

BS EN 60099-9:2014



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Surge arresters

Part 9: Metal-oxide surge arresters without gaps for HVDC converter stations

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National foreword

This British Standard is the UK implementation of EN 60099-9:2014. It is identical to IEC 60099-9:2014.

The UK participation in its preparation was entrusted to Technical Committee PEL/37, Surge Arresters - High Voltage.

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

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English Version

**Surge arresters - Part 9: Metal-oxide surge arresters without
gaps for HVDC converter stations
(IEC 60099-9:2014)**

Parafoudres - Partie 9: Parafoudres à oxyde métallique
sans éclateur pour postes de conversion CCHT
(CEI 60099-9:2014)

Überspannungsableiter - Teil 9: Metalloxidableiter ohne
Funkenstrecken für HGÜ-Stromrichterstationen
(IEC 60099-9:2014)

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Foreword

The text of document 37/417/FDIS, future edition 1 of IEC 60099-9, prepared by IEC/TC 37 "Surge arresters" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60099-9:2014.

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The text of the International Standard IEC 60099-9:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60071-1	NOTE	Harmonized as EN 60071-1.
IEC 60143-1	NOTE	Harmonized as EN 60143-1.
IEC 60633:1998	NOTE	Harmonized as EN 60633:1999 (not modified).
IEC 60507	NOTE	Harmonized as EN 60507.
IEC 62271-1:2007	NOTE	Harmonized as EN 62271-1:2008 (not modified).
ISO 4892-1	NOTE	Harmonized as EN ISO 4892-1.
ISO 4892-2	NOTE	Harmonized as EN ISO 4892-2.
ISO 4892-3	NOTE	Harmonized as EN ISO 4892-3.

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When 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.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60060-1	-	High-voltage test techniques - Part 1: General definitions and test requirements	EN 60060-1	-
IEC 60060-2	-	High-voltage test techniques - Part 2: Measuring systems	EN 60060-2	-
IEC 60068-2-11	1981	Environmental testing - Part 2: Tests - Test Ka: Salt mist	EN 60068-2-11	1999
IEC 60068-2-14	-	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	-
IEC 60068-2-17	-	Environmental testing - Part 2: Tests - Test Q: Sealing	EN 60068-2-17	-
IEC 60071-2	1996	Insulation co-ordination - Part 2: Application guide	EN 60071-2	1997
IEC 60099-4 (mod)	2004	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems	EN 60099-4	2004
IEC 60143-2	-	Series capacitors for power systems - Part 2: Protective equipment for series capacitor banks	EN 60143-2	-
IEC 60270	-	High-voltage test techniques - Partial discharge measurements	EN 60270	-
IEC 60721-3-2	-	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 2: Transportation	EN 60721-3-2	-
IEC 62217	-	Polymeric HV insulators for indoor and outdoor use - General definitions, test methods and acceptance criteria	EN 62217	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 62271-200	2011	High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	EN 62271-200	2012
IEC 62271-203	2011	High-voltage switchgear and controlgear - Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV	EN 62271-203	2012
IEC/TS 60071-5	2002	Insulation co-ordination - Part 5: Procedures for high-voltage direct current (HVDC) converter stations	-	-
IEC/TS 60815-2	-	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 2: Ceramic and glass insulators for a.c. systems	-	-
CISPR 16-1-1	-	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus	EN 55016-1-1	-
CISPR/TR 18-2	-	Radio interference characteristics of overhead power lines and high-voltage equipment - Part 2: Methods of measurement and procedure for determining limits	-	-

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SURGE ARRESTERS –

Part 9: Metal-oxide surge arresters without gaps for HVDC converter stations

1 Scope

This part of IEC 60099 applies to non-linear metal-oxide resistor type surge arresters without spark gaps designed to limit overvoltages in HVDC converter stations of two terminal, multiterminal and back-to-back type up to and including an operating voltage of 1 100 kV. The standard applies in general to porcelain-housed and polymer-housed type arresters but also to gas-insulated metal enclosed arresters (GIS-arresters) solely used as d.c. bus and d.c. line/cable arresters. Arresters for voltage source converters are not covered. Arresters applied on the a.c. systems at the converter station and subjected to power-frequency voltage of 50 or 60 Hz principally without harmonics are tested as per IEC 60099-4. The arresters on a.c.-filters are tested according to this standard.

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

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

IEC 60068-2-11:1981, *Environmental testing – Part 2: Tests. Test Ka: Salt mist*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-17, *Basic environmental testing procedures – Part 2-17: Tests – Test Q: Sealing*

IEC 60071-2:1996, *Insulation co-ordination – Part 2: Application guide*

IEC TS 60071-5:2002, *Insulation co-ordination – Part 5: Procedures for high-voltage direct current (HVDC) converter stations*

IEC 60099-4:2004, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*

IEC 60143-2, *Series capacitors for power systems – Part 2: Protective equipment for series capacitor banks*

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

IEC 60721-3-2, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transportation*

IEC TS 60815-2, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC 62217, *Polymeric HV insulators for indoor and outdoor use – General definitions, test methods and acceptance criteria*

IEC 62271-200:2011, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-203:2011, *High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR/TR 18-2, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 2: Methods of measurement and procedure for determining limits*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1

acceptance tests

tests made on arresters or representative samples after agreement between manufacturer and user

3.2

bending moment

force perpendicular to the longitudinal axis of an arrester multiplied by the vertical distance between the mounting base (lower level of the flange) of the arrester and the point of application of the force

3.3

breaking load

force perpendicular to the longitudinal axis of a porcelain-housed arrester leading to mechanical failure of the arrester housing

3.4

continuous current of an arrester

current flowing through the arrester when energized at the continuous operating voltage

Note 1 to entry: 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.

