IS 9920-4 (1985): Alternating Current Switches for Voltages Above 1000 V, Part 4: Type Tests and Routine Tests [ETD 8: High Voltage Switchgear and Controlgear]

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Indian Standard

SPECIFICATION FOR ALTERNATING CURRENT SWITCHES FOR VOLTAGES ABOVE 1 000 V

PART 4 TYPE TESTS AND ROUTINE TESTS

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SPECIFICATION FOR ALTERNATING CURRENT SWITCHES FOR VOLTAGES ABOVE 1 000 V

PART 4 TYPE TESTS AND ROUTINE TESTS

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Indian Standard

SPECIFICATION FOR ALTERNATING CURRENT SWITCHES FOR VOLTAGES ABOVE 1 000 V

PART 4 TYPE TESTS AND ROUTINE TESTS

0. FOREWORD

0.1 This Indian Standard (Part 4) was adopted by the Indian Standards Institution on 21 February 1985, after the draft finalized by the High Voltage Switchgear and Controlgear Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 Besides this Part 4, the other parts in the series of standards on high voltage switches are:

Part 1 General and definitions;

Part 2 Rating; and

Part 3 Design and construction.

All parts shall be read in conjunction with each other. This part (Part 4) is intended to partially replace IS : 4710-1968*. All the parts in the series together will replace IS : 4710.

0.3 While preparing this standard, considerable assistance has been derived from the following publications issued by the International Electrotechnical Commission (IEC):

IEC Pub 265 (1968) High voltage switches

IEC Pub 265A (1969) Tests for single capacitor bank switching

IEC Pub 265B (1969) Second supplement to Pub 265 (1968)

IEC Pub 265C (1970) Tests for line and cable switching

This standard (Part 4) corresponds appreciably with these IEC Publications and there are no major deviations.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated,

*Specification for switches and switch isolators above 1 000 V but not exceeding 11 000 V.

expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard (Part 4) covers the type tests and routine tests applicable for alternating current switches, for voltages above 1 000 V.

NOTE — For detailed scope of this series of standards *see* **1** of Part 1 of this standard.

2. TERMINOLOGY

2.1 For the purpose of this standard (Part 4), the definitions given in **3** of Part 1 of this standard shall apply.

3. TYPE TESTS

3.0 General — The type tests set out below are for the purpose of proving the characteristics of switches, their operating devices and their auxiliary equipment.

The type tests comprise:

a) Tests to verifiy the insulation level, including withstand tests at power-frequency voltages on auxiliary equipment (*see* **3.1**).

b) Tests to prove that the temperature rise of any part does not exceed the values specified in Part 2 of this standard (*see* **3.2**).

c) Making and breaking tests (*see* **3.3**).

d) Tests to prove the capability of the switch to carry the rated peak withstand current and the rated short-time current (*see* **3.4**).

e) Tests to prove satisfactory operation and mechanical endurance (*see* **3.5**).

f) Tests to prove satisfactory operation under ice conditions (*see* **3.6**).

All tests shall be made on complete switches (filled with the specified types and quantities of liquid or gas at specified pressure), on their opening devices and their auxiliary equipment.

The results of all type tests shall be recorded in type test reports containing the data necessary to prove compliance with this standard.

*Rules for rounding off numerical values (*revised*).

NOTE — In the dielectric test of vacuum interrupters, precautions should be taken to ensure that the level of possible emitted X-radiation is within safe limits.

3.1 Dielectric Tests

3.1.1 *Ambient Air Conditions During Tests* — Reference should be made to IS : 2071 (Part 1)-1974* regarding standard reference atmosphere.

The voltage to be applied during a withstand test is determined by multiplying the specified withstand voltage by the correction factor K ($K = k_d/k_h$), k_d being the air density correction factor and k_h the humidity correction factor. Appendix J of IS : 2516 (Part 4/Sec 2)-1980† gives the method for calculation of k_d and k_h. No humidity correction factor shall be applied for wet tests and for artificial pollution tests.

For switches where external insulation in free air is of principal consideration, correction factor K shall be applied.

For switches having external and internal insulation, the correction factor K shall be applied if its value is between 0·95 and 1·05. However, the application of the correction factor K may be omitted where the satisfactory performance of external insulation has been established. If the correction factor is outside this range, details of dielectric tests shall be subject to agreement between the manufacturer and the user.

For switches having internal insulation only, the ambient air conditions are of no importance and the correction factor K shall not be applied.

3.1.2 *Wet Test Procedure* — The outdoor insulation of swtiches shall be subjected to wet withstand tests under the test procedure given in IS : 2071 (Part 2)-1974‡ which also gives the duration of wet withstand tests.

NOTE 1 — For switching impulse, if the prescribed water resistivity cannot be obtained, a lower value may be used, provided that the switch passes the test. The actual value of water resistivity shall be stated in the test report. If the switch fails, tests should be repeated with the prescribed water resistivity.

NOTE 2 — The method of wetting large switch-disconnectors is under consideration.

3.1.3 *Condition of Switches During Tests* — Dielectric tests shall be made on switches completely assembled, ready for service; the outside surface of insulating parts shall be carefully cleaned.

The switch shall be mounted for test with minimum clearances as specified by the manufacturer. Moreover, the height above ground level

*Methods of high voltage testing: Part 1 General definitions and test requirements (*first revision*).

†Specification for circuit breakers: Part 4 Type tests and routine tests, Sec 4 For voltages above 1 000 V ac.

‡Methods of high voltage testing: Part 2 Test procedures (*first revision*).

shall be approximately as intended for service and stated by the manufacturer.

Equipment tested at one height above ground level will be deemed to be satisfactory if mounted at a greater height in service.

When the distance between the poles of a switch is not inherently fixed by the design, the distance between the poles for the test shall be the minimum value stated by the manufacturer. However, to obviate the necessary of erecting large three-pole switches for test purposes alone, the artificial pollution and the radio-interference voltage tests may be made on a single pole and if the maximum distance between poles is such that there is no risk of flashover between poles, all other dielectric tests may be made on a single pole.

Dielectric tests on switches when in the open position shall be carried out with the minimum isolating distance compatible with the locking arrangements specified in Part 3 of this standard.

When the manufacturer states that supplementary insulation, such as tape or barriers is required to be used in service, such supplementary insulation shall also be used during the tests.

If arcing horns or rings are required for the purpose of system protection, they may be removed or their spacing increased for the purpose of the test. If they are required for stress control, they shall remain in position for the test.

For switches using compressed gas for insulation, dielectric tests shall be performed at lock-out pressure.

In case of doubt arising during the making and breaking tests as to whether a switch-disconnector complies with the requirements of Part 2 of this standard, the dielectric tests on the open switch-disconnector shall be made at this stage. At the discretion of the manufacturer, the tests may be made on new switch-disconnectors in air, if their interrupting chambers and any other insulating parts in the neighbourhood or parallel to the isolating distance which may be affected by the arc are covered with metal foil.

NOTE 1 — This requirement may be amended in order to take account of hygroscopic insulating materials when a specification for such materials and corresponding test becomes available.

NOTE 2—CAUTION: In the dielectric testing of vacuum interrupts, precaution should be taken to ensure that the level of possible emitted X-radiation is within safe limits. National safety codes may influence the safety measures established.

3.1.4 *Application of Test Voltage for Impulse and Power-Frequency Tests* — With reference to Fig. 1 of IS : 2516 (Part 4/Sec 2)-1980* which also

*Specification for circuit breakers: Part 4 Type tests and routine tests, Sec 2 For voltages above 1 000 V ac.

a connection diagram of a three-pole switch, the test voltage shall be applied according to Tables 1 to 3, unless otherwise specified.

TABLE 1 LIGHTNING IMPULSE VOLTAGE TESTS FOR SWITCHES HAVING A RATED VOLTAGE LOWER THAN 420 kV AND SWITCHING IMPULSE VOLTAGE TESTS FOR SWITCHES OF CLASS A HAVING A RATED VOLTAGE 420 kV

(*Clauses* 3.1.4, 3.1.6 *and* 3.1.7)

Test Condition No.	Switch Position	Voltage Applied to	Earth Connected to
1	Closed	Aa	BCbcF
2	Closed	Bb	ACacF
3	Closed	Cc	ABabF
4	Open	A*	BCabcF*
5	Open	B*	ACabcF*
6	Open	C*	ABabcF*
7	Open	a*	ABCbcF*
8	Open	b*	ABCacF*
9	Open	c*	ABCabF*

Note — Test conditions No. 3, 6 and 9 may be omitted if the arrangement of the outer poles is symmetrical with respect to the centre pole and the base. Test conditions No. 7, 8 and 9 may be omitted if the arrangement of the terminals of each pole is symmetrical with respect to the base.

*When testing the insulation across the isolating distance (second test series), it may be necessary to suitably insulate the base F and the terminals of the switch, except the terminal opposite to the energized terminal (*see* **3.1.6**. **3.1.7** Class A). For switching impulse voltage tests of equipment of Class B, the terminal opposite to the energized terminal shall be insulated (*see* **3.1.7**).

3.1.5 *Test Voltages* — The rated withstand voltages U_w to be used for the tests prescribed in **3.1.6** to **3.1.8** shall be in accordance with Part 2 of this standard. In the following clause, U_n indicates the rated voltage of the switch.

3.1.6 *Lightning Impulse Voltage Tests* — Switches shall be subjected to lightning impulse voltage dry tests. The tests shall be performed with voltages of both positive and negative polarity, using the standard lightning impulse 1·2/50, according to IS : 2071 (Part 1)-1974*.

With the switch closed, 15 consecutive impulses at the rated withstand voltage to earth shall be applied for each test condition (*see* **3.1.4**). The switch shall be considered to have passed the test

*Methods of high voltage testing : Part 1 General definitions and test requirements (*first revision*).

successfully if the number of the disruptive discharges to earth or between poles on self-restoring insulation does not exceed two, of each test condition, and if no disruptive discharge on non-self-restoring insulation occurs.

TABLE 2 POWER-FREQUENCY VOLTAGE TESTS

(*Clause* 3.1.4)

Test Condition No.	Switch Position	Voltage Applied to	Earth Connected to
1	Closed	Aa	BCbcF
2	Closed	Bb	ACacF
3	Closed	Cc	ABabF
4	Open	A	BCabcF
5	Open	B	ACabcF
6	Open	C	ABabcF
7	Open	a	ABCbcF
8	Open	b	ABCacF
9	Open	c	ABCabF
10*	Open	A and a	BCbcF
11*	Open	B and b	ACacF
12*	Open	C and c	ABabF

NOTE — Test conditions No. 3, 6, 9 and 12 may be omitted if the arrangement of the outer poles is symmetrical with respect to the centre pole and the base. Test conditions No. 7, 8 and 9 may be omitted if the arrangement of the terminals of each pole is symmetrical with respect to the base.

