PUBLICLY AVAILABLE SPECIFICATION

IEC PAS 60099-7

First edition
2004-04

Surge arresters –

Part 7: Glossary of terms and definitions from IEC publications 60099-1, 60099-4, 60099-6, 61643-1, 61643-12, 61643-21, 61643-311, 61643-321, 61643-331 and 61643-341

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IEC-PAS 60099-7 has been processed by IEC technical committee 37: Surge arresters.

The text of this PAS is based on the following document: This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
37/291/NP	37/296/RVN

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SURGE ARRESTERS – Part 7: Glossary of terms and definitions from IEC publications 60099-1, 60099-4, 60099-6, 61643-1, 61643-12, 61643-21, 61643-311, 61643-321, 61643-331 and 61643-341

1 Scope

This PAS compiles a list of terms and definitions relative to IEC publications from IEC technical committee 37: Surge arresters, and subcommittees 37A: Surge protective devices, and 37B: Surge protective components, current at the date of this publication.

2 Surge arresters – Non-linear resistor type gapped surge arresters for a.c. systems (IEC 60099-1:1991+A1:1999)

2.1
surge arrester*
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:
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:
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
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
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
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

———————

* This type of equipment may be called "surge diverter" in some countries.

2.7
pressure-relief device of an arrester
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
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
frequency of the power system on which the arrester is designed to be used

2.10
disruptive discharge
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
disruptive discharge through a solid

2.12
flashover
disruptive discharge over a solid surface

2.13
sparkover of an arrester
disruptive discharge between the electrodes of the gaps of an arrester

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, 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
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
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) of IEC 60099-1)

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

2.20
chopped voltage impulse
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
peak (crest) value of the full-wave voltage impulse from which a chopped voltage impulse is derived

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 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 3.23.

2.23
virtual front time of an impulse (T_1)
time, in μs, 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
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. This time is expressed in μs

2.26
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 of the tail (T_2). It is written as T_1/T_2, both in μs, the sign "/" having no mathematical meaning

2.27
standard lightning voltage impulse
impulse voltage having a waveshape designation of 1,2/50.

2.28
switching voltage impulse
impulse having a virtual front time greater than 30 μs

2.29
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

2.30
virtual total duration of a rectangular impulse
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
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
surge or impulse current which flows through the arrester after a sparkover of the series gaps

2.33
nominal discharge current of an arrester
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
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
voltage that appears between the terminals of an arrester during the passage of discharge current

2.36
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

2.37
front-of-wave impulse sparkover of an arrester:
impulse sparkover voltage obtained on the wavefront the voltage of which increases linearly with time

2.38
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

2.39
time to sparkover of an arrester
time interval between virtual origin and the instant of sparkover of the arrester. The time is expressed in μs

2.40
impulse sparkover-voltage/time curve
curve which relates the impulse sparkover voltage to the time to sparkover

2.41
prospective current
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

2.42
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

2.43
routine tests
tests made on each arrester or on parts and materials as required to ensure that the product meets the design specifications

2.44
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

2.45
protective characteristics of an arrester
combination of the following:

a) lightning impulse sparkover-voltage/time curve as determined in 8.3.3 of IEC 60099-1;

b) the residual-voltage/discharge-current curve as determined in 8.4 of IEC 60099-1;

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 of IEC 60099-1

2.46
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 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.

3 Surge arresters – Metal-oxide surge arresters without gaps for a.c. systems (IEC 60099-4:1991+A1:1998+A2:2001)

3.1
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

3.2
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

3.3
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 metal-oxide resistor stack

3.4
grading ring of an arrester
metal part, usually circular in shape, mounted to modify electrostatically the voltage distribution along the arrester

3.5
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. A section of an arrester is not necessarily a unit of an arrester

3.6
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. A unit of an arrester is not necessarily a section of an arrester

3.7
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

3.8
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 of IEC 60099-4). The rated voltage is used as a reference parameter for the specification of operating characteristics

NOTE The rated voltage as defined in this document is the 10 s power-frequency voltage used in the operating duty test after high-current or long-duration impulses. Tests used to establish the voltage rating in IEC 60099-1, as well as some national standards, involve the application of repetitive impulses at nominal current with power-frequency voltage applied. Attention is drawn to the fact that these two methods used to established rating do not necessarily produce equivalent values. (A resolution to this discrepancy is under consideration.)

3.9
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 of IEC 60099-4

3.10
rated frequency of an arrester
frequency of the power system on which the arrester is designed to be used

3.11
disruptive discharge
phenomena associated with the failure of insulation under electric stress, which include a collapse of voltage and the passage of current. The term applies to electrical breakdowns in solid, liquid and gaseous dielectric, and combinations of these

NOTE 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.

3.12
puncture (breakdown)
disruptive discharge through a solid

3.13
flashover
disruptive discharge over a solid surface

3.14
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.

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

3.15
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). It is written as T_1/T_2, both in μs, the sign "/" having no mathematical meaning

3.16
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. The virtual time to half-value on the tail shall be 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 of IEC 60099-4).

3.17
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 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 of IEC 60099-4).

3.18
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

3.19
peak (crest) value of an impulse
maximum value of a voltage or current impulse. Superimposed oscillations may be disregarded (see 7.4.2c) and 7.5.4.2e) of IEC 60099-4)

3.20
front of an impulse
part of an impulse which occurs prior to the peak

3.21
tail of an impulse
part of an impulse which occurs after the peak

3.22
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. For current impulses, the reference points shall be 10 % and 90 % of the peak value

NOTE 1 This definition applies only when scales of both ordinate and abscissa are linear.

NOTE 2 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.

3.23
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.

3.24
virtual steepness of the front of an impulse
quotient of the peak value and the virtual front time of an impulse

3.25
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. This time is expressed in µs

3.26
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

3.27
virtual total duration of a rectangular impulse
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

3.28
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

3.29
discharge current of an arrester
impulse current which flows through the arrester

3.30
nominal discharge current of an arrester (I_n)
peak value of lightning current impulse (see 3.17) which is used to classify an arrester

3.31
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

3.32
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

3.33
continuous current of an arrester
continuous current is the current flowing through the arrester when energized at the continuous operating voltage

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.

The continuous current is, for comparison purposes, expressed either by its r.m.s. or peak value.

3.34
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. The reference current shall 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 shall be specified by the manufacturer

NOTE 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 m^2 of disc area for single column arresters.

3.35
reference voltage of an arrester (U_{ref})
peak value of power-frequency voltage divided by $\sqrt{2}$ which shall be applied to the arrester to obtain the reference current. The reference voltage of a multi-unit arrester is the sum of the reference voltages of the individual units

NOTE Measurement of reference voltage is necessary for the selection of a correct test sample in the operating duty test (see 7.5 of IEC 60099-4).

3.36
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.

3.37
power-frequency withstand voltage versus time characteristic of an arrester
voltage which shows the 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 5.10 of IEC 60099-4

3.38
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

3.39
protective characteristics of an arrester
combination of the following:

a) residual voltage for steep current impulse according to 7.3.1 of IEC 60099-4;

b) residual voltage versus discharge current characteristic for lightning impulses according to 6.3.2 of IEC 60099-4. The lightning impulse protection level of the arrester is the maximum residual voltage for the nominal discharge current;

c) residual voltage for switching impulse according to 7.3.3 of IEC 60099-4

The switching impulse protection level of the arrester is the maximum residual voltage at the specified switching impulse currents.

3.40
thermal runaway of an arrester
term used to describe a 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

3.41
thermal stability of an arrester
an 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

3.42
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 Clearing of the fault current through the arrester during disconnection generally is not a function of the device.

3.43
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. 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

3.44
routine tests
tests made on each arrester, or on parts and materials, as required, to ensure that the product meets the design specifications

3.45
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

3.46
housing
external insulating part of an arrester, which provides the necessary creepage distance and protects the internal parts from the environment

NOTE Housing may consist of several parts providing mechanical strength and protection against the environment.

3.47
shed
insulating part projecting from the housing, intended to increase the creepage distance

3.48
polymer housed surge arrester
see 3.60

3.49
fault indicator
device intended to provide an indication that the arrester is faulty and which does not disconnect the arrester from the system

3.50
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 An electrical unit is identical to a "unit of an arrester" as defined in 3.6.

3.51
mechanical unit
portion of an arrester in which the resistors within the unit are mechanically restrained from moving in an axial direction

3.52
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 The gas pressure is normally higher than 1 bar = 10^5Pa.

NOTE 2 A surge-arrester used in gas-insulated switchgear.

3.53
arrester – separable type (separable arrester)
arrester assembled in an insulated or screened housing providing system insulation, intended to be installed in an enclosure for the protection of distribution equipment and systems. Electrical connection may be made by sliding contact or by bolted devices; however, all separable arresters are deadbreak arresters

NOTE Separable arrester use is common European practice.

3.54
arrester – deadfront type (deadfront arrester)
arrester assembled in a shielded housing providing system insulation and conductive ground shield, intended to be installed in an enclosure for the protection of underground and pad mounted distribution equipment and circuits

NOTE 1 Most deadfront arresters are loadbreak arresters.

NOTE 2 Deadfront arrester use is common U.S.A. practice.