Note 2 to entry: The continuous current is, for comparison purposes, expressed either by its r.m.s. or peak value.

3.5

continuous operating voltage of an HVDC-arrester

U_{CHVDC}

maximum continuous voltage characterized by the voltages CCOV, PCOV and DCOV and the frequency DFCOV where applicable and that may be applied continuously between the arrester terminals

3.6

coordination current of an arrester

for a given system under study and for each class of overvoltage, the current through the arrester for which the representative overvoltage is determined

Note 1 to entry: Standard shapes of coordination currents for steep-front, lightning and switching current impulses are given in IEC 60099-4.

Note 2 to entry: The coordination currents are determined by system studies.

3.7

crest value of continuous operating voltage

CCOV

highest continuously occurring crest value of the voltage across the arrester excluding commutation overshoots and commutation notches and calculated with a system model valid for up to approximately 5 kHz

Note 1 to entry: As an example, see Figure 10, given for valve arresters.

3.8

damage limit (mechanical)

lowest value of a force perpendicular to the longitudinal axis of a polymer-housed arrester leading to mechanical failure of the arrester housing

3.9

d.c. component of the continuous operating voltage

DCOV

highest mean or average of the continuous operating voltage, U_{CHVDC} , across the arrester, excluding harmonics and commutation overshoots

Note 1 to entry: As an example, see Figure 11, given for bridge arrester.

3.10

d.c. system voltage

highest mean or average operating voltage to earth, excluding harmonics and commutation overshoots

3.11

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)

Note 1 to entry: It is written as T_1/T_2 , both in microseconds, the sign "/" having no mathematical meaning.

3.12

discharge current of an arrester

impulse current which flows through the arrester

3.13

disruptive discharge

phenomenon associated with the failure of insulation under electric stress, which includes a collapse of voltage and the passage of current

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

Note 2 to entry: 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.

3.14

dominant frequency of continuous operating voltage

DFCOV

the frequency of the harmonic with highest rms-value in the voltage across d.c. and a.c. filter arresters

3.15**electrical unit**

portion of an arrester in which each end of the unit is terminated with an electrode which is exposed to the external environment

Note 1 to entry: An electrical unit may have more than one mechanical unit (see Figure 4 of IEC 60099-4:2004/AMD1:2009).

3.16**equivalent continuous operating voltage of an arrester****ECOV**

r.m.s. value of the sinusoidal power-frequency voltage or d.c. voltage at a metal-oxide surge arrester stressed by operating voltage of any wave shape that generates the same power losses in the metal-oxide material as the actual operating voltage

3.17**flashover**

disruptive discharge over a solid surface

3.18**front of an impulse**

part of an impulse which occurs prior to the peak

3.19**gas-insulated metal enclosed surge arrester****GIS-arrester**

gas-insulated metal-enclosed metal-oxide surge arrester without any integrated series or parallel spark gaps, filled with gas other than air

Note 1 to entry: The gas pressure is normally higher than 1 bar = 10^5 Pa.

Note 2 to entry: A surge arrester used in gas-insulated switchgear.

3.20**grading ring of an arrester**

metal part, usually circular in shape, mounted to modify electrostatically the voltage distribution along the arrester

3.21**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

3.22**housing**

external insulating part of an arrester, which provides the necessary creepage distance and protects the internal parts from the environment

Note 1 to entry: Housing may consist of several parts providing mechanical strength and protection against the environment.

3.23**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, with defining parameters being polarity, peak value, front time and time to half-value on the tail

3.24**insulating base**

a short insulator (or set of insulators) on which the arrester is mounted to provide a means of connecting a current monitoring device between the base of the arrester and earth

3.25**internal grading system of an arrester**

grading impedances, in particular grading capacitors connected in parallel to one single or to a group of non-linear metal-oxide resistors, to control the voltage distribution along the MO resistor stack

3.26**internal parts**

MO resistors with supporting structure and internal grading system, if equipped

3.27**lightning current impulse**

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 1 to entry: The time to half-value on the tail is not critical and may have any tolerance during the residual voltage type tests (see 9.10).

3.28**lightning impulse coordination current**

I_{lco}

a coordination current with a shape equal to the lightning current impulse

3.29**long-duration current impulse**

rectangular current impulse which rises rapidly to maximum value, remains substantially constant for a specified period and then falls rapidly to zero, with defining parameters being polarity, peak value, virtual duration of the peak and virtual total duration

3.30**mean breaking load**

MBL

the average breaking load for porcelain -housed arresters determined from tests

3.31**mechanical unit**

portion of an arrester in which the MO resistors within the unit are mechanically restrained from moving in an axial direction

Note 1 to entry: An arrester may contain more than one mechanical units within an electrical unit (see Figure 13 of IEC 60099-4:2004/AMD1:2009).

Note 2 to entry: A mechanical unit may have more than one electrical unit (see Figure 13 of IEC 60099-4:2004/AMD1:2009).

3.32**metal-oxide surge arrester without gaps**

arrester having non-linear MO resistors connected in series and/or in parallel without any integrated series or parallel spark gaps, incorporated in a housing with terminals for electrical and mechanical connection

Note 1 to entry: Wherever the term “arrester” or “surge arrester” is used in this document, the term refers to a metal-oxide surge arrester without gaps.

