IEEE Std C62.32™-2004
(Revision of IEEE Std C62.32-1981)

IEEE Standards

C62.32™

IEEE Standard Test Methods for Low-Voltage Air Gap Surge-Protective Device Components (Excluding Valve and Expulsion Types)

IEEE Power Engineering Society

Sponsored by the
Surge Protective Devices Committee

IEEE

3 Park Avenue, New York, NY 10016-5997, USA

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Surge Protective Devices Committee
of the
IEEE Power Engineering Society

Approved 12 April 2005

American National Standard Institute

Approved 8 December 2004

IEEE-SA Standards Board

Abstract: This standard applies to air gaps for overvoltage protection applications on systems with operating voltages equal to or less than 600 V rms. This standard contains a series of standard tests for determining the electrical characteristics of these air gap devices. This standard's test criteria and definitions provide a common engineering language beneficial to users and manufacturers of air gap surge protective devices.
Keywords: ac discharge current, air backup gap, air gap, air gap surge protector, back up gap, capacitance, current, discharge current, dc breakdown voltage, dc holdover voltage, dc impulse voltage, dc sparkover voltage, discharge voltage, fail safe, follow on current, impulse life, insulation resistance, maximum single discharge, sparkover, wave shape

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Introduction

This introduction is not a part of IEEE Std C62.32-2004, IEEE Standard Test Methods for Low-Voltage Air Gap Surge-Protective Device Components (Excluding Valve and Expulsion Types).

The low-voltage air gap surge-protective device is a gap-type overvoltage limiter for use on communications, power, and signaling circuits. It has been used in one form or another for many years.

With the development of newer and more sophisticated electronic apparatus, which was usually more vulnerable to the electrical environment, it became evident that there was an industry-wide requirement for improved protective devices. An effort to address this problem was initiated in 1970 when the IEEE Surge Protective Devices Committee formed its Low-Voltage Surge-Protective Devices Working Group.

It soon became apparent that there were no standard terms to describe these devices or standard tests that would permit comparison with other similar or different devices. The working group first addressed the gas tube arrester and published IEEE Std 465.1-1977 (later redesignated as ANSI/IEEE Std C62.31), IEEE Standard Test Specifications for Gas Tube Surge-Protective Devices.

Experts were drawn from any fields ranging from communications and power utilities, through electronics manufacturers, to manufacturers of Air Gap Surge-Protective Devices. The diverse requirements, experiences, and vocabularies of these representatives were melded to produce this standard, which should be of service to all potential users.

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Participants

For the revision of this document, a new working group was formed in 2000. At the time this standard was approved, the working group had the following membership:

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Jack Cawley, *Secretary**
Nisar Chaudhry, *Secretary*

Richard Bentinger	Bill Curry	Donald Turner
	Benny Lee	

*Denotes a member of the working group that is deceased.

Other former members of the working group who contributed to this standard were:

M. Flack, *Chair*
W. W. Hines, *Secretary*

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The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

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IEEE Standard Test Methods for Low-Voltage Air Gap Surge-Protective Device Components (Excluding Valve and Expulsion Types)

1. Scope

This standard applies to air gaps for overvoltage protection applications on systems with operating voltages equal to or less than 600 V rms. These protective devices are designed for limiting the voltages on balanced or unbalanced communication and signaling circuits. Specifically excluded from this standard are valve and expulsion type devices covered by IEEE Std C62.1-1989 [B1][1]. This standard contains a series of standard tests for determining the electrical characteristics of these air gap devices.

The tests in this standard are intended as design tests as defined in *The Authoritative Dictionary of IEEE Standard Terms* [B2], and provide a means of comparison among various air gap surge-protective devices. For those parameters affected by the interaction of the arrester with its associated mounting arrangement, some tests are necessarily applicable to the protector.

Air gap devices are used to provide overvoltage protection in electrical circuits. When the device's breakdown voltage is exceeded, its normal high impedance state changes to a low impedance state to allow conduction of the surge discharge current. After the device conducts the surge discharge current, it interrupts the flow of the system follow current and returns to its high impedance state. In the event of the continuing current not representing normal system conditions, the device continues to provide a low impedance path until an external bypass mechanism is activated, the source of undesired current is de-energized, or a coordinated protective current interrupting element is operated.

This standard's test criteria and definitions provide a common engineering language that is beneficial to the user and manufacturer of air gap surge-protective devices.

Due to the voltage and energy levels employed in the majority of tests contained herein, all measurements should be considered dangerous and appropriate caution should be taken in their performance.

[1]The numbers in brackets correspond to those of the bibliography in Annex A.

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2. Definitions

For the purposes of this standard, the following definitions apply. *The Authoritative Dictionary of IEEE Standard Terms*, Seventh Edition [B2] should be referenced for terms not defined in this clause.

The following definitions apply specifically to air gap surge-protective devices and do not necessarily cover other devices or their applications.

