

# 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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## CONTENTS

FOREWORD.....	8
1 General.....	10
1.1 Scope.....	10
1.2 Normative references.....	10
2 Normal and special service conditions.....	11
3 Terms and definitions.....	11
3.1 General terms.....	11
3.2 Assemblies.....	13
3.3 Parts of assemblies.....	13
3.4 Switching devices.....	13
3.5 Parts of by-pass switches.....	15
3.6 Operation.....	17
3.7 Characteristic quantities.....	18
3.8 Definitions related to series capacitor banks.....	22
3.9 Index of definitions.....	25
4 Ratings.....	28
4.1 Rated voltage ( $U_r$ ).....	28
4.2 Rated insulation level.....	29
4.2.101 Rated insulation level to earth.....	29
4.2.102 Rated insulation level across the by-pass switch.....	29
4.3 Rated frequency ( $f_r$ ).....	29
4.4 Rated normal current ( $I_r$ ) and temperature rise.....	29
4.5 Rated short-time withstand current ( $I_k$ ).....	29
4.6 Rated peak withstand current ( $I_p$ ).....	30
4.7 Rated duration of short-circuit ( $t_k$ ).....	30
4.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits ( $U_a$ ).....	30
4.9 Rated supply frequency of closing and opening devices and auxiliary circuits.....	30
4.10 Rated pressures of compressed gas supply for insulation, operation and/or by-passing and insertion.....	30
4.101 Rated operating sequence.....	30
4.102 Rated by-pass making current ( $I_{BP}$ ).....	30
4.104 Rated reinsertion voltage ( $U_{INS}$ ).....	31
4.105 Rated time quantities.....	32
4.106 Number of mechanical operations.....	32
5 Design and construction.....	32
5.1 Requirements for liquids in by-pass switches.....	32
5.2 Requirements for gases in by-pass switches.....	32
5.3 Earthing of by-pass switches.....	32
5.4 Auxiliary equipment.....	32
5.5 Dependent power operation.....	33
5.6 Stored energy operation.....	34
5.7 Independent manual operation.....	34
5.8 Operation of releases.....	34
5.8.1 Shunt closing releases.....	34

5.8.2	Shunt opening releases .....	34
5.8.3	Capacitor operation of shunt releases .....	34
5.8.4	Under-voltage release .....	34
5.8.101	Multiple releases .....	34
5.8.102	Operation limits of releases .....	34
5.8.103	Power consumption of releases .....	34
5.9	Low- and high-pressure interlocking devices .....	35
5.10	Nameplates .....	35
5.11	Interlocking devices .....	37
5.12	Position indication .....	37
5.13	Degrees of protection by enclosures .....	37
5.14	Creepage distances .....	37
5.15	Gas and vacuum tightness .....	37
5.16	Liquid tightness .....	37
5.17	Fire hazard (flammability) .....	37
5.18	Electromagnetic compatibility .....	37
5.19	X-ray emission .....	38
5.20	Corrosion .....	38
5.101	Requirements for simultaneity within a pole .....	38
5.102	General requirement for operation .....	38
5.103	Pressure limits of fluids for operation .....	38
5.104	Vent outlets .....	38
6	Type tests .....	39
6.1	General .....	40
6.1.1	Grouping of tests .....	40
6.1.2	Information for identification of specimens .....	40
6.1.3	Information to be included in type test reports .....	40
6.2	Dielectric tests .....	41
6.2.1	Ambient air conditions during tests .....	41
6.2.2	Wet test procedure .....	41
6.2.3	Condition of by-pass switch during dielectric tests .....	41
6.2.4	Criteria to pass the test .....	41
6.2.5	Application of test voltage and test conditions .....	42
6.2.6	Tests of by-pass switches of $U_{re} \leq 245$ kV or $U_{rp} \leq 245$ kV .....	42
6.2.7	Tests of by-pass switches of $U_{re} > 245$ kV or $U_{rp} > 245$ kV .....	42
6.2.8	Artificial pollution tests .....	43
6.2.9	Partial discharge tests .....	43
6.2.10	Tests on auxiliary and control circuits .....	43
6.2.11	Voltage test as a condition check .....	43
6.3	Radio interference voltage (r.i.v.) tests .....	44
6.4	Measurement of the resistance of the main circuit .....	44
6.5	Temperature-rise tests .....	45
6.5.1	Conditions of the by-pass switch to be tested .....	45
6.5.2	Arrangement of the equipment .....	45
6.5.3	Measurement of the temperature and the temperature rise .....	45
6.5.4	Ambient air temperature .....	45
6.5.5	Temperature-rise tests of the auxiliary and control equipment .....	45
6.5.6	Interpretation of the temperature-rise tests .....	45