3.33**non-linear metal-oxide resistor
MO 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

3.34**non-significant continuous operating voltage
NCOV**

continuous operating voltage which generates power losses in the arresters so low that no test is necessary to verify thermal stability after injection of a specified energy.

Note 1 to entry: It depends both on the applied voltage and on the design of the arrester if the continuous operating voltage (U_{CHVDC}) shall be considered as significant or non-significant.

Note 2 to entry: Arresters on neutral bus, metallic return and electrode line and arresters across DC reactor are examples of arresters with non-significant continuous operating voltage.

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

maximum value of a voltage or current impulse

Note 1 to entry: Superimposed oscillations may be disregarded.

3.36**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

3.37**peak value of continuous operating voltage
PCOV**

highest continuously occurring crest value of the voltage at the equipment on the d.c. side of the converter station including commutation overshoots, commutation notches and ripple calculated with a model which takes into account stray capacitances/inductances of converter transformers, valves, buswork, etc. and valid for at least 50 kHz

Note 1 to entry: As an example, see Figure 10, given for valve arresters.

3.38**polymer-housed surge arrester**

arrester using polymeric and composite materials for housing.

Note 1 to entry: Designs with an enclosed gas volume are possible. Sealing may be accomplished by use of the polymeric material itself or by a separate sealing system.

3.39**porcelain-housed surge arrester**

arrester using porcelain as housing material, with fittings and sealing systems

3.40**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

3.41**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

3.42**protective characteristics of an arrester**

combination of the following:

- a) residual voltage for steep current impulse excluding and including inductive voltage contribution according to 9.10.2;

Note 1 to entry: The steep current impulse protection level of the arrester is the maximum residual voltage for the steep impulse coordination current.

- b) residual voltage for lightning current impulse according to 9.10.3;

Note 2 to entry: The lightning impulse protection level of the arrester is the maximum residual voltage for the lightning impulse coordination current.

- c) residual voltage for switching current impulse according to 9.10.4

Note 3 to entry: The switching impulse protection level of the arrester is the maximum residual voltage for the switching impulse coordination current.

3.43**puncture
breakdown**

disruptive discharge through a solid

3.44**rated frequency of an arrester**

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

3.45**rated voltage of an arrester**

U_r

r.m.s. value of power-frequency or d.c. voltage equal to the minimum reference voltage (a.c. or d.c.) multiplied by a factor specified by the manufacturer

Note 1 to entry: The rated voltage is used as a reference parameter for the specification of operating characteristics.

3.46**reference current (a.c.) of an arrester**

I_{refAC}

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

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

3.47**reference current (d.c.) of an arrester**

I_{refDC}

peak value (the higher peak value of the two polarities if the current is asymmetrical) of the resistive current used to determine the reference voltage (d.c.) of the arrester

Note 1 to entry: The reference current will be typically in the range of 0,01 mA to 0,5 mA per square centimetre of disc area for single column arresters.

3.48**reference voltage (a.c.) of an arrester** U_{refAC}

peak value of power-frequency voltage divided by $\sqrt{2}$ which is applied to the arrester to obtain the reference current

Note 1 to entry: The reference voltage of a multi-unit arrester is the sum of the reference voltages of the individual units.

Note 2 to entry: Measurement of the reference voltage is necessary for the selection of a correct test sample in the test to verify the thermal energy rating (see 9.14).

3.49**reference voltage (d.c.) of an arrester** U_{refDC}

DC voltage which is applied to the arrester to obtain the reference current

Note 1 to entry: The reference voltage of a multi-unit arrester is the sum of the reference voltages of the individual units.

Note 2 to entry: Measurement of the reference voltage is necessary for the selection of a correct test sample in the test to verify the thermal energy rating (see 9.14).

3.50**repetitive charge transfer rating** Q_{rs}

maximum specified charge transfer capability of an arrester, in the form of a single event or group of surges that may be transferred through an arrester without causing mechanical failure or unacceptable electrical degradation to the MO resistor.

Note 1 to entry: The charge is calculated as the absolute value of current integrated over time. For the purpose of this standard this is the charge that is accumulated in a single event or group of surges lasting for not more than 2 s and which may be followed by a subsequent event at a time interval not shorter than 60 s.

3.51**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 1 to entry: The term "discharge voltage" is used in some countries.

3.52**routine tests**

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

3.53**seal (gas/water tightness)**

ability of an arrester to avoid ingress of matter affecting the electrical and/or mechanical behaviour into the arrester

3.54**section of an arrester****prorated section**

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

Note 1 to entry: A section of an arrester is not necessarily a unit of an arrester. For certain tests, a MO resistor alone constitutes a section.

3.55**shed**

insulating part projecting from the housing, intended to increase the creepage distance

3.56**specified long-term load****SLL**

force perpendicular to the longitudinal axis of an arrester, allowed to be continuously applied during service without causing any mechanical damage to the arrester

3.57**specified short-term load****SSL**

greatest force perpendicular to the longitudinal axis of an arrester, allowed to be applied during service for short periods and for relatively rare events (for example, short-circuit current loads and extreme wind gusts) without causing any mechanical damage to the arrester

Note 1 to entry: SSL does not relate to mechanical strength requirements for seismic loads (see C.2).

3.58**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 is not longer than 20 μs

Note 1 to entry: The time to half-value on the tail is not critical and may have any tolerance during the residual voltage type tests (see 9.10).

