

IEEE Standard for Series Capacitors in Power Systems

Sponsor

**Capacitor Subcommittee
of the
IEEE Transmission and Distribution Committee**

Approved June 14, 1994

IEEE Standards Board

Abstract: Capacitors and assemblies of capacitors, insulation means, switching, protective equipment, and control accessories that form a complete bank for inserting in series with a transmission line are applied. Included are requirements for safety, rating, and protective device levels. Functional requirements for alarm devices, maintenance, design and production tests, and a guide for operation are included. Functional requirements for protective devices are addressed, including varistors and bypass gaps.

Keywords: bypass gap, force-triggered gap, self-triggered gap, series capacitor, trigger circuit

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

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ISBN 1-55937-441-1

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Introduction

(This introduction is not a part of IEEE Std 824-1994, IEEE Standard for Series Capacitors in Power Systems.)

This standard was revised in response to the advances made in series capacitor equipment and use of metal oxide in the protection systems for series capacitor banks. The principal objective of this standard is to provide a basis for uniformity in design and testing, and to assist users in the application of series capacitor equipment.

This standard was revised by a working group sponsored by the Capacitor Subcommittee of the Transmission and Distribution Committee of the IEEE Power Engineering Society.

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1. Overview

1.1 Scope

This standard applies to capacitors and assemblies of capacitors, insulation means, switching, protective equipment, and control accessories that form a complete bank for inserting in series with a transmission line. Included are requirements for safety, rating, and protective device levels. Functional requirements for alarm devices, maintenance, design and production tests, and a guide for operation are included. Functional requirements for protective devices are addressed, including varistors and bypass gaps.

2. References

This standard shall be used in conjunction with the following publications:

ANSI C29.8-1985, American National Standard for Wet-Process Porcelain Insulators (Apparatus, Cap and Pin Type).¹

ANSI C29.9-1983, American National Standard for Wet-Process Porcelain Insulators (Apparatus, Post Type).

ANSI C57.16-1958 (R 1971), American National Standard for Reactors, Requirements, Terminology and Test Code for Current Limiting Reactors (See Appendix, ANSI C57.99-1965).²

ANSI C93.3-1981, American National Standard for Requirements for Power Line Carrier Coupling Capacitors and Coupling Capacitor Voltage Transformers.

ANSI Z55.1-1967 (R 1973), American National Standard for Gray Finishes for Industrial Apparatus and Equipment.³

IEEE Std 4-1978, IEEE Standard Techniques for High Voltage Testing (ANSI).⁴

¹ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

²ANSI C57.16-1958 has been withdrawn; however, copies can be obtained from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

³ANSI Z55.1-1967 has been withdrawn; however, copies can be obtained from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

⁴IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

IEEE Std 18-1992, IEEE Standard for Shunt Power Capacitors (ANSI).

IEEE Std 100-1992, The New IEEE Standard Dictionary of Electrical and Electronics Terms (ANSI).⁵

IEEE Std 1313-1993, IEEE Standard for Power Systems—Insulation Coordination (Formerly ANSI C92.1-1987) (ANSI).

IEEE Std C37.09-1979 (Reaff 1988), IEEE Standard Test Procedure for AC High-Voltage Breakers Rated on a Symmetrical Current Basis (ANSI).

IEEE Std C57.12.00-1993, IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers (ANSI).

IEEE Std C57.13-1993, IEEE Standard Requirements for Instrument Transformers.

IEEE Std C57.19.00-1991, IEEE Standard General Requirements and Test Procedure for Outdoor Power Apparatus Bushings (ANSI).

IEEE Std. C62.11-1993 IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (ANSI).

NEMA LA1-1992, Surge Arresters.⁶

3. Definitions

The definitions used in this standard can be found in IEEE Std 100-1992.⁷ In some instances, the definition in IEEE Std 100-1992 may be either too broad or too restrictive. In such a case, an additional definition or note has been included.

3.1 ambient temperature: The temperature of the medium such as air, gas, or water, into which the heat of the equipment is dissipated.

3.2 bypass current: The current flowing through the bypass switch, protective device, or other devices, in parallel with the series capacitor.

3.3 bypass gap: A gap, or systems of gaps, to protect either the capacitor against overvoltage or the varistor against thermal overload, by carrying load or fault current around the protected equipment for some specified time. The bypass gap normally consists of a power gap and a trigger circuit.

3.4 bypass interlocking device: A device that requires all three phases of the switch to be in the same open or closed position.

3.5 bypass switch: A device such as a switch or circuit breaker used in parallel with a series capacitor and its protective device to shunt line current for some specified time or continuously. This device may also have the capability of inserting and bypassing the capacitor into a circuit carrying a specified level of current.