3.55
deadbreak arrester
arrester which can be connected and disconnected from the circuit only when the circuit is de-energized

3.56
loadbreak arrester
arrester which can be connected and disconnected when the circuit is energized

3.57
arrester – liquid-immersed type (liquid-immersed arrester)
arrester designed to be immersed in an insulating liquid

3.58
fail-open current rating for liquid-immersed arrester
fault current level above which the arrester is claimed to evolve into an open circuit upon failure

3.59
fail-short current rating for liquid-immersed arrester
fault current level below which the arrester is claimed to evolve into a short circuit upon failure

NOTE Definitions 3.57 and 3.58 are preliminary and may be superseded by more general definitions.

3.60
porcelain housed arrester
arrester using porcelain as housing material, with fittings and sealing systems

3.61
polymer housed arrester
arrester using polymeric and composite materials for housing, with fittings

NOTE 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.

3.62
bending moment
horizontal force acting on the arrester housing multiplied by the vertical distance between the mounting base (lower level of the flange) of the arrester housing and the point of application of the force

3.63
terminal line force
force perpendicular to the longitudinal axis of the arrester measured at the centre line of the arrester

3.64
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

3.65
breaking load
force perpendicular to the longitudinal axis of a porcelain housed arrester leading to mechanical failure of the arrester housing

3.66
damage limit
lowest value of a force perpendicular to the longitudinal axis of a polymer housed arrester leading to mechanical failure of the arrester housing

3.67
maximum permissible service load (MPSL)
greatest force perpendicular to the longitudinal axis of a polymer housed arrester, allowed to be applied during service without causing any mechanical damage to the arrester

3.68
maximum permissible dynamic service load (MPDSL)
greatest force perpendicular to the longitudinal axis of a porcelain housed arrester, allowed to be applied during service for short periods (for example, short-circuit current forces, seismic stress) without causing any mechanical damage to the arrester

3.69
permissible static service load (PSSL)
force perpendicular to the longitudinal axis of a porcelain housed arrester, allowed to be continuously applied during service without causing any mechanical damage to the arrester

3.70
internal parts
metal-oxide resistor elements with supporting structure

3.71
seal (gas/water-tightness)
ability of an arrester to avoid ingress of matter affecting the electrical and/or mechanical behaviour into the arrester

4 Surge protective devices connected to low-voltage power distribution systems – Performance requirements and testing methods (IEC 61643-1:1998+A1:2001)

4.1
surge protective device (SPD)
device that is intended to limit transient overvoltages and divert surge currents. It contains at least one non-linear component

4.2
one-port SPD
SPD connected in shunt with the circuit to be protected. A one-port device may have separate input and output terminals without a specific series impedance between these terminals

4.3
two-port SPD
SPD with two sets of terminals, input and output. A specific series impedance is inserted between these terminals

4.4
voltage-switching type SPD
SPD that has a high impedance when no surge is present but can have a sudden change in impedance to a low value in response to a voltage surge. Common examples of components used as voltage-switching devices are spark gaps, gas tubes, thyristors (silicon-controlled rectifiers) and triacs. These SPDs are sometimes called "crowbar type"

4.5
voltage-limiting type SPD
SPD that has a high impedance when no surge is present, but will reduce it continuously with increased surge current and voltage. Common examples of components used as non-linear devices are varistors and suppressor diodes. These SPDs are sometimes called "clamping type"

4.6
combination type SPD
SPD that incorporates both voltage-switching type components and voltage-limiting type components may exhibit voltage-switching, voltage-limiting or both voltage-switching and voltage-limiting behaviour depending upon the characteristics of the applied voltage

4.7
modes of protection
SPDs protective component may be connected line-to-line or line-to-earth or line-to-neutral or neutral-to-earth and combinations thereof. These paths are referred to as modes of protection

4.8
nominal discharge current I_n
crest value of the current through the SPD having a current waveshape of 8/20. This is used for the classification of the SPD for class II test and also for preconditioning of the SPD for class I and II tests

4.9
impulse current I_{imp}
current defined by a current peak value I_{peak} and the charge Q and tested according to the test sequence of the operating duty test. This is used for the classification of the SPD for class I test

4.10
maximum discharge current I_{max} for class II test
crest value of a current through the SPD having an 8/20 waveshape and magnitude according to the test sequence of the class II operating duty test. I_{max} is greater than I_n

4.11
maximum continuous operating voltage U_c
maximum r.m.s. or d.c. voltage which may be continuously applied to the SPDs mode of protection. This is equal to the rated voltage

4.12
standby power consumption P_c
power consumed by the SPD when energized at the maximum continuous operating voltage (U_c) with balanced voltages and phase angles and no load. The SPD is connected in accordance with the manufacturer's instructions

4.13
follow current I_f
current supplied by the electrical power system and flowing through the SPD after a discharge current impulse. The follow current is significantly different from the continuous operating current I_c

4.14
rated load current I_L
maximum continuous rated r.m.s. or d.c. current that can be supplied to a load connected to the protected output of an SPD

4.15
voltage protection level U_p
parameter that characterizes the performance of the SPD in limiting the voltage across its terminals, which is selected from a list of preferred values. This value shall be greater than the highest value of the measured limiting voltages

4.16
measured limiting voltage
maximum magnitude of voltage that is measured across the terminals of the SPD during the application of impulses of specified waveshape and amplitude

4.17
residual voltage U_{res}
peak value of voltage that appears between the terminals of an SPD due to the passage of discharge current

4.18
temporary overvoltage (TOV) characteristic
behaviour of an SPD when subjected to a temporary overvoltage U_T for specific time duration t_T

NOTE This characteristic can be either withstanding a TOV without unacceptable changes in characteristics or functionality or failing as described in 7.7.6.2 of IEC 61643-1.

4.19
load-side surge withstand capability for a two-port SPD
ability of a two-port SPD to withstand surges on the output terminals originated in loads downstream of the SPD

4.20
voltage drop (in per cent)

$$\Delta U = \left((U_{IN} - U_{OUT}) / U_{IN}\right) \times 100\ \%$$

where

U_{IN} is the input voltage and U_{OUT} is the output voltage measured simultaneously with a full rated resistive load connected. This parameter is only used for two-port SPDs

4.21
insertion loss
at a given frequency, the insertion loss of an SPD connected into a given power system is defined as the ratio of voltages appearing across the mains immediately beyond the point of insertion before and after the insertion of the SPD under test. This result is expressed in decibels

NOTE Requirements and tests are under consideration.

4.22
1,2/50 voltage impulse
voltage impulse with a virtual front time (time to rise from 10 % to 90 % of the peak value) of 1,2 μs and a time to half-value of 50 μs

4.23
8/20 current impulse
current impulse with a virtual front time of 8 μs and a time to half-value of 20 μs

4.24
combination wave
combination wave delivered by a generator that applies a 1,2/50 voltage impulse across an open circuit and an 8/20 current impulse into a short circuit. The voltage, current amplitude and waveforms that are delivered to the SPD are determined by the generator and the

impedance of the SPD to which the surge is applied. The ratio of peak open-circuit voltage to peak short-circuit current is 2 Ω; this is defined as the fictive impedance Z_f. The short-circuit current is symbolized by I_{sc}. The open-circuit voltage is symbolized by U_{oc}

4.25
thermal runaway
operational condition when the sustained power dissipation of an SPD exceeds the thermal dissipation capability of the housing and connections, leading to a cumulative increase in the temperature of the internal elements culminating in failure

4.26
thermal stability
an SPD is thermally stable if after the operating duty test causing temperature rise, the temperature of the SPD decreases with time when the SPD is energized at specified maximum continuous operating voltage and at specified ambient temperature conditions

4.27
degradation
change of original performance parameters as a result of exposure of the SPD to surge, service or unfavourable environment

4.28
short-circuit withstand
maximum prospective short-circuit current that the SPD is able to withstand

4.29
SPD disconnector
device (internal and/or external) required for disconnecting an SPD from the power system

NOTE This disconnecting device is not required to have isolating capability. It is to prevent a persistent fault on the system and is used to give an indication of the SPD failure.

There may be more than one disconnector function, for example, an overcurrent protection function and a thermal protection function. These functions may be integrated into one unit or performed in separate units.