*These tests apply only to switch-disconnectors and to switches having a rated voltage 300 kV and above. In these cases, these tests replace tests No. 4, 5, 6, 7, 8 and 9.

With the switch open, and in the case of switches having a rated voltage lower than 420 kV, two test series shall be performed.

The first test series consists of the application of 15 consecutive impulses at the rated withstand voltage to earth for each test condition (*see* Table 1). The switch shall be considered to have passed this first test series successfully if the number of disruptive discharge to earth or between poles on self-restoring insulation does not exceed two, for each test condition, and if no disruptive discharge across the isolating distance and on non-self-restoring insulation occurs.

The second test series shall be performed only for switch-disconnectors and consists of the application of 15 consecutive impulses at the rated withstand voltage across the isolating distance to each terminal in turn (*see* Table 1). The opposite terminal shall be earthed. The terminals of the other poles, the terminal to which the voltage is applied and the base may be insulated in such a way as to prevent disruptive discharges to earth. The switch disconnector shall be considered to have passed this sccond test series successfully if the number of the disruptive discharges across the isolating distance or between poles on self-restoring insulation does not exceed two, for each test condition, and if no disruptive discharge on non-self-restoring insulation occurs.

TABLE 3 SWITCHING IMPULSE VOLTAGE TESTS FOR SWITCH-DISCONNECTORS OF CLASS B AND LIGHTNING IMPULSE VOLTAGE TESTS, FOR SWITCHES HAVING A RATED VOLTAGE 420 kV

(*Clauses* 3.1.4 *and* 3.1.6)

Test Condition No.	Switch Position	Voltage Applied to		Earth Connected to
		Impulse	Power Frequency	
1	Closed	Aa	—	BCbcF
2	Closed	Bb	—	ACacF
3	Closed	Cc	—	ABabF
4	Open	A	a	BCbcF
5	Open	B	b	ACacF
6	Open	C	c	ABabF
7	Open	a	A	BCbcF
8	Open	b	B	ACacF
9	Open	c	C	ABabF

Note — Test conditions No. 3, 6 and 9 may be omitted if the arrangement of the outer poles is symmetrical with respect to the centre pole and the base. Test conditions No. 7, 8 and 9 may be omitted if the arrangement of the terminals of each pole is symmetrical with respect to the base.

With the switch open, and in the case of switches having a rated voltage 420 kV, for each test condition (*see* Table 3) 15 consecutive impulses at the rated withstand voltage shall be applied to one terminal with the opposite terminal energized at the power-frequency voltage $0 \cdot 7 \times U_n/\sqrt{3}$ (rms value). Each lightning impulse shall be synchronized so that it is applied approximately in correspondence to the peak value of the opposite polarity of the power frequency. For the sake of convenience, the rounded-off test values are reported in Table 4.

The switch shall be considered to have passed the test successfully if the number of the disruptive discharge across the isolating distance to earth or between poles on self-restoring insulation does not exceed two for each test condition, and if no disruptive discharge on non-self-restoring insulation occurs.

TABLE 4 ROUNDED-OFF TEST VALVES—LIGHTNING IMPULSE VOLTAGE TESTS

(*Clause* 3.1.6.)

Rated Voltage U_n	Withstand Voltage Across the Switch Applied to		
	One Terminal, Lightning Impulse U_w	Opposite Terminal, Power Frequency	
		$0.7 \times U_n/\sqrt{3}$	$0.7 \times U_n \times \sqrt{2}/\sqrt{3}$
(1)	(2)	(3)	(4)
kV (rms)	kV (peak)	kV (rms)	kV (peak)
420	1 300 1 425	170	240

When the insulation of the switch under test is of a self-restoring type and more accuracy on the statistical behaviour of the test object is needed, as an alternative to the above test procedure (15 impulse) a 50 percent disruptive discharge voltage test may be performed, subject to agreement between the manufacturer and the user. The test procedure shall be according to IS : 2071 (Part 2)-1974*. In the case of test open switches having a rated voltage 420 kV, the value of the power-frequency voltage applied to one terminal shall remain constant.

From the test results, the withstand voltage shall be derived as follows:

$$U_w = V_{50\%} \ (1 - 1.3\sigma) \cong 0.96 \times V_{50\%}$$

taking for the standard deviation the value $\sigma = 0.03$.

NOTE 1 — To take into account the problem of the influence of the lightning impulse on the power-frequency voltage wave, caused by capacitive coupling between the two voltage circuits, the following test requirement should be filled. When testing open switches having a rated voltage 420 kV, the voltage drop on the power-frequency wave, applied to one terminal, should be limited so that the actual test voltage to ground, measured in correspondence to the peak value of the impulse, is not less than the specified value $0.7 \times U_n \times \sqrt{2}/\sqrt{3}$.

To achieve such a condition, the power-frequency voltage could be increased up to, but not more than $U_n \times \sqrt{2}/\sqrt{3}$.

The voltage drop can be greatly reduced by using a capacitor of a convenient value connected in parallel to the terminal of the power-frequency side.

NOTE 2 — Subject to agreement of the manufacturer, the tests with the switch open having a rated voltage of 420 kV can be performed avoiding the use of the power-frequency voltage source. In this case, two test series should be performed:

*Methods of high voltage testing: Part 2 Test procedures (*first revision*).

a) The first test series consists of the application to each terminal in turn of 15 consecutive impulses at a voltage equal to the sum of the rated withstand voltage U_W and the value $0.7 \times U_n \times \sqrt{2}/\sqrt{3}$ (peak value). The opposite terminal should be earthed and the other terminals, the base and the terminal to which the voltage is to be applied insulated in such a way as to prevent disruptive discharge to earth. The switch should be considered to have passed this first test series successfully if the number of the disruptive discharges across the isolating distance or between poles on self-restoring insulation does not exceed two, for each test condition, and if no disruptive discharge on non-self-restoring insulation occurs.

b) The second test series consists of the application to each terminal in turn of 15 consecutive impulses at the rated withstand voltage U_W. The other terminals and the base shall be earthed. The switch should be considered to have passed this second test series successfully if the number of disruptive discharges to earth or between poles on self-restoring insulation does not exceed two, and if no disruptive discharge across the isolating distance and on non-self-restoring insulation occurs.

This test is more severe than that following the specified test procedure.

NOTE 3 — The above tests are not intended to ensure the co-ordination of the insulation to earth with respect to the insulation across the open gap. To achieve this co-ordination the use of suitable protective devices, such as surge diverters and spark gaps, should be considered, particularly for installations having rated voltages of 123 kV and above.

NOTE 4 — Some insulating materials retain a charge after an impulse test and, in these cases, care should be taken when reversing the polarity. To allow the discharge of insulating materials, the use of appropriate methods, such as the application of impulses of the reverse polarity at lower voltage before the tests, is recommended.

3.1.7 *Switching Impulse Voltage Tests* — For rated voltages of 420 kV, switches shall have two classes, Class A and Class B. Class B is applied only to particular switch disconnectors according to the foreseen service conditions and consequently to the switching impulse voltage test procedures applied. The tests shall be performed using the standard impulse 250/2 500 according to IS : 2071 (Part 2)-1974*, and the following requirements:

Dry tests shall be performed using voltages of positive and negative polarities for indoor equipment, and using voltages of positive polarity for outdoor equipment only.

Wet tests shall be performed using voltages of positive and negative polarities for outdoor equipment only.

If during a wet test more than two disruptive discharges on self-restoring insulation occur, the test shall be repeated in the same test conditions; the switch shall be considered to have passed the test successfully if during the repeated test the number of the disruptive discharges

*Methods of high voltage testing: Part 2 Test procedures (*first revision*).

does not exceed two, and if no disruptive discharge on non-self-restoring insulation occurs.

With the switch closed, 15 consecutive impulses at the rated withstand voltage to earth shall be applied for each test condition (*see* **3.1.4**). The switch shall be considered to have passed the test successfully if the number of the disruptive discharges to earth or between poles on self-restoring insulation does not exceed two for each test condition, and if no disruptive discharge on non-self-restoring insulation occurs.

With the switch open, two test series shall be performed depending upon whether the switch is Class A or Class B:

a) The first test series which is applicable to both classes of equipment consists of the application of 15 consecutive impulses at the rated withstand voltage to earth for each test condition (*see* Table 1). The switch shall be considered to have passed this first test series successfully if the number of the disruptive across the isolating distance to earth or between poles on self-restoring insulation does not exceed two for each test condition, and if no disruptive-discharge on non-self-restoring insulation occurs.

b) The second test series depends upon whether the equipment is Class A or Class B and the test procedures are as follows:

Class A (Applicable to Switches and Switch-Disconnectors)

For this class, the second test series consists of the application of 15 consecutive impulses at the rated withstand voltage across the isolating distance (Table 3 of Part 2 of this standard) for each test condition (*see* Table 1). Since, in this case, the applied voltage may be higher than the rated withstand voltage to earth, it is permitted to insulate the terminal to which the voltage is applied, the terminals of the other poles and the base in order to prevent disruptive discharge to earth.

Class B (Applicable to Switch-Disconnectors Only)

For this class, the second test series consists of the application of 15 consecutive impulses at the rated withstand voltage across the isolating distance (*see* Table 3 of Part 2 of this standard) to each terminal in turn with the opposite terminal energized at the power-frequency voltage $U_n/\sqrt{3}$ (rms), and with the other terminals and the base connected to earth (*see* Table 1), Each switching impulse shall be syuchroniged so that itis applied approximately in correspondence to the peak value of the opposite polarity of the power-frequency voltage.

The switch of either class shall be considered to have passed this second test series successfully if, for each test condition, the number of the disruptive discharges across the isolating distance or between poles on self-restoring insulation does not exceed two, and if no disruptive discharge on non-self-restoring insulation across.

For the sake of convenience, the rounded-off test values are reported in Table 5.

TABLE 5 ROUNDED-OFF TEST VALUES—SWITCHING IMPULSE VOLTAGE TESTS

Rated Voltage U_n	Withstand Voltage Across the Isolating Distance Applied to		
	One Terminal, Switching Impulse	Opposite Terminal, Power Frequency	
		$U_n/\sqrt{3}$	$U_n \times \sqrt{2}/\sqrt{3}$
(1)	(2)	(3)	(4)
kV (rms)	kV (peak)	kV (rms)	kV (peak)
420	900	245	345

To take into account the influence of the switching impulse on the power-frequency voltage wave, caused by capacitive coupling between the two voltage circuits, the following test requirements shall be fulfilled.

The voltage drop on the power-frequency wave applied to one terminal shall be limited so that the actual test voltage to earth, measured in correspondence to the peak value of the impulse, is not less than the specified value $U_n \times \sqrt{2}/\sqrt{3}$.

To achieve such a condition, the power-frequency voltage can be increased up to, but not more than, $1{\cdot}2 \times U_n \times \sqrt{2}/\sqrt{3}$.

The voltage drop can be greatly reduced by using a capacitor of a convenient value connected in parallel to the terminal of the power-frequency side.

