

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**High-voltage switchgear and controlgear –  
Part 109: Alternating-current series capacitor by-pass switches**

**Appareillage à haute tension –  
Partie 109: Interrupteurs de contournement pour condensateurs série à courant alternatif**



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IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

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INTERNATIONAL  
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ICS 29.130.10

ISBN 978-2-8322-6673-1

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –****Part 109: Alternating-current series capacitor  
by-pass switches**

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International Standard IEC 62271-109 has been prepared by subcommittee 17A: Switching devices, of IEC technical committee 17: High-voltage switchgear and controlgear.

This third edition cancels and replaces the second edition published in 2008 and Amendment 1:2013. This edition constitutes a technical revision.

This edition contains the following significant technical changes with respect to the previous edition:

- a) the document has been restructured according to edition 2.0 of IEC 62271-1;
- b) the rated voltage assignment across the by-pass switch has been aligned to the rule defined in IEC 60143-1;
- c) clarification has been given regarding rated continuous current of compensated and uncompensated line;
- d) some clarifications have been given following a loss of "suitable precautions";

- e) as per Amendment 2 of IEC 62271-100, the section "Rated time quantities" has been moved to Clause 6 under "Time quantities";
- f) as per Amendment 2 of IEC 62271-100, the section "Test for static mechanical loads" have been moved to Clause 6 under "Static mechanical loads";
- g) additional rules have been introduced for vacuum interrupters during impulse tests;
- h) additional clarifications have been given regarding the number of reduced impulses during impulse tests;
- i) a wider tolerance on the current damping during by-pass making current test-duty has been introduced.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
17A/1208/FDIS	17A/1215/RVD

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

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

A list of all parts of the IEC 62271 series can be found, under the general title *High-voltage switchgear and controlgear*, on the IEC website.

This standard is to be read in conjunction with IEC 62271-100:2008 with its Amendment 1:2012 and Amendment 2:2017, and IEC 62271-1:2017, to which it refers and which is applicable, unless otherwise specified in this standard. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1:2017. Amendments to these clauses and subclauses are given under the same references whilst additional subclauses are numbered from 101.

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

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

**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.**

## HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

### Part 109: Alternating-current series capacitor by-pass switches

#### 1 Scope

This part of IEC 62271 is applicable to AC series capacitor by-pass switches designed for outdoor installation and for operation at frequencies of 50 Hz and 60 Hz on systems having voltages above 52 kV.

It is only applicable to by-pass switches for use in three-phase systems.

This document is also applicable to the operating devices of by-pass switches and to their auxiliary equipment.

#### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-151:2001, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices*

IEC 60050-436:1990, *International Electrotechnical Vocabulary – Chapter 436: Power capacitors*

IEC 60050-441:1984, *International Electrotechnical Vocabulary – Chapter 441: Switchgear, controlgear and fuses*

IEC 60050-614:2016, *International Electrotechnical Vocabulary – Part 614: Generation, transmission and distribution of electricity – Operation*

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

IEC 60137:2017, *Insulated bushings for alternating voltages above 1000 V*

IEC 60143-1:2015, *Series capacitors for power systems – Part 1: General*

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

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

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF<sub>6</sub>) and complementary gases to be used in its mixtures for use in electrical equipment*

IEC 60480, *Guidelines for the checking and treatment of sulphur hexafluoride (SF<sub>6</sub>) taken from electrical equipment and specification for its re-use*

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-4, *High-voltage switchgear and controlgear – Part 4: Handling procedures for sulphur hexafluoride (SF<sub>6</sub>) and its mixtures*

IEC 62271-100:2008, *High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*

IEC 62271-100:2008/AMD1:2012

IEC 62271-100:2008/AMD2:2017

IEC 62271-101, *High-voltage switchgear and controlgear – Part 101: Synthetic testing*

IEC 62271-102:2018, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 60050-151, IEC 60050-436, IEC 60050-441, IEC 60050-614, IEC 60143-1, IEC 60143-2 and IEC 62271-1 apply. Some of them are recalled here for ease of reference.

Additional terms and definitions are classified so as to be aligned with the classification used in IEC 60050-441.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### 3.1 General terms and definitions

##### 3.1.101

##### **switchgear and controlgear**

a general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

[SOURCE: IEC 60050-441:2000, 441-11-01]

##### 3.1.102

##### **outdoor switchgear and controlgear**

switchgear and controlgear suitable for installation in the open air, i.e. capable of withstanding wind, rain, snow, dirt deposits, condensation, ice and hoar frost

[SOURCE: IEC 60050-441:2000, 441-11-05]

##### 3.1.103

##### **short-circuit current**

overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit

[SOURCE: IEC 60050-441:2000, 441-11-07]

**3.1.104  
ambient air temperature**

temperature, determined under prescribed conditions, of the air surrounding the complete switching device or fuse

Note 1 to entry: For switching devices or fuses installed inside an enclosure, it is the temperature of the air outside the enclosure.

[SOURCE: IEC 60050-441:2000, 441-11-13]

**3.1.105  
temperature rise**

<of a part of a by-pass switch>

difference between the temperature of the part under consideration and the ambient air temperature

[SOURCE: IEC 60050-151:2001, 151-16-26, modified – "A reference" has been replaced by "the ambient air".]

**3.1.106  
overvoltage**

<in an electric power system>  
voltage:

- between one line conductor and earth or across a longitudinal insulation having a peak value exceeding the corresponding peak of the highest voltage of the system divided by  $\sqrt{3}$

or;

- between phase conductors having a peak value exceeding the amplitude of the highest voltage of the system

[SOURCE: IEC 60050-614:2016, 614-03-10]

**3.1.107  
unit test**

test carried out on a by-passing or insertion unit or group of units at the by-pass making current or the insertion current, specified for the test on the complete pole of a by-pass switch and at the appropriate fraction of the applied voltage, or the recovery voltage, specified for the test on the complete pole of the by-pass switch

**3.1.108  
external insulation**

distances in atmospheric air, and along the surfaces in contact with atmospheric air of solid insulation of the equipment which are subject to dielectric stresses and to the effects of atmospheric and other environmental conditions from the site

Note 1 to entry: Examples of environmental conditions are pollution, humidity, vermin.