6.6	Short-time withstand current and peak withstand current tests .....	45
6.6.1	Arrangement of the by-pass switch and of the test circuit .....	45
6.6.2	Test current and duration.....	45
6.6.3	Behaviour of the by-pass switch during test.....	45
6.6.4	Conditions of the by-pass switch after test.....	45
6.7	Verification of the degree of protection .....	45
6.7.1	Verification of the IP coding.....	45
6.7.2	Mechanical impact test (verification of the IK coding) .....	45
6.8	Tightness tests.....	46
6.9	Electromagnetic compatibility (EMC) tests.....	46
6.10	Additional tests on auxiliary and control circuits .....	46
6.10.1	General .....	46
6.10.2	Functional tests .....	46
6.10.3	Electrical continuity of earthed metallic parts test.....	46
6.10.4	Verification of the operational characteristics of auxiliary contacts.....	46
6.10.5	Environmental tests .....	46
6.11	X-Radiation test procedure for vacuum interrupters.....	47
6.101	Mechanical and environmental tests .....	47
6.101.1	Miscellaneous provisions for mechanical and environmental tests.....	47
6.101.2	Mechanical operation test at ambient air temperature.....	49
6.101.3	Low and high temperature tests .....	51
6.101.4	Humidity test .....	55
6.101.5	Test to prove the operation under severe ice conditions .....	55
6.101.6	Static terminal load test.....	55
6.102	Miscellaneous provisions for by-pass making and insertion tests .....	57
6.102.1	General.....	57
6.102.2	Number of test specimens.....	57
6.102.3	Arrangement of by-pass switch for tests .....	57
6.102.4	General considerations concerning testing methods.....	59
6.102.5	Synthetic tests .....	61
6.102.6	No-load operations before tests.....	61
6.102.7	Alternative operating mechanisms.....	61
6.102.8	Behaviour of by-pass switch during tests.....	62
6.102.9	Condition of by-pass switch after tests .....	62
6.103	Sequence of the tests .....	64
6.104	By-pass making current test-duty.....	64
6.104.1	General.....	64
6.104.2	Characteristics of supply circuit.....	64
6.104.3	Test voltage .....	65
6.104.4	Test current.....	65
6.105	Insertion current test-duty.....	66
6.105.1	General.....	66
6.105.3	Test voltage .....	67
6.105.4	Test current.....	67
6.105.5	Number of operations.....	67
6.106	Criteria to pass the test duties .....	68
7	Routine tests .....	68
7.1	Dielectric test on the main circuit.....	68

7.2	Dielectric test on auxiliary and control circuits .....	69
7.3	Measurement of the resistance of the main circuit .....	69
7.4	Tightness test .....	69
7.5	Design and visual checks .....	69
7.101	Mechanical operating tests .....	69
8	Guide to the selection of by-pass switches for service .....	70
9	Information to be given with enquiries, tenders and orders .....	71
9.101	Information to be given with enquiries and orders .....	71
9.102	Information to be given with tenders .....	72
10	Rules for transport, storage, installation, operation and maintenance .....	73
10.1	Conditions during transport, storage and installation .....	73
10.2	Installation .....	73
10.2.101	Guide for commissioning tests .....	73
10.2.102	Commissioning checks and test programme .....	74
10.3	Operation .....	79
10.4	Maintenance .....	79
10.4.101	Resistors and capacitors (if applicable) .....	80
11	Safety .....	80
12	Influence of the product on environment .....	80
Annex A (normative)	Tolerances on test quantities during type tests .....	98
Annex B (normative)	Records and reports of type tests .....	102
Annex C (informative)	List of symbols and abbreviations used .....	105
Annex D (informative)	Examples of by-pass switch ratings .....	107
Annex E (informative)	By-pass switches used as the primary by-passing devices .....	114
Annex F (informative)	Explanatory note regarding transient recovery voltage during reinsertion .....	115
Annex G (normative)	Use of mechanical characteristics and related requirements .....	125
Bibliography	.....	127
Figure 1	– By-pass switch – Opening and closing operations .....	81
Figure 2	– By-pass switch – Close-open cycle .....	82
Figure 3	– By-pass switch – Open-close cycle .....	83
Figure 4	– Test sequences for low and high temperature tests .....	84
Figure 5	– Static terminal load forces .....	85
Figure 6	– Directions for static terminal load tests .....	86
Figure 7	– Reference mechanical travel characteristics (idealized curve) .....	87
Figure 8	– Reference mechanical travel characteristics (idealized curve) with the prescribed envelopes centred over the reference curve ( $\pm 5\%$ ), contact separation in this example at time $t = 20$ ms .....	87
Figure 9	– Reference mechanical travel characteristics (idealized curve) with the prescribed envelopes fully displaced upward from the reference curve ( ${}^{+10}_0\%$ ), contact separation in this example at time $t = 20$ ms .....	88
Figure 10	– Reference mechanical travel characteristics (idealized curve) with the prescribed envelopes fully displaced downward from the reference curve ( ${}^0_{-10}\%$ ), contact separation in this example at time $t = 20$ ms .....	88