3.59**steep impulse coordination current** **I_{stico}**

a coordination current with a shape equal to the steep current impulse

3.60**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

3.61**switching impulse coordination current** **I_{swico}**

a coordination current with a shape equal to the switching current impulse

3.62**tail of an impulse**

part of an impulse which occurs after the peak

3.63**terminal line force**

force perpendicular to the longitudinal axis of the arrester measured at the centre line of the arrester

3.64**thermal energy rating** **W_{th}**

maximum specified energy, given in kJ/kV of U_r , that may be injected into an arrester or arrester section in a thermal energy test within 3 minutes time duration without causing a thermal runaway.

Note 1 to entry: This rating is verified in the thermal energy test.

3.65

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 MO resistor elements culminating in failure

3.66

thermal stability of an arrester

state of an arrester if, after an operating duty causing temperature rise, the temperature of the MO resistors decreases with time when the arrester is energized at specified continuous operating voltage and at specified ambient conditions

3.67

torsional loading

each horizontal force at the top of a vertical mounted arrester housing which is not applied to the longitudinal axis of the arrester

3.68

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 1 to entry: 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.

3.69

unipolar sine half-wave current impulse

a unipolar current impulse consisting of one half-cycle of an approximately sinusoidal current

3.70

unit of an arrester

arrester unit

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 1 to entry: A unit of an arrester is not necessarily a section of an arrester.

3.71

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

3.72

virtual front time of a current impulse

T_1

time in microseconds equal to 1,25 multiplied by the time in microseconds for the current to increase from 10 % to 90 % of its peak value

Note 1 to entry: 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.

3.73

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 to entry: For current impulses the reference points shall be 10 % and 90 % of the peak value.

Note 2 to entry: This definition applies only when scales of both ordinate and abscissa are linear.

Note 3 to entry: 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.

3.74

virtual steepness of the front of an impulse

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

3.75

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 microseconds

3.76

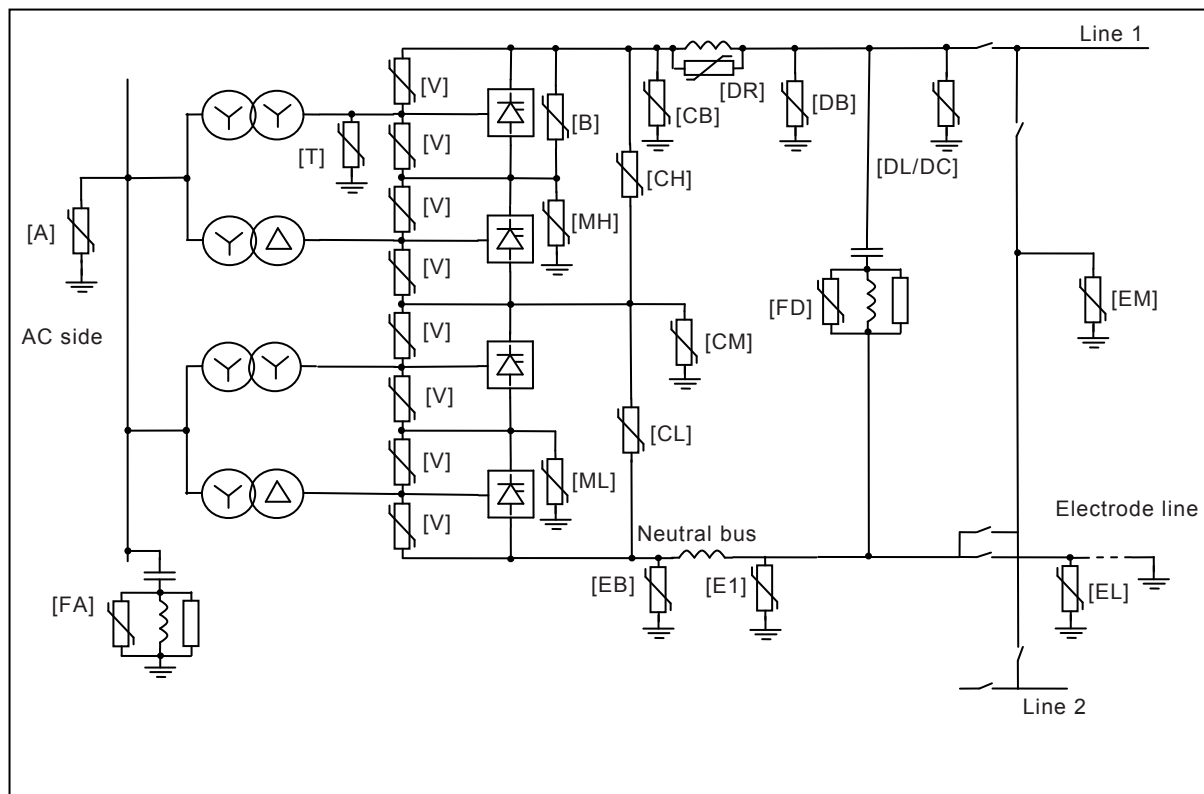
virtual duration of a rectangular impulse

time during which the amplitude of the impulse is greater than 10 % of its peak value

Note 1 to entry: 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.