When the insulation of the switch is of a self-restoring type and more accuracy on the statistical behaviour of the test object is needed, as an alternative to the above test procedure (15 impulses), a 50 percent disruptive discharge voltage test may be performed, for both closed and open conditions, subject to agreement between the manufacturer and the user. The test procedure shall be according to IS : 2071 (Part 2)-1974*. In some cases, however, it may be impossible to satisfactorily determine the 50 percent disruptive discharge voltage across the isolating distance if the number of the discharges to earth is high.

*Methods of high voltage testing: Part 2 Test procedures (*first revision*).

From the test results, the withstand voltage shall be derived as follows:

$$U_w = V_{50\%} (1-1{\cdot}3\sigma) \cong 0{\cdot}92 \times V_{50\%}$$

taking for the standard deviation the value $\sigma = 0{\cdot}06$.

The statistical withstand voltage determined above shall be not less than the appropriate rated switching impulse withstand voltage.

For Class B equipment, when testing the open switch-disconnector under the 50 percent disruptive discharge procedure in accordance with the second test series, the value of the power-frequency voltage applied to one terminal shall remain constant.

NOTE 1 — The above tests are not intended to ensure the co-ordination of the insulation to earth with respect to the insulation across the open gap. To achieve this co-ordination, the use of suitable protective devices, such as surge diverters and spark gaps, should be considered.

NOTE 2 — For Class B equipment, subject to agreement of the manufacturer, the second test series with the switch-disconnector open may be performed avoiding the use of the power-frequency voltage source. In this case, the second test series consists of the application to each terminal in turn of 15 consecutive impulses at a voltage equal to the sum of the rated values of the col (2) and (4) of Table 5. The opposite terminal should be earthed. The other terminals, the terminal to which the voltage is applied and the base should be insulated in such a way as to prevent disruptive discharge to earth.

This test is deemed to be more severe than the standard tests prescribed earlier.

It is emphasized that this test is not mandatory but is an alternative method available to the manufacturer and it is not intended to introduce a third class of switch-disconnectors.

3.1.8 *Power-Frequency Voltage Tests* — Switches shall be subjected to 1 minute power-frequency voltage withstand tests in accordance with IS : 2071 (Part 2)-1974*.

a) For switches having a rated voltage lower than 420 kV, the tests shall be performed in dry conditions, and for outdoor switches only, the tests shall also be made in wet conditions.

   The test voltage shall be raised, for each test condition (*see* **3.1.4**) to the rated withstand voltage, as specified in Part 2 of this standard and shall be maintained for the prescribed time. In the case of switch-disconnectors with the switch-disconnectors open, the test voltage shall be applied simultaneously to the two terminals of each pole, using two different voltage sources in out-of-phase conditions in order to obtain accross the open gap the rated withstand voltage as specified in Part 2 of this standard. Neither of the two voltage values applied to the two terminals

*Methods of high voltage testing: Part 2 Test procedures (*first revision*).

shall be higher than two-thirds of the rated withstand voltage to earth.

NOTE — Subject to agreement of the manufacturer, the test with the switch-disconnector open may be performed using one single voltage source. In this case, the test voltage should be applied to each terminal in turn, the opposite terminal being earthed and the other terminals, the base and the terminal to which the voltage is to be applied being insulated in such a way as to prevent disruptive discharges to earth.

This test is more severe than the standard test prescribed earlier.

The switch shall be considered to have passed the test successfully if no disruptive discharge occurs during the tests.

However, if during a wet test a disruptive discharge on external self-restoring insulation occurs, this test shall be repeated in the same test conditions, and the switch shall be considerd to have passed this test successfully if no further disruptive discharge occurs.

b) For switches having a rated voltage 420 kV, the test shall be performed in dry conditions only.

With the switch closed, the test voltage shall be raised, for each test condition (*see* **3.1.4**, Table 6) to the value prescribed for the routine tests as reported in the following table and shall be maintained for the prescribed time. The switch shall be considered to have passed the test successfully if no disruptive discharge occurs.

With the switch open, for each test condition (*see* **3.1.4**, *Table* 2), the test voltage shall be applied simultaneously to the two terminals of each pole, using two different voltage sources in out-of-phase conditions, in order to obtain across the isolating distance a voltage equal to $2 \cdot 5 \times U_n/\sqrt{3}$.

Values of the total voltage across the isolating distance are reported in Table 6.

TABLE 6 WITHSTAND VOLTAGE-POWER FREQUENCY VOLTAGE TEST

RATED VOLTAGE U_n	WITHSTAND VOLTAGE	
	With the Switch Closed	With the Switch Open (Total Voltage Terminal to Terminal)
(1)	(2)	(3)
kV (rms)	kV (rms)	kV (rms)
420	520	610

Neither of the two voltage values applied to the two terminals shall be higher than U_n. The voltage shall be maintained for the prescribed time and the switch shall be considered to have passed the test successfully if no disruptive discharge occurs.

3.1.9 *Artificial Pollution Tests* — Artificial pollution tests are intended to provide information on the behaviour of external insulation under conditions representative of pollution in service. However, they do not necessarily simulate any particular service condition.

Tests are performed to prove that a test voltage equal to $U_n/\sqrt{3}$ shall be withstood at the specified degree of pollution in three out of four tests, U_n being the rated voltage of the switch.

These tests apply only to outdoor switches and shall be performed by special agreement between the manufacturer and the user. Tests shall be performed on one single pole in closed position only to provide information on the behaviour of insulation to earth.

Since the more appropriate testing method for switches and the maximum degree of pollution acceptable with reference to service conditions are still under consideration, in cases where artificial pollution tests are agreed, the specified degree of pollution and the testing method, subject to agreement between the manufacturer and the user shall be chosen from those described by the relevant Indian Standards [*see* also IS : 2071 (Part 2) - 1974 *].

3.1.10 *Partial Discharge Tests* — No partial discharge test is required to be performed on the complete switch. However, in the case of switches using components for which a relevant Indian Standard exists, including partial discharge measurements (for example bushings, *see* IS : 2099-1973†), evidence shall be produced by the manufacturer showing that those components have passed the partial discharge tests as foreseen by the relevant Indian Standard.

3.1.11 *Tests on Auxiliary and Control Circuits* — Auxiliary and control circuits of swiches shall be subjected to 1 minute power-frequency voltage withstand tests:

a) Between the auxiliary and control circuits connected together as a whole and the base of the switch.

b) If practicable, between each part of the auxiliary and control circuits, which in normal way be insulated from the other parts, and the other parts connected together and to the base.

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*Methods of high voltage testing: Part 2 Test procedures (*first revision*).

†Specification for bushings for alternating voltages above 1 000 volts (*first revision*).

The test voltage shall be 2 000 V. The auxiliary and control circuits of the switch shall be considered to have passed the test successfully if no disruptive discharge during each test occurs.

Normally, the test voltage of motors and other devices used in the auxiliary and control circuits shall be the same as the test voltage of those circuits If such appliances have already been tested in accordance with the appropriate specification, they may be disconnected for these tests.

NOTE — When electronic auxiliary or control circuits are used, different testing procedures and values may be adopted, subject to agreement between the manufacturer and the user.

3.1.12 *Tests for Measuring Radio Interference Level* — These tests apply only to switches having a rated voltage of 123 kV and above, and shall be subject to special agreement between the manufacturer and the user.

Tests may be performed on one pole both in closed and open positions.

The test voltage shall be applied as follows:

a) In the closed position, between the terminals and the earthed base;

b) In the open position, between one terminal and the other terminals connected to the earthed base. Connections are to be reversed if the switch is not symmetrical.

The case, base and other normally earthed parts shall be connected to earth. Care should be taken to avoid influencing the measurement by earthed or unearthed objects near to the test object and to the test and measuring circuit.

The switch shall be dry and clean and at approximately the same temperature as the room in which the test is made. It should not be subjected to other dielectric tests within 2 hours prior to the present test. The test connections shall be so arranged that their ends or cross-sectional dimensions are not a source of radio interference voltage.

The measuring circuit [*see* Fig. 2 of IS : 2516 (Part 4/Sec 2)-1980*] shall comply with Publication 1, ' Specification for radio Interference Measuring Apparatus for the Frequency Range 0·15 MHz to 30 MHz ' second edition (1972), of the International Special Committee on Radio Interference (C.I.S.P.R.). The measuring circuit shall preferably be tuned to a frequency within 10 percent of 0·5 MHz but other frequencies in the range 0·5 to 2 MHz may be used, the

*Specification for circuit-breakers: Part 4 Type tests and routine tests, Sec 2 For voltage above 1 000 V ac.

measuring frequency being recorded. The results shall be expressed in microvolts.

If measuring impedances different from those specified in C.I.S.P.R. publications are used, they shall be not more than 600 Ω nor less than 30 Ω in any case the phase angle shall not exceed 20°. The equivalent radio interference voltage referred to 300 Ω can be calculated assuming the measured voltage to be directly proportional to the resistance, except for test pieces of large capacitance for which a correction made on this basis may be inaccurate.

The filter F shall have a high impedance so that the impedance between the high-voltage conductor and earth is not appreciably shunted as seen from the switch. This filter also reduces circulating radio frequency currents in the test circuit, generated by the h.v. transformer or picked up from extraneous sources. A suitable value for its impedance has been found to be 10 000 to 20 000 Ω at the measuring frequency.

It should be ensured by suitable means that the radio interference background level (radio interference level caused by external field and by the high voltage transformer when magnetized at the full test voltage) is as low as possible and in any case at least 6 dB and preferably 10 dB below the specified radio interference level of the switch to be tested. Calibration methods for the measuring instrument and the measuring circuit shall be in accordance with those specified in the above-mentioned C.I.S.P.R. Publication 1.

As the radio interference level may be affected by fibres or dust setting on the insulators, it is permitted to wipe the insulators with a clean cloth before taken a measurement. The atmospheric conditions during the test shall be recorded. It is not known what correction factors apply to radio interference testing, but it is known that tests may be sensitive to high-relative humidity and the results of tests may be open to doubt if the relative humidity exceeds 80 percent.

The following test procedure shall be followed:

A voltage 1·1 $U_n/\sqrt{3}$ shall be applied to the switch and maintained for at least 5 min, U_n being the rated voltage of the switch. The voltage shall then be decreased by steps down to 0·3 $U_n/\sqrt{3}$, raised again by steps to the initial value and finally decreased by steps to 0·3 $U_n/\sqrt{3}$. At each step, a radio interference measurement shall be taken and the radio interference level, as recorded during the last run, shall be plotted versus the applied voltage; the curve so obtained is the radio interference characteristic of the switch. The amplitude of voltage steps shall be approximately 0·1 $U_n/\sqrt{3}$.

The switch shall be considered to have passed the test success fully if the radio interference level at 1·1 $U_n/\sqrt{3}$, as read from the radio interference characteristic, does not exceed 2 500 μV.