Figure 11 – Equivalent testing set-up for unit testing of by-pass switches with more than one separate by-pass units .....	89
Figure 12 – Typical test circuit for the by-pass making current test-duty .....	90
Figure 13 – Oscillogram obtained from the typical test circuit for the by-pass making current test-duty .....	91
Figure 14 – Typical LC test circuit for the insertion current test-duty .....	92
Figure 15 – Oscillogram obtained from the typical LC test circuit for the insertion current test-duty .....	93
Figure 16 – Typical test circuit for the insertion current test-duty (mainly for high rated insertion current) .....	94
Figure 17 – Oscillogram obtained from the typical test circuit shown in Figure 16 for the insertion current test-duty .....	95
Figure 18 – Typical direct test circuit for the insertion current test-duty .....	96
Figure 19 – Oscillogram obtained from the typical direct test circuit for the insertion current test-duty .....	97
Figure E.1 – Typical components layout for by-pass switches used as the primary by-passing device.....	114
Figure F.1 – Typical example of the transient reinsertion voltage across a by-switch for a low compensation factor scheme ( $k = 0,2$ ) and for a power swing of 1,8 p.u.....	121
Figure F.2 – Typical example of the transient reinsertion voltage across a by-switch for an high compensation factor scheme ( $k = 0,5$ ) and for a power swing of 1,8 p.u. ....	122
Figure F.3 – Comparison of the calculated transient reinsertion voltage examples and possible testing envelopes for 50 Hz systems .....	122
Figure F.4 – Comparison of the calculated transient reinsertion voltage examples and possible testing envelopes for 60 Hz systems .....	123
Table 1 – Nameplate information .....	36
Table 2 – Type tests .....	40
Table 3 – Invalid tests .....	41
Table 4 – Number of operating sequences .....	50
Table 5 – Examples of static horizontal and vertical forces for static terminal load test .....	56
Table 6 – Application of voltage for dielectric test on the main circuit.....	68
Table A.1 – Tolerances on test quantities for type tests .....	99
Table D.1 – Typical ratings for a series capacitor bank by-pass switch – Cases 1 to 6 .....	108
Table D.2 – Typical series capacitor bank by-pass switch ratings – Cases 7 to 12 .....	110
Table D.3 – Typical series capacitor bank by-pass switch ratings – Cases 13 to 18 .....	112
Table F.1 – Typical examples of transient reinsertion voltages for systems not having power swing nor emergency overload, $I_{load} = 1,0$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 50$ Hz.....	116
Table F.2 – Typical examples of transient reinsertion voltages for systems not having power swing but with an emergency overload, $I_{load} = 1,2$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 50$ Hz .....	116
Table F.3 – Typical examples of transient reinsertion voltages for systems not having power swing but with an emergency overload, $I_{load} = 1,4$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 50$ Hz .....	116
Table F.4 – Typical examples of transient reinsertion voltages for systems not having power swing but with an emergency overload, $I_{load} = 1,6$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 50$ Hz .....	117