4.30
degrees of protection provided by enclosure (IP code)
extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or against ingress of water (see IEC 60529)

4.31
type tests
tests which are made upon the completion of the development of a new SPD design. They are used to establish representative performance and to demonstrate compliance with the relevant standard. 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

4.32
routine tests
tests made on each SPD or on parts and materials as required to ensure that the product meets the design specifications

4.33
acceptance tests
tests which are made when it has been agreed between the manufacturer and the purchaser that the SPD or representative samples of an order are to be tested

4.34
decoupling network
device intended to prevent surge energy from being propagated to the power network during energized testing of SPD. Sometimes called a "back filter"

4.35
class I tests
tests carried out with the nominal discharge current I_n defined in 4.8, the 1,2/50 voltage impulse defined in 4.22, and the maximum impulse current I_{imp} for class I test defined in 4.9

4.36
class II tests
tests carried out with the nominal discharge current I_n defined in 4.8, the 1,2/50 voltage defined in 4.22, and the maximum discharge current I_{max} for class II test defined in 4.10

4.37
class III tests
tests carried out with the combination wave (1,2/50, 8/20) defined in 4.24

4.38
overcurrent protection
overcurrent device (for example, circuit-breaker or fuse), which could be part of the electrical installation located externally upstream of the SPD

4.39
residual current device (RCD)
mechanical switching device or association of devices intended to cause the opening of the contacts when the residual or unbalanced current attains a given value under specified conditions

4.40
sparkover voltage of a voltage-switching SPD
maximum voltage value before disruptive discharge between the electrodes of the gap of an SPD

4.41
specific energy W/R for class I test
energy dissipated by the impulse current I_{imp} in a unit resistance of 1 Ω. It is equal to the time integral of the square of the current $W/R = \int i^2 dt$

4.42
prospective short-circuit current of a power supply I_p
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

4.43
follow current interrupting rating I_{fi}
prospective short-circuit current that an SPD is able to interrupt by itself

4.44
residual current I_{PE}
current flowing through the PE terminal, when the SPD is energized at the maximum continuous operating voltage (U_c) when connected according to the manufacturer's instructions

4.45
status indicator
device that indicates the operational status of an SPD

NOTE Such indicators may be local with visual and/or audible alarms and/or may have remote signalling and/or output contact capability.

4.46
output contact
contact included in a circuit separate from the main circuits and linked to an SPD disconnector or a status indicator

4.47
temporary overvoltage (TOV) failure behaviour
behaviour of an SPD which is connected between phase/neutral terminals and earth terminals under TOV conditions (earth failure in HV systems affecting the LV system) described in IEC 60364-4-442

NOTE This temporary overvoltage can exceed the temporary overvoltage withstand capability U_T of an SPD.

4.48
nominal a.c. voltage of the system U_o
nominal line-to-neutral voltage (r.m.s. value of the a.c. voltage) of the system

5 Low-voltage surge protective devices – Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods (IEC 61643-21:2000)

5.1
model number
code, either applied to the SPD or included in its documentation, that is used to identify the SPD

5.2
preferred values
values for the parameters listed in the tables for the various tests, preferred in the sense that their use promotes uniformity and provides a means of comparison among various protective devices. They also provide a common engineering language beneficial to the user and manufacturer of surge protectors used in telecommunications and signalling networks. However, specific applications may require values other than the preferred values of the tables

5.3
overstressed fault mode
mode 1 condition wherein the voltage-limiting part of the SPD has been disconnected. The voltage-limiting function is no longer present, but the line is still operable

mode 2 condition wherein the voltage-limiting part of the SPD has been short-circuited by a very low impedance within the SPD. The line is inoperable, but the equipment is still protected by a short circuit

mode 3 situation wherein the SPD has undergone an internal open circuit on the network side of the voltage-limiting part of the SPD. The line is inoperable but the equipment is still protected by an open line

5.4
protection
application of methods and means to prevent the propagation of stressful electrical energy beyond a designed interface

5.5
current response time
time required for a current-limiting component to operate at a specified current and a specified temperature

5.6
maximum continuous operating voltage, U_c
maximum voltage (d.c. or r.m.s.) which may be continuously applied to SPD terminals without causing any degradation in the transmission characteristics of the SPD

5.7
maximum interrupting voltage
maximum voltage (d.c. or r.m.s.) that can be applied to the current-limiting components of an SPD without degradation of the SPD. This voltage may be equal to the U_c of the SPD or may be a higher value depending on the arrangement of the current-limiting component(s) within the SPD

5.8
surge protective device (SPD)
device intended to limit transient overvoltages and divert surge currents. It contains at least one non-linear voltage-limiting component

5.9
voltage limiting
action of the SPD that causes all voltages exceeding a predetermined value to be reduced

5.10
current limiting
action of an SPD, containing at least one non-linear current-limiting component, that causes all currents exceeding a predetermined value to be reduced

5.11
non-resettable current limiting
action of an SPD that limits current only one time

5.12
resettable current limiting
action of an SPD that limits current and can be manually reset after operating

5.13
self-resetting current limiting
action of an SPD that limits current and will self-reset after the disturbing current is removed

5.14
voltage-clamping-type SPD
SPD that has a high shunt impedance when no surge is present, but the impedance reduces continuously with increasing surge current and voltage. Common examples of components used as voltage clamping devices are varistors and suppression diodes. These are sometimes referred to as "limiting-type" SPDs

5.15
voltage-switching type SPD
SPD that has a high shunt impedance when no surge is present, but has a sudden and large reduction in impedance in response to a voltage surge. Common examples of components used as voltage-switching devices are air gaps, sealed gas tubes, and thyristors. These are sometimes referred to as "crowbar-type" SPDs

5.16
voltage protection level U_p
parameter that characterizes the performance of the SPD in limiting the voltage across its terminals. This value of voltage is greater than the highest measured value of impulse-limiting voltage and is specified by the manufacturer

5.17
multi-stage SPD
SPD which has more than one voltage-limiting component. These voltage-limiting components may or may not be electrically separated by a series component. The voltage-limiting components may be either switching or clamping types

5.18
blind spot
situation where voltages above the maximum continuous operating voltage U_c may cause incomplete operation of the SPD. Incomplete operation of the SPD means not all of the stages in a multi-stage SPD have operated during the impulse test. This may result in overstressing of components in the SPD

5.19
a.c. durability
characteristic of an SPD which allows it to conduct alternating current of a specific magnitude and duration for a specified number of times

5.20
impulse durability
characteristic of an SPD which allows it to conduct impulse current of a specified waveform and peak value for a specified number of times

5.21
current reset time
time required for a self-resettable current limiter to revert to its normal or quiescent state

5.22
rated current
maximum current a current-limiting SPD can conduct continuously with no change in the operating characteristics of the current-limiting components

5.23
insulation resistance
resistance between designated terminals of an SPD when U_c is applied to those terminals

5.24
return loss
modulus of the reciprocal of the reflection factor, generally expressed in decibels (dB)

NOTE When impedances can be defined, the return loss in dB is given by the formula:

$20 \log_{10} \mathrm{MOD} [(Z_1+Z_2)/(Z_1-Z_2)]$

where Z_1 is the characteristic impedance of the transmission line ahead of the discontinuity, or the impedance of the source, and Z_2 is the impedance after the discontinuity or load impedance seen from the junction between the source and the load [IEV 702-07-25, modified].

5.25
bit error ratio (BER)
ratio of the number of bit errors to the total number of bits transmitted in a given time interval

5.26
insertion loss
loss resulting from the insertion of an SPD into a transmission system. It is the ratio of the power delivered to that part of the system following the SPD, before insertion of the SPD, to the power delivered to that same part after insertion of the SPD. The insertion loss is generally expressed in decibels

[IEV 726-06-07, modified]

5.27
near-end crosstalk (NEXT)
crosstalk that is propagated in a disturbed channel in the direction opposite to the direction of propagation of the current in the disturbing channel. The terminal of the disturbed channel at which the near-end crosstalk is present is ordinarily near to, or coincides with, the energized terminal of the disturbing channel

5.28
longitudinal balance (analogue voice frequency circuits)
electrical symmetry of the two wires comprising a pair with respect to ground

5.29
longitudinal balance (data transmission)
measure of the similarity of impedance to ground (or common) for the two or more conductors of a balanced circuit. This term is used to express the degree of susceptibility to common mode interference

5.30
longitudinal balance (communication and control cables)
ratio of the disturbing common mode (longitudinal) r.m.s. voltage (V_s) to ground and the resulting differential mode (metallic) r.m.s. voltage (V_m) of the SPD under test, expressed in dB

NOTE The longitudinal balance in dB is given by the formula:

$20 \log_{10} V_s/V_m$

where V_s and V_m are measured at the same frequency.

5.31
longitudinal balance (telecommunications)
ratio of the disturbing common mode (longitudinal) voltage V_s and the resulting differential mode (metallic) voltage V_m of the SPD under test, expressed in dB

6 Components for low-voltage surge protective devices – Specification for gas discharge tubes (GDT) (IEC 61643-311:2001)

6.1
arc current
current that flows after sparkover when the circuit impedance allows a current to flow that exceeds the glow-to-arc transition current

6.2
arc voltage (arc mode voltage)
voltage drop across the GDT during arc current flow

6.3
arc-to-glow transition current
current required for the GDT to pass from the arc mode into the glow mode

6.4
current turn-off time
time required for the GDT to restore itself to a non-conducting state following a period of conduction. This applies only to a condition where the GDT is exposed to a continuous specified d.c. potential under a specified circuit condition

6.5
d.c. breakdown voltage
voltage at which the GDT transitions from a high-impedance off to a conduction state when a slowly rising d.c. voltage is applied

6.6
d.c. holdover
in applications where a d.c. voltage exists on a line, a holdover condition is one in which a GDT continues to conduct after it is subjected to an impulse large enough to cause breakdown. Factors that affect the time required to recover from the conducting state include the d.c. voltage and the d.c. current

6.7
d.c. holdover voltage
maximum d.c. voltage across the terminals of a GDT under which it may be expected to clear and to return to the high-impedance state after the passage of a surge, under specified circuit conditions

6.8
d.c. sparkover voltage
voltage at which the GDT sparks over when slowly increasing d.c. voltage is applied

6.9
GDT discharge current
current that flows through a GDT after sparkover occurs

NOTE In the event that the current passing through the GDT is alternating current, it will be r.m.s. value. In instances where the current passing through the GDT is an impulse current, the value will be the peak value.