[SOURCE: IEC 60050-614:2016, 614-03-02]

**3.1.109  
internal insulation**

internal distances of the solid, liquid or gaseous insulation of equipment, which are protected from the effects of atmospheric and other external conditions

[SOURCE: IEC 60050-614:2016, 614-03-03]

**3.1.110****self-restoring insulation**

insulation which completely recovers its insulating properties within a short time interval after a disruptive discharge

[SOURCE: IEC 60050-614:2016, 614-03-04]

**3.1.111****non-self-restoring insulation**

insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge

[SOURCE: IEC 60050-614:2016, 614-03-05]

**3.1.112****disruptive discharge**

phenomenon associated with the failure of insulation under electric stress, which includes a collapse of voltage and the passage of current

Note 1 to entry: This term applies to electric breakdown in solid, liquid and gaseous dielectrics and combinations of these.

Note 2 to entry: A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self-restoring insulation); in a liquid or gaseous dielectric, the loss may be temporary only.

Note 3 to entry: The term "sparkover" is used when a disruptive discharge occurs in a gaseous or liquid dielectric. The term "flashover" is used when a disruptive discharge occurs over the surface of a solid dielectric in a gaseous or liquid medium. The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

[SOURCE: IEC 60050-614:2016, 614-03-16, modified – Note 3 to entry added.]

**3.1.113****restrike performance**

expected probability of restrike during insertion current test-duty as demonstrated by specified type test

Note 1 to entry: Specific numeric probabilities cannot be applied throughout a by-pass switch service life.

**3.1.114****re-ignition**

<of an AC mechanical switching device>

resumption of current between the contacts of a mechanical switching device during a breaking operation with an interval of zero current of less than a quarter cycle of power frequency

[SOURCE: IEC 60050-441:2000, 441-17-45]

**3.1.115****restrike**

<of an AC mechanical switching device>

resumption of current between the contacts of a mechanical switching device during a breaking operation with an interval of zero current of a quarter cycle of power frequency or longer

[SOURCE: IEC 60050-441:2000, 441-17-46]

**3.1.116****non-sustained disruptive discharge****NSDD**

disruptive discharge associated with current interruption which does not result in the resumption of power frequency current or, in the case of insertion does not result in a current in the series capacitor bank

Note 1 to entry: Oscillations following NSDDs are associated with the parasitic capacitance and inductance local to or of the by-pass switch itself. NSDDs may also involve the stray capacitance to ground of nearby equipment.

Note 2 to entry: This note applies to the French language only.

**3.2 Assemblies**

No particular definitions.

**3.3 Parts of assemblies**

No particular definitions.

**3.4 Switching devices****3.4.101****switching device**

device designed to make or break the current in one or more electric circuits

[SOURCE: IEC 60050-441:2000, 441-14-01]

**3.4.102****mechanical switching device**

switching device designed to close and open one or more electric circuits by means of separable contacts

Note 1 to entry: Any mechanical switching device may be designated according to the medium in which its contacts open and close, e.g. air, SF<sub>6</sub>, oil.

[SOURCE: IEC 60050-441:2000, 441-14-02]

**3.4.103****by-pass switch**

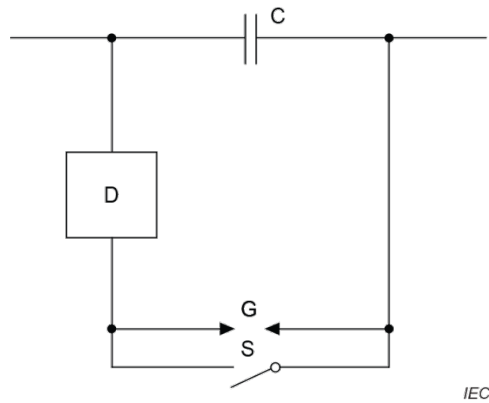
three-phase switching device used in parallel with a series capacitor and its overvoltage protector to shunt line current of a specified level for a specified time, or continuously

Note 1 to entry: By-pass switches can be three-pole or single-pole operated

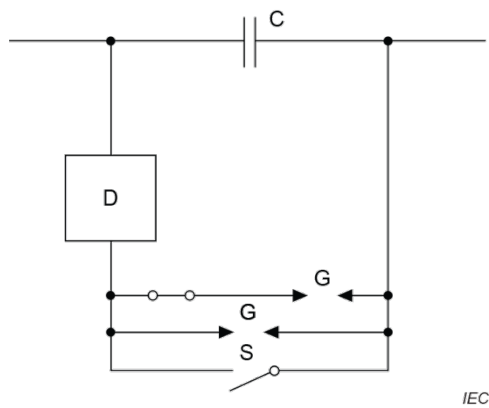
Note 2 to entry: Besides by-passing the capacitor, this device normally has the capability to insert the capacitor into a circuit that carries a specified level of current.

Note 3 to entry: By-pass switches are normally used in conjunction with a fast by-passing device, for example, spark-gap (for special applications without the use of a fast by-passing device, see Annex E).

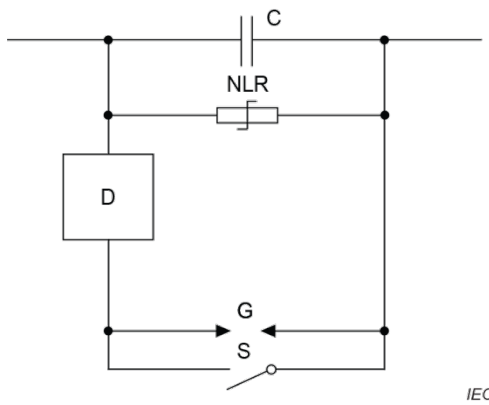
Note 4 to entry: Examples of series capacitor layouts using a fast by-passing device in parallel with the by-pass switch (see IEC 60143-1) are given in Figure 1.



Single gap



Dual gap



Non-linear resistor with by-pass gap

**Key**

- C series capacitor
- D damping circuit
- G spark-gap
- S by-pass switch
- NLR non-linear resistor

**Figure 1 – Different layouts for series capacitor banks**

**3.4.104**

**by-pass switch class M1**

by-pass switch with normal mechanical endurance as demonstrated by specific type tests

**3.4.105****by-pass switch class M2**

frequently operated by-pass switch for special service requirements and designed so as to require only limited maintenance as demonstrated by specific type tests.