2.1 air gap surge arrester: A gap or gaps, in air at ambient atmospheric pressure, designed to protect apparatus and personnel, or both, from high transient voltages.

2.2 air gap surge protector: A protective device, consisting of one or more air gap surge arresters; optional fuses, short-circuiting devices, etc.; and a mounting assembly, for limiting surge voltages on low-voltage (600 V rms or less) electrical and electronic equipment or circuits.

2.3 back-up air gap devices: An air gap device connected in parallel with a sealed gas tube device, having a higher breakdown voltage than the gas tube, which provides a secondary means of protection in the event of a venting to atmosphere by the primary gas tube device.

2.4 breakdown: The abrupt transition of the gap resistance from a high resistance state to a relatively low value. In the case of a gap, this is sometimes referred to as sparkover or ignition. (*See:* **sparkover**)

2.5 clearing: The characteristic of some types of air gap surge arresters to exhibit a low resistance and then to revert to a high resistance state as a result of an external influence.

2.6 clearing source: A defined electrical source that is intentionally applied as a clearing stimulus to an air gap surge-protective device under laboratory test conditions encountered during normal usage.

2.7 current turn-off time: The time required for the arrester to restore itself to a non-conducting state following a period of conduction. This definition applies only to a condition where the arrester is exposed to a continuous specified dc potential under a specified circuit condition.

2.8 dc breakdown voltage: The minimum dc voltage with a ramp rate (100V/s to 2000V/s) that will cause breakdown or sparkover when applied across the terminals of an arrester.

2.9 dc holdover: In applications where a dc voltage exists on a line, a holdover condition is one in which a surge-protective device continues to conduct after the time required to recover from the conducting state that included the dc voltage and the current.

2.10 dc holdover voltage: The maximum dc voltage across the terminal of an arrester under which it may be expected to clear and return to the high impedance state after the passage of a surge, under specified circuit conditions.

2.11 discharge current: The current that flows through an arrester when sparkover occurs.

2.12 discharge voltage: The voltage that appears across the terminals of an arrester during the passage of discharge current.

2.13 fail-safe: Use of this term is not recommended. See 4.18.

2.14 follow (power) current (follow on current): The current from the connected power source that flows through an arrester during and following the passage of discharge current.

2.15 impulse sparkover voltage: The highest value of voltage attained by an impulse of a designated waveshape and polarity applied across the terminals of an arrester prior to the flow of discharge current. Sometimes referred to as surge or impulse breakdown voltage.

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2.16 short circuit: An abnormal connection of relatively low impedance, whether made accidentally or intentionally, between two points of different potential in a circuit.

2.17 sparkover: A disruptive discharge between electrodes of a measuring gap, voltage control gap, or protective device.

3. Service conditions

3.1 Normal service conditions

Arresters and protectors conforming to this standard shall be capable of successful operation under the following conditions, which shall be specified by the manufacturer or user, as appropriate.

3.1.1 Physical conditions

a) Ambient temperature range
b) Atmospheric pressure range
c) Humidity conditions
d) Mechanical shock conditions

3.1.2 System conditions

a) The frequency range (and dc, or both)
b) Voltage and current under both normal and fault conditions

3.2 Unusual service conditions

The following service conditions may require special consideration in the design or application of air gap surge-protective devices, and should be called to the attention of the manufacturer.

3.2.1 Physical conditions

a) An ambient temperature different from the normal service conditions
b) Atmospheric pressure differing from the normal service conditions
c) Exposure to damaging fumes or vapors, excessive dirt or current conducting deposits, excessive humidity, moisture, dripping water, steam, or salt spray and abnormal vibrations or shocks

WARNING
Air gap devices should not be employed in explosive atmospheres.

d) Limitation on weight or space, including clearances to nearby conducting objects; particularly at atmospheric pressures differing from those specified
e) Non-operating conditions such as those encountered during transportation or storage

3.2.2 System conditions

a) Voltage, current, or frequency resulting in operating conditions whereby the ratings of the devices are exceeded
b) Exposure to direct lightning strikes
c) Any other unusual conditions known to the user

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4. Standard design test criteria

4.1 General

The design tests described in 4.6 to 4.16 provide standardized methods for making single observations of a specified property of an air gap surge-protective device. These properties vary from measurement to measurement making it necessary to provide statistical descriptions of the property in order to compare products. The following procedure shall be used to describe any property that has been determined to have important statistical aspects. A product sample shall be chosen in a manner consistent with the definition of design tests as provided by *The Authoritative Dictionary of IEEE Standard Terms* [B2]. A sufficient number of devices shall be tested and the characteristic in question measured as described in the applicable design test until the parameters of the underlying statistical distribution are determined within confidence limits specified by the manufacturer or user. Values relating to the product sample such as, but not limited to, mean, median, maximum, minimum, and standard deviation may then be stated.