3.2 Temperature-Rise Tests

3.2.1 *Temperature-Rise Test of the Main Circuits* — The test for temperature rise of the main circuits shall be made on a new switch with clean contact parts. These tests may be made on a single pole when the rated voltage exceeds 72·5 kV.

The switch shall be mounted approximately as under the usual service conditions, including all normal covers of any part of the switch, and shall be protected against undue external heating or cooling.

Temporary connections to the main circuits shall be such that no appreciable amount of heat is conducted away from, or conveyed to, the switch during the test. In case of doubt, the temperature rise at the terminals of the main circuits and at the temporary connections at a distance of 1 m from the terminals shall be measured. The difference of temperature shall not exceed 5°C.

The test shall be made with the rated normal current of the switch and at rated frequency (tolerance on the latter ± 5 percent).

The test shall be made over a period of time sufficient for the temperature rise to reach a constant value (for practical purposes this condition is obtained when the variation does not exceed 1°C per hour).

The time for the whole test may be shortened by pre-heating the circuit with a higher value of current.

The temperature rise of the different parts of the switch shall not exceed the values specified in Part 2 of this standard. Otherwise the switch shall be considered to have failed the test.

NOTE — In certain circumstances it may be necessary to repeat the temperature-rise test (*see* 3.3.7).

3.2.2 *Temperature-Rise Tests of the Auxiliary Equipment* — The test shall be made with the specified supply (ac or dc) and, for ac at its rated frequency (tolerance ± 5 percent).

The auxiliary equipment shall be tested at a voltage equal to 110 percent of the rated supply voltage or at their rated current.

Under-voltage releases shall be tested at a voltage corresponding to their rated voltage.

Circuits having a rated current shall be tested over a period of time sufficient for the temperature rise to reach a constant value (for practical purposes this condition is obtained when the variation does not exceed 1°C per hour).

For circuits energized only during switch operation, the tests shall be made under the following conditions:

a) When the switch has an automatic breaking device for interruption of the auxiliary circuit at the end of the operation, the circuit shall be energized ten times, the interval between the end of one operation and the beginning of the following being 10 seconds or, if the construction of the switch does not permit this, the lowest interval possible;

b) When the switch has no automatic breaking device for interruption of the auxiliary circuit at the end of the operation, the circuit shall be energized once for 30 seconds.

For electrical operating devices, these tests shall be repeated after cooling down, at a supply voltage of 80 percent of the rated supply voltage.

The temperature rise of any part of the auxiliary circuit or operating device shall not exceed the values specified in Part 2 of this standard, otherwise the apparatus shall be considered to have failed the test.

3.2.3 *Measurement of Temperature* — For coils, the method of measuring the temperature rise by variation of resistance shall generally be used. Other methods are permitted only if it is impossible to use the resistance method.

For conductors other than coils, the temperature of the different parts shall be measured with thermometers or thermocouples of any suitable type, placed at the hottest accessible spot.

For measurement with thermometers or thermocouples, the following precautions shall be taken:

1) Thermocouples or the bulbs of thermometers shall be suitably protected against cooling from outside. The protected area shall, however, be negligible compared with the cooling area of the apparatus under test.

2) Good heat conductivity between the thermometer, or thermocouple, and the surface of the part under test shall be ensured.

3.2.4 *Ambient Temperature* — The ambient temperature is the average temperature of the air surrounding the switch, or the complete unit (for enclosed switches, it is the air outside the enclosure). It shall be measured during the last quarter of the test period by means of an adequate number of thermometers equally distributed around the switch at about the average height of its current-carrying parts and at a distance of about 1 m from the switch. The thermometers shall be protected against air currents and heat radiation. In order to get mean values of ambient temperature in spite of rapid changes in temperature, the thermometers can be put into small oil-filled cans with oil contents of about half a litre.

During the last quarter of the test period, the change of ambient temperature shall not exceed 1°C per hour. If this is not possible because of unfavourable temperature conditions of the test room, the temperature of an identical apparatus under the same ambient conditions, but without current, can be taken as a substitute for the ambient air temperature. This additional switch shall not be subjected to undue heat radiation.

3.2.5 *Measurement of the Resistance of the Main Circuits* — This measurement shall be made for comparison between the switch type tested for temperature rise and other switches of the same type.

The measurement shall be made with dc by measuring the voltage drop or the resistance across the terminals of each pole.

The current during the test shall have any convenient value between 100 A and the rated normal current if this exceeds 100 A; for lower values of rated normal current, the value of the current during the test shall be approximately equal to the rated normal current.

Approximately the same value of current shall be used during the routine tests as during type test.

The measurement of the dc voltage drop or of the resistance shall be made before the temperature-rise test.

The measured value of the dc voltage drop or of the resistance shall be given in the type-test report as well as the general conditions during the test (current, ambient temperature, etc).

3.3 Making and Breaking Tests

3.3.1 *Breaking Current* — The current broken shall be symmetrical with negligible decrement, the contacts of the switch not being separated until transient currents due to the closing of the circuit have subsided. The breaking current is the average of the currents broken in all poles.

The difference between the average of these currents and the values obtained on each pole shall not exceed 10 percent of the average value.

3.3.2 *Breaking Capacity* — The breaking capacity performance in a test shall be stated in terms of:

a) the test voltage;
b) the breaking current;
c) the circuit power-factor; and
d) the test-circuit.

3.3.3 *Peak Making Current* — The peak making current on short-circuit shall be expressed by the maximum making current in any pole.

3.3.4 *Short-Circuit Making Capacity* — The short-circuit making capacity performance in a test shall be expressed by:

a) the applied voltage; and
b) the peak making current.

3.3.5 *Conditions of Severity for Short-Circuit Making Capacity and for Breaking Capacity Tests* — The short-circuit making capacity and the breaking capacity tests shall be carried out under the conditions specified in the following clauses:

a) Arrangement of the switch for tests — **3.3.6**;
b) Behaviour of the switch during tests and condition of the switch after tests — **3.3.7**;
c) Applied-voltage before short-circuit making capacity tests — **3.3.8**;
d) Test voltage for breaking capacity tests — **3.3.9**;
e) Test circuits for breaking capacity tests — **3.3.10**;
f) Determination of power-factor — **3.3.11**;
g) Test frequency — **3.3.12**;
h) Earthing of test circuit — **3.3.13**;
j) Test duties — **3.3.14**;
k) Application of test duties — **3.3.15**; and
m) Tolerances — **3.3.16**.

3.3.6 *Arrangement of the Switch for Tests* — The switch under test shall be mounted complete on its own support or on an equivalent support. Its operating mechanism shall be operated in the manner specified and in particular, if it is electrically/pneumatically operated it shall be operated at the minimum voltage/air pressure, as specified in Part 2 of this standard unless current chopping influences the test results. In the latter case, the switch shall be operated at a voltage or air pressure within the tolerances specified in Part 2 of this standard chosen so as to obtain the highest contacts peed at contact separation and maximum current extinguishing properties.

It shall be shown that the switch shall operate satisfactorily under the above conditions on no-load. The travel of the moving contacts shall be recorded, if possible.

Switches with independent manual operation may be operated by an arrangement provided for the purpose of making remote control possible.

Due consideration shall be given to the choice of the live side connections. When the switch is intended for power supply from both sides and the physical arrangement of one side of the break or breaks of the switch differs from that of the other side, the live side of test-circuit shall be connected to one side so as to represent the most onerous condition. In case of doubt, part of the operations shall be carried out with the supply connected on one side and part with the supply connected on the other side.

The switch shall conform in all its details to certified drawings of its type.

It shall be tested according to its type as follows:

a) Single-enclosure type.

A switch having all its arcing contacts supported within a common enclosure shall be tested as a complete unit.

b) Multi-enclosure type.

A multi-pole switch in which each pole is a separate unit shall be tested preferably as a complete multi-pole switch, but for convenience or owing to limitation of testing facilities, one single-pole unit of the switch may be tested, provided that it is equivalent to, or not in a more favourable condition than the complete multi-pole switch over the range of tests in respect of:

i) speed of make;

ii) speed of break;

iii) availability of arc-extinguishing medium;

iv) power and strength of closing and tripping mechanism; and

v) rigidity of structure.

Tests on a single pole may be carried out only after agreement by the manufacturer.

3.3.7 *Behaviour of Switch During and Condition of Switch after Tests* — When tested for breaking and making in normal service conditions, the behaviour of the switch shall be in accordance with Part 2 of this standard. When tested for rated short-circuit making capacity, the behaviour of the switch shall be in accordance with Part 2 of this standard.

NOTE — For reconditioning after test duties, *see* Part 2 of this standard.

In case of doubt on the ability of the switch to carry its rated normal current after the performance of any of the appropriate test series 1 to 6 of **3.3.14**, a temperature rise test shall be made to check that the temperature-rise values specified in Part 2 of this standard are not exceeded. An overhaul of the apparatus is authorized after each of these temperature-rise tests.

In case of doubt on the ability of the switch to carry its rated normal current after the performance of test duty 7 of **3.3.14**, a temperature-rise test shall be made to check that the temperature-rise values of metallic parts in contact with insulating materials specified in Part 2 of this standard, are not exceeded by more than 10°C. No temperature-rise limits apply to other parts of the switch.

Furthermore, for types other than liquid-filled, vacuum of confined gas switches, if there is any appreciable emission of flame or metallic particles, the tests shall be made with metallic screens placed in the vicinity of the live parts separated from them by a clearance distance which the manufacturer shall specify. The screens, frame and other normally earthed parts shall be insulated from earth, but connected thereto by a suitable device to indicate any leakage current to earth. There shall be no indication of appreciable leakage current during the tests.

For the verification of the insulation level of switch-disconnectors, *see* **3.1**.

NOTE 1 — When in a three-phase test the neutral of the load is earthed and the neutral of the supply circuit is free from earth, the leakage current to earth will depend on the impedances of the circuit after the first phase has cleared until all phases have cleared. After current interruption in all phases, the leakage current is dependent mainly on the capacitance of the supply circuit to earth.

NOTE 2 — When in a breaking capacity test the recovery voltage in one phase is during some cycles substantially lower than the average of the phase recovery voltages, this may in some cases be a sign that the switch has not performed properly. In this even, additional tests may be necessary.

3.3.8 *Applied Voltage Before Short-Circuit Making Capacity Tests* — The applied voltage before the short-circuit making capacity tests is the rms voltage of the test circuit immediately before the tests.

The difference between the average value of the voltages applied on all the phases and the applied voltage of each phase, shall not exceed 5 percent of the average value.

The average value of the applied voltage before the test shall be as nearly as possible equal to the rated voltage U_n and shall not exceed this value by more than 10 percent.

For a single-pole unit of a three-phase switch, however, when tested in a single-phase circuit, the applied voltage shall be $U_n/\sqrt{3}$ and shall not exceed this value by more than 10 percent.