6.10
discharge voltage
peak value of voltage that appears across the terminals of a GDT during the passage of GDT discharge current

6.11
discharge voltage current characteristic
variation of peak values of discharge voltage with respect to GDT discharge current

6.12
gas discharge tube
gap, or gaps, in an enclosed discharge medium, other than air at atmospheric pressure, designed to protect apparatus or personnel, or both, from high transient voltages

6.13
glow current (glow mode current)
current that flows after breakdown when the circuit impedance limits the follow current to a value less than the glow-to-arc transition current

6.14
glow-to-arc transition current
current required for the GDT to pass from the glow mode into the arc mode

6.15
glow voltage (glow-mode voltage)
peak value of voltage drop across the GDT when a glow current is flowing

6.16
impulse sparkover voltage
highest value of voltage attained by an impulse of a designated voltage rate-of-rise and polarity applied across the terminals of a GDT prior to the flow of the discharge current

6.17
impulse waveform
impulse waveform designated as x/y having a rise time of x µs and a decay time to half-value of y µs as standardized in IEC 61180-1

6.18
nominal alternating discharge current
for currents with a frequency of 15 Hz to 62 Hz, current which the GDT is designed to carry for a defined time

6.19
nominal d.c. sparkover voltage
voltage specified by the manufacturer to indicate the target value of sparkover voltages of a particular type of GDT products

6.20
nominal impulse discharge current
peak value of the impulse current with a defined waveshape with respect to time for which the GDT is rated

6.21
sparkover (breakdown)
abrupt transition of the gap resistance from practically infinite value to a relatively low value

6.22
transverse voltage
for a GDT with three electrodes, the difference in the discharge voltages between terminal A and B (see Figure 2 of IEC 61643-311) of the gaps assigned to the two conductors of the circuit during the passage of discharge current

6.23
transition time
time required for the voltage across a conducting gap to drop into the arc or glow region after the gap initially begins to conduct

7 Components for low-voltage surge protective devices – Specifications for avalanche breakdown diode (ABD) (IEC 61643-321:2001)

7.1
avalanche breakdown diode ABD
component intended to limit transient voltages and divert surge currents. This is a two-terminal diode that may be packaged with multiple elements having a common terminal

7.2
clamping voltage V_C
peak voltage measured across the ABD during the application of a peak impulse current I_{PP} for a specified waveform

NOTE Due to the thermal, reactive, or other effects, peak voltage and peak pulse current are not necessarily coincident in time. Also shown as V_{CL}.

7.3
rated peak impulse current I_{PPM}
rated maximum value of peak impulse current I_{PP} that may be applied without causing diode failure

NOTE The impulse waveshape used for diode characterization is 10/1 000 μs unless otherwise specified.

7.4
maximum working voltage (maximum d.c. voltage) V_{WM}
maximum peak working or d.c. voltage which may be continuously applied to the ABD without degradation or damaging effects. For a.c. applied voltages, the maximum working r.m.s. voltage is V_{WMrms}

NOTE It is also shown as V_{RM} (rated maximum) and known as rated stand-off voltage.

7.5
stand-by current I_D
maximum current that flows through the ABD at maximum working voltage for a specified temperature

NOTE Also shown as I_R for reverse leakage current.

7.6
breakdown (avalanche) voltage V_{BR}
voltage measured across the ABD at a specified pulsed d.c. current I_T (or I_{BR}) on the V-I characteristics curve at, or near, the place where the avalanche occurs

7.7
capacitance C_j
capacitance between two terminals of the ABD measured at a specific frequency and bias

NOTE Also shown as C.

7.8
rated peak impulse power dissipation P_{PPM}
peak pulse power dissipation resulting from the product of rated peak impulse current I_{PPM} and clamping voltage V_C

$$P_{PPM} = I_{PPM} \times V_C$$

NOTE Also shown as P_P.

7.9
rated forward surge current I_{FSM}
maximum peak current for an 8,3 ms or 10 ms half-sine wave without causing device failure (applies to unidirectional ABDs only)

7.10
forward voltage V_{FS}
peak voltage measured across the ABD for a specified forward surge current I_{FS} (applies to unidirectional ABDs only)

NOTE Also shown as V_F.

7.11
temperature coefficient of breakdown voltage αV_{BR}
ratio of the change in breakdown voltage V_{BR} to changes in temperature

NOTE Expressed as either mV/K or %/K.

7.12
temperature derating
derating above a specified base temperature for either peak impulse current or peak impulse power

NOTE Expressed in percentage of the current or power.

7.13
thermal resistance R_{thJA}, R_{thJC}, R_{thJL}
junction to ambient, case or lead terminal temperature rise per unit input of applied power expressed as K/W

7.14
transient thermal impedance Z_{thJA}, Z_{thJC}, Z_{thJL}
change in the difference between the virtual junction temperature and the temperature of a specific reference point or region (ambient, case or lead) at the end of a time interval. This change is divided by the step function change in power dissipation at the beginning of the same time interval which causes the change of temperature difference.

NOTE Thermal resistance is expressed as K/W.

7.15
rated average power dissipation $P_{M(AV)}$
rated average power dissipation in the device due to repetitive pulses at a specified current and temperature without causing device failure

7.16
peak overshoot voltage V_{OS}
excess voltage above the clamping voltage V_C of the device for a given current that occurs when current waves of less than, or equal to, 10 µs virtual front duration are applied

NOTE This value may be expressed as a percentage of the clamping voltage V_C for a 10/1 000 µs current wave.

7.17
pulsed d.c. test current I_T
test current for measurement of the breakdown voltage V_{BR}. This is defined by the manufacturer and usually given in mA with a pulse duration of less than 40 ms

NOTE Also shown as I_{BR}.

7.18
peak impulse current I_{PP}
peak impulse current value applied across the ABD to determine the clamping voltage V_C for a specified waveshape

8 Components for low-voltage surge protective devices – Specification for metal oxide varistors (MOV) (IEC 61643-331:2001)

8.1
single-pulse peak current I_{TM}
rated maximum value which may be applied for a single impulse of specified waveform, without causing MOV failure.

NOTE Unless otherwise specified, 8/20 µs waveshape is used. In some cases the rated line voltage may also be applied.

8.2
multiple-pulse peak current I_{TSM}
rated maximum value which may be applied for repetitive applications of an impulse of specified waveform, without causing MOV failure.

NOTE Unless otherwise specified, 8/20 μs waveform is used.

8.3
multiple-pulse peak current derating for against pulse width
graphical representation of rated multiple-pulse peak current against rectangular pulse width for different numbers of impulses

NOTE Typically, curves are provided for indefinite, 10^6, 10^5, 10^4, 10^3, $10^2$and 10 pulses together with a single-pulse curve.

8.4
temperature derating curve
graphical representation of parameter derating against temperature.

NOTE Typical parameters are rated voltage, impulse current, energy and average power dissipation

8.5
single-pulse maximum energy W_{TM}
rated maximum value which may be absorbed for a single pulse of a specified waveform

NOTE Unless otherwise specified, 2 ms rectangular pulse is used (IEC 60060).

8.6
maximum continuous voltage V_M
voltage that may be applied continuously at a specified temperature

8.7
maximum continuous a.c. voltage $V_{M(AC)}$
r.m.s a.c. sinusoidal voltage (less than 5 % total harmonic distortion) may be applied continuously at a specified temperature

8.8
maximum continuous d.c. voltage $V_{M(DC)}$
d.c. voltage that may be applied continuously at a specified temperature

8.9
maximum continuous power dissipation P_M
average power that may be continuously dissipated for a given life expectancy

8.10
standby current I_D
impulse current of defined amplitude and waveshape

NOTE 1 It is also called a leakage current.

NOTE 2 This is the specified peak pulse current when measuring the MOV clamping voltage, V_C.

8.11
nominal varistor voltage V_N
voltage across the MOV measured at a specified pulsed current (I_N) of specific duration

NOTE The MOV manufacturer specifies the current. Otherwise, 1 mA is normally used. The pulse duration should be less than 40 ms, unless otherwise specified. In general, nominal value ±10 % is specified by the manufacturer.

8.12
clamping voltage V_C
peak voltage across the MOV measured under conditions of a specified peak pulse current (I_P) and specified waveform.

8.13
capacitance C_V
capacitance across the MOV measured at a specified frequency and voltage

8.14
equivalent series inductance L_V
effective inductance measured across the MOV terminals at a given frequency

8.15
pulse current I_N
rectangular pulse current of defined amplitude and duration

9 Components for low-voltage surge protective devices – Specification for thyristor surge suppressors (TSS) (IEC 61643-341:2003)

9.1
repetitive peak off-state voltage, V_{DRM}
rated maximum (peak) instantaneous voltage that may be applied in the off-state conditions including all d.c. and repetitive voltage components

9.2
repetitive peak on-state current, I_{TRM}
rated maximum (peak) value of a.c. power-frequency on-state current of specified waveshape and frequency which may be applied continuously

9.3
non-repetitive peak on-state current, I_{TSM}
rated maximum (peak) value of a.c. power-frequency on-state surge current of specified waveshape and frequency which may be applied for a specified time or number of a.c. cycles

9.4
non-repetitive peak impulse current, I_{PPSM}, I_{TSM}
rated maximum value of peak impulse current of specified amplitude and waveshape that may be applied

NOTE There are several symbols that are used for this rating. The merits of these symbols are as follows.