4.2 Ambient conditions

The tests described herein should be performed on devices as required by the application. Unless otherwise specified, ambient test conditions should be as follows:

Temperature	25 ˚C ± 5 ˚C
Relative Humidity	Less than 60%
Atmospheric Pressure	80 kPa to 104 kPa

The performance of air gap surge arresters during certain tests may be strongly affected by the amount of absorbed and adsorbed water. It is recommended that these arresters be stabilized at a desired temperature/humidity condition prior to testing. For carbon electrode devices, a period of six days may be required. If the ambient test conditions differ from the stabilization conditions, exposure of a given device to ambient conditions during the test should be minimal.

4.3 Necessary precautions for testing air gaps

When discharges occur across an air gap, particulate debris are likely to be deposited on the faces of the electrodes. This collection of debris may form extremely delicate structures that can substantially affect the results of tests involving repetitive breakdown of the gap (for example, 4.6, 4.8, and 4.9). Care must be taken, therefore, to avoid unintentional disarrangement or clearing of this debris through mechanical or electrical disturbances. The test environment should be free from appreciable shock or vibration stimuli and specimens should not be moved either between successive breakdowns or between breakdown and measurement. Also, special care must be taken in the design and construction of multi-sample test equipment, such as that used for impulse life testing, to minimize the coupling of energy between samples.

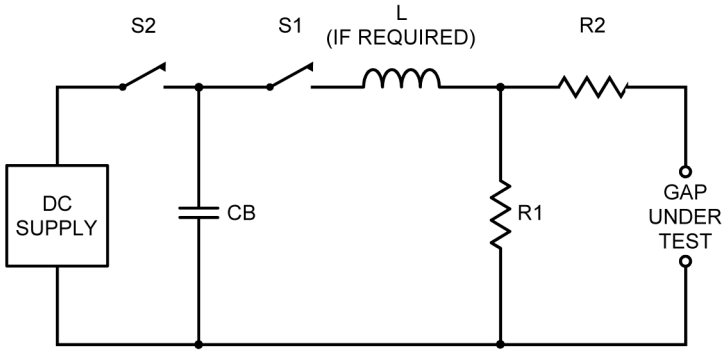
4.4 Current waveform decay time

The current waveform decay time produced by some impulse generators when driving a low impedance load (device under test conducting) will be considerably shorter than that produced when driving a high impedance load (device not conducting). When measurable leakage exists in an air gap device after extinguishing of the arc, current flow related to the high impedance generator waveform continues through the leakage path. This current tends to clear or burn out the leakage path, which is often electrically fragile. In order for results obtained with different generators to be compared, the high- and low-impedance current waveshape decay times shall not differ by more than 20% for low current impulse life testing. One method of accomplishing this is to use the circuit of Figure 1 with R2 at least five times the resistance of R1, for peak currents

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of 50 A or less. For higher impulse life currents and for other impulse life currents, and for other impulse testing (see 4.10 and 4.11), the fragile leakage paths have less effect upon the results and the practical ratio of the test equipment configuration. In these cases, R1 should not be more than ten times R2.



NOTE 1—S2 = open before S1 closes

NOTE 2—CB = Main capacitor bank; low inductance oil filled units are strongly recommended

NOTE 3—R2 ≥ 5 × R1 for impulse life currents of 50 A or less. R1 ≤ 10× R2 for impulse life currents greater than 50 A and for other impulse tests (4.10 and 4.11)

Figure 1—Method of controlling high and low impedance current waveshape

4.5 Insulation resistance measurement and clearing source

Because of the variable electrical sensitivity and non-linearity of leakage paths that may develop in air gap devices, the manner in which insulation resistance measurement potentials (or clearing source potentials, if used) are connected to the device under test may significantly affect test results. For instance, random relay contact bounce may produce major effects. In order for comparison of test results from different facilities to be meaningful, it is recommended that the potentials be applied as a smooth ramp from zero volts to the desired final value. In the absence of special requirements, it is recommended that duration of the ramp be greater than 1 ms.

4.6 DC breakdown voltage test

a) The arrester shall be tested using a ramp voltage waveform, with a specified voltage rate-of-rise employing a suitable circuit such as that shown in Figure 2. Two groups of arresters shall be tested using one group for each polarity. This is to determine any dc breakdown polarity sensitivity. Only one dc breakdown voltage test shall be performed for each arrester. The measurement shall be made after application of a clearing source, if such a source is specified.

