IEC 60143-1

Edition 5.0 2015-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Series capacitors for power systems –
Part 1: General

Condensateurs série destinés à être installés sur des réseaux –
Partie 1: Généralités

IEC 60143-1:2015-06(en-fr)

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INTERNATIONAL ÉLECTROTECHNICAL COMMISSION

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SERIES CAPACITORS FOR POWER SYSTEMS –

Part 1: General

FOREWORD

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International Standard IEC 60143-1 has been prepared by IEC technical committee 33: Power capacitors and their applications.

This fifth edition cancels and replaces the fourth edition, published in 2004. This edition constitutes a technical revision.

The main change with respect to the previous edition is that the endurance test has been replaced by an ageing test because voltage cycling is already performed in the cold duty test. The guide section has been expanded regarding long line correction and altitude correction. In addition the insulation tables and references to other standards have been updated.

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

FDIS	Report on voting
33/578/FDIS	33/580/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 parts in the IEC 60143 series, published 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 website 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- withdrawn,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.

The contents of the corrigendum of April 2017 have been included in this copy.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

SERIES CAPACITORS FOR POWER SYSTEMS –

Part 1: General

1 Scope and object

This part of IEC 60143 applies both to capacitor units and capacitor banks intended to be used connected in series with an a.c. transmission or distribution line or circuit forming part of an a.c. power system having a frequency of 15 Hz to 60 Hz.

The primary focus of this standard is on transmission application.

The series capacitor units and banks are usually intended for high-voltage power systems. This standard is applicable to the complete voltage range.

This standard does not apply to capacitors of the self-healing metallized dielectric type.

The following capacitors, even if connected in series with a circuit, are excluded from this standard:

– capacitors for inductive heat-generating plants (IEC 60110-1);
– capacitors for motor applications and the like (IEC 60252 (all parts));
– capacitors to be used in power electronics circuits (IEC 61071);
– capacitors for discharge lamps (IEC 61048 and IEC 61049).

For standard types of accessories, such as insulators, switches, instrument transformers, external fuses, etc. see the pertinent IEC standard.

NOTE 1 Additional requirements for capacitors to be protected by internal fuses, as well as the requirements for internal fuses, are found in IEC 60143-3. See also Annex C.

NOTE 2 Additional requirements for capacitors to be protected by external fuses, as well as the requirements for external fuses, are found in Annex A and Annex C.

NOTE 3 A separate standard for series capacitor accessories (spark-gaps, varistors, discharge reactors, current-limiting damping reactors, damping resistors, circuit-breakers, etc.), IEC 60143-2, has been revised and was completed in 2012. A separate standard for internal fuses for series capacitors, IEC 60143-3 has been revised and was completed in 2013.

NOTE 4 Some information regarding fuseless capacitor units and fuseless capacitor banks is found in Annex C.

The object of this standard is:

– to formulate uniform rules regarding performance, testing and rating;
– to formulate specific safety rules;
– to serve as 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.

NOTE If there is a conflict between this standard and a standard listed below, the text of IEC 60143-1 prevails.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at www.electropedia.org)

IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60071-1:2006, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60071-2:1996, *Insulation co-ordination – Part 2: Application guide*

IEC 60143-2:2012, *Series capacitors for power systems – Part 2: Protective equipment for series capacitor banks*

IEC 60143-3:1998, *Series capacitors for power systems – Part 3: Internal fuses*

IEC 60143-4: 2010 *Series capacitors for power systems – Part 4: Thyristor controlled series capacitors*

IEC 60549:2013, *High-voltage fuses for the external protection of shunt capacitors*

IEC 60871-1: 2014 Shunt capacitors for a.c power systems having a rated voltage above 1000V – Part 1: General

IEC 62271-1:2007, *High-voltage switchgear and controlgear – Part 1: Common specifications*

IEEE Std. 693:1997, *IEEE Recommended Practice for Seismic Design of Substations*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
ambient air temperature (for capacitors)
temperature of air at the proposed location of the capacitor installation

3.2
bypass switch
device such as a switch or circuit-breaker used in parallel with a series capacitor and its overvoltage protector to shunt line current for some specified time or continuously

Note 1 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 bank control, remote control or by an operator. The device may be mounted on the platform or on the ground near the platform. Besides bypassing the capacitor, this device shall also have the capability of inserting the capacitor into a circuit carrying a specified level of current.

