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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Series capacitors for power systems – Part 2: Protective equipment for series capacitor banks

Condensateurs série destinés à être installés sur des réseaux – Partie 2: Matériel de protection pour les batteries de condensateurs série

IEC 60143-2:2012

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CONTENTS

FOREWORD 4
1 Scope 6
2 Normative references 7
3 Terms and definitions 9
4 Quality requirements and tests 15
4.1 Overvoltage protector 15
4.2 Protective spark gap 16
4.2.1 Purpose 16
4.2.2 Classification of triggering principles 16
4.2.3 Tests 16
4.3 Varistor 21
4.3.1 Purpose 21
4.3.2 Classification 21
4.3.3 Tests 22
4.4 Bypass switch 26
4.5 Disconnectors and earthing switches 26
4.5.1 Purpose 26
4.5.2 Classification 27
4.5.3 Tests 27
4.6 Discharge current-limiting and damping equipment (DCLDE) 28
4.6.1 Purpose 28
4.6.2 Classification 28
4.6.3 Tests 28
4.7 Voltage transformer 32
4.7.1 Purpose 32
4.7.2 Classification 32
4.7.3 Tests 32
4.8 Current sensors 33
4.8.1 Purpose 33
4.8.2 Classification 33
4.8.3 Current transformer tests 33
4.8.4 Electronic transformer tests 33
4.8.5 Optical transducer tests 33
4.9 Coupling capacitor 34
4.9.1 Purpose 34
4.9.2 Tests 34
4.10 Signal column 34
4.10.1 Purpose 34
4.10.2 Tests 34
4.11 Fibre optical platform links 34
4.11.1 Purpose 34
4.11.2 Tests 35
4.12 Relay protection, control equipment and platform-to-ground communication equipment 35
4.12.1 Purpose 35
4.12.2 Classification 35

4.12.3 Tests 35
5 Guide 36
5.1 General 36
5.2 Specification data for series capacitors 36
5.3 Protective spark gap 37
5.4 Varistor 38
5.4.1 General 38
5.4.2 Varistor voltage-current characteristic 39
5.4.3 Varistor current and voltage waveforms during a system fault 40
5.4.4 Comments on varistor definitions and type tests 41
5.5 Bypass switch 44
5.6 Disconnectors 44
5.7 Discharge current-limiting and damping equipment 44
5.7.1 Purpose of the Discharge Current-Limiting and Damping Equipment 44
5.7.2 Location of the DCLDE 45
5.7.3 Configuration of the DCLDE 47
5.7.4 Miscellaneous comments regarding the DCLDE 48
5.8 Voltage transformer 49
5.9 Current transformer 49
5.10 Relay protection, control equipment and platform-to-ground communication equipment 49
5.11 Protection redundancy 51
5.12 Commissioning tests 52
5.13 Energization tests 52
Bibliography 54

Figure 1 – Typical nomenclature of a series capacitor installation 7
Figure 2 – Classification of overvoltage protection 16
Figure 3 – Illustration of waveforms in recovery voltage test 19
Figure 4 – Typical voltage-current characteristics of one specific metal oxide varistor element (95 mm diameter) 40
Figure 5 – Current, voltage and energy waveforms for a phase-to-earth fault 41
Figure 6 – Conventional location in the bypass branch 45
Figure 7 – DCLDE in series with the capacitor and the parallel connected MOV 45
Figure 8 – DCLDE in series with the capacitor and parallel to the MOV 45
Figure 9 – Only a discharge current-limiting reactor 47
Figure 10 – Discharge current-limiting reactor connected in parallel with a damping resistor. A varistor is connected in series with the resistor 47
Figure 11 – Discharge current-limiting reactor connected in parallel with a damping resistor. A small spark gap is connected in series with the resistor 47
Figure 12 – Current-limiting and damping equipment with and without damping resistor 48

Table 1 – Summary of varistor energy absorption design criteria (example) 38
Table 2 – Overview of typical series capacitor bank protections 51

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SERIES CAPACITORS FOR POWER SYSTEMS –

Part 2: Protective equipment for series capacitor banks

FOREWORD

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International Standard IEC 60143-2 has been prepared by IEC technical committee 33: Power capacitors and their applications.