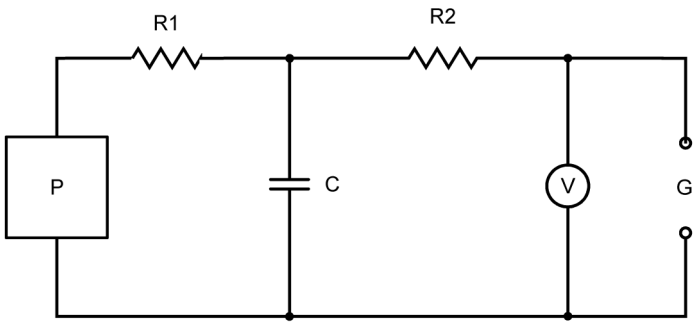
NOTE 1—If clearing or preconditioning by a voltage that simulates normally applied events is performed, the waveform duration, amplitude, and source impedance shall be specified.[2]

[2]Notes in text, tables, and figures are given for information only, and do not contain requirements needed to implement the standard.

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P = variable dc voltage power supply. Load ripple and current output regulation shall be < 3.0% under full power
R1 = 50 kΩ charging current limiting resistor
C = 1 μF dc charging capacitor (non-electrolytic)
R2 = discharge current limiting resistor (10 Ω)
V = voltmeter or oscilloscope for observing dc breakdown voltage
G = gap under test

NOTE TO FIGURE—The value of R2 in parenthesis is recommended in the absence of special requirements.

Figure 2—Circuit for DC breakdown voltage test

b) For determining the dc breakdown voltage distribution of a sample group of arresters, only unused arresters shall be tested.

c) When a sufficient statistical sample group has been tested consistent with 4.1, the appropriate statistical characterizations shall be prepared.

NOTE 2—Unless otherwise specified, a voltage ramp with a rate up to 2000 V/s is recommended.

4.7 Capacitance test

Separate capacitance measurements shall be performed between all terminals of the protector at a specified frequency. In measurements involving multielectrode arresters, a three-terminal measuring instrument is required. All terminals not involved in the test shall be connected to a ground plane in the measuring instrument.

NOTE—In the absence of requirements relating to a special application, a frequency of 1 MHz is suggested for this test.

4.8 Insulation resistance test

Separate insulation resistance measurements shall be performed between all terminals of the arrester in accordance with Figure 3. The measurement shall be made after application of a clearing source, if such a source is specified. Terminals not involved in the measurement shall be left floating.

NOTE 1—In the absence of requirements relating to special applications, the arrester shall be tested with a dc power supply of Figure 3 equal to 100 V. Further, the ratio V/RL of Figure 3 is 10 mA or less. In the case of a test voltage of 100 V, RL is 10 000 Ω.

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NOTE 2—In the case of carbon electrode devices, because of the tendency of carbon particles to be present under certain conditions in the air gap, it is essential that the voltage application circuit be as shown in Figure 3 since the leakage path may be altered in time by passage of measurement current. Transients resulting from uncontrolled application of a voltage source through relay contacts or other switching circuits may significantly affect the leakage path.

NOTE 3—The clearing source characteristics (for example, open-circuit voltage and short-circuit current) should simulate normal sources present on the circuit being protected, which may assist in clearing of fragile leakage paths produced during operation of an air gap surge arrester. The clearing source should be specified by the user and shall be applied in a manner consistent with 4.3.