Table F.5 – Typical examples of transient reinsertion voltages for systems having power swing, $I_{load} = 1,8$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 50$ Hz.....	117
Table F.6 – Typical examples of transient reinsertion voltages for systems having power swing, $I_{load} = 2,0$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 50$ Hz.....	117
Table F.7 – Typical examples of transient reinsertion voltages for systems having power swing, $I_{load} = 2,3$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 50$ Hz.....	118
Table F.8 – Typical examples of transient reinsertion voltages for systems having power swing, $I_{load} = 2,5$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 50$ Hz.....	118
Table F.9 – Typical examples of transient reinsertion voltages for systems not having power swing nor emergency overload, $I_{load} = 1,0$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 60$ Hz.....	118
Table F.10 – Typical examples of transient reinsertion voltages for systems not having power swing but with an emergency overload, $I_{load} = 1,2$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 60$ Hz.....	119
Table F.11 – Typical examples of transient reinsertion voltages for systems not having power swing but with an emergency overload, $I_{load} = 1,4$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 60$ Hz.....	119
Table F.12 – Typical examples of transient reinsertion voltages for systems not having power swing but with an emergency overload, $I_{load} = 1,6$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 60$ Hz.....	119
Table F.13 – Typical examples of transient reinsertion voltages for systems having power swing, $I_{load} = 1,8$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 60$ Hz.....	120
Table F.14 – Typical examples of transient reinsertion voltages for systems having power swing, $I_{load} = 2,0$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 60$ Hz.....	120
Table F.15 – Typical examples of transient reinsertion voltages for systems having power swing, $I_{load} = 2,3$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 60$ Hz.....	120
Table F.16 – Typical examples of reinsertion recovery voltages for systems having power swing, $I_{load} = 2,5$ p.u.; $U_{PL} = 2,2$ p.u.; $\beta = 0,85$ and $f = 60$ Hz.....	121
Table G.1 – Summary of type tests related to mechanical characteristics .....	126

## 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: High-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This second edition cancels and replaces the first edition, published in 2006, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

- By-passing test duty has been split with operations at rated by-pass making current  $I_{BP}$  and operations at capacitor bank discharge current  $I_{DISCHARGE}$ .
- Equivalence regarding applicability of test parameters (current peak and frequency) during by-pass making tests in relation with service conditions have been reviewed and changed accordingly.
- Recovery voltage waveshape during insertion test duty has been recalculated and optimized. An explanatory note on the calculation of the recovery voltage is given in Annex F.

- Withdrawal of the electrical endurance class BP2. Such devices are now covered in informative Annex E
- Addition of Annex D which gives examples of typical by-pass switch ratings.

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

FDIS	Report on voting
17A/837/FDIS	17A/844/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 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 and IEC 62271-1 (2007), 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. 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 publication will remain unchanged until the maintenance result 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.

# HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

### 1 General

#### 1.1 Scope

This part of IEC 62271 is applicable to a.c. 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 standard is also applicable to the operating devices of by-pass switches and to their auxiliary equipment.

#### 1.2 Normative references

The following referenced documents are indispensable for the application 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 60050-604:1987, *International Electrotechnical Vocabulary – Chapter 604: Generation, transmission and distribution of electricity – Operation*

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

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

IEC 60143-2:1994, *Series capacitors for power systems – Part 2: Protective equipment for series capacitor banks*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF<sub>6</sub>) 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 60529, *Degrees of protection provided by enclosures (IP Code)*

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

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

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

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

IEC 62271-303, *High-voltage switchgear and controlgear – Part 303: Use and handling of sulphur hexafluoride (SF<sub>6</sub>)*

## 2 Normal and special service conditions

Clause 2 of IEC 62271-1 is applicable.

## 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 60050-604, 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.

### 3.1 General terms

**3.1.101  
switchgear and controlgear**  
[IEV 441-11-01]

**3.1.102  
outdoor switchgear and controlgear**  
[IEV 441-11-05]

**3.1.103  
short-circuit current**  
[IEV 441-11-07]

**3.1.104  
ambient air temperature**  
[IEV 441-11-13]

**3.1.105  
temperature rise (of a part of a by-pass switch)**  
difference between the temperature of the part and the ambient air temperature

**3.1.106  
overvoltage (in a system)**  
any voltage between one phase and earth or between phases having a peak value or values exceeding the corresponding peak of the highest voltage for equipment

[IEV 604-03-09, modified]

### **3.1.107** **unit test**

test made 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 air and the surfaces in contact with open air of solid insulation of the equipment, which are subject to dielectric stresses and to the effects of atmospheric and other external conditions such as pollution, humidity, vermin, etc.