I_{PPSM} This is technically correct as it is the maximum or peak (M) non-repetitive (S) value of I_{PP}.

I_{TSM} For short-duration impulses this is not technically correct as the maximum (M) value of non-repetitive (S) current may not occur when the device is in the on-state (T) condition.

I_{PPM} The use of this symbol for a non-repetitive value is discouraged. This symbol is the rated maximum (M) repetitive value of I_{PP}.

I_{PP} The use of this symbol for a rated value is discouraged. The term peak impulse current is a circuit parameter and is defined as the peak current for a series of essentially identical pulses.

9.5
repetitive peak reverse voltage, V_{RRM}
rated maximum (peak) instantaneous voltage that may be applied in the reverse blocking direction including all d.c. and repetitive voltage components

9.6
non-repetitive peak forward current, I_{FSM}
rated maximum (peak) value of a.c. power-frequency forward surge current of specified waveshape and frequency which may be applied for a specified time or number of a.c. cycles

9.7
repetitive peak forward current, I_{FRM}
rated maximum (peak) value of a.c. power-frequency forward current of specified waveshape and frequency which may be applied continuously

9.8
critical rate of rise of on-state current, di/dt, (di_T/dt)cr
rated value of the rate of rise of current which the device can withstand without damage

9.9
off-state voltage, V_D
d.c. voltage when the device is in the off-state

9.10
off-state current, I_D
d.c. value of current that results from the application of the off-state voltage, V_D

9.11
repetitive peak off-state current, I_{DRM}
maximum (peak) value of off-state current that results from the application of the repetitive peak off-state voltage, V_{DRM}

9.12
breakover voltage, $V_{(BO)}$
maximum voltage across the device in or at the breakdown region measured under specified voltage rate of rise and current rate of rise

NOTE Where a breakdown characteristic has several $V_{(BO)}$ values that need to be referenced, a numeric suffix can be added and the relevant part of the breakdown current range specified, for example

$$V_{(BO)1},\ 0 < I_{(BR)} < 10\ \text{mA}$$

9.13
holding current, I_H
minimum anode, principal, or thyristor current that maintains the thyristor in the on-state

9.14
off-state capacitance, C_o, C_J
differential capacitance at the specified terminals in the off-state measured at specified frequency f amplitude V_d and d.c. bias V_D

9.15
repetitive peak reverse current, I_{RRM}
maximum (peak) value of reverse current that results from the application of the repetitive peak reverse voltage, V_{RRM}

9.16
peak forward recovery voltage, V_{FRM}
maximum value of forward conduction voltage across the device upon the application of a specified voltage rate of rise and current rate of rise following a zero or specified reverse-voltage condition

9.17
critical rate of rise of off-state voltage, dv/dt, (dv_D/dt)cr
maximum rate of rise of voltage (below V_{DRM}) that does not cause switching from the off state to the on state

9.18
breakdown voltage, $V_{(BR)}$
voltage across the device in the breakdown region (prior to the switching point) at a specified breakdown current, $I_{(BR)}$

NOTE For positive breakdown slope devices, $V_{(BR)}$ may be used as an alternative to V_{DRM}.

9.19
breakdown current, $I_{(BR)}$
current through the device in the breakdown region

9.20
breakover current, $I_{(BO)}$
instantaneous current flowing at the breakover voltage, $V_{(BO)}$

9.21
switching voltage, V_S
instantaneous voltage across the device at the final point in the breakdown region prior to switching into the on state

9.22
switching current, I_S
instantaneous current flowing through the device at the switching voltage, V_S

9.23
on-state voltage, V_T
voltage across the device in the on-state condition at a specified current, I_T

9.24
on-state current, I_T
current through the device in the on-state condition

9.25
forward voltage, V_F
voltage across the device in the forward conducting state at a specified current, I_F

9.26
forward current, I_F
current through the device in the forward conducting state

9.27
switching resistance, R_S
derived equivalent slope resistance of the breakdown region, R_S, computed by

$$(V_{(BO)} - V_S) / (I_S - I_{(BO)}) \qquad (1)$$

9.28 insulation resistance
derived equivalent insulation resistance of the device, computed by

$$V_D / I_D \tag{2}$$

9.29
temperature coefficient of breakdown voltage, $\alpha V_{(BR)}$, $dV_{(BR)}/dT_J$
ratio of the change in breakdown voltage, $V_{(BR)}$, to changes in temperature

NOTE Expressed as either mV/K or %/K with reference to the 25 °C value of breakdown voltage. Alternatives to mV/K and %/K are mV/°C and %/°C.

9.30
variation of holding current with temperature
change in holding current, I_H, with changes in temperature and shown as a graph

9.31
temperature derating
derating with temperature above a specified base temperature, expressed as a percentage, such as may be applied to peak pulse current

9.32
thermal resistance, R_{thJL}, R_{thJC}, R_{thJA} ($R_{\theta JL}$, $R_{\theta JC}$, $R_{\theta JA}$)
effective temperature rise per unit power dissipation of a designated junction, above the temperature of a stated external reference point (lead, case or ambient) under conditions of thermal equilibrium

NOTE Thermal resistance is usually expressed as K/W with °C/W as an alternative.

9.33
transient thermal impedance, $Z_{thJL(t)}$, $Z_{thJC(t)}$, $Z_{thJA(t)}$ ($Z_{\theta JL(t)}$, $Z_{\theta JC(t)}$, $Z_{\theta JA(t)}$)
change in the difference between the virtual junction temperature and the temperature of a specified reference point or region (lead, case, or ambient) at the end of a time interval, divided by the step function change in power dissipation at the beginning of the same time interval which causes the change of temperature difference

NOTE 1 Thermal impedance is usually expressed as K/W with °C/W as an alternative.

NOTE 2 It is the thermal impedance of the junction under conditions of change and is generally given in the form of a curve as a function of the duration of an applied power pulse.

9.34
(virtual) junction temperature, T_J, T_{VJ}
theoretical temperature representing the temperature of the junction(s) calculated on the basis of a simplified model of the thermal and electrical behaviour of the device

NOTE The term “virtual-junction temperature” is particularly applicable to multi-junction semiconductors and is used to denote the temperature of the active semiconductor element when required in specifications and test methods. The term “junction temperature”, T_J, is used interchangeably with the term “virtual junction temperature”, T_{VJ}, in this standard.

9.35
maximum junction temperature, T_{JM}
maximum value of permissible junction temperature, due to self-heating, which a TSS can withstand without degradation

9.36
storage temperature range, T_{stg}min. to T_{stg}max.
temperature range over which the device can be stored without any voltage applied

NOTE Preferred temperature ranges (selected from IEC 60747-1, Chapter VI, Clause 5 and IEC 60749, Chapter III, 1.2) are

0 °C to 125 °C

–55 °C to 125 °C

–65 °C to 150 °C

9.37
gate trigger current, I_{GT}
lowest gate current required to switch a device from the off state to the on state

9.38
gate trigger voltage, V_{GT}
gate voltage required to produce the gate trigger current, I_{GT}

9.39
gate-to-adjacent terminal peak off-state voltage
maximum gate-to-cathode voltage for a P-gate device or gate-to-anode voltage for an N-gate device that may be applied in such a way that a specified off-state current, I_D, at a rated off-state voltage, V_D, is not exceeded

9.40
peak off-state gate current, I_{GDM}
maximum gate current that results from the application of the peak off-state gate voltage, V_{GDM}

9.41
gate reverse current, adjacent terminal open, I_{GAO} , I_{GKO}
current through the gate terminal when a specified gate bias voltage, V_G, is applied and the cathode terminal for a P-gate device or anode terminal for an N-gate device is open-circuited

9.42
gate reverse current, main terminals short-circuited, I_{GAS}, I_{GKS}
current through the gate terminal when a specified gate bias voltage, V_G, is applied and the cathode terminal for a P-gate device or anode terminal for an N-gate device is short-circuited to the third terminal

NOTE This definition only applies to devices with integrated series gate blocking diodes.

9.43
gate reverse current, on-state, I_{GAT}, I_{GKT}
current through the gate terminal when a specified gate bias voltage, V_G, is applied and a specified on-state current, I_T, is flowing

NOTE This definition only applies to devices with integrated series gate blocking diodes.

9.44
gate reverse current, forward conducting state, I_{GAF}, I_{GKF}
current through the gate terminal when a specified gate bias voltage, V_G, is applied and a specified forward conduction current, I_F, is flowing

NOTE This definition only applies to conducting unidirectional devices with integrated series gate blocking diodes.

9.45
gate switching charge, Q_{GS}
charge through the gate terminal, under impulse conditions, during the transition from the off state to the switching point, when a specified gate bias voltage, V_G, is applied

9.46
peak gate switching current, I_{GSM}
maximum value of current through the gate terminal during the transition from the off state to the switching point, when a specified gate bias voltage, V_G, is applied

9.47
gate-to-adjacent terminal breakover voltage, $V_{GK(BO)}$, $V_{GA(BO)}$
gate-to-cathode voltage for a P-type device or gate to anode voltage for an N-gate device at the breakover point

NOTE This is equivalent to the voltage difference between the breakover voltage, $V_{(BO)}$, and the specified gate voltage, V_G .