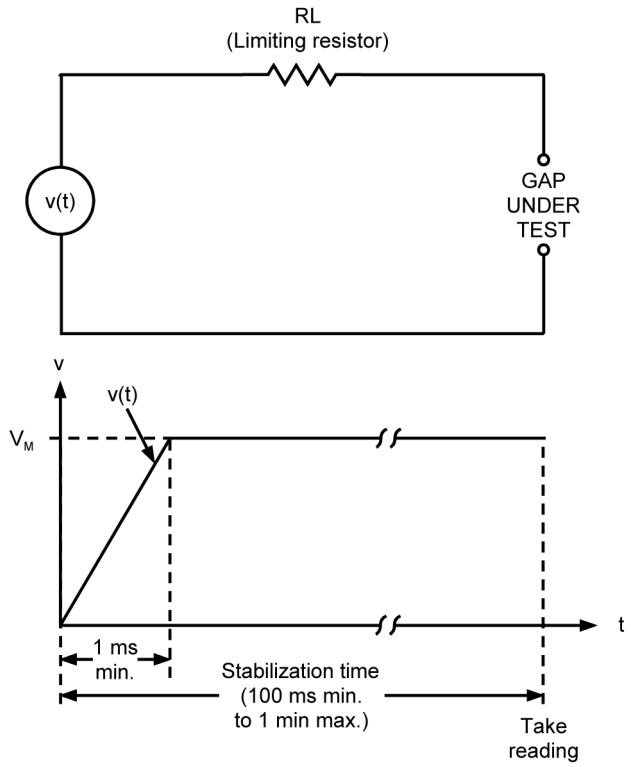


Figure 3—Insulation resistance test

4.9 Initial impulse breakdown voltage test

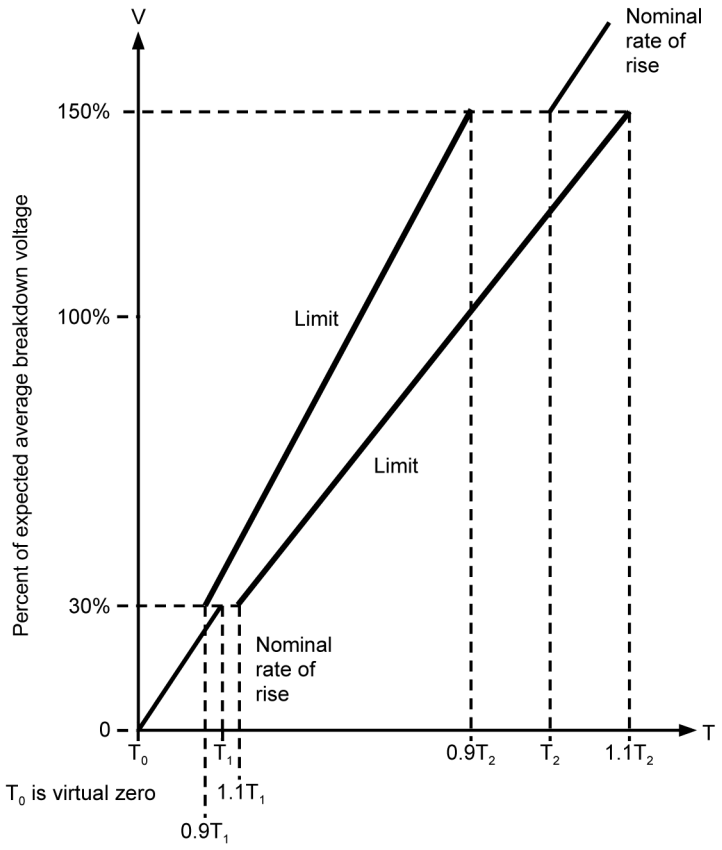
The purpose of this test is to determine the initial impulse breakdown voltage of an air gap arrester. The voltage generator used for this test must be capable of maintaining the waveform specified by Figure 4. Since the intent of this test is the measurement of initial impulse breakdown voltage on the front of the wave, the tail of the impulse wave is unspecified.

With a specified polarity and with a ramp voltage that has a specified rate of rise applied to an unused arrester, record the breakdown voltage level. The test shall be performed employing an unused arrester for each polarity.

NOTE—In the absence of special requirements, the rates of rise should be one or more of the following: 100 V/μs, 500 V/μs, 1 kV/μs, 5 kV/μs, and 10 kV/μs.

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NOTE—Impulse breakdown test waveform (non-conducting) must be within enclosed limits.

Figure 4—Impulse breakdown test waveform

4.10 Impulse breakdown voltage variability test

Tests shall be performed to determine the variability of impulse breakdown voltage. The voltage rate of rise, crest current, and current decay time to half crest shall be specified. A minimum of ten impulses, five of each polarity, shall be applied to each arrester and the breakdown voltage for each impulse shall be recorded to determine variability and polarity sensitivity. The samples shall be divided into two groups; half shall be tested in the minus-plus sequence and half in the plus-minus sequence. Separate arresters shall be employed for each rate of rise. Clearing shall not be permitted between impulses.

NOTE 1—In the absence of special requirements, the rates of rise should be one or more of the following: 100 V/μs, 500 V/μs, 1 kV/μs, 5 kV/μs, and 10 kV/μs.

NOTE 2—In the absence of special requirements, a crest of 20 A and a decay time to half crest of 500 μs are recommended.

NOTE 3—This test is usually inapplicable for backup air gap devices.

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4.11 Maximum single impulse discharge current test

The following list items shall be employed when performing the single impulse discharge current test:

a) The protector must be capable of conducting a maximum single impulse discharge current, regardless of polarity, from its line terminal to the common terminal. Unless otherwise specified, devices shall not fail by the high breakdown mode; a limited percentage, to be stated, may fail by the low breakdown, short circuit, or low insulation modes as defined in 4.17. Tests shall be performed in both polarities using both 8/20 μs and 10/1000 μs waveforms. The maximum single impulse discharge current for a given condition is the maximum peak current at that condition that can be conducted within the stated failure rate. Four groups of separate devices shall be tested using one group for each polarity and waveshape combination.

b) For protectors employing multi-gap arresters, independent maximum single impulse discharge currents shall be discharged simultaneously through each gap adjacent to the common electrode.

c) When this test is applied to backup air gap devices, failure in a short-circuit or low breakdown mode as described in 4.17.1 and 4.17.2 is to be expected.