4 Typical HVDC converter station schemes, arrester types, locations and operating voltage

Figures 1 to 3 show the single line diagrams of typical HVDC converter stations equipped with one or two 12-pulse converter bridges in series. The main differences between the schemes consist in the presence, or not, of commutated capacitors or controlled series capacitors on the a.c. side of the HVDC converter station. Possible arrester locations are shown in Figures 1 to 3. Some of these arresters may be redundant and could be excluded depending on the specific design. In Figures 4 and 5 typical shapes of the operating voltages are shown. For the curves in Figure 4 a low-frequency model has been used to calculate the voltage curves which result in the “classic” shapes. For the curves in Figure 5 a more accurate high-frequency modelling has been used. In general the more accurate modelling gives higher voltage peaks which should be taken into account in the design and testing of the arresters. The low-frequency curves are given for a better understanding. In general the low-frequency modelling here is valid for up to approximately 5 kHz and the high-frequency modelling from 50 kHz to 1 MHz. For valve arresters normally the operating voltage is calculated with the arresters connected since the commutation overshoots may be affected by the arrester. If the voltage instead is calculated without the arresters this in general results in a more conservative result, i.e. higher voltage peaks. However, if the arrester is allowed to limit the commutation overshoots during service the continuous power losses in the arrester must be determined taking into account this limitation.



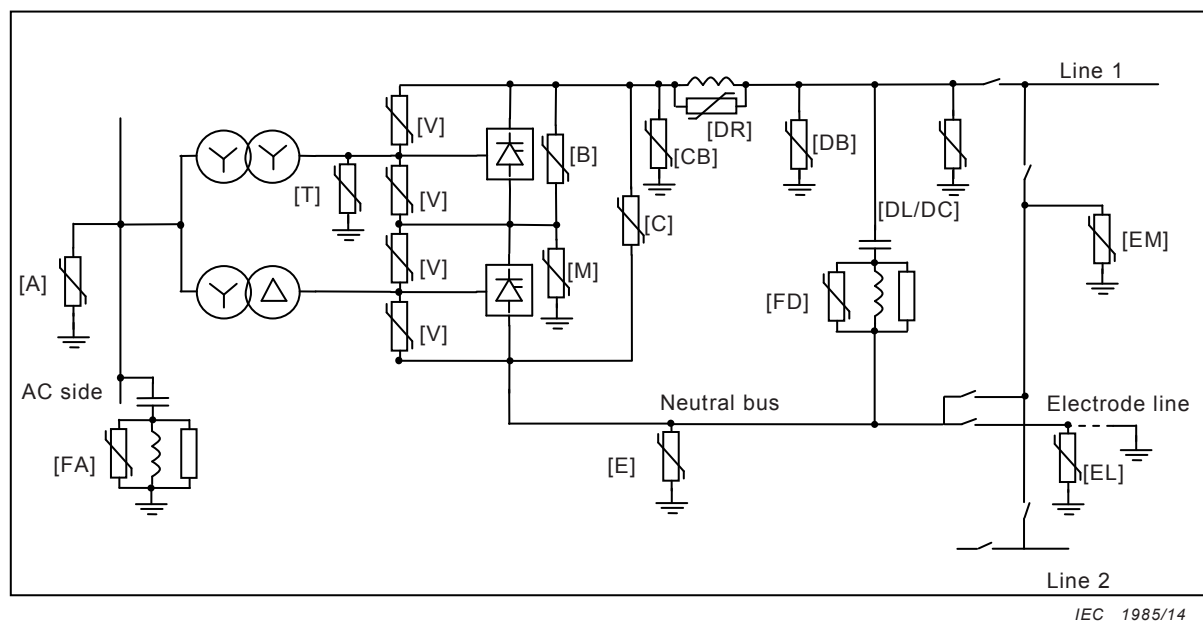
IEC 1984/14

Key

A:	a.c. arresters	DL/DC:	d.c. line/cable arrester	FD:	d.c. filter arrester
B:	bridge arrester	DR:	smoothing reactor arrester	MH:	mid-point bridge arrester (high-voltage bridge)
CB:	converter unit d.c. bus arrester	EB:	converter neutral arrester (valve side of smoothing reactor)	ML:	mid-point bridge arrester (low-voltage bridge)
CH:	HV converter unit arrester (high voltage bridge)	EL:	electrode line arrester	T:	transformer valve winding arrester
CL:	LV converter unit arrester (low voltage bridge)	EM:	metallic return arrester	V:	valve arrester
CM:	arrester between converters	E1:	d.c. neutral bus arrester (line side of smoothing reactor)		
DB:	d.c. bus arrester	FA:	a.c. filter arrester		

NOTE The d.c. and a.c. filters may be much more complex than shown in the figure. Not all arresters are used for every project. The figure does not show exact location of the arresters e.g. the a.c. arresters are usually located close to the transformers.