3.3
capacitor
word used when it is not necessary to distinguish between the different meanings of the words capacitor unit and the assembly of capacitors associated with a segment

3.4
capacitor unit
unit
assembly of one or more capacitor elements in the same container with terminals brought out

[SOURCE: IEC 60050-436:1990, 436-01-04]

3.5
(capacitor) element
device consisting essentially of two electrodes separated by a dielectric

[SOURCE: IEC 60050-436:1990, 436-01-03]

3.6
capacitor losses
active power dissipated in the capacitor

Note 1 to entry: All loss-producing components should be included. For a unit, this includes losses from the dielectric, discharge device, internal fuses (if applicable) and internal connections. For the bank, this includes losses from the units, external fuses (if applicable) and busbars. See Annex B for additional discussion.

[SOURCE: IEC 60050-436:1990, 436-04-10]

3.7
cooling air temperature
temperature of cooling air measured at the hottest position in the capacitor assembly of a segment, under rated current and steady-state conditions, midway between two units

Note 1 to entry: If only one unit is involved, it is the temperature measured at a point approximately 0,1 m away from the capacitor container and at two-thirds of the height from its base.

3.8
degree of compensation
k
degree of series compensation, k (of a line section) is

$$k = 100\ (X_C / X_L)\ \%$$

where

X_C is the capacitive reactance of the series capacitor;

X_L is the total positive sequence inductive reactance of the transmission line section on which the series capacitor is applied.

3.9
discharge device (of a capacitor)
device connected across the terminals of the capacitor or built into the capacitor unit, capable of reducing the residual voltage across the capacitor effectively to zero after the capacitor has been disconnected from the supply

Note 1 to entry: Further requirements on the size of the discharge device are found in 8.1.

[SOURCE: IEC 60050-436:1990, 436-03-15, modified (modified definition, addition of Note 1 to entry)]

3.10
external fuse (of a capacitor)
fuse connected in series with a capacitor unit or with a group of parallel units

3.11
fuseless capacitor bank
capacitor bank without any fuses, internal or external, constructed of parallel strings of capacitor units. Each string consists of capacitor units connected in series

Note 1 to entry: See Annex C for an explanation of “string”.

3.12
highest voltage of a three-phase system
highest r.m.s. phase-to-phase voltage which occurs under normal operating conditions at any time and at any point of the system

Note 1 to entry: It excludes voltage transients (such as those due to system switching) and temporary voltage variations due to abnormal system conditions (such as due to faults or sudden disconnection of large loads).

3.13
highest voltage for equipment
U_m
highest r.m.s. value of phase-to-phase voltage for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment standards

Note 1 to entry: This voltage is the maximum value of the highest voltage of the system for which the equipment may be used.

[SOURCE: IEC 60050-604:1987, 604-03-01]

3.14
insulation level
U_i
non-simultaneous combination of test voltages (power-frequency (U_{ipf}) or switching impulse, and lightning impulse) which characterizes the insulation of the capacitor with regard to its capability of withstanding the electric stresses between terminals and earth, between phases and between terminals and metalwork (e.g. platform) not at earth potential

3.15
internal fuse of a capacitor
fuse connected inside a capacitor unit, in series with an element or group of elements

[SOURCE: IEC 60050-436:1990, 436-03-16]

3.16
limiting voltage
U_{lim}
maximum peak of the power frequency voltage occurring between capacitor unit terminals immediately before or during operation of the overvoltage protector, divided by $\sqrt{2}$

SEE: 5.1.4

Note 1 to entry: This voltage appears either during conduction of the varistor or immediately before ignition of the spark gap.