4.12 Impulse life test

The following list items shall be employed when performing the Impulse life test:

a) Tests shall be conducted on devices to establish a current-life characteristic based on the number of discharges to failure. Separate devices shall be used for each current level and each polarity tested. Test set mounting shall position arresters as in normal service and shall be clean and free from residue that may influence test results. The impulse discharge current and waveshape shall be measured with the device in the test circuit to assure that device breakdown does not cause the waveshape or crest to depart from the values specified.

b) For multi-gap devices, independent impulse life test currents shall be discharged simultaneously through each gap adjacent to the common electrode.

c) After one or more arresters are installed in the test set, and prior to initiation of the life test, each sample shall be cleared for up to 1 s by the application of 180 V DC in series with a 115 V, 7 W light bulb. Arresters that are still shorted at the end of the one-second application (as indicated by a sustained glow of the lamp) shall be replaced, and the clearing process shall be repeated on the new arrester. Unless otherwise specified, further clearing shall not be permitted after life testing begins.

d) Failure criteria for this test are defined in 4.17. The sequence and timing for tests shall be as follows:

   1) A life-test surge shall be applied to the air gap under test.
   2) There shall be a time delay of 1 s to 2 s during which voltage is not applied to the air gap.
   3) The air gap shall be tested for short-circuit failure as described in item f).
   4) There shall be another time delay of 1 s to 2 s during which voltage is not applied to the air gap.
   5) The dc breakdown of the air gap shall be measured as described in item g).
   6) The test program shall be applied to the next air gap, if applicable, but an interval of between 1 min and 2 min must exist between repeated test sequences on any one air gap.

NOTE 1—The surge on which an air gap is first detected to have failed shall be the last surge credited to the device. (For example, a sample failing on the first surge would be credited with a life of one.)

e) The life impulse circuit shall be as depicted in Figure 1. In the absence of other requirements, it is suggested that the impulse life tests be made with peak current amplitudes of 500 A, 50 A, and 10 A of both polarities and a current waveshape rising to virtual peak in less than 20 μs and decaying to one-half the crest value in 950 μs to 1050 μs.

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NOTE 2—In Figure 1, switch S1 shall remain closed for at least 100 ms to ensure that the current through the air gap is not interrupted by the switch.

f) To test for short-circuit failure, a dc power supply with a range of 0 V to 100 V in series with a 100 Ω resistor shall be connected to the air gap while the voltage is set at 0. Voltage across the air gap and 100 Ω resistor shall be increased from 0 V to 100 V in 1 ms ± 10% and be maintained at this value for 150 ms minimum. When the current flow is integrated over a period of 100 ms commencing 50 ms after the voltage is first applied, it shall yield a current × time product less than 9 mAs.

g) To test for dc breakdown, a voltage ramp rising up to 2000 V/s, unless otherwise specified, shall be used to charge a 1 μF ± 20% capacitor that is discharged in series with a 100 000 Ω resistor and the test specimen. One breakdown of the air gap shall be performed, and the value shall be within tolerances specified by the user.

h) The polarity of the life impulse, short-circuit test, and dc breakdown test shall be the same.

i) Additional tests employing separate devices and a clearing source that simulates field conditions may be required between each impulse prior to measurement of failure criteria. The clearing source shall be defined. The source shall be applied in a controlled and consistent manner.

j) Impulse life is not a required characteristic for backup air gap devices. However, it is recommended that impulse life tests should be performed at appropriate current levels to ensure that failure occurs only in a short-circuit or low breakdown mode as described in 4.17.1 and 4.17.2.

4.13 AC discharge current test

a) The protector shall, for a period of time, pass 50 Hz or 60 Hz discharge current, which may be created by direct contact with, or by induction from, a nearby power line. Many protectors contain mechanisms internal or external, or both, to the arrester that conducts the alternating current when the conducting capacity of the arrester has been exceeded. The purpose of this test is to determine the period of time for which protectors can conduct alternating current without activation of the safety mechanisms for various current levels. For this test, permanent activation of these fail-short safety mechanisms shall be required, unless the device survives for 15 min, at which time the tests may be terminated.

b) To determine the time required for the arc to be extinguished by the activation of the device fail-short mechanism, a discharge current of 1 A rms of 50 Hz or 60 Hz should be continuously applied to a statistically significant sample of gap devices.

c) When fail-short actuation of all specimen devices has been timed, the data shall be reviewed to determine the longest time interval during which not more than 10% of the units have become permanently shorted by fail-short actuation (for example, the period beyond which fewer than 90% of the units survived).

d) The steps b) and c) shall be repeated for a like number of specimens at each of the following additional rms discharge currents: 10 A and 30 A.

e) A graph needs to be plotted of the 90% survival time to include all three values of rms discharge current.

f) For multigap arresters, independent ac discharge currents shall be discharged simultaneously through each gap to the common electrode.

g) This test is not usually applicable to backup air gap devices.

4.14 Pulsed AC test

Under certain conditions, an air gap device may be subjected to 50 Hz or 60 Hz related waveforms of limited duration associated with an alternating current power source. These tests characterize the ability of a device to conduct a series of such events without failure.