3.3.9 *Test Voltage for Breaking Capacity Tests* — The test voltage U_t for breaking capacity tests shall be measured in accordance with the indications of Fig. 1 immediately after the breaking or during the flow of current.

In the case of tests for closed-loop breaking capacity, the test voltage shall be measured immediately after breaking.

The test voltage shall, as nearly as possible, be equal to:

a) The rated voltage of the switch in case of three-phase tests on a three-pole switch, or single-phase tests for closed loop breaking capacity for which the test voltage shall be 25 percent of this value.

b) *K* times the phase-to-earth voltage corresponding to the rated voltage in case of single-phase tests on a three-pole switch. The values of *K* are specified in the relevant test clauses.

3.3.10 *Test Circuits for Breaking Capacity Tests*

3.3.10.1 *Mainly active load* — The test consists of a supply and a load circuit (*see* Fig. 2 and 3).

The supply circuit shall have a power-factor not exceeding 0·2 and shall meet the following two requirements:

a) The symmetrical component of the short-circuit current of the supply circuit shall never exceed the rated short-time current of the switch nor be less than 5 percent of this current.

b) The impedance of the supply circuit shall be as close as possible to 12 to 18 percent of the total impedance of the test circuit.

NOTE — *See* Appendix A for calculation of impedance of the supply circuit.

With the agreement of the manufacturer, the value of this impedance of the supply circuit may be raised to approximately 25 percent of the total impedance of the test circuit; test duty 2 of **3.3.14.2** for closed loop breaking is not then required.

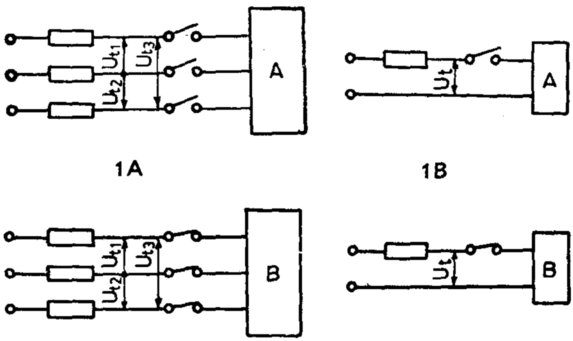
The values of the natural frequencies and amplitude factors of the supply circuit under short-circuit conditions shall not exceed the values specified (values under consideration), or otherwise specified, by more than the indicated tolerance.

The load circuit shall have a power factor of approximately 0·7 (between 0·65 and 0·75) and shall consist of reactors with resistors in parallel. These resistors shall consume the major part of the active power.

NOTE — When for convenience of testing, an impedance is inserted in series with the load (for instance when a transformer is used between the switch and the load), this impedance is considered to form part of the supply circuit.

3.3.10.2 *Closed loop* — The test circuit (*see* Fig. 4 and 5) shall have a power-factor not exceeding 0·3, and if a resistor is used, it shall be connected in series with the reactance.

The values of the natural frequencies and amplitude factors of the supply circuit shall not exceed the values specified (values under consideration), or otherwise specified, by more than the indicated tolerances.



A = mainly active load or transformer off-load

1A Measurement of test voltage in 3-phase mainly active load and transformer off-load breaking tests.

$$U_t = \frac{U_{t1} + U_{t2} + U_{t3}}{3}$$

1B Measurement of test voltage in single-phase mainly active load and transformer off-load breaking tests.

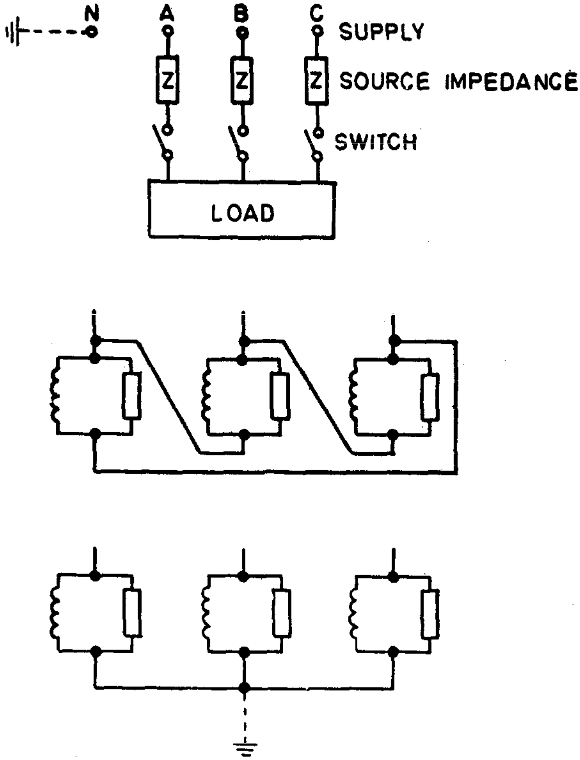
B = single capacitor bank or line or cable

1C Measurement of test voltage in 3-phase single capacitor bank, line charging and cable charging breaking tests.

$$U_t = \frac{U_{t1} + U_{t2} + U_{t3}}{3}$$

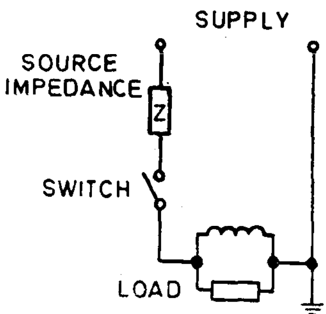
1D Measurement of test voltage in single-phase single-capacitor bank, line charging and cable charging breaking tests.

FIG. 1 MEASUREMENT OF TEST VOLTAGE



Load cos $\phi = 0{\cdot}7 \pm 0{\cdot}05$

FIG. 2 THREE-PHASE CIRCUIT FOR MAINLY ACTIVE LOAD CURRENT TESTS



Load cos $\phi = 0{\cdot}7 \pm 0{\cdot}05$

FIG. 3 SINGLE-PHASE CIRCUIT FOR MAINLY ACTIVE LOAD CURRENT TESTS

3.3.10.3 *Transformer off-load* — The test circuit is under consideration.

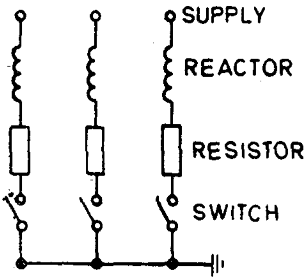


FIG. 4 THREE-PHASE CIRCUIT FOR CLOSED LOOP CURRENT TESTS

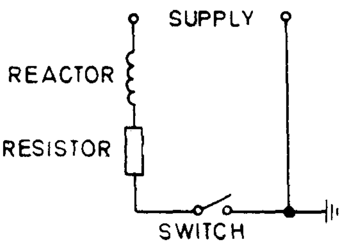


FIG. 5 SINGLE-PHASE CIRCUIT FOR CLOSED LOOP CURRENT TESTS

3.3.10.4 *Single capacitor bank* — *See* Appendix B.

3.3.10.5 *Line-charging* — *See* Appendix C.

3.3.10.6 *Cable-charging* — *See* Appendix D.

3.3.11 *Determination of Power-Factor* — The power-factor in each phase shall be determined by calculation from the circuit constants or by measurement. The power-factor of a polyphase circuit shall be taken as the average of the power-factors in each phase.

During the tests, this average values shall conform to the values specified in **3.3.10.**

3.3.12 *Test Frequency* — For switches with rated frequencies of 50 Hz the test duties shall be carried out at the rated frequency with a tolerance of ± 10 percent of a frequency between 45 Hz and 63 Hz.

3.3.13 *Earthing of Test Circuit*

3.3.13.1 *Three-phase tests of a three-pole switch* — The switch (with its frame earthed as in service) shall be connected in a circuit having either the neutral point of the supply earthed or the neutral point of the load earthed. In the first case, the zero sequence impedance shall be less than three times the positive sequence impedance on the supply side. The connections used shall be indicated in the test report.

3.3.13.2 *Single-phase tests of a single-pole switch* — The circuit and the frame of the switch shall be so connected that the voltage conditions between live parts and earth within the switch after arc-extinction reproduce service voltage conditions. The connections used shall be indicated in the test report.

3.3.13.3 *Single-phase tests of a single-pole unit of a three-pole switch* — The circuit and the frame of the switch shall be so connected that the voltage conditions between live parts and the frame after arc-extinction approximate to those that would exist in a three-pole switch if tested complete in a three-phase circuit in accordance with **3.3.13.1**.

3.3.14 *Test Duties*

3.3.14.1 *Test series 1* — For mainly active current switching (test circuit Fig. 4 and 5):

Test duty 1a	5 closing-opening operations at 100 percent of the rated mainly active load breaking capacity.
Test duty 1b1	For oil switches: 20 closing-opening operations at 5 percent of the rated mainly active load breaking capacity.
Test duty 1b2	For all other switches: 20 closing-operation at 5 percent of the rated mainly active load breaking capacity or, if this value is lower than 5 A, at 5 A.
Test duty 1c1	For category A switches: 15 closing-opening operations at 100 percent of the rated mainly active load breaking capacity.
Test duty 1c2	For category B switches (with rated normal current not exceeding 630 A; *see* Part 2 of this standard; frequent operation at full load current): 100 closing-opening operations at 100 percent of the rated mainly active load breaking capacity.

NOTE 1 — In the closing-opening operations, the opening operation shall follow the closing operations with an intentional time delay between the two operations sufficient for any transient currents to subside.

NOTE 2 — The manufacturer may indicate a minimum time interval between closing-opening operations.

In single-phase tests on a single-pole of a three-pole switch, for mainly active current switching, the appropriate value of *K* [*see* **3.3.9**(b)] is 1 for the making operations and 1·5 for the breaking operations. With the consent of the manufacturer, the tests may be made with a value of *K* = 1·5.

3.3.14.2 *Test series 2* — For closed loop current breaking (test circuit, Fig. 4 and 5):

Test duty 2	20 opening operations at 100 percent of the rated closed loop breaking capacity.

NOTE 1 — For convenience of testing, closing operations may be introduced with the consent of the manufacturer.

NOTE 2 — The manufacturer may indicate a minimum time interval between operations.

In single phase tests on a single pole of a three-pole switch, for closed loop current breaking, the value of *K* [*see* **3.3.9** (b)] is 0·37.

3.3.14.3 *Test series 3* — For transformer off-load current breaking, tests are under consideration.

3.3.14.4 *Test series 4* — For single capacitor bank switching, *see* Appendix B.

3.3.14.5 *Test series 5* — For line-charging breaking capacity, *see* Appendix C.

3.3.14.6 *Test series 6* — For cable-charging breaking capacity, *see* Appendix D.

3.3.14.7 *Test series 7* — For short-circuit making capacity of switches with a rated short-circuit making capacity.

Test duty 7	2 closing operations, with a time interval of 3 minutes, at 100 percent of the rated short-circuit making capacity.