This second edition cancels and replaces the first edition published in 1994. It constitutes a technical revision. The main changes with respect to the previous edition are:

- updated with respect to new and revised component standards;
- updates with respect to technology changes. Outdated technologies have been removed, i.e. series capacitors with dual self-triggered gaps. New technologies have been added, i.e. current sensors instead of current transformers;
- the testing of spark gaps has been updated to more clearly specify requirements and testing procedures. A new bypass making current test replaces the old discharge current test;
- Clause 5, Guide, has been expanded with more information about different damping circuits and series capacitor protections

The text of this standard is based on the following documents:

FDIS	Report on voting
33/517/FDIS	33/521/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 60143 series, under the general title *Series capacitors for power systems*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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SERIES CAPACITORS FOR POWER SYSTEMS –

Part 2: Protective equipment for series capacitor banks

1 Scope

This part of IEC 60143 covers protective equipment for series capacitor banks, with a size larger than 10 Mvar per phase. Protective equipment is defined as the main circuit apparatus and ancillary equipment, which are part of a series capacitor installation, but which are external to the capacitor part itself. The recommendations for the capacitor part are given in IEC 60143-1:2004. The protective equipment is mentioned in Clause 3 and 10.6 of IEC 60143-1:2004.

The protective equipment, treated in this standard, comprises the following items listed below:

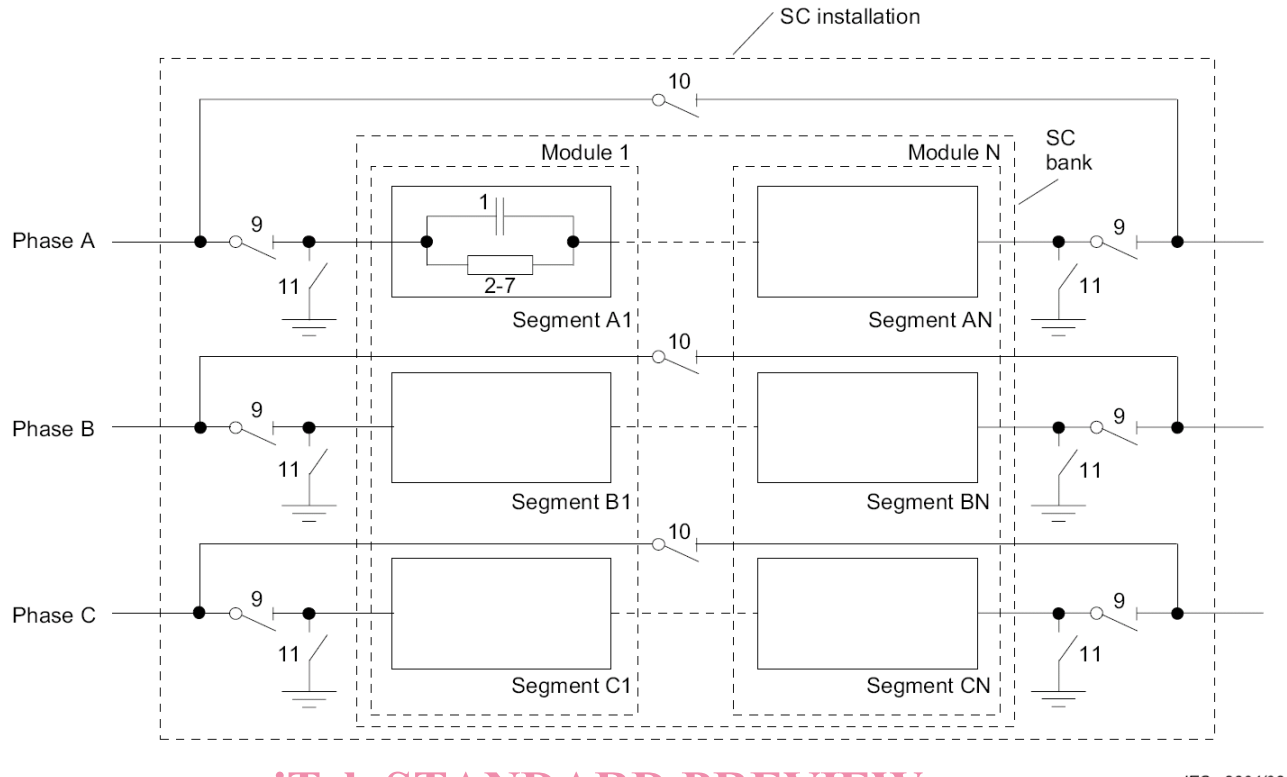
– overvoltage protector,
– protective spark gap,
– varistor,
– bypass switch,
– disconnectors and earthing switches,
– discharge current-limiting and damping equipment,
– voltage transformer,
– current sensors,
– coupling capacitor,
– signal column,
– fibre optical platform links,
– relay protection, control equipment and platform-to-ground communication equipment.