9.48
asymmetrical bidirectional TSS
thyristor having substantially different switching behaviour in the first and third quadrants of the principal voltage-current characteristic

9.49
bidirectional TSS
thyristor having switching behaviour in the first and third quadrants of the principal voltage-current characteristic

9.50
forward-blocking TSS
TSS that switches only for negative main terminal-2 (cathode) voltage and exhibits a blocking state for positive main terminal-2 voltage

9.51
forward-conducting TSS
TSS that switches only for negative main terminal-2 (cathode) voltage and conducts large currents at positive main terminal-2 voltage comparable in magnitude to the on-state voltage

9.52
negative breakdown resistance TSS
TSS, the static breakdown characteristic of which has a net negative resistance slope prior to switching

9.53
N-gate thyristor
gated thyristor in which the gate terminal is connected to the N-region adjacent to the P-region to which the anode is connected and that is normally switched to the on state by applying a negative signal between the gate and anode terminals

9.54
P-gate thyristor
gated thyristor in which the gate terminal is connected to the P-region adjacent to the N-region to which the cathode is connected and that is normally switched to the on state by applying a positive signal between the gate and cathode terminals

9.55
positive-breakdown-resistance TSS
TSS the static breakdown characteristic ofo which has a net positive-resistance slope prior to switching

9.56
reverse-blocking TSS
TSS that exhibits a blocking state for positive cathode voltage

9.57
reverse-conducting TSS
TSS that exhibits a conducting state for positive cathode voltage

9.58
symmetrical bidirectional TSS
thyristor having substantially the same switching behaviour in the first and third quadrants of the principal voltage-current characteristic

9.59
thyristor
bistable semiconductor device comprising three or more junctions that can be switched from the off state to the on state or vice versa, such switching occurring within at least one quadrant of the principal voltage-current characteristic

9.60
unidirectional TSS
TSS that has switching characteristics in only one quadrant of the principal voltage-current characteristic

9.61
anode
electrode by which current enters the thyristor, when the thyristor is in the on state with the gate open-circuited

[IEC 60747-6]

NOTE This term does not apply to bidirectional thyristors.

9.62
cathode
electrode by which current leaves the thyristor, when the thyristor is in the on state with the gate open-circuited

NOTE This term does not apply to bidirectional thyristors.

9.63
gate
electrode connected to one of the semiconductor regions to introduce a control current

9.64
main terminals
the two terminals through which the principal current flows

NOTE The main terminals may be named by application usage, for example, in telecommunications, terminals may be named after line connections: R (ring), T (tip) and G (ground) or A, B and C (common)

9.65
main terminal 1
main terminal that is named 1 by the device manufacturer

9.66
main terminal 2
main terminal that is named 2 by the device manufacturer

9.67
(electrical) terminal
externally available point of connection

9.68
blocking
term describing the state of a semiconductor device or junction that imposes high resistance to the passage of current

9.69
breakdown
phenomena occurring in a reverse biased semiconductor junction, the initiation of which is observed as a transition from a region of high dynamic resistance to a region of substantially lower dynamic resistance for increasing magnitude of reverse current

9.70
breakdown region
portion of the characteristic that starts with the transition from the high dynamic resistance off state to a substantially lower dynamic resistance and extending to the switching point

9.71
breakover point
any point in the breakdown region voltage-current characteristic for which the differential resistance is zero and where the principal voltage reaches a maximum value

[IEC 60747-6, definition 2.16, modified]

NOTE If more than one breakover point exists in the breakdown region, the one with the highest voltage value is characterized.

9.72
characteristic
inherent and measurable property of a device

NOTE Such a property may be electrical, mechanical, thermal, hydraulic, electromagnetic, or nuclear and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

9.73
clipping (clamping)
form of limiting in which all the instantaneous values of a signal exceeding a predetermined threshold value are reduced to values close to that of the threshold, all other instantaneous values of the signal being preserved

[IEV 702-04-33]

NOTE The word clamping is often used instead of clipping, although IEV 702-04-37 defines clamping as "a process in which some feature of a recurrent signal, for instance, its d.c. component, is held at a reference value".

9.74
crowbarring
form of limiting whereby when the instantaneous value of a signal becomes greater than a predetermined threshold value a low impedance shunt is activated. When active, the shunt, in conjunction with the signal source impedance, reduces the signal amplitude

9.75
forward/reverse blocking quadrant
quadrant of the principal voltage-current characteristic in which the device exhibits a reverse blocking state

[IEC 60747-6, modified]

NOTE This will be the first quadrant for a forward blocking TSS and the third quadrant for a reverse blocking TSS.

9.76
forward/reverse conducting quadrant
quadrant of the principal voltage-current characteristic in which the device exhibits a forward direction conduction state
[IEC 60747-6, modified]

NOTE This will be the first quadrant for a forward conducting TSS and the third quadrant for a reverse conducting TSS.

9.77
forward direction

a) direction of current in a P-N junction that results when the P-type semiconductor region is at a positive potential relative to the N-type region
b) direction of current in a semiconductor device that results when the P-type semiconductor region connected to one terminal is at a positive potential relative to the N-type region connected to the other terminal

NOTE This definition does not apply if one or more junctions are connected in series with at least one other junction whose P and N regions are reversed.

9.78
maximum rating (absolute maximum rating)
rating that establishes either a limiting capability or a limiting condition beyond which damage to the device may occur

NOTE A limiting condition may be either a maximum or a minimum.

9.79
negative differential-resistance (region)
region of the principal voltage-current characteristic in the switching quadrant where the differential resistance is negative and the thyristor switches between the breakdown and on-state regions
[IEC 60747-6, modified]

9.80
non-repetitive current rating
maximum rating that may be applied to the device for a minimum of 100 times over the life of the device without failure

NOTE During the rated condition, the device is permitted to exceed its maximum rated junction temperature for short periods of time. The device is not required to block voltage or retain any gate control during or immediately following this rated condition until the device has returned to the original equilibrium conditions. This rated condition may be repeated after the device has returned to the original thermal equilibrium conditions.

9.81
off state (region)
state of the TSS in a quadrant in which switching can occur, that corresponds to the high dynamic-resistance portion of the characteristic between the origin and the beginning of the breakdown region
[IEC 60747-6, modified]

9.82
on state (region)
condition of the TSS corresponding to the low-resistance low-voltage portion of the principal voltage-current characteristic in the switching quadrant(s)

9.83
parameter
device descriptor that is measurable or quantifiable, such as a characteristic or rating

9.84
principal current
generic term for the current through the device excluding any gate current

NOTE It is the current through both main terminals.

9.85
principal voltage
voltage between the main terminals

NOTE 1 In the case of reverse blocking and reverse conducting thyristors, the principal voltage is called positive when the anode potential is higher than the cathode potential and negative when the anode potential is lower than the cathode potential.

NOTE 2 For bidirectional thyristors, the principal voltage is called positive when the potential of main terminal 2 is higher than the potential of main terminal 1.

NOTE 3 For forward-conducting thyristors the principal voltage is called positive when the cathode potential is higher than the anode potential and negative when the cathode potential is lower than the anode potential.

9.86
principal voltage-current characteristic (principal characteristic)
function, usually represented graphically, relating the principal voltage to the principal current

9.87
quadrant
when the principal voltage-current characteristic is expressed graphically, the voltage, v, and current, i, axes create four areas called quadrants. These quadrants are termed counter clockwise as first, second, third and forth quadrants. The characteristic occurs in the first quadrant, $+v$ and $+i$, and the third quadrant, $-v$ and $-i$

9.88
rating
nominal value of any electrical, thermal, mechanical, or environmental quantity assigned to define the operating conditions under which a component, machine, apparatus, electronic device, etc., is expected to give satisfactory service

NOTE 'Rating' is a generic term. See also **maximum rating** (3.2.3.11 of IEC 61643-341).

9.89
repetitive rating
maximum rating that may be continuously applied to the thyristor

9.90
reverse direction

a) direction of current in a P-N junction that results when the N-type semiconductor region is at a positive potential relative to the P-type region

b) direction of current in a semiconductor device that results when the N-type semiconductor region connected to one terminal is at a positive potential relative to the P-type region connected to the other terminal

NOTE This definition may not apply if one or more junctions are connected in series with at least one other junction whose P and N regions are reversed.

9.91
switching point
point in the principal voltage-current characteristic at which the thyristor regenerates and initiates switching into the on-state

NOTE This point occurs at the termination of the breakdown region and the start of the negative differential-resistance region

9.92
switching quadrant
quadrant of the principal voltage-current characteristic in which the device is intended to switch between the off-state and the on-state

NOTE For a bidirectional thyristor, the switching quadrants are the first quadrant and the third quadrant. For a reverse blocking or reverse conducting thyristor, the switching quadrant is the first quadrant. For a forward conducting or reverse conducting thyristor, the switching quadrant is the third quadrant.