NOTE — In case the peak making current does not attain 100 percent of the rated short-circuit making capacity in both tests, these tests are still valid if the peak making current attains 100 percent in one test and 90 percent in the other test. It is, however, not always possible to reach these values due to pre-arcing; in this case evidence shall be given that the peak making currents attained are representative of conditions the switch is required to meet in accordance with its rated short-circuit making capacity. The peak value of the prospective current shall not be less than 100 percent of the rated short-circuit making capacity and shall not exceed 110 percent of this value.

3.3.15 *Application of Test Duties* — The application of the test duties shall be in accordance with Table 7.

TABLE 7 APPLICATION OF TEST DUTIES

TEST DUTY	GENERAL PURPOSE SWITCHES			TRANSFORMERS OFF-LOAD SWITCHES	SINGLE CAPACITOR BANK SWITCHES	REMARKS AND CONDITIONS
	<200A	200 to 630A	>630A			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 a	x	x	x	—	—	—
1 b1	x	x	x	—	—	b1: oil switches
1 b2	x	x	x	—	—	b2: all other switches
1 c1	x	x	x	—	—	c1: category A switches
1 c2	x	x	—	—	—	c2: category B switches
2	—	y	y	—	—	Tests mandatory unless supply circuit impedance in test duty 1 is 25% (*see* **3.3.10.1**)
3	x	x	x	x	—	
4	—	—	—	—	x	
5	—	x	x	—	—	
6	—	x	x	—	—	
7	y	y	y	y	y	Test mandatory for switches having Ima (includes all indoor and outdoor switches <38 kV)

x = Tests mandatory.

y = Tests subject to condition in col **7**.

With the following exceptions, test duties may be made in any order and the switch may be reconditioned after any complete test series in accordance with Part 2 of this standard.

3.3.15.1 *General purpose switches* — The test duties in test series 1 shall follow each other in the order given. Test duty 7 shall, where it is required, follow test series 1 without reconditioning.

3.3.15.2 *Transformer off-load switches* — Test duty 7 shall, where it is required, follow test series 3 without reconditioning.

3.3.15.3 *Single capacitor bank switches* — Test duty 7 shall, where it is required, follow test series 4 without reconditioning.

3.3.16 *Tolerances* — The test voltage in all tests of test series 1 to 6 is subject to a tolerance of ± 5 percent of the specified value.

The upper tolerances on the currents in test duties 1a, 1c and 2 is ± 10 percent.

The tolerance on the current in test duty 1b is ± 20 percent of the specified values.

The tolerance of the applied voltage in test duty 7 shall not exceed the limit specified in **3.3.14.7**.

The upper tolerance on the current in test duty 7 is + 10 percent (for lower tolerance *see* Note under **3.3.14**).

3.3.17 *Test Report* — The test report (*see* **3.0**) shall contain the following oscillographic or other records relating to the test duties:

a) current in each phase;
b) voltage between each phase and earth on both sides of the switch;
c) instant of energizing of the trip coil, if any;
d) travel of moving contacts, if possible.

3.4 Short-Circuit Current Carrying Capability

3.4.1 *Test to Prove the Capability of Carrying the Rated Peak Withstand Current and the Rated Short-Time Current* — Switches shall be subjected to a test to prove the capability of carrying the rated peak withstand current and the rated short-time current.

The test shall be made with the switch in the closed position at any suitable voltage and starting at any convenient temperature.

The test shall be made at the rated frequency ± 25 percent.

In principle, the current shall be applied for the specified short-time. Its rms value, determined from the oscillogram, shall not be less than the rated short-time current in pole at least.

The peak value of the first major half-cycle of the test current shall not be less than the rated peak withstand current and shall not exceed his value by more than 10 percent.

When, however, the characteristics of the test plant are such that the above requirements cannot be obtained, the following deviations are permitted provided that in (a) and (b) below the product of the square of the current and the duration, obtained during the tests, shall not be less than the product of the square of the rated short-time current and the specified short-time:

a) If the decrement of the short-circuit current of the test plant is such that the rated short-time current, cannot be obtained for the rated time without applying initially an excessively high current, the rms value of the current may be permitted to fall below the specified value during the test and the duration of the test increased appropriately, provided that the value of the highest peak current is not less than specified and that the time is not more than 5 seconds.

b) If, in order to obtain the required peak value, the rms value of the current is increased above the specified current the duration of test may be reduced accordingly.

The test may be single-phase or three-phase. In the case of single-phase tests, the following shall apply:

On a three-pole switch, the test shall be carried out on two adjacent poles.

In the case of separate poles, the test may be carried out on either two poles or one pole with the return conductor at phase distance. Above a rated voltage of 72·5 kV, the return conductor need not be taken into account.

The conductors to and from the switch shall be arranged in the approximate position they will be expected to occupy when in service. The test circuit arrangement shall be described in the type-test report.

The distance from pole-to-pole when not fixed by inherent design (for example, when single-pole designs are used to form a three-pole unit), shall be in accordance with the information in **3.1.4**.

During the test to prove the capability to carry the rated peak withstand current and the rated short-time current, a switch shall not show undue stress, for example, in the case of a liquid-filled switch, there shall be no outward emission of flame, liquid or gas. After the test, the switch shall not show any deterioration and must be capable of operating normally.

3.5 Operation and Mechanical Endurance

3.5.1 *General Test Conditions* — Unless otherwise specified, the tests shall be made at the ambient temperature of the test location.

The auxiliary supply voltage of the operating device shall be measured at the terminals with full current flowing. Auxiliary equipment forming part of the operating device shall be included. However, no intentional addition to the impedance (for example, for regulation of the voltage) between the voltage source and the terminals of the device is permitted.

3.5.2 *Mechanical Endurance Tests* — Mechanical endurance tests shall be made by applying 1 000 operating cycles without voltage and current in the main circuits.

The tests shall be made on switches equipped with their own operating mechanisms or devices.

On a switch having a power-operated operating mechanism:

— 900 closing-opening operations shall be made at rated supply voltage and/or rated pressure of compressed gas supply.

— 50 closing-opening operations at the specified minimum supply voltage and/or maximum pressure of compressed gas supply.

— 50 closing-opening operations at the specified maximum supply voltage and/or maximum pressure of compressed gas supply.

These tests shall be made at such a rate that the temperature rise of the energized electrical components do not exceed the values given in Table 6. During the tests, occasional lubrication, but no mechanical adjustment, is permitted.

The switches under test shall attain the closed and open positions during each operating cycle.

After the tests, all parts, including contacts, shall be in good condition and shall not show undue wear.

3.6 Operation Under Ice Conditions — [*See* IS : 9921 (Part 4)-1985*].

4. ROUTINE TESTS

4.0 General

4.0.1 The tests described below are for the purpose of revealing faults in material or construction. They do not impair the properties and reliability of a proper test object in a good state. These are acceptance tests and should be carried out on a number of samples to be agreed upon between the manufacturer and the user. They comprise:

a) power-frequency voltage dry tests in accordance with **4.1**.

b) voltage tests for auxiliary circuits in accordance with **3.1.11**.

c) measurement of the resistance of the main circuits in accordance with **4.2**.

d) tests to prove satisfactory operation in accordance with **4.3**.

*Specification for alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 V : Part 4 Type tests and routine tests.

Test reports of these tests are normally not necessary unless otherwise agreed upon between the manufacturer and the user.

NOTE — Where switches are insufficiently assembled at the manufacturer's works to enable routine tests to be made on complete switches, tests on part assemblies should be the subject of agreement between the manufacturer and the user.

4.1 Power Frequency Voltage Dry Withstand Tests on the Main Circuit

4.1.1 The test shall be made according to IS : 2071 (Part 2)-1974* and to **3.1.1** on complete switches, or on separate poles in new, clean and dry conditions.

When switches are not completely assembled before shipment, separate tests shall be made on all the major insulation components, such as bushings, insulators and insulating operating rods. In this event, test voltages should be subject to agreement between the manufacturer and the user.

The test voltage shall be raised to the withstand value specified and maintained for 1 minute. For the test conditions, *see* Table 8.

TABLE 8 METHOD FOR POWER-FREQUENCY VOLTAGE DRY TEST ON MAIN CIRCUITS

(*Clause* 4.1.1)

TEST CONDITION No.	SWITCH POSITION	VOLTAGE APPLIED TO	EARTH CONNECTED TO
(1)	(2)	(3)	(4)
1*	Closed	AaCc	BpF
2*	Closed	BP	AaCcF
3	Open	ABC	abcF
4	Open	abc	ABCf

*If the insulation between poles is air at atmospheric pressure, test condition No. 1 and 2 may be combined, the test voltage being applied between all parts of the main circuit connected together and the base.

The switch shall be considered to have passed the tests successfully if, during the tests, no disruptive discharge occurs.

For switches having a rated voltage lower than 420 kV, the test voltage shall be that specified in Part 2 of this standard under '1 minute power-frequency withstand voltage'.

For switches having a rated voltage 420 kV, the test voltage shall be 520 kV.

*Methods of high voltage testing: Part 2 Test procedures (*first revision*).

4.2 Measurement of the Resistance of the Main Circuits

4.2.1 The resistance of each main circuit of switches should be measured under conditions as near as possible similar to those conditions under which the corresponding type test was made.

The measured resistance shall not exceed the lower of the two values:

$$1{\cdot}5\,R_u \text{ and } R_u\,\frac{T}{T_u}$$

where

R_u = the resistance measured during the corresponding type-test.

T_u = the temperature rise measured at the hottest spot of the main circuit during the type test for temperature rise.

T = the maximum temperature rise at the hottest spot of the main circuit as specified in Part 2 of this standard.

4.3 Operating Test

4.3.1 Operating tests are made to ensure that switches comply with the prescribed operating conditions within the specified voltage and supply pressure limits of their operating devices.

During the tests, which are performed without voltage or current in the main circuits in the general test conditions given in **3.5.1**, it shall be verified in particular that the switches open and close correctly when their operatings devices are energized or under pressure. It shall also be verified that the operation will not cause any damage to the switches.

The tests shall comprise:

a) At rated supply voltage and/or pressure of compressed gas supply, and for hand-operated switches: 50 operating cycles.

b) At specified maximum supply voltage and/or pressure of compressed gas supply: 10 operating cycles.

c) At specified minimum supply voltage and/or pressure of compressed gas supply: 10 operating cycles.

During these tests, no adjustment shall be made and the operation shall be faultless. The open and closed positions shall be attained during each operating cycle.

After these tests, no parts of the switch shall have been damaged.

APPENDIX A

(*Clause* 3.3.10.1)

CALCULATION OF THE IMPEDANCE OF THE SUPPLY CIRCUIT FOR MAINLY ACTIVE CURRENT SWITCHING TESTS

A-1. The calculation of the value of the impedance of the supply circuit, which is specified in **3.3.10.1**, has been expressed by the following symbols:

U_n = rated voltage;

I_t = breaking current specified in **3.3.14.1** for relevant test duty 1a, 1b1, 1b2, 1c1 or 1c2;

I_{th} = rated short-time current;

Z_t = total impedance of the test circuit;

Z_{th} = impedance corresponding to the rated short-time current; and

Z = impedance of the supply circuit.

