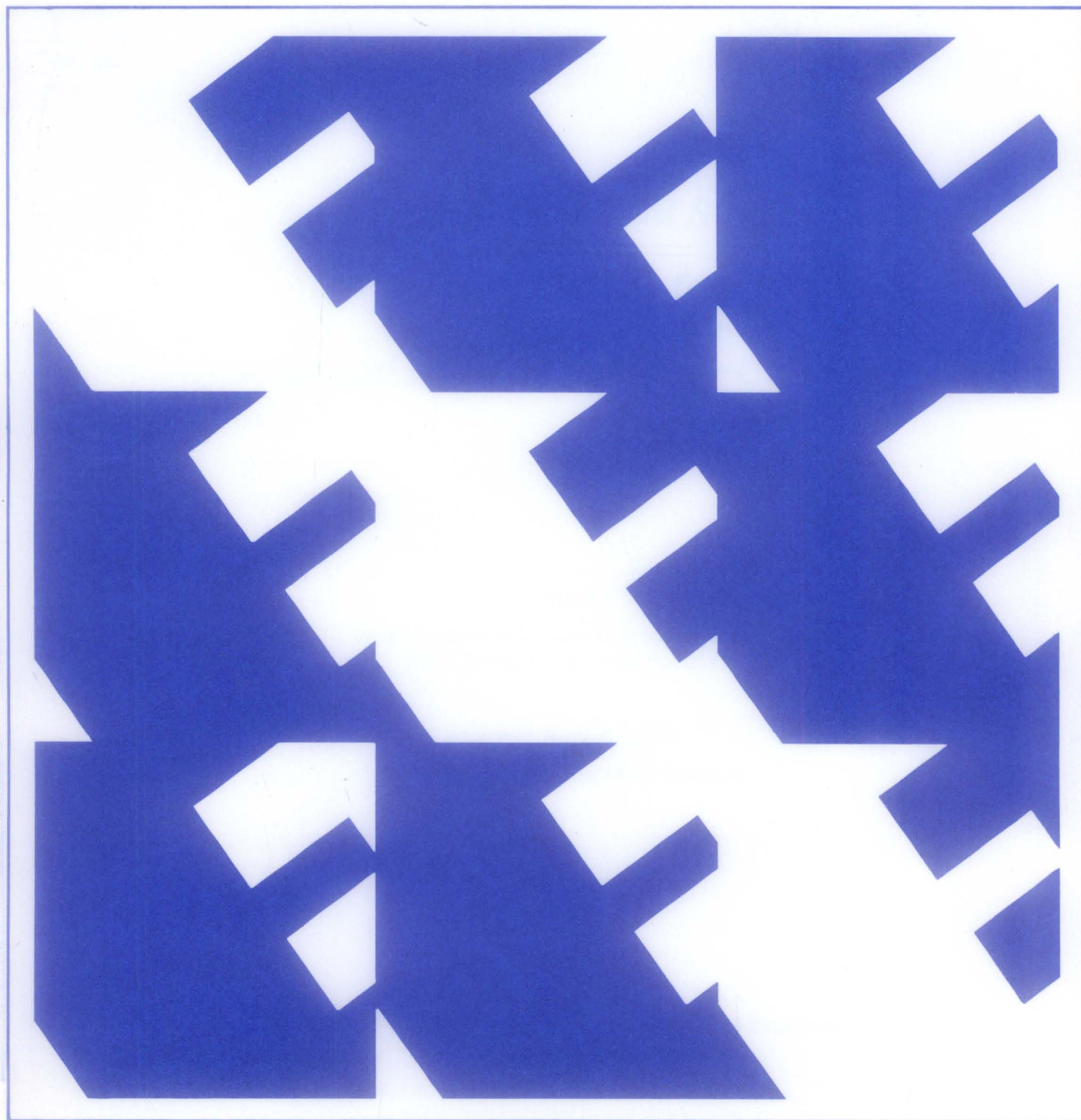


IEEE Standard for Surge Arresters for Alternating-Current Power Circuits

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ANSI/IEEE Std 28-1974



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**IEEE Standard for
Surge Arresters for
Alternating-Current Power Circuits**

Sponsor
Surge Protective Devices Committee of the
IEEE Power Engineering Society

Approved April 30, 1975
American National Standards Institute

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Foreword

(This Foreword is not a part of ANSI/IEEE Std 28-1974, IEEE Standard for Surge Arresters for Alternating-Current Power Circuits.)