Note 1 to entry: This type of by-pass switch is normally used on multi-segmented capacitors where the control of the capacitor impedance is a frequent duty.

**3.5 Parts of by-pass switches****3.5.101****pole of a switching device**

the portion of a switching device associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together

Note 1 to entry: A switching device is called single-pole if it has only one pole. If it has more than one pole, it may be called multipole (two-pole, three-pole, etc.) provided the poles are or can be coupled in such a manner as to operate together.

[SOURCE: IEC 60050-441:2000, 441-15-01]

**3.5.102****main circuit**

<of a switching device>

all the conductive parts of a switching device included in the circuit which it is designed to close or open

[SOURCE: IEC 60050-441:2000, 441-15-02]

**3.5.103****control circuit**

<of a switching device>

all the conductive parts (other than the main circuit) of a switching device which are included in a circuit used for the closing operation or opening operation, or both, of the device

[SOURCE: IEC 60050-441:2000, 441-15-03]

**3.5.104****auxiliary circuit**

<of a switching device>

all the conductive parts of a switching device which are intended to be included in a circuit other than the main circuit and the control circuits of the device

Note 1 to entry: Some auxiliary circuits fulfil supplementary functions such as signalling, interlocking, etc., and, as such, they may be part of the control circuit of another switching device.

[SOURCE: IEC 60050-441:2000, 441-15-04]

**3.5.105****contact**

<of a mechanical switching device>

conductive parts designed to establish circuit continuity when they touch and which, due to their relative motion during an operation, open or close a circuit or, in the case of hinged or sliding contacts, maintain circuit continuity

[SOURCE: IEC 60050-441:2000, 441-15-05]

**3.5.106****contact  
contact piece**

one of the conductive parts forming a contact

[SOURCE: IEC 60050-441:2000, 441-15-06]

**3.5.107****main contact**

contact included in the main circuit of a mechanical switching device, intended to carry, in the closed position, the current of the main circuit

[SOURCE: IEC 60050-441:2000, 441-15-07]

**3.5.108****arcing contact**

contact on which the arc is intended to be established

Note 1 to entry: An arcing contact may serve as a main contact; it may be a separate contact so designed that it opens after and closes before another contact which it is intended to protect from injury.

[SOURCE: IEC 60050-441:2000, 441-15-08]

**3.5.109****control contact**

contact included in a control circuit of a mechanical switching device and mechanically operated by this device

[SOURCE: IEC 60050-441:2000, 441-15-09]

**3.5.110****auxiliary contact**

contact included in an auxiliary circuit and mechanically operated by the switching device

[SOURCE: IEC 60050-441:2000, 441-15-10]

**3.5.111****auxiliary switch**

<of a mechanical switching device>

switch containing one or more control and/or auxiliary contacts mechanically operated by a switching device

[SOURCE: IEC 60050-441:2000, 441-15-11]

**3.5.112****“a” contact  
make contact**

control or auxiliary contact which is closed when the main contacts of the mechanical switching device are closed and open when they are open

[SOURCE: IEC 60050-441:2000, 441-15-12]

**3.5.113****“b” contact;  
break contact**

control or auxiliary contact which is open when the main contacts of a mechanical switching device are closed and closed when they are open

[SOURCE: IEC 60050-441:2000, 441-15-13]

### **3.5.114**

#### **sliding contact**

contact in which relative movement of the contact pieces is substantially in a direction parallel to the contact surface

[SOURCE: IEC 60050-441:2000, 441-15-15]

### **3.5.115**

#### **rolling contact**

contact in which one contact piece rolls on the other

[SOURCE: IEC 60050-441:2000, 441-15-16]

### **3.5.116**

#### **release**

<of a mechanical switching device>

device, mechanically connected to a mechanical switching device, which releases the holding means and permits the opening or the closing of the switching device

[SOURCE: IEC 60050-441:2000, 441-15-17]

### **3.5.117**

#### **arc control device**

device, surrounding the arcing contacts of a mechanical switching device, designed to confine the arc and to assist in its extinction

[SOURCE: IEC 60050-441:2000, 441-15-18]

### **3.5.118**

#### **position indicating device**

part of a mechanical switching device which indicates whether it is in the open, closed, or where appropriate, earthed position

[SOURCE: IEC 60050-441:2000, 441-15-25]

### **3.5.119**

#### **connection**

two or more conductors designed to ensure permanent circuit continuity when forced together by means of screws, bolts or the equivalent

### **3.5.120**

#### **terminal**

component provided for the connection of a device to external conductors

### **3.5.121**

#### **by-pass unit**

#### **insertion unit**

part of a by-pass switch which in itself acts as a by-pass switch and which, in series with one or more identical and simultaneously operated by-pass or insertion units, forms the complete by-pass switch

Note 1 to entry: By-pass units and insertion units are normally combined but may be separated. Each unit may have several contacts.

Note 2 to entry: The means controlling the voltage distribution between units may differ from unit to unit.

### **3.5.122** **module**

<of a by-pass switch> assembly which generally comprises by-pass or insertion units, post-insulators (for live tank by-pass switches), bushings (for dead tank by-pass switches) and mechanical parts and which is mechanically and electrically connected to other identical assemblies to form a pole of a by-pass switch

### **3.5.123** **enclosure**

part of switchgear and controlgear providing a specified degree of protection of equipment against external influences and a specified degree of protection against an approach to or contact with live parts and against contact with moving parts

[SOURCE: IEC 60050-441:2000, 441-13-01, modified – "a part of an assembly" has been changed for "part of switchgear and controlgear"]

### **3.5.124** **operating mechanism**

part of the by-pass switch that actuates, through the power kinematic chain, the main circuit contacts of the by-pass switch

### **3.5.125** **power kinematic chain**

mechanical connecting system from and including the operating mechanism up to and including the moving contacts

Note 1 to entry: See also Figure 1 of IEC 62271-102:2018.

### **3.5.126** **alternative operating mechanism**

mechanism obtained when a change in the power kinematic chain of the original operating mechanism or the use of an entirely different operating mechanism leads to the same mechanical characteristics

Note 1 to entry: Mechanical characteristics are defined in 7.101.1.1. The use of mechanical characteristics and related requirements are described in Annex G.

Note 2 to entry: An alternative operating mechanism can implement an operating principle different from the original one (for example the alternative mechanism can be spring-operated and the original hydraulic).