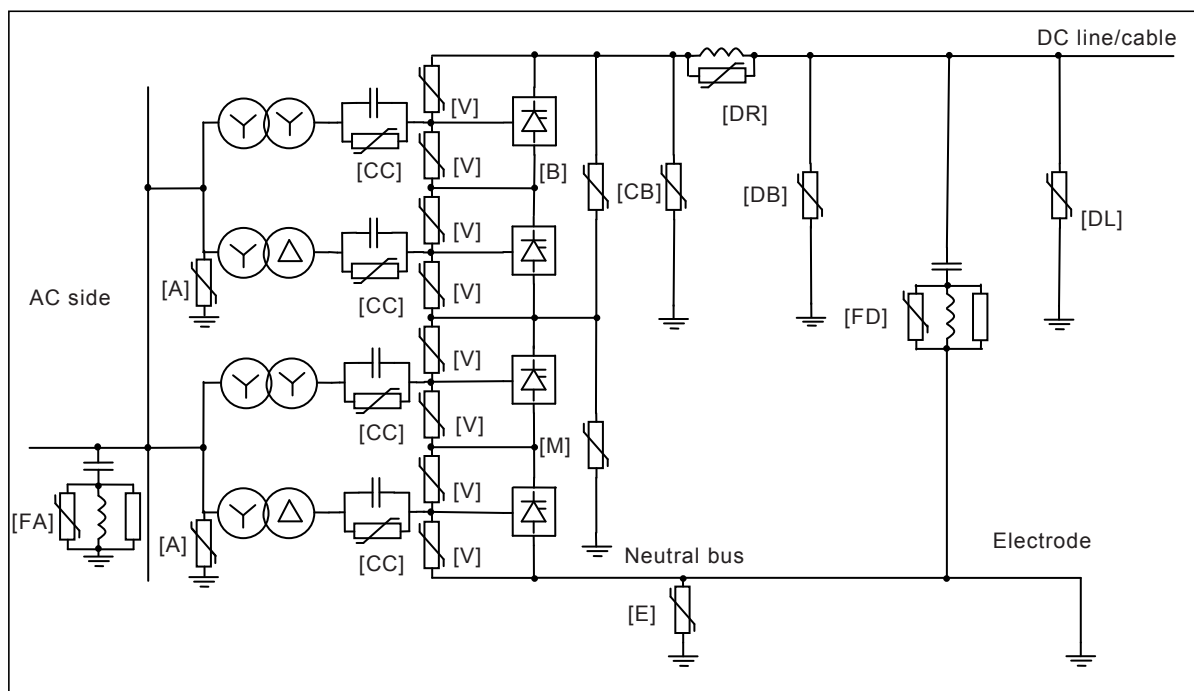
Figure 1 – Single line diagram of typical converter station with two 12-pulse converter bridges per pole

**Key**

A:	a.c. arresters	DL/DC:	d.c. line/cable arrester	FA:	a.c. filter arrester
B:	bridge arrester (6-pulse)	DR:	smoothing reactor arrester	FD:	d.c. filter arrester
C:	converter unit arrester	E:	d.c. neutral bus arrester	M:	mid-point d.c. bus arrester
CB:	converter unit d.c. bus arrester	EL:	electrode line arrester	T:	transformer valve winding arrester
DB:	d.c. bus arrester	EM:	metallic return arrester	V:	valve arrester

NOTE The d.c. and a.c. filters may be much more complex than shown in the figure. Not all arresters are used for every project.

Figure 2 – Single line diagram of typical converter station with one 12-pulse converter bridge per pole



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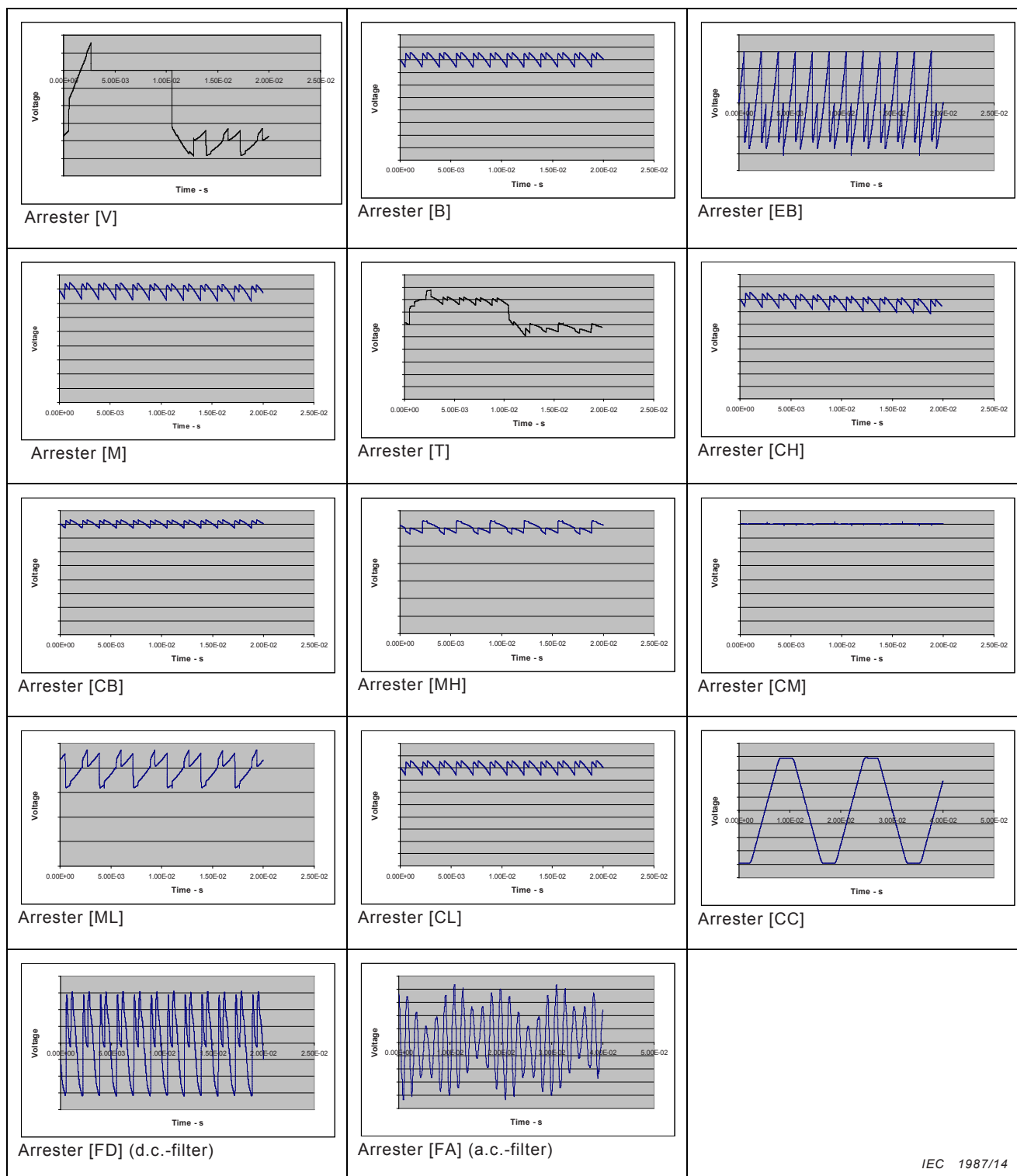
Key