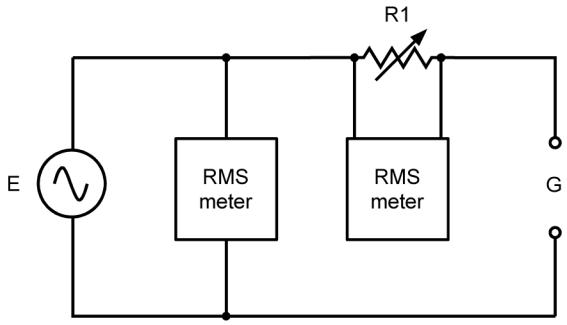
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4.14.1 Pulsed AC life tests

Protectors shall be subjected to repetitive sinusoidal 50 Hz or 60 Hz current applications using appropriate circuitry as shown in Figure 5. The open-circuit (rms) supply voltage, the short-circuit (rms) supply current, and duration of each current application shall be specified. The time between current applications shall be sufficient to allow return to ambient conditions. Failure criteria shall be those defined in 4.17. The number of current applications until failure shall be recorded.

NOTE—In the absence of other requirements, it is recommended that the test conditions consist of one-second applications at a rms short-circuit current of 1 A and a driving voltage of 707 V rms (1000 V peak).



E = 50 Hz or 60 Hz timed source
R1 = limiting resistor
G = gap under test

Figure 5—Pulsed AC life test

4.14.2 Pulsed AC gap erosion test

Due to normal clearing action, considerable deterioration of device characteristics (such as leakage or low breakdown voltage) may occur before a failed device is detected and replaced. Prior to replacement, arc erosion may cause widening of the gap or buildup of particles resulting in unacceptable breakdown voltages. To investigate this possible device behavior, the test of 4.14.1 may be performed using the failure modes described in 4.17.2 and 4.17.3.

NOTE—Additional failure criteria may be employed to reflect actual field conditions for which device replacement may be necessary

4.15 Alternating follow-on current test

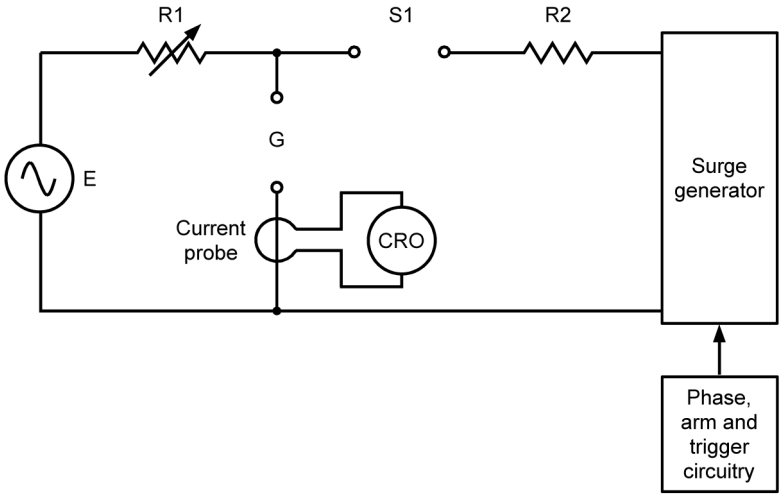
The purpose of this test is to determine the maximum alternating current that the arrester will extinguish without failure, as specified in 4.17. To measure this characteristic, an alternating current source, 50 Hz or 60 Hz, shall be applied as shown in Figure 6, with one of the following open-circuit rms ac voltages: 25 V, 120 V, 208 V, 240 V, or 480 V, depending upon the application (to be stated). The power frequency source current shall be resistance limited to produce approximately unity power factor conditions. This alternating current source shall have the capability to provide a follow-on current applied at 30 electrical degrees or less after the zero value of the alternating currents source. The impulse current shall be unidirectional and of the same polarity as the applied half cycle of the alternating current source. The impulse should be of sufficient amplitude and time duration to trigger arc conduction from the ac circuit.

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NOTE 1—In the absence of special requirements, it is suggested that the device be required to extinguish not later than 30 electrical degrees after the first alternating current zero and that subsequent breakdown not occur; determination of failure may be indicated by measurements of insulation resistance and dc breakdown.

NOTE 2—This test is not usually applicable to backup air gap devices.



E = 50 Hz or 60 Hz supply
R1 = limiting resistor
R2 = isolation resistor
S1 = isolation gap
CRO = cathode ray oscilloscope
G = gap under test

NOTE 1—Resistance of 50 Hz or 60 Hz supply << R1.

NOTE 2—R2 must be sufficiently large to cause prompt extinguishing of the isolation gap.

NOTE 3—Surge protection of the 50 Hz or 60 Hz supply may be necessary.