This document supersedes IEEE Std 28-1972 (ANSI C62.1-1971) and revises many portions of the previous edition. Three new significant design tests have been added to determine:

- (1) The highest 1.2×50 standard impulse which the surge arrester will allow without spark-over
- (2) The effect of external contamination on sparkover
- (3) Surge arrester disconnector characteristics

Additional substantive changes include:

- (1) New definition of prorated section
- (2) Revision of Table 1 to include a 25 kV distribution surge arrester and special ratings for rotating machine protection
- (3) Increase in maximum rate-of-rise for front-of-wave sparkover test
- (4) Expanded range of currents in the discharge voltage test
- (5) Reduced high current test for station surge arresters to 65 kA
- (6) Expanded Table 4 to include test values for 550 kV and 800 kV system surge arresters
- (7) General revision of pressure-relief test

The Surge Protective Devices Committee, SPD, of the Power Engineering Society developed those portions of this document 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 rating and dimensional information included in this standard. In the judgement of IEEE, this information is reasonably consistent with good engineering practice.

This standard has been approved by the National Electrical Manufacturers' Association as a NEMA Standard. It constitutes, by reference only, an integral part of the NEMA Standards Publication for Surge Arresters, LA 1.

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 the development of international specifications. Useful information has also been received for the benefit of this standard.

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 the Secretary, IEEE Standards Board, Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017.

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An American National Standard

IEEE Standard for Surge Arresters for Alternating-Current Power Circuits

1. Scope

This standard applies to surge-protective devices designed for repeated limiting of voltage surges on 50- 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 (lightning 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."

*Deprecated.

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 protector tube. An expulsion arrester used primarily for the protection of line and switch insulation.

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

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

2.10 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
- protector tube

NOTE: See 4.2 for the test requirements.

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

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

2.11.2 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.

2.12 grading or control ring. A metal part, usually circular or oval in shape, mounted to

modify electrostatically the voltage gradient or distribution.

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

2.14 deflector. A means for directing the flow of the gas discharge from the vent of the arrester.

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

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

2.17 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.

2.18 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.

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

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

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

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

2.23 impulse. A surge of unidirectional polarity.

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

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

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

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

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

2.29 wave shape designation (of an impulse).

2.29.1 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 2.31. 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.

2.29.2 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 $75A \times 1000$ wave.

2.30 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 percent and 90 percent crest value, or through points on the front of the voltage wave at 30 percent and 90 percent crest value.

2.31 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 durations less than $30 \mu s$, either full or chopped on the front, crest, or tail, 1.67 times the time for the voltage to increase from 30 to 90 percent of its crest value.

(2) For voltage waves with wave front durations of 30 or more μs , 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 percent of crest value.

2.32 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.

2.33 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.

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

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

2.36 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.

2.37 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.

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

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

2.40 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 American National Standard Voltage Values for Preferred Basic Impulse Insulation Levels, C92.1-1971, for standard wave shape.

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

2.42 nominal system voltage. A nominal val-

ue assigned to designate a system of a given voltage class.

NOTE: See American National Standard Voltage Ratings for Electric Power Systems and Equipment (60 Hz), C84.1-1970.

2.43 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 American National Standard Voltage Ratings for Electric Power Systems and Equipment (60 Hz), C84.1-1970.

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

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

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

2.46 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 intentionally grounded, either solidly or through a grounding device.

2.47 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 affecting 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 percent 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.

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

2.49 voltage rating. The designated maximum permissible operating voltage between