic of an arrester (temporary overvoltage, TOV)
power frequency withstand voltage versus time characteristic showing maximum time durations for which corresponding power frequency voltages may be applied to arresters without causing damage or thermal instability under specified conditions in accordance with 5.9.

2.38
prospective current of a circuit
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

2.39
protective characteristics of an arrester

Regarded as a combination of the following:

a) residual voltage for steep current impulse and front-of-wave sparkover according to 7.3.2 and 7.3.6.2

b) residual voltage versus discharge current characteristic for lightning impulses and the 1,2/50 impulse sparkover according to 7.3.3 and 7.3.7.2

c) residual voltage for switching impulse and the switching impulse sparkover according to 7.3.4 and 7.3.8.2

2.40
thermal runaway of an arrester
situation when the sustained power loss of an arrester exceeds the thermal dissipation capability of the housing and connections, leading to a cumulative increase in the temperature of the resistor elements culminating in failure

2.41
thermal stability of an arrester
arrester is thermally stable if, after an operating duty causing temperature rise, the temperature of the resistor elements decreases with time when the arrester is energized at specified continuous operating voltage and at specified ambient conditions

2.42
arrester disconnector
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 The device is not required to clear arrester fault current.

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 the relevant standard

NOTE Once made, these tests need not be repeated unless the design is changed so as to modify its performance. In such a case only the relevant tests need be repeated.

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

2.47
follow current of an arrester
current from the connected power source which flows through an arrester following the passage of discharge current

2.48
average sparkover voltage
This can be sub-divided into two types:

2.48.1
power frequency sparkover voltage
average of at least five successive power frequency sparkovers

2.48.2
lightning impulse sparkover voltage
average of at least five successive lightning impulse sparkovers

2.49
impulse sparkover voltage of an arrester
highest value of voltage attained before sparkover during an impulse of given waveshape and polarity applied between the terminals of an arrester

2.50
front-of-wave sparkover voltage of an arrester
impulse sparkover voltage obtained on the wavefront of the voltage which increases linearly with time

2.51
standard lightning impulse sparkover voltage of an arrester
lowest prospective peak value of a standard lightning voltage impulse which, when applied to an arrester, causes sparkover on every application

2.52
time to sparkover of an arrester
time interval between virtual origin and the instant of sparkover of the arrester, expressed in µs

2.53
impulse sparkover voltage-time curve
curve which relates the impulse sparkover of the voltage to the time to sparkover

2.54
grading current
peak value of current flowing through the arrester while power frequency voltage is applied

2.55
metal-oxide surge arrester with gapped structures
arrester having non-linear metal-oxide resistors connected in series and/or in parallel with any internal or external series or shunt spark gaps