Note 3 to entry: A change in the secondary equipment does not lead to an alternative operating mechanism.

## **3.6 Operational characteristics of by-pass switches**

### **3.6.101** **operation**

<of a mechanical switching device>  
transfer of the moving contact(s) from one position to an adjacent position

Note 1 to entry: For a circuit-breaker, this may be a closing operation or an opening operation.

Note 2 to entry: If distinction is necessary, an operation in the electrical sense, e.g. make or break, is referred to as a switching operation, and an operation in the mechanical sense, e.g. close or open, is referred to as a mechanical operation.

[SOURCE: IEC 60050-441:2000, 441-16-01]

### **3.6.102** **operating cycle**

<of a mechanical switching device>  
succession of operations from one position to another and back to the first position through all other positions, if any

[SOURCE: IEC 60050-441:2000, 441-16-02]

### **3.6.103**

#### **operating sequence**

<of a mechanical switching device>

succession of specified operations with specified time intervals

[SOURCE: IEC 60050-441:2000, 441-16-03]

### **3.6.104**

#### **closing operation**

<of a mechanical switching device>

operation by which the device is brought from the open position to the closed position

[SOURCE: IEC 60050-441:2000, 441-16-08]

### **3.6.105**

#### **opening operation**

<of a mechanical switching device>

operation by which the device is brought from the closed position to the open position

[SOURCE: IEC 60050-441:2000, 441-16-09]

### **3.6.106**

#### **auto-reopening**

operating sequence of a by-pass switch whereby, following its closing, it opens automatically after a predetermined time

### **3.6.107**

#### **positive opening operation**

<of a mechanical switching device>

opening operation which, in accordance with specified requirements, ensures that all the main contacts are in the open position when the actuator is in the position corresponding to the open position of the device

[SOURCE: IEC 60050-441:2000, 441-16-11]

### **3.6.108**

#### **positively driven operation**

operation which, in accordance with specified requirements, is designed to ensure that auxiliary contacts of a mechanical switching device are in the respective positions corresponding to the open or closed position of the main contacts

[SOURCE: IEC 60050-441:2000, 441-16-12]

### **3.6.109**

#### **dependent power operation**

<of a mechanical switching device>

operation by means of energy other than manual, where the completion of the operation is dependent upon the continuity of the power supply (to solenoids, electric or pneumatic motors, etc.)

[SOURCE: IEC 60050-441:2000, 441-16-14]

**3.6.110****stored energy operation**

operation by means of energy stored in the mechanism itself prior to the switching operation and sufficient to complete the specified operating sequence under predetermined conditions

**3.6.111****independent manual operation**

<of a mechanical switching device>

stored energy operation where the energy originates from manual power, stored and released in one continuous operation, such that the speed and force of the operation are independent of the action of the operator

[SOURCE: IEC 60050-441:2000, 441-16-16]

**3.6.112****closed position**

<of a mechanical switching device>

position in which the predetermined continuity of the main circuit of the device is secured

[SOURCE: IEC 60050-441:2000, 441-16-22]

**3.6.113****open position**

<of a mechanical switching device>

position in which the predetermined clearance between open contacts in the main circuit of the device is secured

[SOURCE: IEC 60050-441:2000, 441-16-23]

**3.6.114****shunt release**

release energized by a source of voltage

Note 1 to entry: The source of voltage may be independent of the voltage of the main circuit.

[SOURCE: IEC 60050-441:2000, 441-16-41]

**3.6.115****anti-pumping device**

device that prevents the reopening after an open-close operation as long as the device initiating opening is maintained in the position for opening

**3.6.116****interlocking device**

device which makes the operation of a switching device dependent upon the position or operation of one or more other pieces of equipment

[SOURCE: IEC 60050-441:2000, 441-16-49]

**3.6.117****by-pass switch with lock-out preventing opening**

by-pass switch in which none of the moving contacts can insert the capacitor if the opening command is initiated while the conditions that cause the closing operation remain established