See Figure 1.

Principles involved in the application and operation of series capacitors are given in Clause 5.

Examples of fault scenarios are given in Clause 5.

Examples of protective schemes utilizing different overvoltage protectors are given in 4.1.



Key

1 assembly of capacitor units
2-7 main protective equipment
9 isolating disconnector
10 bypass disconnector
11 earth switch

Figure 1 – Typical nomenclature of a series capacitor installation

NOTE Most series capacitors are configured with a single module, unless the reactance and current requirements result in a voltage across the bank that is impractical for the supplier to achieve with one module. Normally each module has its own bypass switch but a common bypass switch can be used for more than one module. See 10.2.3 of IEC 60143-1:2004 for additional details.

The object of this standard is:

– to formulate uniform rules regarding performance, testing and rating,
– to illustrate different kinds of overvoltage protectors,
– to provide a guide for installation and operation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60044 (all parts), *Instrument transformers*

IEC 60044-1, *Instrument transformers – Part 1: Current transformers*

IEC 60044-8, *Instrument transformers – Part 8: Electronic current transformers*

IEC 60060 (all parts), *High-voltage test techniques*

IEC 60076-1, *Power transformers – Part 1: General*

IEC 60076-6:2007, *Power transformers – Part 6: Reactors*

IEC 60099-4:2009, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*

IEC 60143-1:2004, *Series capacitors for power systems – Part 1: General*

IEC 60255-5, *Electrical relays – Part 5: Insulation coordination for measuring relays and protection equipment – Requirements and tests*

IEC 60255-21, *Electrical relays – Part 21: Vibration, shock, bump and seismic test on measuring relays and protection equipment – Section One – Vibration tests (sinusoidal)*

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

IEC 60358-1, *Coupling capacitors and capacitor dividers – Part 1: General rules*

IEC 60358-2, *Coupling capacitors and capacitor dividers – Part 2: AC or DC single-phase coupling capacitor connected between line and ground for power line carrier frequency (PLC) application*[1]

IEC 60794-1-1, *Optical fibre cables - Part 1: Generic specification – General*

IEC 60794-2, *Optical fibre cables - Part 2: Indoor cables – Sectional specification*

IEC 61000-4-29, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input port immunity tests*

IEC 61109, *Insulators for overhead lines – Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1 000 V – Definitions, test methods and acceptance criteria*

IEC 61300-3-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-4: Examinations and measurements – Attenuation*

IEC 61869-3, *Instrument transformers – Part 3: Additional requirements for inductive voltage transformers*

IEC 61869-5, *Instrument transformers – Part 5: Additional requirements for capacitor voltage transformers*

IEC 62271-1, *High-voltage switchgear and controlgear – Part 1: Common specifications*

IEC 62271-102:2001, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC 62271-109:2008, *High-voltage switchgear and controlgear – Part 109: Alternating current series capacitor bypass switches*

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1 To be published.

NOTE No standard exists for varistors for series capacitors (SC). The relevant tests for series capacitors varistors are therefore dealt with in this standard.

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply:

NOTE The definitions of capacitor parts and accessories in this standard are in accordance with IEC 60143-1:2004.

3.1
back-up gap
supplementary gap which may be set to spark over at a voltage level higher than the protective level of the primary protective device, and which is normally placed in parallel with the primary protective device

3.2
bank protection
general term for all protective equipment for a capacitor bank, or part thereof

3.3
bypass current
current flowing through the bypass switch or spark gap in parallel with the series capacitor

3.4
bypass switch
device such as a switch or a circuit-breaker used in parallel with a series capacitor and its overvoltage protector to shunt line current for a specified time, or continuously

Note 1 to entry: Besides bypassing the capacitor, this device may also have the capability of inserting the capacitor into a circuit and carrying a specified current.