Figure 6—Alternating follow-on current test

4.16 DC holdover test

The following list items shall be employed when performing the DC holdover test:

a) This test shall determine the maximum values of direct current and their duration for a given open circuit dc voltage and specified circuit conditions that the device can extinguish. When the device is subjected to an impulse sufficient to cause breakdown of the arrester, it is expected to return to its high impedance state after it has conducted the impulse current.

b) The current impulse that is applied to the gap of the arrester shall be a 100 A peak, 10/1000 μs wave. Three impulses shall be applied at not greater than one-minute intervals. These tests shall be repeated with new test specimens and the connections reversed.

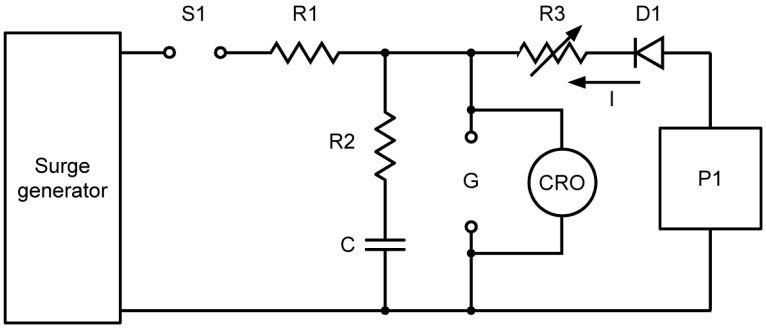
c) Tests shall be conducted, using the circuit shown in Figure 7, with the dc voltage (P1) fixed at a value to be stated (typically the system operating voltage) and of the same polarity as the impulse. Resistor R3, in the circuit, shall be decreased from values for which no holdover is observed until holdover occurs for greater than a stated period; current I shall be stated for this condition.

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NOTE 1—In the absence of special requirements, it is recommended that tests be conducted with the dc voltage (P1) fixed at 50 V or 150 V, or both, (to be stated), that R2 and C1 (Figure 7) be deleted, and that a maximum time for extinguishing of 150 ms be specified. Where it is desired to simulate the effect of a specific application, appropriate values of R2 and C1 may be employed. The values shown in Figure 7 simulate a paired telephone cable.

NOTE 2—This test is not usually applicable to backup air gap devices.



P1 = Constant voltage dc supply or battery (transient free ± for unit impulse currents from zero to full load and from full load to zero)
S1 = isolation gap or equivalent device
C = optional capacitor for simulating application conditions (0.083 mF)[a]
R1 = impulse limiting resistor or wave-shaping network
R2 = optional resistor for simulating circuit resistance (136 Ω)[a]
R3 = dc current limiting resistor
CRO = oscilloscope for observing air gap voltage breakdown or extinguishing time
G = gap under test
I = direct current through R3 with G short-circuited
D1 = isolation diode

[a]Tests shall be performed with R2 and C1 deleted from the circuit. Additional tests may be performed with values of R2 and C1 as specified by the user.

NOTE—Values in parentheses are recommended in the absence of special requirements.

Figure 7—Circuit for DC holdover test

4.17 Failure mode

In the absence of special requirements, the following criteria are suggested:

4.17.1 Short-circuit failure mode

In this mode, the device has become permanently short-circuited.

4.17.2 Low breakdown voltage failure mode

In this mode, a device has a dc breakdown voltage of less than a specified value.

4.17.3 High breakdown voltage failure mode

In this mode, a device has a dc or impulse breakdown voltage of greater than a specified value.

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4.17.4 Low insulation resistance failure mode

In this mode, a device has an insulation resistance of less than a specified value.

NOTE—For many communications applications and in the absence of other requirements, the following failure criteria shall apply to the previous subclauses; for 4.17.2, 180 V DC when the current is limited to less than 10 mA; for 4.17.3, 1000 V impulse breakdown (100 V/μs rate of rise) when the current is limited to less than 1 A except where otherwise specified; and for 4.17.4, 1 MΩ.

4.18 Fail-safe operation

The use of the term fail-safe to describe a failure mode of an air gap device is discouraged for the following reason. Failure of a device can occur in any of the modes previously described. Some users may consider that the short-circuit mode is the most desirable failure mode. However, system objectives of other users can require that a particular device should fail in a high breakdown failure mode in order to achieve the desired performance of the system. Thus, failure in the short mode, while considered fail-safe by many users, may in fact be opposite the desired (safe) mode of other users.

Therefore, the recommended practice is to describe the failure by one of the failure modes defined in 4.17.1 through 4.17.4.

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Annex A

(informative)

Bibliography

[B1] IEEE Std C62.1™-1989, IEEE Standard for Gapped Silicon Carbide Surge Arresters for AC powercircuits.[3, 4, 5]

[B2] IEEE 100, *The Authoritative Dictionary of IEEE Standard Terms*, Seventh Edition, New York, The Institute of Electrical and Electronics Engineers, Inc.

[3]IEEE Std C62.1-1989 has been withdrawn; however, copies can be obtained from Global Engineering, 15 Inverness Way East, Englewood, CO 80112-5704, USA, tel. (303) 792-2181 (http://global.ihs.com/).

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