⁵IEEE Std 100-1992 states that wave shape designation is measured in microseconds (μ s). To avoid confusion, in this standard where other units of measurement are necessary, units ns, μ s, or ms are shown after all wave shape designations.

⁶NEMA publications are available from the National Electrical Manufacturers Association, 2101 L Street NW, Washington, DC 20037, USA.

⁷Information on references can be found in clause 2.

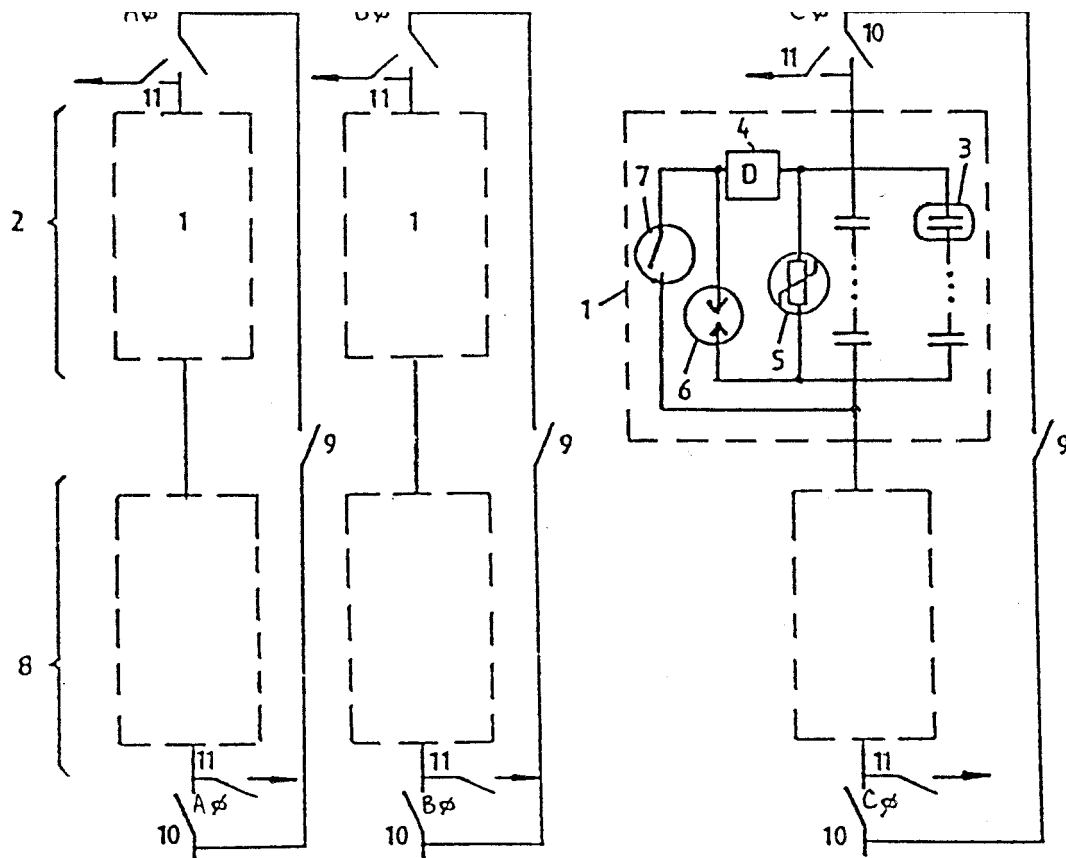
3.6 capacitor: An assembly of one or more capacitor elements in a single container, with one or more insulated terminals brought out.

3.7 capacitor bus: The main conductors that serve to connect the capacitor assemblies in series with the line.

3.8 capacitor element: The smallest unit of a capacitor consisting of metallic foil plates separated by a dielectric film made typically of a polymer, paper, or combination of the two materials.

3.9 capacitor fuse: A capacitor fuse that provides an externally visible indication of fuse operation.

3.10 capacitor group: An assembly of more than one capacitor connected in parallel between two buses or terminals (see figure 1).



- 1—Capacitor segment (1 ϕ)
- 2—Capacitor switching step/Capacitor module (3 ϕ)
- 3—Capacitor group
- 4—Discharge current limiting damping device
- 5—Varistor
- 6—Bypass gap
- 7—Bypass switch
- 8—Additional switching steps when required
- 9—External bypass disconnect switch
- 10—External isolating disconnect switch
- 11—External grounding disconnect switch

Figure 1—Typical series capacitor bank nomenclature

3.11 capacitor platform: A structure that supports the capacitor rack assemblies and all associated equipment and protective devices, and is supported on insulators compatible with line-to-ground insulation requirements.

3.12 capacitor rack: A frame that supports one or more capacitors.