Note 2 to entry: This device shall also have the capability of bypassing the capacitor during specified power system fault conditions. The operation of the device is initiated by the capacitor control, remote control or an operator. The device may be mounted on the platform or on the ground near the platform.

3.5
bypass disconnector
device to short-circuit the series capacitor after it is bypassed by the bypass switch

Note 1 to entry: Installed to keep the line in service while the bypass switch or series capacitor bank are maintained.

3.6
bypass fault current
current flowing through the bypassed series capacitor bank caused by a fault on the line

Note 1 to entry: See also “through fault current” and “partial fault current”.

3.7
bypass gap (protective gap)
gap, or system of gaps, to protect either the capacitor (type K) against overvoltage or the varistor (type M) against overload by carrying load or fault current around the protected parts for a specified time

3.8
bypass interlocking device
device that requires all three poles of the bypass switch to be in the same open or closed position

3.9
capacitor unbalance protection
device to detect unbalance in capacitance between capacitor groups within a phase, such as that caused by blown capacitor fuses or faulted capacitor elements, and to initiate an alarm or the closing of the bypass switch, or both

3.10
capacitor platform
structure that supports the capacitor/rack assemblies and all associated equipment and protective devices, and is supported on insulators compatible with phase-to-earth insulation requirements

3.11
continuous operating voltage
COV
MCOV of a varistor
(maximum) continuous operating voltage, COV is the designated permissible r.m.s. value of power frequency voltage that may be applied continuously between the varistor terminals

Note 1 to entry: COV of the series capacitor varistor is usually equal to the rated voltage of the series capacitor. This definition is different from the definition of COV (U_c) for a ZnO arrester according to IEC 60099-4:2009.

Note 2 to entry: In IEC 60099-4:2009 U_c is used to designate "continuous operating voltage". However, in this standard, COV is used to designate "continuous operating voltage". The reason is that U_C is used to designate "capacitor voltage" in the IEC 60143 series.

Note 3 to entry: Consideration of short-time overvoltages of the series capacitor, such as voltages produced by swing currents and overload currents, should be taken into account when the protective level of the varistor is determined.

3.12
discharge current-limiting and damping equipment
reactor or reactor with a parallel connected resistor to limit the current magnitude and frequency and to provide a sufficient damping of the oscillation of the discharge of the capacitors upon operation of the bypass gap or the bypass switch

3.13
external fault
line fault occurring outside the protected line section containing the series capacitor bank

3.14
fault-to-platform protection
device to detect insulation failure on the platform that results in current flowing from normal current-carrying circuit elements to the platform and to initiate the closing of the bypass switch

3.15
forced-triggered bypass gap
bypass gap that is designed to operate on external command on quantities such as MOV energy, current magnitude, or rate of change of such quantities

Note 1 to entry: 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 operate only during internal faults.

3.16
insertion
opening of the bypass switch to place the series capacitor in service

3.17
insertion current
r.m.s. current that flows through the series capacitor bank after the bypass switch has opened

Note 1 to entry: This current may be at the specified continuous, overload or swing current magnitudes.

3.18
insertion voltage
peak voltage appearing across the series capacitor bank upon the interruption of the bypass current with the opening of the bypass switch

3.19
internal fault
line fault occurring within the protected line section containing the series capacitor bank

3.20
isolating disconnector
devices to connect or disconnect the bypassed series capacitor from the line

SEE: Figure 1.

3.21
leakage current (of a varistor)
continuous current flowing through the varistor when energized at a specified power-frequency voltage

Note 1 to entry: At COV, and at a varistor element temperature equal to normal ambient temperature, the leakage current is usually mainly capacitive.

3.22
limiting voltage
maximum peak of the power frequency voltage occurring between capacitor unit terminals immediately before or during operation of the overvoltage protector, divided by √2

Note 1 to entry: This voltage appears either during conduction of the varistor or immediately before ignition of the spark gap. See IEC 60143-1:2004 for details.