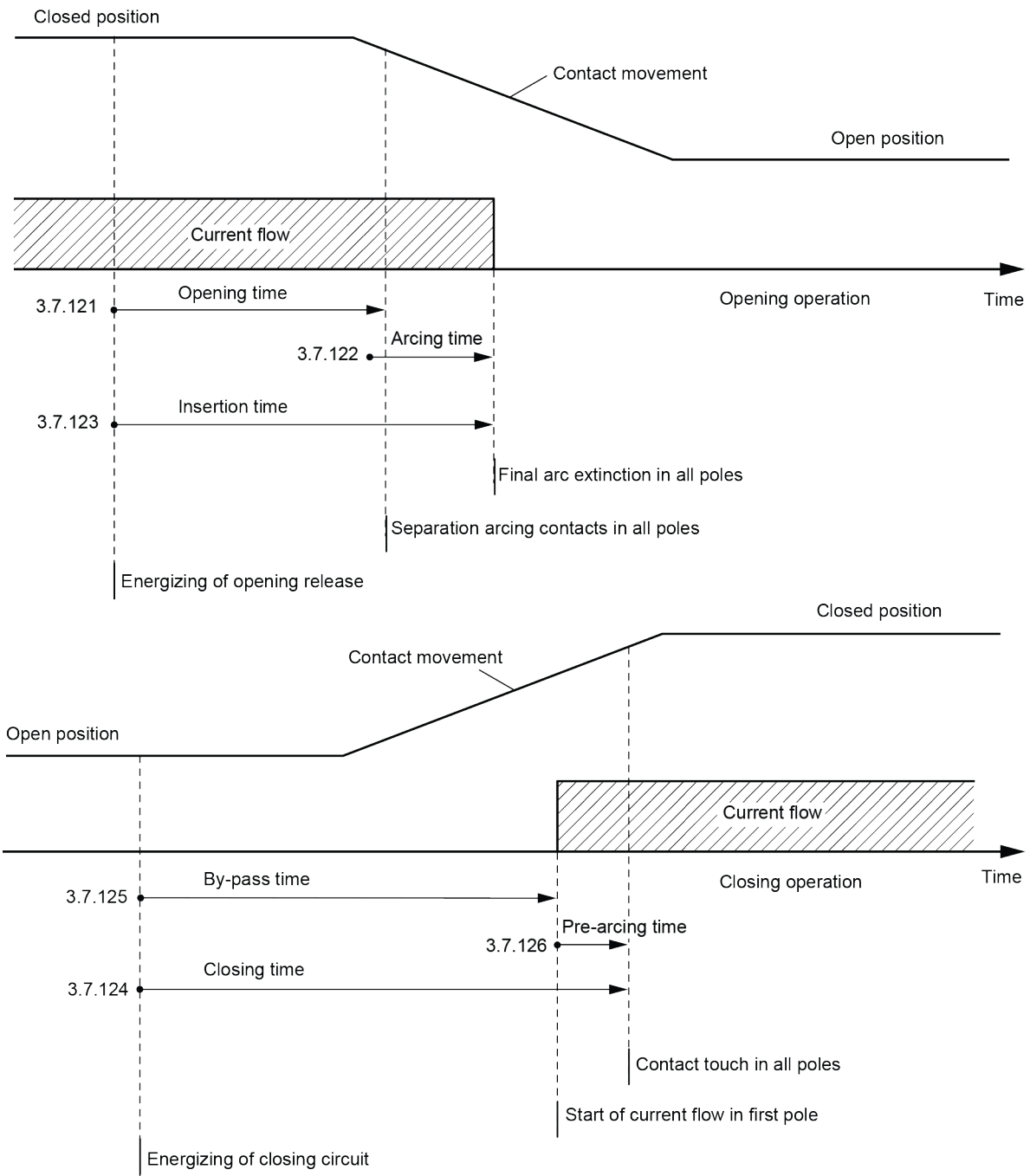
**3.7 Characteristic quantities**

Figures 2 to 4 illustrate some definitions of this subclause.

Time quantities (see definitions 3.7.120 to 3.7.130) are expressed in milliseconds or in cycles. When expressed in cycles, the power frequency shall be stated in brackets.

Concerning Figures 2 to 4:

- In practice, there will be a time spread between the travel of the contacts of the three poles. For clarity, the travel of the contacts in the figures is indicated by a single line for all three poles.
- In practice, there will be a time spread between both the start and end of current flow in the three poles. For clarity, both the start and end of current flow in the figures are indicated by a single line for all three poles.



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Figure 2 – By-pass switch – Opening and closing operations

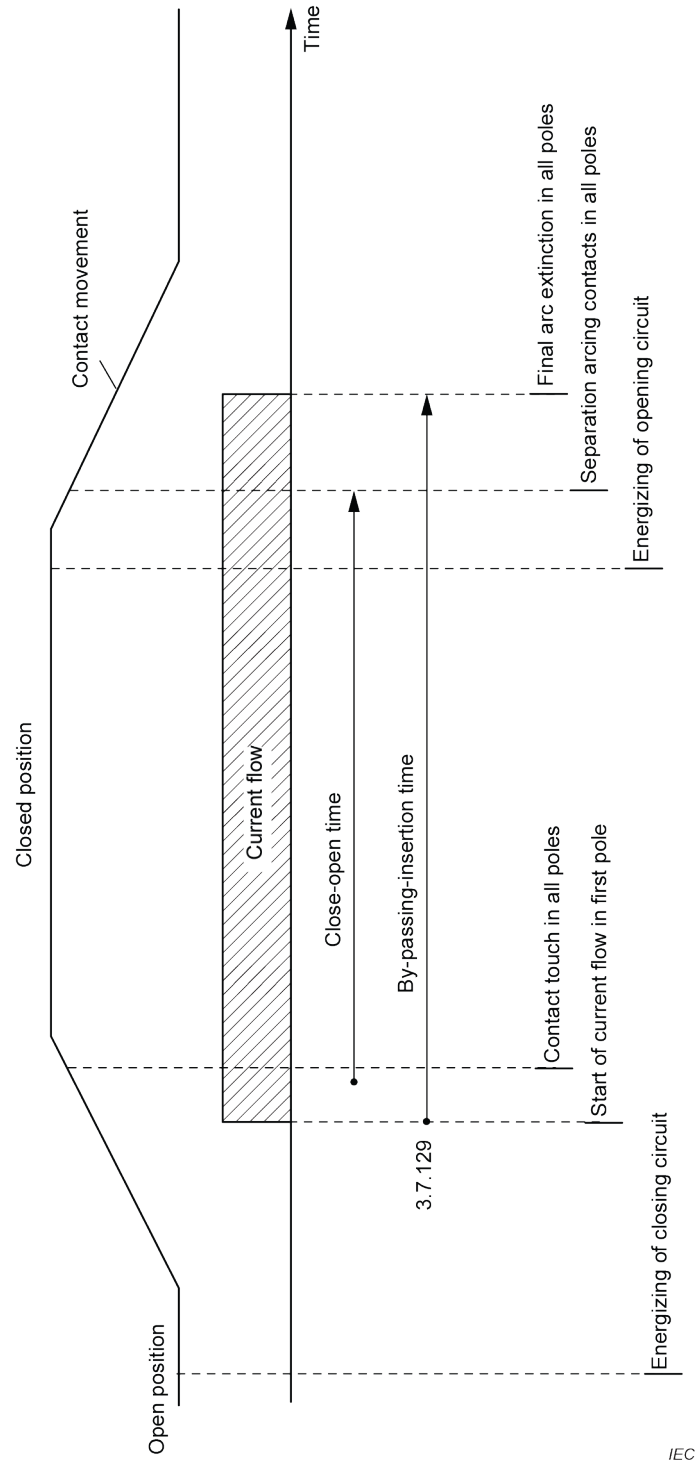
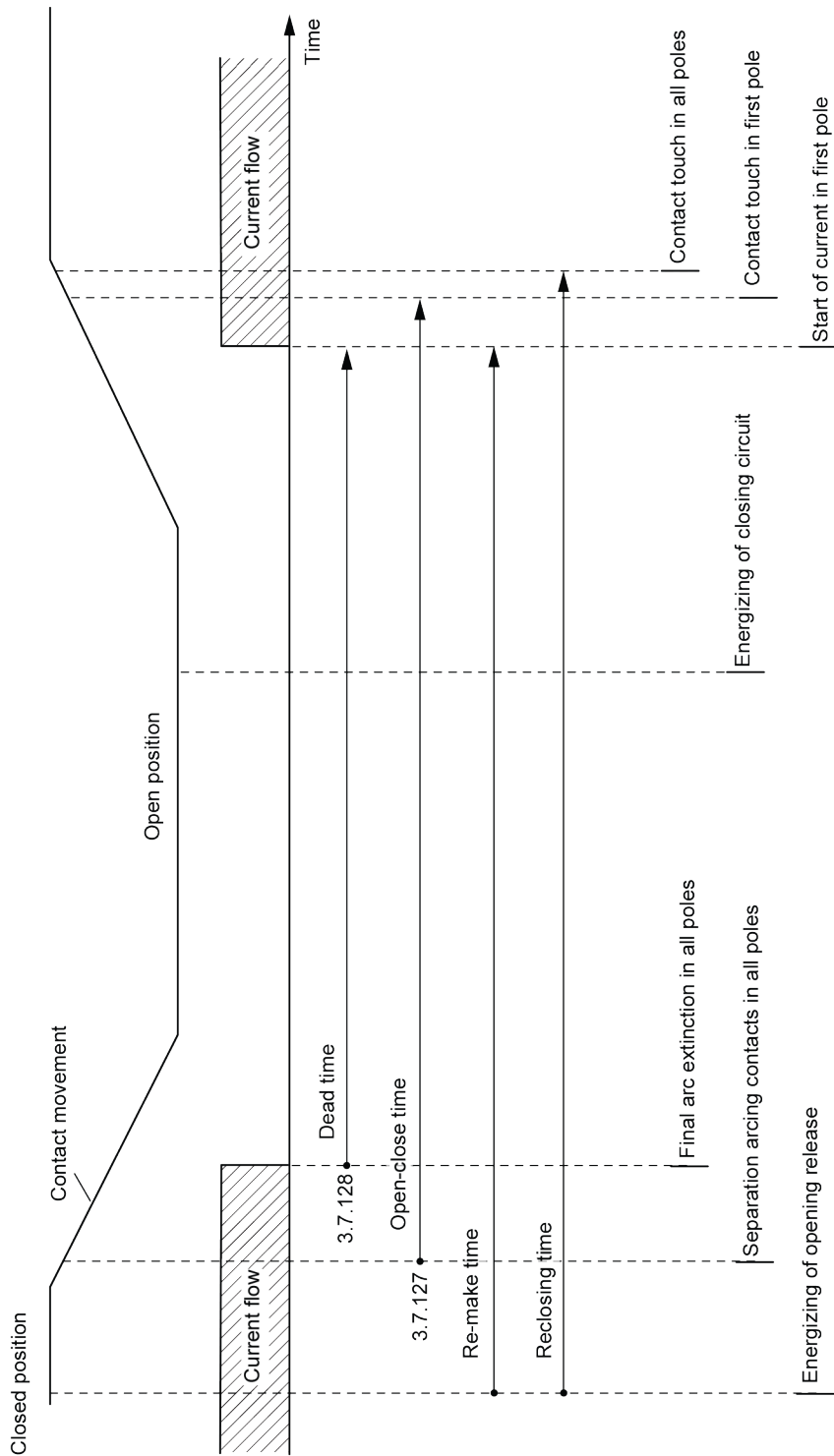