[IEV 604-03-02, modified]

### **3.1.109** **internal insulation**

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

[IEV 604-03-03]

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

insulation which completely recovers its insulating properties after a disruptive discharge

[IEV 604-03-04]

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

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

[IEV 604-03-05]

### **3.1.112** **disruptive discharge**

phenomenon associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero

NOTE 1 This term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these.

NOTE 2 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 only temporary (self-restoring insulation).

NOTE 3 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.

### **3.1.113** **restrike performance**

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

NOTE Specific numeric probabilities cannot be applied throughout a by-pass switch service life.

### **3.1.114** **re-ignition (of an a.c. mechanical switching device)**

[IEV 441-17-45]

**3.1.115**  
**restrike (of an a.c. mechanical switching device)**  
 [IEV 441-17-46]

**3.1.116**  
**non-sustained disruptive discharge (NSDD)**  
 disruptive discharge associated with current interruption, that does not result in the resumption of power frequency current or, in the case of insertion does not result in current in the series capacitor bank

NOTE 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.

## 3.2 Assemblies

No particular definitions.

## 3.3 Parts of assemblies

No particular definitions.

## 3.4 Switching devices

**3.4.101**  
**switching device**  
 [IEV 441-14-01]

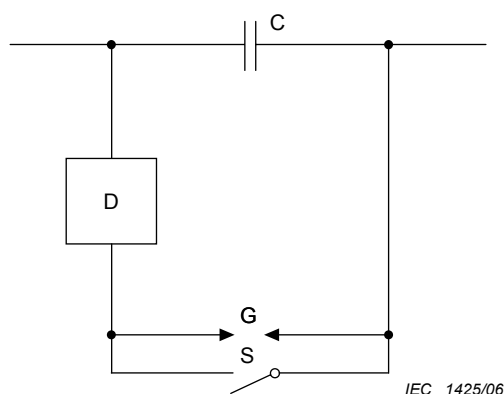
**3.4.102**  
**mechanical switching device**  
 [IEV 441-14-02]

**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. By-pass switches may be three-pole or single-pole operated

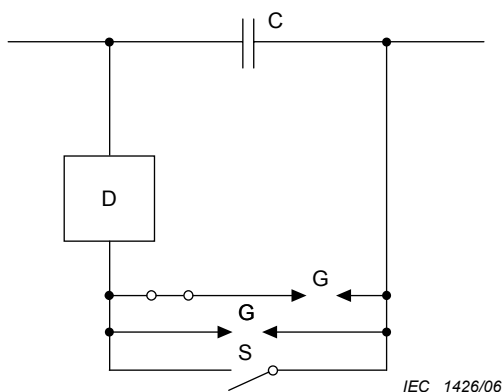
NOTE 1 Besides by-passing the capacitor, this device normally has the capability to insert the capacitor into a circuit that carries a specified level of current.

NOTE 2 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).

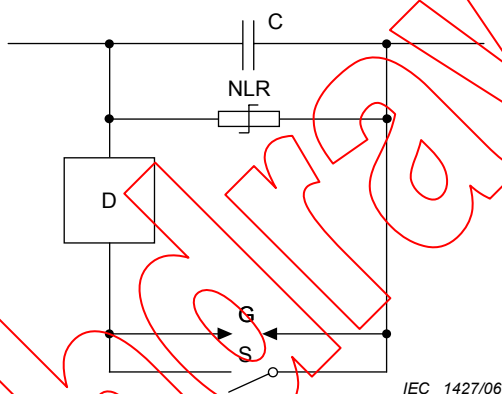
Examples of series capacitor layouts using a fast by-passing device in parallel with the by-pass switch (see IEC 60143-1) are shown below:



**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

**3.4.104**

**by-pass switch class M1**

by-pass switch with normal mechanical endurance (mechanically type tested for 2 000 operating sequences) not falling into the category of class M2 as defined in 3.4.105

**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 (by-pass switch with extended mechanical endurance, mechanically type tested for 10 000 operating sequences). 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**

[IEV 441-15-01]

#### 3.5.102

**main circuit**

[IEV 441-15-02]