10 Low-voltage surge protective devices – Surge protective devices connected to low-voltage power distribution systems – Selection and application principles (IEC 61643-12:2002)

10.1
surge protective device (SPD)
device that is intended to limit transient overvoltages and divert surge currents. It contains at least one non-linear component

[IEC 61643-1, definition 3.1]

10.2
continuous operating current (I_c)
current flowing through each mode of protection of the SPD when energized at the maximum continuous operating voltage (U_c) for each mode

[IEC 61643-1, definition 3.12]

10.3
maximum continuous operating voltage (U_c)
maximum r.m.s. or d.c. voltage which may be continuously applied to the SPD's mode of protection. This is equal to the rated voltage

[IEC 61643-1, definition 3.11]

10.4
voltage protection level (U_p)
parameter that characterizes the performance of the SPD in limiting the voltage across its terminals, which is selected from a list of preferred values. This value is greater than the highest value of the measured limiting voltages

[IEC 61643-1, definition 3.15]

10.5
measured limiting voltage
maximum magnitude of voltage that is measured across the terminals of the SPD during the application of impulses of specified waveshape and amplitude

[IEC 61643-1, definition 3.16]

10.6
residual voltage (U_{res})
peak value of voltage that appears between the terminals of an SPD due to the passage of discharge current

[IEC 61643-1, definition 3.17]

10.7
temporary overvoltage (U_T)
maximum r.m.s. value or d.c. overvoltage that the protective device can withstand and that exceeds the maximum continuous operating voltage (U_c) for a specified time duration

NOTE 1 Adapted from 3.18 of IEC 61643-1 by adding the following note.

NOTE 2 U_T is a voltage declared by the manufacturer at which the SPD has a defined characteristic for a given specific duration (this means either no change in the performance after application of the temporary overvoltage or the failure should be such that there is no hazard for either personnel, equipment or facility).

10.8
temporary overvoltage of the network (U_{TOV})
power-frequency overvoltage occurring on the network at a given location, of relatively long duration. TOVs may be caused by faults inside the LV system ($U_{TOV,LV}$) or inside the HV system ($U_{TOV,HV}$)

NOTE Temporary overvoltages, typically lasting up to several seconds, usually originate from switching operations or faults (for example, sudden load rejection, single-phase faults, etc.) and/or from non-linearity (ferro-resonance effects, harmonics, etc.)

10.9
nominal discharge current (I_n)
crest value of the current through the SPD having a current waveshape of 8/20. This is used for the classification of the SPD for class II test and also for preconditioning of the SPD for class I and II tests

[IEC 61643-1, definition 3.8]

10.10
impulse current (I_{imp})
current peak value (I_{peak}) and the charge (Q) tested according to the test sequence of the operating duty test. This is used for the classification of the SPD for class I test

[IEC 61643-1, definition 3.9, modified]

10.11
combination wave
delivered by a generator that applies a 1,2/50 voltage impulse across an open circuit and an 8/20 current impulse into a short circuit. The voltage, current amplitude and waveforms that are delivered to the SPD are determined by the generator and the impedance of the SPD to which the surge is applied. The ratio of peak open-circuit voltage to peak short-circuit current is 2 Ω, this is defined as the fictive impedance (Z_f). The short-circuit current is symbolized by (I_{sc}). The open-circuit voltage is symbolized by (U_{oc})

[IEC 61643-1, definition 3.24]

10.12
8/20 current impulse
current impulse with a virtual front time of 8 µs and a time to half-value of 20 µs

[IEC 61643-, definition 3.23]

10.13
1,2/50 voltage impulse
voltage impulse with a virtual front time (time to rise from 10 % to 90 % of the peak value) of 1,2 µs and a time to half-value of 50 µs

[IEC 61643-1, definition 3.22]

10.14
thermal runaway
operational condition when the sustained power dissipation of an SPD exceeds the thermal dissipation capability of the housing and connections, leading to a cumulative increase in the temperature of the internal elements culminating in failure

[IEC 61643-1, definition 3.25]

10.15
thermal stability
an SPD is thermally stable if after the operating duty test causing temperature rise, the temperature of the SPD decreases with time when the SPD is energized at specified maximum continuous operating voltage and at specified ambient temperature conditions

[IEC 61643-1, definition 3.26]

10.16
SPD disconnector
device for disconnecting an SPD from the system in the event of SPD failure. It is to prevent a persistent fault on the system and to give visible indication of the SPD failure

NOTE 1 Adapted from 3.29 of IEC 61643-1 by adding the following note.

NOTE 2 At least three functions are needed for SPD disconnectors: protection against thermal problems (such as thermal runaway on varistors, etc.), protection against internal short circuits and protection against indirect contact. These functions may be achieved by one or more disconnector(s). Each disconnector may either be integrated into the SPD or external to it. They may be used in the SPD circuit or in line with the supply.

10.17
type tests
tests which are made upon the completion of the development of a new SPD design. They are used to establish representative performance and to demonstrate compliance with the relevant standard. 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

[IEC 61643-1, definition 3.31]

10.18
routine tests
tests made on each SPD or on parts and materials as required to ensure that the product meets the design specifications

[IEC 61643-1, definition 3.32]

10.19
acceptance tests
tests which are made when it has been agreed between the manufacturer and the purchaser that the SPD or representative samples of an order are to be tested

[IEC 61643-1, definition 3.33]

10.20
degrees of protection provided by enclosure (IP code)
extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or against ingress of water (see IEC 60529)

[IEC 61643-1, definition 3.30]

10.21
voltage drop (in per cent)

$$\Delta U = [(U_{\mathrm{in}} - U_{\mathrm{out}}) / U_{\mathrm{in}}] \times 100\ \%$$

where U_{in} is the input voltage and U_{out} is the output voltage measured simultaneously with a full rated resistive load connected. This parameter is only used for two-port SPDs

[IEC 61643-1, definition 3.20]

10.22
insertion loss
at a given frequency, the insertion loss of an SPD connected into a given power system is defined as the ratio of voltages appearing across the mains immediately beyond the point of insertion before and after the insertion of the SPD under test. This result is expressed in decibels (dB)

NOTE Requirements and tests are under consideration.

[IEC 61643-1, definition 3.21]

10.23
load-side surge withstand capability for a two-port SPD
ability of a two-port SPD to withstand surges on the output terminals originated in loads downstream of the SPD

[IEC 61643-1, definition 3.19]

10.24
short-circuit withstand
maximum prospective short-circuit current that the SPD is able to withstand

NOTE 1 Adapted from 3.28 of IEC 61643-1 by adding the following note.

NOTE 2 This definition refers both to d.c. and a.c. 50/60 Hz. Two short-circuit withstand values may be defined for two-port SPDs or one-port SPDs having separated input and output terminals: one corresponding to an internal short circuit (by-passing the internal active part) and another one corresponding to an external short circuit directly at the output terminals (case of a failure at the load). In IEC 61643-1, the short-circuit withstand test is only for internal short circuits. An external short-circuit test is under consideration.

10.25
one-port SPD
SPD connected in shunt with the circuit to be protected. A one-port device may have separate input and output terminals without a specified series impedance between these terminals

NOTE 1 Adapted from 3.2 of IEC 61643-1 by adding the following note.

NOTE 2 Figure 1 of IEC 61643-12 shows some typical one-port SPDs and the generic drawing for a one-port SPD (Figure 1c of IEC 61643-12). A one-port SPD may be connected in shunt (Figure 1a of IEC 61643-12) or in line with the power supply (Figure 1b of IEC 61643-12). In the first case, the load current is not flowing through the SPD. In the second case, the load current is flowing through the SPD and the temperature rise under load current and the associated maximum admissible load current may be determined as for a two-port SPD. Figures 3b to 3d of IEC 61643-12 show the response of various types of one-port SPD to an 8/20 impulse applied via a combination wave generator.

10.26
two-port SPD
SPD with two sets of terminals, input and output. A specific series impedance is inserted between these terminals

NOTE 1 Adapted from 3.3 of IEC 61643-1 by adding the following note.

NOTE 2 The measured limiting voltage may be higher at the input terminals than at the output terminals. Therefore, equipment to be protected is to be connected to the output terminals. Figure 2 of IEC 61643-12 shows typical two-port SPDs. Figures 3e and 3f of IEC 61643-12 show the response of a two-port SPD to an 8/20 impulse applied via a combination wave generator.

10.27
voltage-switching type SPD
SPD that has a high impedance when no surge is present but can have a sudden change in impedance to a low value in response to a voltage surge. Common examples of components used as voltage-switching devices are spark-gaps, gas discharge tubes (GDT), thyristors (silicon-controlled rectifiers) and triacs. These SPDs are sometimes called "crowbar type"

NOTE 1 Adapted from 3.4 of IEC 61643-1 by adding the following note.

NOTE 2 A voltage-switching device has a discontinuous U versus I characteristic. Figure 3c of IEC 61643-12 shows the response of a typical voltage switching SPD to an impulse applied via a combination wave generator.

10.28
voltage-limiting type SPD
SPD that has a high impedance when no surge is present but will reduce it continuously with increased surge current and voltage. Common examples of components used as non-linear devices are: varistors and suppressor diodes. These SPDs are sometimes called "clamping type"

NOTE 1 Adapted from 3.5 of IEC 61643-1 by adding the following note.