Figure 3 – By-pass switch – Close-open cycle



IEC

**Figure 4 – By-pass switch – Open-close cycle**

### 3.7.101 rated value

quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment

Note 1 to entry: Examples of rated value usually stated for fuses: voltage, current, breaking capacity.

**3.7.102****prospective current**

<of a circuit and with respect to a switching device or a fuse>

current that would flow in the circuit if each pole of the switching device or the fuse were replaced by a conductor of negligible impedance

Note 1 to entry: The method to be used to evaluate and to express the prospective current is to be specified in the relevant publications.

[SOURCE: IEC 60050-441:2000, 441-17-01]

**3.7.103****prospective peak current**

peak value of the first current loop of the prospective current during the transient period following initiation

Note 1 to entry: The definition assumes that the current is made by an ideal by-pass switch, i.e. with the instantaneous and simultaneous transition of its impedance across the terminals of each pole from infinity to zero. The peak value may differ from one pole to another; it depends on the instantaneous voltage across the capacitor prior to by-passing.

**3.7.104****peak current**

peak value of the first current loop during the transient period following initiation

**3.7.105****transient by-pass current**

superposition of capacitor bank discharge current and power-frequency current

**3.7.106****by-pass making current**

peak value of the by-pass current in a pole of a by-pass switch during the transient period following the initiation of current during a by-passing operation

Note 1 to entry: The value is the maximum instantaneous value of the sum of the capacitor bank discharge current component and the power-frequency current component. In case of system faults, the power-frequency fault current is equal to the maximum varistor coordinating current or for schemes without varistor, the actual maximum power-frequency fault current at the particular location.

Note 2 to entry: The peak value may differ from one pole to another and from one operation to another as it depends on the instantaneous capacitor voltage prior to by-passing.

Note 3 to entry: Where, for a three-phase circuit, a single value of peak value of by-pass making current is referred to, this is, unless otherwise stated, the highest value in any phase.

Note 4 to entry: The maximum power-frequency fault current at a particular location or the maximum varistor coordinating current is generally much lower than the rated peak withstand current of the by-pass switch.

**3.7.107****insertion current****by-pass insertion current**

steady state root-mean-square current that flows through the by-pass switch immediately prior to opening

**3.7.108****insertion capacity**

value of prospective current that a by-pass switch is capable of inserting at the stated voltage under prescribed conditions of use and behaviour

**3.7.109****by-passing capacity**

value of prospective current that a by-pass switch is capable of by-passing at a stated voltage under prescribed conditions of use and behaviour

**3.7.110****short-circuit making capacity**

making capacity for which the prescribed conditions include a short circuit at the terminals of the switching device

[SOURCE: IEC 60050-441:2000, 441-17-10]

**3.7.111****short-time withstand current**

current that a circuit or a switching device in the closed position can carry during a specified short time under prescribed conditions of use and behaviour

[SOURCE: IEC 60050-441:2000, 441-17-17]

**3.7.112****peak withstand current**

value of peak current that a circuit or a switching device in the closed position can withstand under prescribed conditions of use and behaviour

[SOURCE: IEC 60050-441:2000, 441-17-18]

**3.7.113****applied voltage**

<of a switching device>

voltage which exists across the terminals of a pole of a switching device just before the making of the current

[SOURCE: IEC 60050-441:2000, 441-17-24]

**3.7.114****recovery voltage**

voltage which appears across the terminals of a pole of a switching device or a fuse after the breaking of the current

Note 1 to entry: This voltage may be considered in two successive intervals of time, one during which a transient voltage exists, followed by a second one during which the power frequency or the steady-state recovery voltage alone exists.