A:	a.c. arresters	DB:	d.c. bus arrester	FA:	a.c. filter arrester
B:	bridge arrester (6-pulse)	DL/DC:	d.c. line/cable arrester	FD:	d.c. filter arrester
CB:	converter unit d.c. bus arrester	DR:	smoothing reactor arrester	M:	mid-point d.c. bus arrester
CC:	capacitor arrester	E:	d.c. neutral bus arrester	V:	valve arrester

NOTE The d.c. and a.c. filters may be much more complex than shown in the figure. Not all arresters are used for every project.

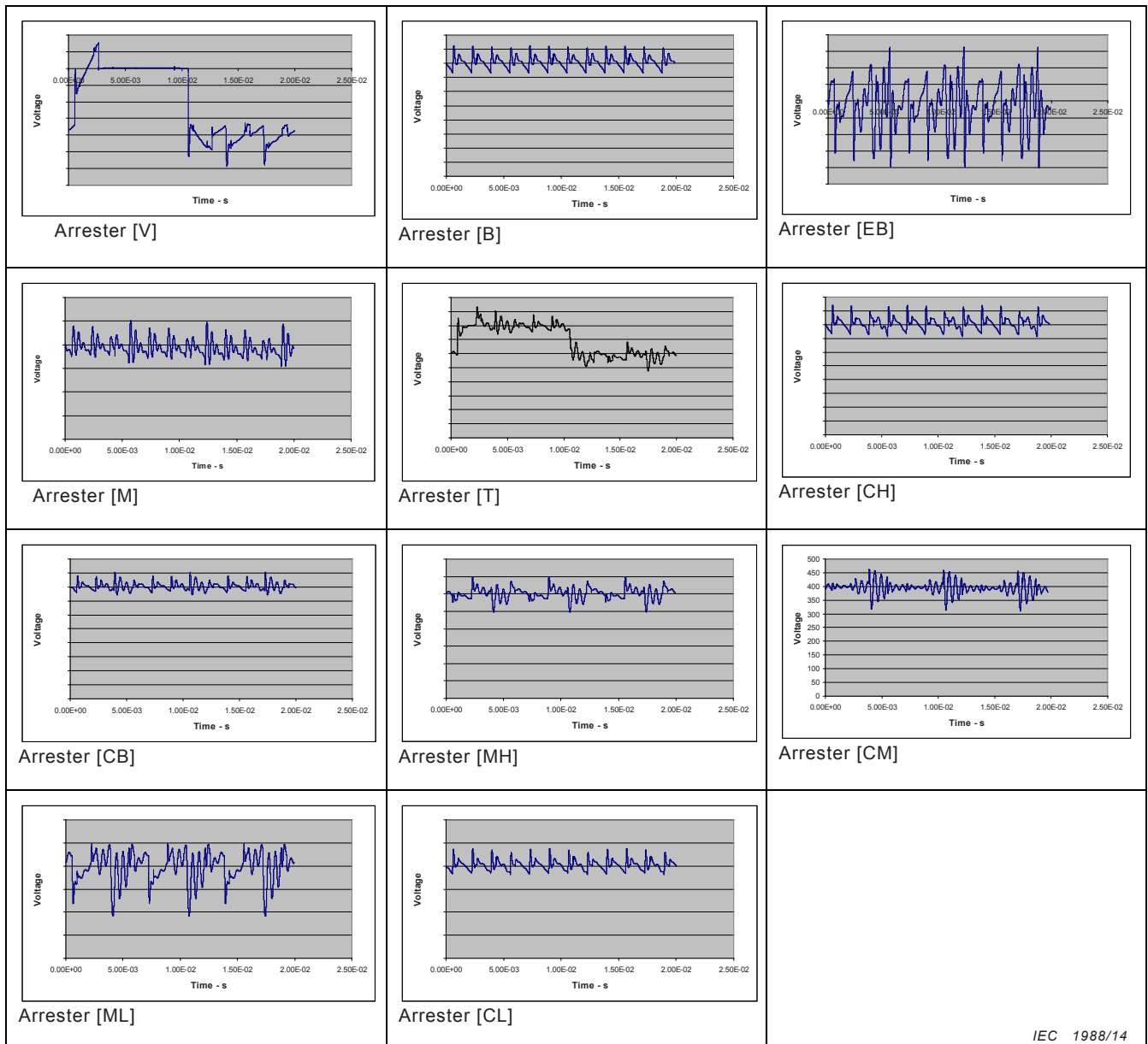
Figure 3 – Single line diagram of typical capacitor commutated converter (CCC) pole with two 12-pulse converters in series

Other circuit configurations are shown in Figures D.1 and D.2 in Annex D.