NOTE 2 A voltage-limiting device has a continuous U versus I characteristic. Figure 3b of IEC 61643-12 shows the response of a typical voltage-limiting SPD to an impulse applied via a combination wave generator.

10.29
combination type SPD
SPD that incorporates both voltage-switching type components and voltage-limiting type components may exhibit voltage-switching, voltage-limiting, or both voltage-switching and voltage-limiting behaviour depending upon the characteristics of the applied voltage

NOTE 1 Adapted from 3.6 of IEC 61643-1 by adding the following note.

NOTE 2 Figures 3d and 3e of IEC 61643-12 show the response of various typical combination-type SPDs to a combination wave impulse.

10.30
modes of protection
SPD protective components may be connected line to line or line to earth or line to neutral or neutral to earth and combination thereof. These paths are referred to as modes of protection

[IEC 61643-1, definition 3.7]

10.31
follow current (I_f)
current supplied by the electrical power system and flowing through the SPD after a discharge current impulse. The follow current is significantly different from the continuous operating current (I_c)

[IEC 61643-1, definition 3.13]

10.32
maximum discharge current (I_{max}) for class II test
crest value of a current through the SPD having an 8/20 waveshape and magnitude according to the test sequence of the class II operating duty test. I_{max} is greater than I_n

[IEC 61643-1, definition 3.10]

10.33
degradation
change of original performance parameters as a result of exposure of the SPD to surge, service or unfavourable environment

NOTE 1 Adapted from 3.27 of IEC 61643-1 by adding the following note.

NOTE 2 Degradation is a measure of the ability of an SPD to withstand the conditions for which it is designed throughout its service life. Two type tests are applied to provide confidence with respect to degradation. The first one is the operating duty test and the second is the ageing test. However, these two tests may be combined.

The operating duty test is conducted by applying a specified number of defined current waveshapes to the SPD. Permitted changes in the SPD characteristics are given in IEC 61643-1.

The ageing test is carried out at a specified temperature with a voltage of specified magnitude and duration applied to the SPD. Permitted changes in the SPD characteristics are given in this standard (this test is under consideration).

This can be used to determine the SPD prospective installed life which should also consider the following:

– replacement policy;
– location and accessibility;
– acceptable failure rate;
– operating practices.

10.34
residual current device (RCD)
mechanical switching device or association of devices intended to cause the opening of the contacts when the residual or unbalanced current attains a given value under specified conditions

[IEC 61643-1, definition 3.37]

10.35
nominal voltage of the system
voltage by which a system or equipment is designated and to which certain operating characteristics are referred (for example, 230/400 V).

Under normal system conditions, the voltage at the supply terminals may differ from the nominal voltage as determined by the tolerances of the supply systems

NOTE 1 In this standard, a tolerance of ±10 % is used.

The nominal voltage of the system phase to earth is called U_n (see IEC 60038)

NOTE 2 The line-to-neutral voltage of the system is called U_0.

10.36
class I test
test carried out with the nominal discharge current (I_n) defined in 4.8, the 1,2/50 voltage impulse defined in 4.22, and the maximum impulse current I_{imp} for class I test defined in 4.9

10.37
class II test
test carried out with the nominal discharge current (I_n) defined in 4.8, the 1,2/50 voltage impulse defined in 4.22, and the maximum discharge current I_{max} for class II test defined in 4.9

10.38
class III test
tests carried out with the combination wave (1,2/50, 8/20) defined in 4.24

NOTE Adapted from 3.35.3 of IEC 61643-1.

10.39
rated load current (I_L)
maximum continuous rated r.m.s. or d.c. current that can be supplied to a load connected to the protected output of an SPD

NOTE 1 Adapted from 3.14 of IEC 61643-1 by adding the following note.

NOTE 2 This is only relevant to SPD(s) having separate input and output terminals.

10.40
backup overcurrent protection
overcurrent device (for example, fuse or circuit-breaker), which is a part of the electrical installation located externally upstream of the SPD, to avoid overheating and destruction in case the SPD is unable to interrupt the power-frequency short-circuit current

[IEC 61643-1, definition 3.6]

10.41
maximum continuous operating voltage of the power system at the SPD location (U_{cs})
maximum r.m.s. or d.c. voltage to which the SPD may be subjected at the point of application of the SPD. This takes into account only voltage regulation and/or voltage drop or increase. It is directly linked to U_0

Also called actual maximum system voltage (see Figure 6 of IEC 61643-12).

NOTE This voltage does not take into account harmonics, faults, TOVs or transient conditions.

10.42
sparkover voltage of a voltage-switching SPD
maximum voltage value before disruptive discharge between the electrodes of the gap of an SPD

NOTE 1 Adapted from 3.38 of IEC 61643-1 by adding the following note.

NOTE 2 A voltage-switching SPD may be based on components other than gaps (for example, silicon-based components).

10.43
lightning protection system (LPS)
complete system used to protect a structure and its contents against the effects of lightning

11 Surge arresters – Surge arresters containing both series and parallel gapped structures – Rated 52 kV and less (IEC 60099-6:2002)

11.1
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 of IEC 60099-6 for metal-oxide surge arrester with series gapped structures.

11.2
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

11.3
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

11.4
grading ring of an arrester
metal part usually circular in shape, mounted to modify electrostatically the voltage distribution along the arrester

11.5
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.

11.6
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.

11.7
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

11.8
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 of IEC 60099-6)

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.)

11.9
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 of IEC 60099-6

11.10
rated frequency of an arrester
frequency of the power system on which the arrester is designed to be used

11.11
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.

11.12
puncture (breakdown)
disruptive discharge through a solid

11.13
flashover
disruptive discharge over a solid surface

11.14
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.

11.15
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

11.16
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 of IEC 60099-6).

11.17
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 of IEC 60099-6).

11.18
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.

11.19
peak (crest) value of an impulse
maximum value of a voltage or current impulse

NOTE Superimposed oscillations may be disregarded (see 7.4.2c) and 7.5.3.2e) of IEC 60099-6).

11.20
front of an impulse
part of an impulse which occurs prior to the peak

11.21
tail of an impulse
part of an impulse which occurs after the peak

11.22
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.

11.23
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.

11.24
virtual steepness of the front of an impulse
quotient of the peak value and the virtual front time of an impulse

11.25
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

11.26
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

11.27
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.

11.28
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

11.29
discharge current of an arrester
impulse current which flows through the arrester

11.30
nominal discharge current of an arrester, I_n
peak value of lightning current impulse (see 2.17 and Table 1 of IEC 60099-6) which is used to classify an arrester

11.31
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

11.32
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

11.33
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.

11.34
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 m^2 of disc area for single column arresters.

11.35
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.

11.36
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.

11.37
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 of IEC 60099-6

11.38
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

11.39
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 of IEC 60099-6;
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 of IEC 60099-6;
c) residual voltage for switching impulse and the switching impulse sparkover according to 7.3.4 and 7.3.8.2 of IEC 60099-6

11.40
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

11.41
thermal stability of an arrester
an 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

11.42
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.

11.43
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.

11.44
routine tests
tests made on each arrester, or on parts and materials, as required, to ensure that the product meets the design specifications

11.45
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

11.46
sparkover of an arrester
disruptive discharge between the electrodes of the gaps of an arrester

11.47
follow current of an arrester
current from the connected power source which flows through an arrester following the passage of discharge current

11.48
power-frequency sparkover voltage
average of at least five successive power-frequency sparkovers

11.49
lightning impulse sparkover voltage
average of at least five successive lightning impulse sparkovers

11.50
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

11.51
front-of-wave sparkover voltage of an arrester
impulse sparkover voltage obtained on the wavefront of the voltage which increases linearly with time

11.52
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

11.53
time to sparkover of an arrester
time interval between virtual origin and the instant of sparkover of the arrester, expressed in μs

11.54
impulse sparkover voltage-time curve
curve which relates the impulse sparkover of the voltage to the time to sparkover

11.55
grading current
peak value of current flowing through the arrester while power frequency voltage is applied

11.56
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

11.57
power-frequency sparkover voltage
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

11.58
line arrester
type of arrester that is commonly applied to power systems to reduce the risk of insulator flashover during a lightning transient

NOTE It is not generally used to protect the insulator from other types of transients such as switching surges. Neither is it generally used to protect any equipment other than line insulators.

11.59
fast front protective level
highest of either the steep current residual voltage at (I_n) or the front-of-wave impulse sparkover voltage

11.60
standard lightning impulse protective level
highest of either the residual voltage at nominal current (I_n) or 1,2/50 lighting impulse sparkover voltage

11.61
switching impulse protective level
highest of either the maximum residual voltage for the specified switching current or the specified switching impulse sparkover voltage

11.62
main series metal-oxide resistors
resistors that carry energy during an impulse, not to be confused with resistors that separate gaps for voltage grading

NOTE Measurement of reference voltage is necessary for the selection of a correct test sample in the operating duty test (see 6.2).

11.63
series gap
intentional gap(s), between spaced electrodes in series with one or more metal-oxide resistors, across which all or part of the imparted terminal voltage appears

11.64
shunt gap
intentional gap(s) between spaced electrodes electrically in parallel with one or more main metal-oxide resistors

11.65
switching voltage impulse
impulse voltage having a virtual front time greater than 30 μs

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