#### 3.5.103

**control circuit**

[IEV 441-15-03]

#### 3.5.104

**auxiliary circuit**

[IEV 441-15-04]

#### 3.5.105

**contact**

[IEV 441-15-05]

#### 3.5.106

**contact piece**

[IEV 441-15-06]

#### 3.5.107

**main contact**

[IEV 441-15-07]

#### 3.5.108

**arcing contact**

[IEV 441-15-08]

#### 3.5.109

**control contact**

[IEV 441-15-09]

#### 3.5.110

**auxiliary contact**

[IEV 441-15-10]

#### 3.5.111

**auxiliary switch**

[IEV 441-15-11]

#### 3.5.112

**“a” contact;**

**make contact**

[IEV 441-15-12]

#### 3.5.113

**“b” contact;**

**break contact**

[IEV 441-15-13]

**3.5.114**  
**sliding contact**  
[IEV 441-15-15]

**3.5.115**  
**rolling contact**  
[IEV 441-15-16]

**3.5.116**  
**release**  
[IEV 441-15-17]

**3.5.117**  
**arc control device**  
[IEV 441-15-18]

**3.5.118**  
**position indicating device**  
[IEV 441-15-25]

**3.5.119**  
**connection (bolted or equivalent)**  
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  
[IEV 151-12-12, modified]

**3.5.121**  
**by-pass (or 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 By-pass units and insertion units are normally combined but may be separated. Each unit may have several contacts.

NOTE 2 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 (see IEC 60529) of equipment against external influences and a specified degree of protection against approach to or contact with live parts and against contact with moving parts

[IEV 441-13-01, modified]

**3.5.124****operating mechanism**

part of 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 See also A.3.5.111 of IEC 62271-102.

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

an alternative operating mechanism is 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 Mechanical characteristics are defined in 6.101.1.1. The use of mechanical characteristics and related requirements are described in Annex G.

NOTE 2 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 A change in the secondary equipment does not lead to an alternative operating mechanism.

**3.6 Operation****3.6.101****operation**

[IEV 441-16-01]

**3.6.102****operating cycle**

[IEV 441-16-02]

**3.6.103****operating sequence**

[IEV 441-16-03]

**3.6.104****closing operation**

[IEV 441-16-08]

**3.6.105****opening operation**

[IEV 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**

[IEV 441-16-11]

**3.6.108****positively driven operation**

[IEV 441-16-12]

**3.6.109**  
**dependent power operation**  
[IEV 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**  
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  
  
[IEV 441-16-16]

**3.6.112**  
**closed position**  
[IEV 441-16-22]

**3.6.113**  
**open position**  
[IEV 441-16-23]

**3.6.114**  
**shunt release**  
[IEV 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**  
[IEV 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 which cause the closing operation remain established

### **3.7 Characteristic quantities**

Figures 1 to 3 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.

**3.7.101**  
**rated value**

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

**3.7.102**

**prospective current (of a circuit and with respect to a switching device or a fuse)**  
[IEV 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 The definition assumes that the current is made by an ideal by-pass switch, i.e. with 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**

**peak value of transient by-pass current**

peak value of the transient 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. This 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 shall be equal to the maximum varistor coordinating current or for schemes without varistor, the actual maximum power-frequency fault current at the particular location

NOTE 1 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 2 Where, for a three-phase circuit, a single value of peak value of transient by-pass current is referred to, this is, unless otherwise stated, the highest value in any phase.

NOTE 3 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 by-pass switch.

**3.7.107**

**(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 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**

[IEV 441-17-10]

**3.7.111**  
**short-time withstand current**  
[IEV 441-17-17]

**3.7.112**  
**peak withstand current**  
[IEV 441-17-18]

**3.7.113**  
**applied voltage**  
[IEV 441-17-24]

**3.7.114**  
**recovery voltage**  
[IEV 441-17-25]

**3.7.115**  
**power-frequency  
recovery voltage**  
[IEV 441-17-27]

**3.7.116**  
**peak arc voltage**  
[IEV 441-17-30]

**3.7.117**  
**clearance**  
[IEV 441-17-31]

**3.7.118**  
**clearance between poles**  
[IEV 441-17-32]

**3.7.119**  
**clearance to earth**  
[IEV 441-17-33]

**3.7.120**  
**clearance between open contacts**  
[IEV 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.

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 1 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 2 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 multipole switching device)**

interval of time between the instant of the first initiation of an arc and the instant of final arc extinction in all poles

[IEV 441-17-38]

**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 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 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 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 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 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 The dead time may vary, e.g. due 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 The by-pass insertion time may vary due to the variation of the pre-arcing and arcing times.