IEC 1987/14

Figure 4 – Typical continuous operating voltages for different arresters – low-frequency modelling (location as per Figures 1 to 3, fundamental frequency 50 Hz)



IEC 1988/14

Figure 5 – Typical continuous operating voltages for different arresters – high-frequency modelling (location as per Figures 1 to 3, fundamental frequency 50 Hz)

5 Identification and classification

5.1 Arrester identification

Metal-oxide surge arresters for HVDC applications shall be identified by the following minimum information which shall appear on a nameplate permanently attached to the arrester:

- continuous operating voltage where applicable defined by
 - CCOV
 - PCOV
 - DCOV
 - ECOV;
- rated voltage;

- rated short-circuit withstand current in kiloamperes (kA). For arresters for which no short-circuit rating is claimed, the sign “0” shall be indicated;
- residual voltage at specified coordination current (where applicable) given in x kV at y kA;
- the manufacturer’s name or trade mark, type and identification of the complete arrester;
- identification of the assembling position of the unit (for multi-unit arresters only);
- the year of manufacture;
- serial number;
- for GIS arresters the rated gas pressure for insulation at 20 °C.

5.2 Arrester classification

Surge arresters, covered by this standard, are classified by their location and main protection purpose (e.g. valve arrester, d.c. bus arrester, neutral bus arrester, etc.).

6 Service conditions

6.1 Normal service conditions

Surge arresters which conform to this standard shall be suitable for normal operation under the following service conditions:

- a) for outdoor installation ambient temperature within the range -40 °C to $+40\text{ °C}$;
- b) solar radiation of maximum $1,1\text{ kW/m}^2$;
- c) for indoor installation in valve halls ambient temperature within the range $+5\text{ °C}$ to $+60\text{ °C}$. The temperature in the valve halls may be controlled to a lower value than 60 °C which in such case could be considered in determining the start temperature in the thermal recovery test (see 9.14.3.2 and Annex B);
- d) altitude not exceeding 1 000 m;
- e) wind speed $\leq 34\text{ m/s}$;
- f) vertical erection;
- g) voltage applied continuously between the terminals of the arrester not exceeding its continuous operating voltage.

6.2 Abnormal service conditions

Surge arresters subject to other than normal application or service conditions may require special consideration in design, manufacture or application. The use of this standard in case of abnormal service conditions is subject to agreement between the manufacturer and the user. Possible abnormal service conditions are:

- a) temperature in excess of $+40\text{ °C}$ for outdoor installation and in excess of $+60\text{ °C}$ for indoor installations or below -40 °C ;
- b) applications at altitude higher than 1 000 m;
- c) fumes or vapours which may cause deterioration of insulating surface or mounting hardware;
- d) excessive contamination by smoke, dirt, salt spray or other conducting materials;
- e) excessive exposure to moisture, humidity, dropping water or steam;
- f) live washing of arrester;
- g) explosive mixtures of dust, gases or fumes;
- h) abnormal mechanical conditions (earthquake (see Annex C.2), vibrations, wind velocity $> 34\text{ m/s}$, high ice loads, high cantilever stresses);
- i) unusual transportation or storage;

- j) heat sources near the arrester;
- k) non-vertical erection and suspended erection;
- l) torsional loading of the arrester;
- m) tensile loading of the arrester;
- n) use of the arrester as mechanical support;
- o) high magnetic fields due to close vicinity to reactors.

7 Requirements

7.1 Insulation withstand of the arrester housing

The arrester shall be designed such that the housings are able to adequately withstand voltages during conduction of lightning and switching impulse currents and during anticipated maximum power frequency and d.c. overvoltages. The external insulation withstand capability of the housings of porcelain and polymer-housed arresters shall be demonstrated by tests according to 9.2 and the insulation withstand capability of GIS arresters shall be tested in accordance with 11.7.4.2, while the internal insulation withstand capability shall be demonstrated by tests according to 9.15 or 9.14.3.1.

7.2 Reference voltage

The reference voltage (U_{refAC} or U_{refDC}) (see 3.48 and 3.49) of each arrester shall be measured by the manufacturer at the reference current (I_{refAC} or I_{refDC}) selected by the manufacturer (see 3.46 and 3.47). The minimum reference voltage of the arrester at the reference current for routine tests shall be specified and published in the manufacturer's data.

7.3 Residual voltage

The purpose of the measurement of residual voltages is to obtain the maximum residual voltages for a given design for all specified currents and wave shapes. These are derived from the type test data and from the maximum residual voltage at a lightning impulse current used for routine tests as specified and published by the manufacturer.

The maximum residual voltage of a given arrester design for any current and wave shape is calculated from the residual voltage of sections tested during type tests multiplied by a specific scale factor. This scale factor is equal to the ratio of the declared maximum residual voltage, as checked during the routine tests, to the measured residual voltage of the sections at the same current and wave shape.

Manufacturers' literature shall contain, for each arrester listed, the following residual voltage information:

- Maximum lightning impulse residual voltage at the lightning impulse coordination current of the arrester (see 9.10.3)
- Maximum switching impulse residual voltage at the switching impulse coordination current of the arrester (see 9.10.4)
- Maximum steep current impulse residual voltage, excluding inductive voltage contribution, for an impulse current having peak value equal to the steep impulse coordination current of the arrester (see 9.10.2)
- Maximum steep current impulse residual voltage, including inductive voltage contribution, for an impulse current having peak value equal to the steep impulse coordination current of the arrester. This residual voltage shall be equal to

Maximum steep current impulse residual voltage (see 9.10.2), excluding inductive voltage contribution + Magnitude of inductive voltage drop (U_L)

where U_L is calculated as follows: