

IEEE Standard for Surge Arresters for AC Power Circuits

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ANSI/IEEE C62.1-1981



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**IEEE Standard for Surge
Arresters for AC Power Circuits**

Sponsor
**Surge Protective Devices Committee of the
IEEE Power Engineering Society**

Approved September 18, 1980
IEEE Standards Board

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Foreword

(This Foreword is not a part of ANSI/IEEE C62.1-1981, IEEE Standard for Surge Arresters for Alternating-Current Power Circuits.)

This standard supersedes IEEE Std 28-1974 (ANSI C62.1-1975) and many parts of the standard has been revised. Four significant design tests have been added to determine

(1) The switching impulse discharge voltage for intermediate and station arresters rated 60 kV and higher

(2) The fault-current withstand capability for valve-type distribution arresters for which a fault-current withstand rating is claimed

(3) The capability of 550 kV and 800 kV system arresters to withstand duty-cycle operations at impulse currents of 15 kA and 20 kA

(4) The contamination withstand capability of the distribution arrester disconnecter under prolonged external arrester leakage current

Additional substantive changes include:

(1) Deleted reference to deprecated term lightning arrester

(2) Deleted reference to protector tubes

(3) The use of words standard, nonstandard, and preferred have been deleted or replaced

(4) Revision of voltage withstand requirements of housings for intermediate and station arresters rated 60 kV and above

(5) Table 3 revised to list voltage withstand tests of housing insulation for arresters rated 48 kV and below

(6) Added insulation withstand values in Table 3 for 25 kV distribution arresters

(7) Test evaluations added for the station and intermediate arresters after the high-current, short-durations tests

(8) Wave shape tolerance changed for high-current, short-duration test

(9) Duration of current increased for low-current, long-duration test for distribution arresters

(10) Deleted shorting of series gap of distribution arrester for the low-current, long-duration test

(11) Reduced the test duration for station arresters above

72 kV rating from 0.2 s to 0.1 s

(12) Table 5 changed for station arresters to delete classes, increase the high-current level for ratings 240 kV and above, and to require rating in amperes on the nameplate

(13) Changed reference for distribution arrester mounting brackets

(14) Editorial clarification in implications of service conditions

(15) Editorial clarification in title and for the measurement instrument for the duty cycle test

(16) Editorial clarification to add guidance for judging physical condition of arresters after the duty cycle test

(17) Addition of minimum leakage distance for arresters rated 60 kV and higher

(18) Added a certification test procedure for valve-type arresters 36 kV and below

The Surge Protective Devices Committee (SPD), of the IEEE Power Engineering Society developed those sections of this standard which fall within the scope of IEEE. SPD maintains close liaison with the American National Standards Institute Committee on Surge Arresters, ANSI C62, which is organized specifically to develop consensus standards. A delegation of SPD members participated in the activities of ANSI C62 which included inputs to SPD and development of ratings and dimensional information included in this standard. In the judgment of IEEE, this information is reasonably consistent with good engineering practice.

This standard constitutes by reference only an integral part of the National Electrical Manufacturers Association (NEMA) Standards Publication for Surge Arresters, NEMA LA 1-1976.

Prior to and during development of this edition close liaison has been maintained with the International Electrotechnical Commission's surge arrester standardizing activity with the result that contributions have been made to development of international specifications.

It is the policy of both the Institute of Electrical and Electronics Engineers and American National Standards Committee C62 to maintain this standard current with the state of the technology. Comments on this standard, as well as suggestions for additional material that should be included are invited. These should be addressed to:

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An American National Standard

IEEE Standard for Surge Arresters for AC Power Circuits

1. Scope

This standard applies to surge-protective devices designed for repeated limiting of voltage surges on 50 Hz or 60 Hz power circuits by passing surge discharge current and subsequently automatically interrupting the flow of follow current. This standard applies to devices for separate mounting and to those supplied integrally with other equipment.

2. Definitions

The following definitions apply specifically to surge arresters and do not necessarily cover other applications.

2.1 surge arrester. A protective device for limiting surge voltages on equipment by discharging or bypassing surge current; it prevents continued flow of follow current to ground, and is capable of repeating these functions as specified.

NOTE: Hereafter, the term *arrester* as used in this standard shall be understood to mean *surge arrester*.