NOTE 2 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

r.m.s. value of sinusoidal power-frequency voltage that the by-pass switch can withstand during tests made under specified conditions and for a specified time

[IEV 604-03-40, modified]

### 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 Depending on the shape of wave, the term may be qualified as "switching impulse withstand voltage" or "lightning impulse withstand voltage".

### 3.7.135

#### minimum functional pressure for operation

pressure, referred to the standard atmospheric air conditions of +20 °C and 101,3 kPa, 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 operating device becomes necessary

NOTE This pressure is often designated as interlocking pressure (refer to 3.6.5.6 of IEC 62271-1).

### 3.7.136

#### minimum functional pressure for by-passing, insertion and insulation

pressure for by-passing, insertion and for insulation, referred to the standard atmospheric air conditions of +20 °C and 101,3 kPa, 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 See also 3.6.5.5 of IEC 62271-1.

NOTE 2 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.

## 3.8 Definitions related to series capacitor banks

### 3.8.1

#### capacitor

the word "capacitor" is 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)**

quick-acting device that 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

[IEV 436-03-14, modified]

**3.8.3****rated capacitance (of a capacitor)**

$C_N$   
capacitance value for which the capacitor has been designed

[IEV 436-01-12, modified]

**3.8.4****rated current (of a capacitor)**

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

[IEV 436-01-13, modified]

**3.8.5****rated reactance (of a capacitor)**

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

**3.8.6****rated voltage (of a capacitor)**

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

[IEV 436-01-15, modified]

**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 (or bank)**

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

NOTE 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 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 r.m.s. 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 load or fault current around the protected parts for a specified time (see Figure 2 of IEC 60143-2)

**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**

r.m.s. 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 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.

**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**

transient voltage, power-frequency voltage, or both, 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 capacitor bank. The maximum peak value of the capacitor discharge current occurs when the capacitor bank is charged to the protective level

 $U_{PL}$ **3.9 Index of definitions****A**

"a" contact, make contact	3.5.112
Alternative operating mechanism	3.5.126
Ambient air temperature	3.1.104
Anti-pumping device	3.6.115
Applied voltage	3.7.113
Arcing contact	3.5.108
Arcing time	3.7.122
Arc control device	3.5.117
Auto-reopening	3.6.106
Assemblies	3.2
Auxiliary circuit	3.5.104
Auxiliary contact	3.5.110
Auxiliary switch	3.5.111

**B**

"b" contact, break contact	3.5.113
Bank protection	3.8.10
Break contact	3.5.113

By-pass current	3.8.11
By-pass fault current	3.8.12
By-pass gap (protective gap)	3.8.13
By-pass insertion current	3.7.107
By-passing-insertion time	3.7.129
By-pass interlocking device	3.8.14
By-pass (or insertion) unit	3.5.121
By-pass switch	3.4.103
By-pass switch class M1	3.4.104
By-pass switch class M2	3.4.105
By-pass switch with lock-out preventing opening	3.6.117
By-pass time	3.7.125
By-passing capacity	3.7.109

**C**

Capacitor	3.8.1
Capacitor bank discharge current ( $I_{DISCHARGE}$ )	3.8.28
Clearance	3.7.117
Clearance between open contacts	3.7.120
Clearance between poles	3.7.118
Clearance to earth	3.7.119
Closed position	3.6.112
Closing operation	3.6.104
Closing time	3.7.124
Connection (bolted or the equivalent)	3.5.119
Contact	3.5.105
Contact piece	3.5.106
Control circuit	3.5.103
Control contact	3.5.109
Current-limiting damping equipment	3.8.15

**D**

Dead time (during auto-reclosing)	3.7.128
Dependent power operation	3.6.109
Disruptive discharge	3.1.112

**E**

Enclosure	3.5.123
External insulation	3.1.108

**I**

Impulse withstand voltage	3.7.134
Independent manual operation	3.6.111
Insertion	3.8.16
Insertion current	3.8.17
Insertion capacity	3.7.108
Insertion time	3.7.123
Insertion voltage	3.8.18
Insulation level	3.7.132
Interlocking device	3.6.116
Internal insulation	3.1.109