[SOURCE: IEC 60050-441:2000, 441-17-25]

**3.7.115****power-frequency recovery voltage**

recovery voltage after the transient voltage phenomena have subsided

[SOURCE: IEC 60050-441:2000, 441-17-27]

**3.7.116****peak arc voltage**

<of a mechanical switching device>

maximum instantaneous value of voltage which under prescribed conditions appears across the terminals of a pole of a switching device during the arcing time

[SOURCE: IEC 60050-441:2000, 441-17-30]

**3.7.117****clearance**

distance between two conductive parts along a string stretched the shortest way between these conductive parts

[SOURCE: IEC 60050-441:2000, 441-17-31]

### **3.7.118**

#### **clearance between poles**

clearance between any conductive parts of adjacent poles

[SOURCE: IEC 60050-441:2000, 441-17-32]

### **3.7.119**

#### **clearance to earth**

clearance between any conductive parts and any parts which are earthed or intended to be earthed

[SOURCE: IEC 60050-441:2000, 441-17-33]

### **3.7.120**

#### **clearance between open contacts**

total clearance between the contacts, or any conductive parts connected thereto, of a pole of a mechanical switching device in the open position

[SOURCE: IEC 60050-441:2000, 441-17-34]

### **3.7.121**

#### **opening time**

opening time of a by-pass switch defined according to the tripping method as stated below and with any time delay device forming an integral part of the by-pass switch adjusted to its minimum setting

Note 1 to entry: For a by-pass switch tripped by any form of auxiliary power, the opening time is the interval of time between the instant of energising the opening release, the by-pass switch being in the closed position, and the instant when the arcing contacts have separated in all poles.

Note 2 to entry: For by-pass switches with more than one insertion unit per pole, the instant when the arcing contacts have separated in all poles is determined as the instant of contact separation in the first unit of the last pole.

Note 3 to entry: The opening time includes the operating time of any auxiliary equipment necessary to open the by-pass switch and forming an integral part of the by-pass switch.

### **3.7.122**

#### **arcing time**

<of a pole>

interval of time between the instant of the first initiation of an arc in a pole and the instant of final arc extinction in that pole

[SOURCE: IEC 60050-441:2000, 441-17-37]

### **3.7.123**

#### **insertion time**

interval of time between the beginning of the opening time of a by-pass switch and the end of the arcing time

### **3.7.124**

#### **closing time**

interval of time between energizing the closing circuit, the by-pass switch being in the open position, and the instant when the contacts touch in all poles

Note 1 to entry: The closing time includes the operating time of any auxiliary equipment necessary to close the by-pass switch and forming an integral part of the by-pass switch.

**3.7.125**  
**by-pass time**

interval of time between energising the closing circuit, the by-pass switch being in the open position, and the instant when the current begins to flow in the first pole

Note 1 to entry: The by-pass time includes the operating time of any auxiliary equipment necessary to close the by-pass switch and forming an integral part of the by-pass switch.

Note 2 to entry: The by-pass time may vary, e.g. due to the variation of the pre-arcing time.

**3.7.126**  
**pre-arcing time**

interval of time between the initiation of current flow in the first pole during a by-passing operation and the instant when the contacts touch in all poles for three-phase conditions or the instant when the contacts touch in the arcing pole for single-phase conditions

Note 1 to entry: The pre-arcing time depends on the instantaneous value of the applied voltage during a specific by-passing operation and therefore may vary considerably.

**3.7.127**  
**open-close time**

interval of time between the instant when the arcing contacts have separated in all poles and the instant when the contacts touch in the first pole during a by-passing operation

Note 1 to entry: Unless otherwise stated, it is assumed that the closing release incorporated in the by-pass switch is energized at the instant when the contacts have separated in all poles during opening. This represents the minimum open-close time.

**3.7.128**  
**dead time**

<during auto-reclosing>

interval of time between final arc extinction in all poles in the insertion operation and the first re-establishment of current in any pole in the subsequent by-passing operation

Note 1 to entry: The dead time can vary, for example owing to the variation of the pre-arcing time.

**3.7.129**  
**by-passing-insertion time**

interval of time between the initiation of current flow in the first pole during a by-passing operation and the end of the arcing time during the subsequent insertion operation

Note 1 to entry: The by-pass insertion time may vary due to the variation of the pre-arcing and arcing times.

Note 2 to entry: The by-pass insertion time should be compatible with system requirements.

**3.7.130**  
**minimum trip duration**

minimum time the auxiliary power is applied to the opening release to ensure complete opening of the by-pass switch

**3.7.131**  
**minimum close duration**

minimum time the auxiliary power is applied to the closing device to ensure complete closing of the by-pass switch

**3.7.132**  
**insulation level**

for a by-pass switch, a characteristic defined by values indicating the insulation withstand voltages to earth and/or across the by-pass units

**3.7.133****power-frequency withstand voltage**

RMS value of sinusoidal power-frequency voltage that the by-pass switch can withstand during tests made under specified conditions and for a specified duration

[SOURCE: IEC 60050-614:2016, 614-03-22, modified, words "insulation of the given equipment" has been replaced by "by-pass switch"]

**3.7.134****impulse withstand voltage**

peak value of the standard impulse voltage wave which the insulation of the by-pass switch withstands under specified test conditions

Note 1 to entry: Depending on the shape of the wave, the term may be qualified as "switching impulse withstand voltage" or "lightning impulse withstand voltage".

**3.7.135****minimum functional pressure  $\rho_{mm}$  for operation**

pressure (in Pa), for operation, referred to the standard atmospheric air conditions of +20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, at which and above which rated characteristics of a by-pass switch are maintained and at which a replenishment of the energy storage device becomes necessary

Note 1 to entry: This pressure is often designated as interlocking pressure (refer to 3.6.5.6 of IEC 62271-1:2017).