3.23
loss-of-control power protection
means to initiate the closing of the bypass switch upon the loss of normal control power

3.24
main gap
part of the protective spark gap, that shall carry the fault current during a specified time, comprising two or more heavy-duty electrodes

3.25
minimum reference voltage (of a varistor)
$U_{\mathbf{MRef}}$
minimum permissible reference voltage for a complete varistor or varistor unit measured at a specified temperature, typically (20 ± 15) °C

Note 1 to entry: See Figure 4 and comments in Clause 5.

3.26
module
capacitor switching step
three-phase function unit, that consists of one capacitor segment (possibly several) per phase with provision for interlocked operation of the single-phase bypass switches

SEE: Figure 1.

Note 1 to entry: The bypass switch of a module is normally operated on a three-phase basis. However, in some applications for protection purposes, the bypass switch may be required to temporarily operate on an individual phase basis.

3.27
overvoltage protector
quick-acting device (usually MOV or voltage triggered spark gap) which limits the instantaneous voltage across the series capacitor to a permissible value at power-system faults or other abnormal network conditions

3.28
platform
structure that supports one or more segments of the bank and is supported on insulators compatible with phase-to-ground insulation requirements

3.29
platform control power
energy source(s) available at platform potential for performing operational and control functions

3.30
platform-to-ground communication equipment
devices to transmit operating, control and alarm signals between the platform and ground level, as a result of operation or protective actions

3.31
protective level
U_{pl}
maximum peak of the power frequency voltage appearing across the overvoltage protector during a power system fault

Note 1 to entry: The protective level may be expressed in terms of the actual peak voltage across a segment or in terms of the per unit of the peak of the rated voltage across the capacitor segment. This voltage appears either during conduction of the varistor or immediately before ignition of the spark gap.

3.32
rated short-time energy (of a varistor)
maximum energy the varistor can absorb within a short period of time, without being damaged due to thermal shock

Note 1 to entry: The short time energy is usually expressed in J, kJ or MJ.

3.33
reference current (of a varistor)
peak value of the resistive component of a power-frequency current used to determine the reference voltage of the varistor

Note 1 to entry: The reference current is chosen in the transition area between the leakage current and the conduction current region, typically in the range 1 mA to 20 mA for a single varistor column (see Figure 4).

3.34
reference voltage (of a varistor)
peak value of power-frequency voltage divided by √2 measured at the reference current of the varistor

Note 1 to entry: Measurement of the reference voltage is necessary for the selection of correct test samples in the type testing.

3.35
reinsertion
restoration of line current through the series capacitor from the bypass path

3.36
reinsertion current
transient current flowing through the series capacitor after the opening of the bypass path during reinsertion

3.37
reinsertion voltage
transient voltage appearing across the series capacitor after the opening of the bypass path during reinsertion

3.38
residual voltage (of a capacitor)
voltage remaining between terminals of a capacitor at a given time following disconnection of the supply

3.39
residual voltage (of a varistor)
peak value of voltage that appears between the terminals of a varistor during passage of current

3.40
section (of a varistor)
complete, suitably assembled part of a varistor necessary to represent the behaviour of a complete varistor with respect to a particular test

Note 1 to entry: A section of a varistor is not necessarily a unit of a varistor.

3.41
segment
single-phase assembly of groups of capacitors which has its own voltage-limiting devices and relays to protect the capacitors from overvoltages and overloads

SEE: Figure 1.

3.42
subharmonic protection
device that detects subharmonic current of specified frequency and duration and initiates an alarm signal or corrective action, usually bypassing the capacitor bank

3.43
sustained bypass current protection
means to detect prolonged current flow through the overvoltage protector and to initiate closing of the bypass switch

3.44
sustained overload protection
device that detects capacitor voltage above rating but below the operating level of the overvoltage protector and initiates an alarm signal or corrective action

3.45
swing current
highest value of the oscillatory portion of the current during the transient period following a large disturbance

Note 1 to entry: The swing current is measured in A r.m.s. and is characterized by a specified amplitude, frequency and decay time-constant. The swing current is propagated from electromechanical oscillations of the synchronous machines in the actual power system. The frequency of these oscillations is typically in the range 0,5 Hz to 2 Hz.