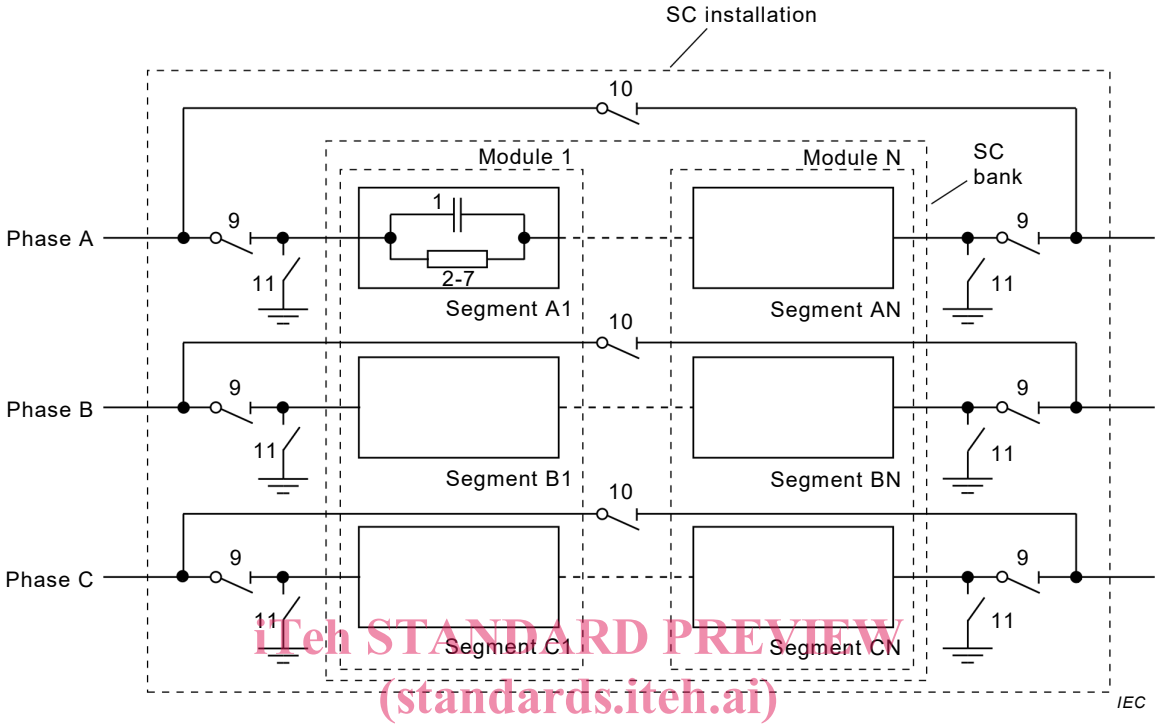
3.17
line terminal
terminal to be connected to the power system

[SOURCE: IEC 60050-436:1990, 436-03-01, modified (modified definition)]

3.18
module (of a series capacitor)
switchable step of a series capacitor consisting of identical segments in each phase (see Figure 1), which furthermore are also equipped with provisions for a common operation of the bypass switch of each of these segments

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.

Note 2 to entry: Figure 1 shows a typical nomenclature of a series capacitor installation.



Key

1 assembly of capacitor units

2-7 main protective equipment (Figure 2c) and Annex D)

9 isolating disconnector

10 bypass disconnector

11 earth switch

NOTE 1 A SC Installation includes a SC Bank plus 9, 10 and 11.

NOTE 2 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 may be used for more than one module. See clause 10.2.3 for additional details.

Figure 1 – Typical nomenclature of a series capacitor installation

3.19
overvoltage protector (of a series capacitor)
quick-acting device (usually MOV or a self triggered spark gap) which limits the voltage across the capacitor to a permissible value when that value would otherwise be exceeded as a result of a circuit fault or other abnormal power system conditions

3.20
power frequency withstand voltage
U_{ipf}
wet power frequency withstand voltage of bushings and insulators

3.21
protective level
U_{pl}
magnitude of the 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 (see 5.1.4, 10.4 and 10.5). This voltage appears either during conduction of the varistor or immediately before ignition of the spark gap.

3.22
rated capacitance (of a capacitor)
C_N
capacitance value for which the capacitor has been designed

3.23
rated current of a capacitor
I_N
r.m.s. value of the alternating current for which the capacitor has been designed

[SOURCE: IEC 60050-436:1990, 436-01-13]

3.24
rated frequency (of a capacitor)
f_N
frequency of the system in which the capacitor is intended to be used

[SOURCE: IEC 60050-436:1990, 436-01-14, modified (modified definition)]

3.25
rated output (of a capacitor)
Q_N
reactive power derived from rated reactance and rated current

Note 1 to entry: For the bank, the rated three-phase reactive power rating in Mvar (Q_N) is defined by the equation:

$$Q_N = 3 \times I^2_N \times X_N$$

where

I_N is the rated current, in kA;

X_N is the rated reactance, in Ω.

3.26
rated reactance (of capacitor)
X_N
reactance of each phase of the series capacitor at rated frequency and 20 °C dielectric temperature

3.27
rated voltage (of the bank)
power system phase-to-phase voltage for which the phase-to-ground insulation system is designed

3.28
rated voltage (of a capacitor)
U_N
r.m.s. value of the voltage between the terminals, derived from rated reactance and rated current $U_N = X_N \times I_N$