3.13 capacitor segment: A single-phase assembly of groups of capacitors that has its own voltage-limiting device and relays to protect the capacitors from overvoltages and overloads (see figure 1).

3.14 capacitor switching step: A three-phase function that consists of one or more capacitor segments per phase with capacitor bypass devices connected in parallel control devices, and provision for interlocked operation of the single-phase or three-phase switches when bypassing or inserting the capacitor segments (see figure 1). This is sometimes referred to as a capacitor module.

3.15 capacitance unbalance detection function: The detection of objectionable unbalance in capacitance between capacitor groups within a phase, such as that caused by blown capacitor fuses or faulted capacitors, and to initiate an alarm, the closing of the capacitor bypass switch, or both.

3.16 discharge current limiting device: A reactor or equivalent device to limit the current magnitude and frequency of the discharge of the capacitors during closing operations of the bypass switch or gap (see figure 1).

3.17 discharge device: An internal or external device permanently connected in parallel with the terminals of a capacitor for the purpose of reducing the residual voltage after the capacitor is disconnected from an energized line.

3.18 external line fault: A fault that occurs on lines or equipment other than the transmission line that includes the series capacitor installation.

3.19 forced-triggered gap: A bypass gap that is designed to operate on external command on quantities such as varistor energy, current magnitude, or rate of change of such quantities. The sparkover of the gap is initiated by a trigger circuit. After initiation, an arc is established in the power gap. Forced-triggered gaps typically sparkover only during internal faults.

3.20 fused capacitor: A capacitor in combination with a fuse, either external or internal to the case.

3.21 insertion: The opening of the capacitor bypass device to place the series capacitor in service with or without load current flowing.

3.22 insertion current: The steady state root-mean-square current that flows through the series capacitor after the bypass device has opened.

3.23 insertion voltage: The steady state root-mean-square voltage appearing across the series capacitor upon the interruption of the bypass current with the opening of the bypass device.

3.24 insulation level: The combination of power frequency and impulse test voltage values that characterize the insulation of the capacitor bank with regard to its capability of withstanding the electric stresses between platform and earth, or between platform-mounted equipment and the platform.

3.25 internal line fault: A fault that occurs on the transmission line section that includes the series capacitor installation.

3.26 lockout protection function: A function that blocks the opening of the bypass switch and prevents insertion of the switching steps, following the closure of the bypass switch from a cause that warrants inspection or maintenance.

3.27 loss of control power protection: A means to initiate the closing of the bypass device upon the loss of normal control power.

3.28 overload detection: A means to detect excessive overload of series capacitor bank components and to initiate an alarm signal, the closing of the associated bypass switch, or both.

3.29 platform control power: Energy source(s) available at platform potential for performing protection and control functions.

3.30 platform fault-detection: A means used to detect insulation failure on the platform that results in current flowing from normal current-carrying circuit elements to the platform.

3.31 platform-to-ground signaling devices: Devices to transmit protection, control, and alarm functions to and from the platform.

3.32 power gap: The part of the bypass gap that carries the fault current after sparkover of the bypass gap.

3.33 protective device: A bypass gap, varistor, or other device that limits the voltage on the capacitor segment to a predetermined level when overcurrent flows through the series capacitor (that is, during system faults, system swings, or other abnormal events), and that is capable of carrying capacitor discharge, system fault, and load current for the specified duration.

3.34 protective level of the bypass gap: The maximum instantaneous voltage (including tolerance) appearing across the capacitor immediately before or during operation of the bypass gap.

3.35 protective level of the varistor: The maximum instantaneous voltage appearing across the capacitor at a specified current through the varistor.

3.36 reinsertion: The restoration of load current to the series capacitor from the bypass path (see figure 1).

3.37 reinsertion current: The transient current, load current, or both, flowing through the series capacitor after the opening of the bypass path.

3.38 reinsertion voltage: The transient voltage, steady-state voltage, or both, appearing across the series capacitor after the opening of the bypass path.

3.39 self-triggered gap: A bypass gap that is designed to sparkover on the voltage that appears across the gap terminals. The sparkover of the gap is normally initiated by a trigger circuit set at a specified voltage level. A self-triggered bypass gap may be used for the primary protection of the capacitor. The self-triggered gap may sparkover during external as well as internal faults.

3.40 series capacitor: A device that has the primary purpose of introducing capacitive reactance in series with an electric circuit.

3.41 series capacitor bank: An assembly of capacitors and associated auxiliaries, such as structures, support insulators, switches, and protective devices, with control equipment required for a complete operating installation.

3.42 subharmonic detector: A device that detects subharmonic current of specified frequency and duration and initiates an alarm signal or corrective action.