**3.7.136****minimum functional pressure  $\rho_{me}$  for by-passing, insertion and insulation**

pressure (in Pa), for by-passing, insertion and for insulation, referred to the standard atmospheric air conditions of +20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, at which and above which rated characteristics of a by-pass switch are maintained and at which a replenishment of the by-passing, insertion and/or insulating fluid becomes necessary

Note 1 to entry: See also 3.6.5.5 of IEC 62271-1:2017.

Note 2 to entry: For by-pass switches with a sealed pressure system (also termed sealed-for-life), the minimum functional pressure for by-passing and insertion is the one at which the rated characteristics of the by-pass switch are maintained taking into account the pressure drop at the end of the expected operating life.

**3.7.137****initiation of closing operation**

instant of receipt of a command for a closing operation at the control circuit

**3.7.138****initiation of opening operation**

instant of receipt of a command for an opening operation at the control circuit

**3.8 Terms and definitions related to series capacitor banks****3.8.1****capacitor**

term 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

**3.8.2****overvoltage protector**

<of a series capacitor>

fast-acting device intended to limit 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

[SOURCE: IEC 60050-436:1990, 436-03-14, modified – words added: "when that value would otherwise be exceeded as a result of a circuit fault or other abnormal power system conditions"]

### 3.8.3 rated capacitance

$C_N$   
<of a capacitor>  
capacitance value for which the capacitor has been designed

### 3.8.4 rated current of a capacitor

$I_N$   
RMS value of the alternating current for which the capacitor has been designed

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

### 3.8.5 rated reactance

$X_N$   
<of a capacitor>  
reactance of each phase of the series capacitor at rated frequency and 20 °C dielectric temperature

### 3.8.6 rated voltage

$U_N$   
<of a capacitor>  
RMS value of the voltage between the terminals, derived from rated reactance and rated current  $U_N = X_N \times I_N$

[SOURCE: IEC 60050-436:1990, 436-01-15, modified – words "of the alternating voltage for which the capacitor has been designed." Have been replaced by " of the voltage between the terminals, derived from rated reactance and rated current  $U_N = X_N \times I_N$ "]

### 3.8.7 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  $\sqrt{2}$

### 3.8.8 series capacitor bank

three-phase assembly of capacitors with associated protection and insulated support structure

Note 1 to entry: The bank may include one or more modules.

### 3.8.9 segment

<of a series capacitor>  
where each phase of a bank is divided into one or more series connected parts, of which each part contains its own assembly of capacitor units, overvoltage protector, protective functions and bypass switch, each such complete part is called segment

Note 1 to entry: Segments are not normally separated by isolating disconnectors. More than one segment can be on the same insulated platform.

**3.8.10****bank protection**

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

**3.8.11****by-pass current**

steady-state RMS current flowing through the by-pass switch in parallel with the capacitor

**3.8.12****by-pass fault current**

current flowing through the by-passed series capacitor bank caused by a fault on the line

**3.8.13****by-pass gap (protective gap)**

gap, or system of gaps, to protect either the capacitor (type K) against overvoltage or the non-linear resistor (type M) against overload by carrying the load or fault current around the protected parts for a specified time (see Figure 2 of IEC 60143-2:2012)

**3.8.14****by-pass interlocking device**

device that requires all three poles of the by-pass switch to be in the same open or closed position

**3.8.15****current-limiting damping equipment**

reactor or a reactor with a parallel connected resistor to limit the current magnitude and frequency and to provide a sufficient damping of the discharge of the capacitors upon operation of the by-pass gap or the by-pass switch

**3.8.16****insertion**

opening of the series capacitor by-pass switch to insert the series capacitor in series with the transmission line

**3.8.17****insertion current**

RMS current that flows through the series capacitor after the by-pass switch has opened. This current may be at the specified continuous or overload current magnitudes

**3.8.18****insertion voltage**

peak voltage appearing across the series capacitor upon transfer of the by-pass current with the opening of the by-pass switch

**3.8.19****main gap**

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

**3.8.20****module**

<capacitor switching step>

three-phase function unit consisting of one capacitor segment (possibly several) per phase with provision for interlocked operation of the single-phase by-pass switches

**3.8.21**  
**non-linear resistor**  
**varistor**

device to act as overvoltage protection of the capacitor consisting of resistors with a non-linear voltage-dependent resistance (normally metal-oxide varistors)

**3.8.22**  
**protective level**

$U_{PL}$

magnitude of the maximum peak of the power-frequency voltage appearing across the overvoltage protector during a power system fault ( $U_{PL} = U_{LIM} \times \sqrt{2}$ )

Note 1 to entry: The protective level may be expressed in terms of the actual peak voltage across a segment or in terms of per unit of the peak of the rated voltage across the capacitor.

**3.8.23**  
**reinsertion**

restoration of load current to the series capacitor from the by-pass path

**3.8.24**  
**reinsertion current**

transient current, power-frequency current, or both, flowing through the series capacitor during the opening of the by-pass path

**3.8.25**  
**reinsertion voltage**

recovery voltage appearing across the series capacitor during the opening of the by-pass path

**3.8.26**  
**temporary overvoltage**

temporary power-frequency voltage higher than the continuous rated voltage of the series capacitor

**3.8.27**  
**varistor coordinating current**

magnitude of the maximum varistor current associated with the protective level

**3.8.28**  
**capacitor bank discharge current**

$I_{DISCHARGE}$

current which flows during the discharging of the capacitor bank

Note 1 to entry: The maximum peak value of the capacitor discharge current occurs when the capacitor bank is charged to the protective level  $U_{PL}$ .

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#### 4 Normal and special service conditions

Clause 4 of IEC 62271-1:2017 is applicable.

#### 5 Ratings

##### 5.1 General

The characteristics of a by-pass switch, including its operating devices and auxiliary equipment, that shall be used to determine the ratings are the following.

*Rated characteristics to be given for all by-pass switches*

- a) rated voltage to earth ( $U_{re}$ ) and across the by-pass switch ( $U_{rp}$ );
- b) rated insulation level to earth ( $U_{pe}$ ,  $U_{de}$ ,  $U_{se}$ ) and across the by-pass switch ( $U_{pp}$ ,  $U_{dp}$ ,  $U_{sp}$ );
- c) rated frequency ( $f_r$ );
- d) rated continuous current ( $I_r$ );
- e) rated short-time withstand current ( $I_k$ );
- f) rated peak withstand current ( $I_p$ );
- g) rated duration of short-circuit ( $t_k$ );