2.2 valve element. A resistor that, because of its nonlinear current-voltage characteristic, limits the voltage across the arrester terminals during the flow of discharge current and contributes to the limitation of follow current at normal power-frequency voltage.

2.3 expulsion element. A chamber in which an arc is confined and brought into contact with gas-evolving material.

2.4 series gap. An intentional gap(s) between spaced electrodes: it is in series with the valve or expulsion element of the arrester, substantially isolating the element from line or ground, or both, under normal line-voltage conditions.

2.5 valve arrester. An arrester that includes a valve element.

2.6 expulsion arrester. An arrester that includes an expulsion element.

2.7 indoor arrester. An arrester that, because of its construction, must be protected from the weather.

2.8 outdoor arrester. An arrester that is designed for outdoor use.

2.9 classification of arresters. Arrester classification is determined by prescribed test requirements. These classifications are:

- station valve arrester
- intermediate valve arrester
- distribution valve arrester
- distribution expulsion arrester
- secondary valve arrester

NOTE: See 5.2 for the test requirements.

2.10 terminals. The conducting parts provided for connecting the arrester across the insulation to be protected.

2.10.1 ground terminal. The conducting part provided for connecting the arrester to ground.

2.10.2 line terminal. The conducting part provided for connecting the arrester to the circuit conductor.

NOTE: When a line terminal is not supplied as an integral part of the arrester, and the series gap is obtained by providing a specified air clearance between the line end of the arrester and a conductor, or arcing electrode, etc, the words *line terminal* used in the definition refer to the conducting part that is at line potential and that is used as the line electrode of the series gap.

2.11 grading or control ring. A metal part, usually circular or oval in shape, mounted to modify electrostatically the voltage gradient or distribution.

2.12 vent. An intentional opening for the escape of gases to the outside.

2.13 deflector. A means for directing the flow

of the gas discharge from the vent of the arrester.

2.14 discharge indicator. A means for indicating that the arrester has discharged.

2.15 discharge counter. A means for recording the number of arrester discharge operations.

2.16 arrester disconnecter. A means for disconnecting an arrester in anticipation of, or after, a failure in order to prevent a permanent fault on the circuit and to give indication of a failed arrester.

NOTE: Clearing of the power current through the arrester during disconnection generally is a function of the nearest source-side overcurrent-protective device.

2.17 prorated section. A complete, suitably housed part of an arrester, comprising all necessary components, including gaseous medium, in such a proportion as to accurately represent, for a particular test, the characteristics of a complete arrester.

2.18 lightning. An electric discharge that occurs in the atmosphere between clouds or between clouds and ground.

2.19 lightning surge. A transient electric disturbance in an electric circuit caused by lightning.

2.20 wave. The variation with time of current, potential, or power at any point in an electric circuit.

2.21 surge. A transient wave of current, potential, or power in an electric circuit.

2.22 impulse. A surge of unidirectional polarity.

2.23 oscillatory surge. A surge that includes both positive and negative polarity values.

2.24 crest (peak) value (of a wave, surge, or impulse). The maximum value that it attains.

2.25 wave front (of a surge or impulse). That part which occurs prior to the crest value.

2.26 wave tail (of an impulse). That part between the crest value and the end of the impulse.

2.27 wave shape (of an impulse test wave). The graph of the wave as a function of time.

2.28 wave shape designation (of an impulse).

2.28.1 The wave shape of an impulse (other than rectangular) of a current or voltage is

designated by a combination of two numbers. The first, an index of the wave front, is the virtual duration of the wave front in microseconds as defined in 2.30. The second, an index of the wave tail, is the time in microseconds from virtual zero to the instant at which one-half of the crest value is reached on the wave tail. Examples are 1.2/50 and 8/20 waves.

2.28.2 The wave shape of a rectangular impulse of current or voltage is designated by two numbers. The first designates the minimum value of current or voltage which is sustained for the time in microseconds designated by the second number. An example is the 75 A · 1000 μ s wave.

2.29 virtual zero point (of an impulse). The intersection with the zero axis of a straight line drawn through points on the front of the current wave at 10% and 90% crest value, or through points on the front of the voltage wave at 30% and 90% crest value.

2.30 virtual duration of wave front (of an impulse). The virtual value for the duration of the wave front is as follows:

(1) For voltage waves with wave front duration less than 30 μ s, either full or chopped on the front, crest, or tail, 1.67 times the time for the voltage to increase from 30 to 90% of its crest value.

(2) For voltage waves with wave front duration of 30 or more μ s, the time taken by the voltage to increase from actual zero to maximum crest value.

(3) For current waves, 1.25 times the time for the current to increase from 10 to 90% of crest value.

2.31 nominal rate of rise (of an impulse). Of a wave front, the slope of the line that determines the virtual zero. It is usually expressed in volts or amperes per microsecond.

2.32 disruptive discharge. The sudden and large increase in current through an insulating medium, due to the complete failure of the medium under the electrostatic stress.

2.33 flashover. A disruptive discharge around or over the surface of a solid or liquid insulator.

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

2.35 time to impulse sparkover. The time

between virtual zero of the voltage impulse causing sparkover and the point on the voltage wave at which sparkover occurs.

2.36 impulse sparkover volt-time characteristic. The sparkover response of the device to impulses of a designated wave shape and polarity, but of varying magnitudes.

NOTE: For an arrester, this characteristic is shown by a graph of values of crest voltage plotted against time to sparkover.

2.37 power-frequency withstand voltage. A specified root-mean-square test voltage at power frequency that will not cause a disruptive discharge.

2.38 impulse withstand voltage. The crest value of an impulse that, under specified conditions, can be applied without causing a disruptive discharge.

2.39 basic impulse insulation level (bil). A reference impulse insulation strength expressed in terms of the crest value of withstand voltage of a standard full impulse voltage wave.

NOTE: See ANSI C92.1-1971 (R1978) [5].

2.40 system (circuit) voltage. The root-mean-square power-frequency voltage from line to line as distinguished from the voltage from line to neutral.

2.41 nominal system voltage. A nominal value assigned to designate a system of a given voltage class.

NOTE: See ANSI C84.1-1977 [4].

2.42 maximum (highest) system voltage. The highest voltage at which a system is operated.

NOTE: This is generally considered to be the maximum system voltage as prescribed in ANSI C84.1-1977 [4].

2.43 fault current. The current from the connected power system that flows in a short circuit.

2.44 recovery voltage. The voltage that occurs across the terminals of a pole of circuit-interrupting device upon the interruption of the current.

NOTE: For an arrester, this occurs as a result of interruption of the follow current.

2.45 grounded system. An electric system in which at least one conductor or point (usually the neutral conductor or neutral point of transformer or generator windings) is inten-

tionally grounded, either solidly or through a grounding device.

2.46 coefficient of grounding. The ratio E_{LG} / E_{LL} , expressed as a percentage, of the highest root-mean-square line-to-ground power-frequency voltage E_{LG} on a sound phase, at a selected location, during a fault to ground effecting one or more phases to the line-to-line power-frequency voltage E_{LL} which would be obtained, at the selected location, with the fault removed.

NOTES: (1) Coefficients of grounding for three-phase systems are calculated from the phase-sequence impedance components as viewed from the selected location. For machines use the subtransient reactance.

(2) The coefficient of grounding is useful in the determination of an arrester rating for a selected location.

(3) A value not exceeding 80% is obtained approximately when for all system conditions the ratio of zero-sequence reactance to positive-sequence reactance is positive and less than 3, and the ratio of zero-sequence resistance to positive-sequence reactance is positive and less than 1.

2.47 rating. The designation of an operating limit for a device.

2.48 voltage rating. The designated maximum permissible operating voltage between its terminals at which an arrester is designed to perform its duty cycle. It is the voltage rating specified on the nameplate.

2.49 power-frequency current-interrupting rating (of an expulsion arrester). A designation of the range of the symmetrical root-mean-square fault currents of the system for which the arrester is designed to operate. An expulsion arrester is given a maximum current-interrupting rating and may also have a minimum current-interrupting rating.

2.50 power-frequency sparkover voltage. The root-mean-square value of the lowest power-frequency sinusoidal voltage that will cause sparkover when applied across the terminals of an arrester.

2.51 impulse sparkover voltage. The highest value of voltage attained by an impulse of a designated wave shape and polarity applied across the terminals of an arrester prior to the flow of discharge current.

2.52 discharge current. The surge current that flows through an arrester when sparkover occurs.

2.53 discharge voltage. The voltage that appears across the terminals of an arrester during