A-2. Calculate Z_t and Z_{th} from U_n, I_t and I_{th} as follows:

a) For three-phase tests on a three-pole switch:

$$Z_t = \frac{U_n}{\sqrt{3}\, I_t} \; ; \quad Z_{th} = \frac{U_n}{\sqrt{3}\, I_{th}}$$

b) For single-phase tests on a three-pole switch:

$$Z_t = \frac{1 \cdot 5\, U_n}{\sqrt{3}\, I_t} \; ; \quad Z_{th} = \frac{1 \cdot 5\, U_n}{\sqrt{3}\, I_{th}}$$

c) For single-phase tests on a single-pole switch:

$$Z_t = \frac{U_n}{I_t} ; \; Z_{th} = \frac{U_n}{I_{th}}$$

Select the appropriate of the five possibilities given below according to the relation of Z_t and Z_{th}, and thus determine Z.

Sl No.	*Relation of Z_t and Z_{th}*	*Value of Z*
1	$Z_{th} \leqslant 0 \cdot 12\, Z_t$ and $0 \cdot 18\, Z_t \leqslant 20\, Z_{th}$	$0 \cdot 12\, Z_t \leqslant Z \leqslant 0 \cdot 18\, Z_t$
2	$0 \cdot 12\, Z_t < Z_{th} < 0 \cdot 18\, Z_t$	$Z_{th} \leqslant Z \leqslant 0 \cdot 18 Z_t$
3	$0 \cdot 12\, Z_t < 20\, Z_{th} < 0 \cdot 18\, Z_t$	$0 \cdot 12\, Z_t \leqslant Z \leqslant 20\, Z_{th}$
4	$0 \cdot 18\, Z_t \leqslant Z_{th}$	Z approximately equal but not less than Z_t
5	$20\, Z_{th} \leqslant 0 \cdot 12\, Z_t$	Z approximately equal but not more than $20\, Z_{th}$

APPENDIX B

(*Clause* 3.3.10.4)

TESTS FOR SINGLE CAPACITOR BANK SWITCHING

B-0. This Appendix applies to single capacitor bank switches (generally referred to as ' switches ' here) and includes the additional provisions concerning breaking-capacity test referred to in **3.3.10.4** to **3.3.14.4**.

NOTE — The requirement of switches intended to be used for switching multiple (parallel) capacitor banks should be the subject of agreement between the manufacturer and the user, particularly with regard to the peak value and frequency of the inrush current.

B-1. OPERATION IN NORMAL SERVICE CONDITIONS

B-1.1 In addition to the requirements applying to single capacitor bank switches in Part 2 of the standard, the standard conditions of use for switches for restricted (neutral earthed) application include the earthing conditions of the neutrals of the system and of the capacitor bank.

B-2. BEHAVIOUR IN NORMAL SERVICE CONDITIONS

B-2.1 In addition to the conditions specified in Part 2 of the standard the capacitor bank overvoltages between lines and to neutral point, produced when three-pole switches for universal application perform the operations therein, shall not exceed the corresponding values of assigned maximum capacitor bank overvoltages.

B-3. SINGLE CAPACITOR BANK BREAKING CAPACITY TESTS

B-3.0 The provisions given below are supplementary to **3.3.1** to **3.3.17**.

Single capacitor bank breaking capacity tests on three-pole switches for universal application may be made three-phase or single-phase with the limitation, however, that single-phase tests may be used only for those switches which are restrike-free. Three-phase tests are recommended.

NOTE 1 — It is assumed that a switch is restrike-free, if restrikes do not occur during single-phase tests.

NOTE 2 — From single-phase tests made with a three-pole switch for universal application, it is not possible to draw conclusions for estimating overvoltages which may occur in three-phase tests if the switch restrikes.

The tests on switches for restricted (neutral earthed) application may be made three-phase or single-phase.

NOTE — If an agreement has been made between the manufacturer and the user concerning switches used for switching multiple capacitor banks making tests may also be required simulating such performance. The performance of the switch during these tests shall be stated in terms of the peak making current and the frequency of the inrush current.

B-3.1 Supplementary Conditions of Severity — Tests for single capacitor bank switching shall be carried out under the supplementary conditions specified as follows:

a) Wave-form of the current (**B-3.2**);

b) Test voltage (**B-3.3**);

c) Characteristics of supply circuit (**B-3.4**);

d) Discharge time constant of the capacitor bank (**B-3.5**);

e) Earthing of test circuit (**B-3.6**);

f) Test series 4 (**B-3.7**); and

g) Test report (**B-3.8**).

B-3.2 Wave-Form of the Current — The wave-form of the current to be broken should, as nearly as possible, be sinusoidal. This condition is considered to be complied with if the ratio of the rms value of the current to the rms value of the fundamental component does not exceed 1·2.

The current to be broken shall not go through zero more than once per half cycle.

B-3.3 Test Voltage — For three-phase tests on a three-pole switch, or single-pole switch, the test voltage shall be that given in **3.3.9**(a).

For single-phase tests on a three-pole switch, the test voltage shall be that given in **3.3.9**(b) with the following values of K:

a) $K = 1·4$ for switches for universal application, provided that the maximum non-simultaneity of contact separation in different poles of the switch does not exceed 1/6 of a cycle at the rated frequency of the switch.

NOTE — The requirement regarding non-simultaneity of contact separation shall be proved before and after the mechanical endurance tests.

b) $K = 2·0$ for switches for universal application without regard to simultaneity of contact separation in different poles.

c) $K = 1·0$ for switches for restricted (neutral earthed) application.

NOTE — The result of the tests should not be used for estimating overvoltages occurring at a voltage differing from the test voltage.

B-3.4 Characteristics of the Supply Circuit — Tests for single capacitor bank breaking capacity shall be performed using two different supply circuits as specified below:

a) Supply circuit No. 1.

A supply circuit having an impedance such that the symmetrical component of its short-circuit current does not exceed

10 percent the rated short-time current of the switch. However, if necessary, the impedance shall be reduced below the value given by this requirement, so that the voltage variation caused by switching the capacitive current does not exceed 10 percent.

NOTE — The impedance of supply circuit No. 1 for test duty 4(b) may accordingly differ from that for test duty 4(a) (*see* Part 2).

b) Supply circuit No. 2.

A supply circuit having an impedance which is as low as possible, but not so low that its symmetrical short-circuit current exceeds the rated short-time current of the switch.

The capacitance of both supply circuits shall be as low as possible but not so low that their natural frequency exceeds the value specified (values under consideration).

NOTE — Limitations in the operation of power systems or laboratories and abnormal stresses of insulation which might occur during the tests may prevent the specified test conditions from being completely met; such deviations shall, in all cases, be clearly stated in the test report.

B-3.5 Discharge Time Constant of the Capacitor Banks — The value of the discharge time constant is greatly influenced by the apparatus (such as instrument transformers) connected to the capacitor bank.

The characteristics of the capacitor bank circuit shall be such as to give a voltage decay of not more than 10 percent at the end of an interval of 10 millisecond (ms) after final arc extinction.

NOTE — Precautions shall be taken to avoid voltage transformers giving rise to ferro-resonance phenomena during breaking operations.

B-3.6 Earthing of Test Circuit — The earthing of the test circuit shall be in accordance with **3.3.13** except that:

a) for three-phase tests of a three-pole switch for universal application the neutral point of the supply shall always be earthed, and the neutral point of the capacitor bank shall be insulated; and

b) for three-phase tests of a three-pole switch for restricted (earthed neutral) application both the neutral point of the supply and the neutral point of the capacitor bank shall be earthed.

B-3.7 Test Series 4 — Test series 4 of **3.3.14** shall consist of four test duties in accordance with Table 9.

Test duties 4(a) and 4(c) are not required if the rated single capacitor bank breaking capacity is less than 50 A.

TABLE 9 TEST SERIES 4

Test Duty No.	Supply Circuit (B-3.4)	Test Current (in Percent) of the Rated Single Capacitor Bank Breaking Capacity
4 a	1	20 to 40
4 b	1	100 „ 110
4 c	2	20 „ 40
4 d	2	100 „ 110

i) For three-phase tests each test duty shall comprise 10 tests.

ii) For single-phase tests, there are two possibilities:

a) if point-on-wave control is used for the breaking operations, each test duty shall comprise 12 tests distributed at intervals of approximately 30 electrical degrees;

b) if point-on-wave control is not used for the breaking operations, the number of tests for each test duty shall be 30.

Break tests or tests consisting of operating cycles (*see* Part 1 of this standard) may be performed in test duties 4a, 4b and 4c. All the tests in test duty 4d shall consist of operating cycles.

If single-phase tests are made, the closing in at least two of them shall occur within 15 electrical degrees of the peak value of the applied voltage.

No appreciable charge shall remain on the capacitor bank before a making operation.

NOTE — In case a switch is required for very frequent operation, a special agreement between the manufacturer and the user on the number of tests shall be made (*see* Part 2 of the standard).

B-3.8 Test Report — In addition to meeting the requirements of **3.3.15** the test report shall state the values of overvoltages on the supply side and on the capacitor side of the switch and the capacitor bank over between lines and to neutral point.

The test report shall also state the absence or presence of restrikes.

APPENDIX C

(*Clause* 3.3.10.5)

FIELD TESTS FOR LINE-CHARGING BREAKING CAPACITY

C-0. GENERAL

C-0.1 This Appendix applies to field testing of general purpose switches with rated normal currents equal to or greater than 200 A (generally referred to as 'switches' here) within the scope of the standard and includes the additional provisions concerning breaking capacity tests referred to in **3.3.10.5** to **3.3.14.5**.

Tests for the line-charging breaking capacity are generally not required for switches with rated voltages lower than or equal to 72·5 kV.

If tests for the cable-charging breaking capacity have been made, it is not necessary to make line-charging breaking capacity tests if the rated line-charging breaking capacity is less than 50 percent of the rated cable-charging breaking capacity.

A series combination of an overhead line with short lengths of cable is covered by this Appendix.

NOTE 1 — Cables are considered to be short if their total charging current does not exceed 20 percent of the overhead line charging current and the charging current of any cable adjacent to the switch does not exceed 10 percent of the overheadline-charging current. In any case, the total current should not exceed the rated line-charging breaking capacity.

NOTE 2 — Switches for use with overhead lines which include series capacitors are not within the scope of this Appendix.

C-0.2 Tests to prove the ability of a switch to switch overhead lines on no-load can be made either as laboratory tests or as field tests. This Appendix applies to field tests only.

NOTE — Methods for laboratory tests to simulate overhead line switching on no-load are under consideration.

The possibilities of carrying out field tests are, however, often limited and rigid rules for, the tests cannot always be followed. This is, for example, due to limitations in the operation of power systems and abnormal stresses on insulation which might occur during the tests.