**L**

Limiting voltage ( $U_{LIM}$ )	3.8.7
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**M**

Main circuit	3.5.102
Main contact	3.5.107
Main gap	3.8.19
Make contact	3.5.112

Mechanical switching device		3.4.102
Minimum close duration		3.7.131
Minimum functional pressure for by-passing, insertion and insulation		3.7.136
Minimum functional pressure for operation		3.7.135
Minimum trip duration		3.7.130
Module (of a by-pass switch)		3.5.122
Module (capacitor switching step)		3.8.20
	<b>N</b>	
Non-linear resistor (varistor)		3.8.21
Non-self-restoring insulation		3.1.111
Non-Sustained Disruptive Discharge (NSDD)		3.116
	<b>O</b>	
Open-close time		3.7.127
Opening operation		3.6.105
Opening time		3.7.121
Open position		3.6.113
Operating cycle		3.6.102
Operating mechanism		3.5.124
Operating sequence		3.6.103
Operation		3.6.101
Outdoor switchgear and controlgear		3.1.102
Overvoltage (in a system)		3.1.106
Overvoltage protector (of a series capacitor)		3.8.2
	<b>P</b>	
Parts of assemblies		3.3
Peak arc voltage		3.7.116
Peak current		3.7.104
Peak value of the transient by-pass current		3.7.106
Peak withstand current		3.7.112
Pole		3.5.101
Position indicating device		3.5.118
Positively driven operation		3.6.108
Positive opening operation		3.6.107
Power-frequency recovery voltage		3.7.115
Power-frequency withstand voltage		3.7.133
Power kinematic chain		3.5.124
Pre-arcing time		3.7.126
Prospective current (of a circuit and with respect to a switching device or a fuse)		3.7.102
Prospective peak current		3.7.103
Protective level $U_{PL}$		3.8.22
	<b>R</b>	
Rated capacitance (of a capacitor) $C_N$		3.8.3
Rated current (of a capacitor) $I_N$		3.8.4
Rated reactance (of a capacitor) $X_N$		3.8.5
Rated voltage (of a capacitor) $U_N$		3.8.6
Rated value		3.7.101
Recovery voltage		3.7.114
Re-ignition (of an a.c. mechanical switching device)		3.1.114
Reinsertion		3.8.23
Reinsertion current		3.8.24
Reinsertion voltage		3.8.25
Release		3.5.116
Restrike (of an a.c. mechanical switching device)		3.1.115
Restrike performance		3.1.112
Rolling contact		3.5.115
	<b>S</b>	

Segment (of a series capacitor)		3.8.9
Self-restoring insulation		3.1.110
Series capacitor bank (or bank)		3.8.8
Short-circuit current		3.1.103
Short-circuit making capacity		3.7.110
Short-time withstand current		3.7.111
Shunt release		3.6.114
Sliding contact		3.5.114
Stored energy operation		3.6.110
Switchgear and controlgear		3.1.101
Switching device		3.4.101
	<b>T</b>	
Temperature rise (of a part of a by-pass switch)		3.1.105
Temporary overvoltage		3.8.26
Terminal		3.5.120
Transient by-pass current		3.7.105
	<b>U</b>	
Unit test		3.1.107
	<b>V</b>	
Varistor coordinating current		3.8.27

#### 4 Ratings

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 and across the by-pass unit;
- b) rated insulation level to earth and across the by-pass unit;
- c) rated frequency;
- d) rated normal current;
- e) rated short-time withstand current;
- f) rated peak withstand current;
- g) rated duration of short-circuit;
- h) rated supply voltage of closing and opening devices and of auxiliary circuits;
- i) rated supply frequency of closing and opening devices and of auxiliary circuits;
- j) rated pressures of compressed gas supply and/or of hydraulic supply for operation, insertion, by-passing and insulation, as applicable;
- k) rated by-pass making current;
- l) rated by-pass insertion current;
- m) rated reinsertion voltage (peak value);
- n) rated operating sequence;
- o) rated time quantities.

The rated characteristics of the by-pass switch are referred to the rated operating sequence.

#### 4.1 Rated voltage ( $U_r$ )

Subclause 4.1 of IEC 62271-1 is applicable with the following addition.