This Appendix is recommended for providing the best indication of the switch ability when it is possible to carry out field tests.

C-1. OPERATION IN NORMAL SERVICE CONDITIONS

C-1.1 In addition to the requirements applying to general purpose switches in Part 2 of the standard, the standard conditions of use of three-pole switches include the earthing condition of the neutral of the power system corresponding to that for which the switches have been tesed.

C-2. LINE-CHARGING BREAKING CAPACITY TESTS

C-2.0 General

C-2.0.1 The provisions given below are supplementary to **3.3.1** to **3.3.17.**

Tests of three-pole switches may be made three-phase or single-phase with the limitation, however, that single-phase tests may only be used before switches which are restrike-free and which are intended for use in an earthed neutral system (*see* IS : 2165-1977*).

NOTE 1 — It is assumed that a switch is restrike-free if, during single-phase tests, restrikes do not occur.

NOTE 2 — It is not possible to draw, from single-phase tests made with a three-pole switch, conclusions for estimating overvoltages which may occur in three-phase tests if the switch restrikes.

C-2.1 Supplementary Conditions of Severity — Test for line-charging breaking capacity shall be carried out under the supplementary conditions specified in the following:

a) Wave-form of the current (**C-2.2**),
b) Test voltage (**C-2.3**),
c) Characteristics of the supply circuit (**C-2.4**),
d) Characteristics of the overhead lines (**C-2.5**),
e) Earthing of the supply circuit for tests on three-pole switches (**C-2.6**),
f) Test series 5 (**C-2.7**), and
g) Test report (**C-2.8**).

C-2.2 Wave-Form of the Current — The wave-form of the current to be broken should, as nearly as possible, be sinusoidal. This condition is considered to be complied with if the ratio of the rms value of the current to the rms value of the fundamental component does not exceed 1·2.

The current to be broken shall not be through zero more than once per half cycle.

C-2.3 Test Voltage — For three-phase tests on a three-pole switch, or single-phase tests on a single-pole switch, the test voltage shall be that given in **3.3.9**(a).

*Specification for insulation co-ordination (*second revision*).

For single-phase tests on a three-pole switch, a three-phase supply shall be used. The conductors of the other two phases shall remain connected to the supply. The test voltage shall be that given in **3.3.9**(a) and shall be measured as in a three-phase test.

NOTE — The result of the tests should not be used for estimating over-voltage occurring at a voltage differing from the test voltage.

C-2.4 Characteristics of the Supply Circuit — Tests for line-charging breaking capacity shall be made using a supply circuit such that the symmetrical component of its short-circuit current does not exceed the rated short-time current of the switch nor is less than 5 percent of this current.

The capacitance of the supply circuit shall be as low as possible but not so low that its natural frequency exceeds the value specified (values under consideration).

NOTE — Limitations in the operation of power systems and abnormal stresses of insulation which might occur during the tests, may prevent the specified test conditions from being completely met. Such deviations shall, in all cases, be clearly stated in the test report.

C-2.5 Characteristics of the Overhead Lines — The characteristics of overhead lines utilized for performing test should be such that the voltage decay does not exceed 10 percent at the end of an interval of 10 minutes after final arc extinction.

The use of several lines connected in parallel in order to increase the charging current is not allowed.

NOTE — Since the voltage decay may be very much influenced by apparatus, such as voltage transformers, connected to the line, the measurements should preferably be made with suitable voltage dividers. Also, if nevertheless voltage transformers are used, precautions should be taken to avoid these giving rise to ferro-resonance phenomena during breaking operations.

C-2.6 Earthing of the Supply Circuit for Tests on Three-Pole Switches

a) Switches intended to operate in an earthed neutral system [*see* IS : 2165 (Part 1)-1977*].

The switch with its frame earthed as in service, shall be connected in a supply circuit having its neutral earthed.

NOTE — For single-phase tests, the neutral of the three-phase supply circuit shall also be earthed.

b) Switches intended to operate in an isolated neutral system or in a resonant earthed system [*see* IS : 2165 (Part 1)-1977*].

*Specification for insulation co-ordination : Part 1 Phase to earth insulation co-ordination, Principles and rules. (*second revision*).

The switch, with its frame earthed as in service, shall be connected in a supply circuit having neutral isolated or connected to earth through an arc-suppression coil.

C-2.7 Test Series 5 — Test series 5 of **3.3.14** shall consist of two duties in accordance with Table 10.

TABLE 10 TEST DUTIES

Test Duty No.	Test Current in Percent of the Rated Line-Charging Breaking Capacity
(1)	(2)
5a	20 to 40
5b	100 ,, 110

Test duty 5a is not correct if the rated line-breaking capacity is less than 25A.

i) For three-phase tests, each test duty shall comprise 10 tests.

ii) For single-phase tests, there are two possibilities:

a) if point-on-wave control is used for the breaking operations, each test duty shall comprise 12 tests distributed at intervals of approximately 30 electrical degrees; and

b) if point-on-wave control is not used for the breaking operations, the number of tests in each test duty shall be 30.

Break tests or tests consisting of operating cycles may be performed provided that test duty 5b contains at least two operating cycles (*see* Part 1 of the standard).

C-2.8 Test Report — In addition to meeting the requirements of **3.3.17**, the test report shall state the values of overvoltages on the supply side and on the line side of the switch.

The test report shall also state the absence or presence of restrikes.

APPENDIX D

(*Clause* 3.3.10.6)

TESTS FOR CABLE-CHARGING BREAKING CAPACITY

D-0. GENERAL

D-0.1 This Appendix applies to general purpose switches with rated normal currents equal to or greater than 200 A (generally referred to as 'switches' in the following clauses within the scope of the standard) and includes the additional provisions concerning breaking capacity tests referred to in **3.3.10.6** to **3.3.14.6**.

A series combination of a cable with a short length of overhead line is covered by this Appendix.

NOTE — An overhead line is considered to be short if its charging current does not exceed 1 percent of the cable-charging current.

D-1. OPERATION IN NORMAL SERVICE CONDITIONS

D-1.1 In addition to the requirements applicable to general purpose switches in Part 1 of this standard, the standard conditions of use of three-pole switches include the earthing condition of the neutral of the power system corresponding to that for which the switch has been tested.

D-2. TESTS FOR CABLE-CHARGING BREAKING CAPACITY

D-2.0 General — The provisions given below are supplementary to **3.3.1** to **3.3.17**.

For three-pole switches having a rated voltage lower than or equal to 24 kV, the tests shall be made three-phase.

NOTE — 24 kV is considered to be the limit voltage for the general use of belted cables.

For three-pole switches intended for use in earthed neutral systems [*see* IS : 2165 (Part 1)-1977*] having a rated voltage exceeding 24 kV, the tests may be made three-phase or single phase.

For three-pole switches intended for use in isolated neutral and resonant earthed systems the tests shall be made three-phase. The test may be made as field tests or as laboratory tests, employing cables or capacitors.

D-2.1 Supplementary Conditions of Severity — Tests for cable charging breaking capacity shall be carried out under the supplementary conditions specified as follows:

a) Wave-form of the current (**D-2.2.1**),
b) Test voltage (**D-2.3**),
c) Characteristics of the supply circuit (**D-2.4**),
d) Characteristics of the capacitive circuit to be switched (**D-2.5**),
e) Earthing of the test circuit (**D-2.6**),
f) Test series 6 (**D-2.7**), and
g) Test report (**D-2.8**).

D-2.2 Wave-Form of the Current — The wave-form of the current to be broken should, as nearly as possible, be sinusoidal. This condition is

*Specification for insulation co-ordination (*second revision*).

considered to be complied with if the ratio of the rms value of the current to the rms value of the fundamental component does not exceed 1·2.

The current to be broken shall not go through more than once per half cycle.

D-2.3 Test Voltage — For three-phase tests on a three-pole switch, or single-phase tests on a single-pole switch, the test voltage shall be that given in **3.3.9**(a).

For single-phase tests on a three-pole switch, the test voltage shall be that given in **3.3.9**(b) with value of $K = 1$.

NOTE — The result of the tests should not be used for estimating overvoltages occurring at a voltage differing from the test voltage.

D-2.4 Characteristics of the Supply Circuit (*see* **3.3.10.1**) **Used For Test Duty 1a** — *See* **3.3.14.1**.

D-2.5 Characteristics of the Capacitive Circuit to be Switched — When cables are used for the capacitive circuit, an overhead line shall not be placed between the cables and the switch.

When testing a three-pole switch having a rated voltage less than or equal to 24 kV, the cables shall be three-core belted cables.

For three-phase tests of a three-pole switch having a rated voltage exceeding 24 kV, the cables shall be three-core screened or single core cables.

Capacitors may be used to simulate cables. When testing three-pole switches having a rated voltage less than or equal to 25 kV, the capacitor bank shall consist of two banks having approximately equal charging currents, connected in parallel; at least one of these capacitor banks shall be star-connected so that its neutral can be earthed. Resistors may not be connected in series with the capacitors.

D-2.6 Earthing of the Test Circuit — The earthing of the test circuit shall be in accordance with **3.13.3** except that:

a) for three-phase tests of a switch intended for use in earthed neutral systems [*see* IS: 2165 (Part 1)-1977*], the neutral point of the supply shall be earthed;

b) for three-phase tests of a switch intended for use in isolated neutral and resonant earthed systems, the neutral point of the supply shall be isolated. The capacitance to earth shall be as low as possible;

*Specification for insulation co-ordination (*second revision*).

c) for three-phase tests of a switch having a rated voltage less than or equal to 24 kV, the sheath of the belted cable (or the neutral point of one of the parallel connected capacitor banks) shall be earthed;

d) for three-phase tests of a switch having a rated voltage exceeding 24 kV, the screens (or sheaths) of the cable (or the neutral point of the capacitor bank) shall be earthed.

D-2.7 Test Series 6 — Test series 6 of **3.3.14** shall consist of two duties in accordance with Table 11.

TABLE 11 TEST DUTIES

Test Duty No.	Test Current (in Percent) of Rated Cable-Charging Breaking Capacity
(1)	(2)
6a	20 to 40
6b	100 ,, 110

Test duty 6a is not required if the rated cable-charging breaking capacity is less than 50 A.

i) For three-tests, each test duty shall comprise 10 tests.

ii) For single-phase tests, there are two possibilities:

a) if point-on-wave control is used for the breaking operations, each test duty shall comprise twelve tests distributed at intervals of approximately 30 electrical degrees;

b) if point-on-wave control is not used for the breaking operations, the number of tests in each test duty shall be 30.

Break tests or tests consisting of operating cycles may be performed provided that test duty 6b contains at least two operating cycles (*see* Part 2 of this standard).

D-2.8 Test Report — In addition to meeting the requirements of **3.3.17,** the test report shall state the values of overvoltage on the supply side and on the load side of the switch. The test report shall also state the absence or presence of restrikes.

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