BS 6581:1995

# Common clauses for high-voltage switchgear and controlgear standards —

## (Implementation of CENELEC HD 448 S3)

ICS 29.120.60

# Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee PEL/17, Switchgear, controlgear and HV-LV co-ordination, upon which the following bodies were represented:

ASTA Certification Services

Association of Manufacturers Allied to the Electrical and Electronic Industry (BEAMA Ltd.)

British Railways Board

Copper Development Association

ERA Technology Ltd.

Electricity Association

GAMBICA (BEAMA Ltd.)

Health and Safety Executive

Ministry of Defence

Transmission and Distribution Association (BEAMA Ltd.)

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Association of Consulting Engineers

British Cable Makers' Confederation

Electrical Installation Equipment Manufacturers' Association (BEAMA Ltd.)

Engineering Equipment and Materials Users' Association

Institution of Incorporated Executive Engineers

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# Contents

# National foreword

This British Standard has been prepared by Technical Committee PEL/17 and is the English language version of HD 448 S3:1995, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 694:1980 and its amendments 1:1985 and 2:1993 published by the International Electrotechnical Commission (IEC).

This British Standard supersedes BS 6581:1985 which is withdrawn.

**Cross-references**

| Publications referred to | Corresponding British Standard |
|---|---|
| HD 472 S1:1988 (IEC 38:1975) | BS 7697:1993 *Nominal voltages for low voltage public electricity supply systems* |
| IEC 50(441):1974 | BS 4727 *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms*<br>Part 2. *Terms particular to power engineering*<br>Group 06:1985 *Switchgear and controlgear terminology (including fuse terminology)*<br>BS 923 *Guide on high-voltage testing techniques* |
| HD 588.1 S1:1991 (IEC 60-1:1989) | Part 1:1990 *General* |
| EN 60060-2:1994 (IEC 60-2:1994) | BS EN 60060 *High-voltage test techniques*<br>Part 2:1995 *Measuring systems*<br>BS 5622 *Guide for insulation co-ordination* |
| IEC 71-1:1976 | Part 1:1979 *Terms, definitions, principles and rules* |
| HD 540.2 S1:1991 (IEC 71-2:1976) | Part 2:1979 *Application guide* |
| HD 566 S1:1990 (IEC 85:1984) | BS 2757:1986 *Method for determining the thermal classification of electrical insulation* |
| IEC 270:1981 | BS 4828:1985 *Guide for partial discharge measurements* |
| EN 60507:1993 (IEC 507:1991) | BS EN 60507:1993 *Artificial pollution tests on high-voltage insulators to be used on a.c. systems* |
| IEC 233:1974 | BS 4963:1973 *Specification for tests on hollow insulators for use in high voltage electrical equipment* |
| HD 578 S1:1992 (IEC 273:1990) | BS 3297 *Post insulators of ceramic material or glass for nominal voltages greater than 1 000 V*<br>Part 2:1993 *Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1 000 V* |

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**Summary of pages**

This document comprises a front cover, an inside front cover, pages i and ii, the HD title page, pages 2 to 32, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

HARMONIZATION DOCUMENT
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HD 448 S3

February 1995

ICS 29.120.60

Supersedes HD 448 S2:1989

Descriptors: High-voltage switchgear and controlgear, requirements, testing

English version

# Common clauses for high-voltage switchgear and controlgear standards

(IEC 694:1980 + A1:1985 + A2:1993)

Clauses communes pour les normes de l'appareillage à haute tension
(CEI 694:1980 + A1:1985 + A2:1993)

Gemeinsame Bestimmungen für Hochspannungsschaltgeräte-Normen
(IEC 694:1980 + A1:1985 + A2:1993)

This Harmonization Document was approved by CENELEC on 1994-12-06. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for implementation of this Harmonization Document on a national level.

Up-to-date lists and bibliographical references concerning such national implementation may be obtained on application to the Central Secretariat or to any CENELEC member.

This Harmonization Document exists in three official versions (English, French, German).

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

**CENELEC**

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B-1050 Brussels**



Ref. No. HD 448 S3:1995 E

## Foreword

The text of the International Standard IEC 694:1980 and its amendments 1:1985 and 2:1993, prepared by SC 17A, High-voltage switchgear and controlgear, of IEC TC 17, Switchgear and controlgear, was submitted to the formal vote and was approved by CENELEC as HD 448 S3 or 1994-12-06 without any modification.

The following dates were fixed:

- latest date of by which the existence of the HD has to be announced at national level (doa) 1995-06-01
- latest date by which the HD has to be implemented at national level by publication of a harmonized national standard or by endorsement (dop) 1995-12-01
- latest date by which the national standards conflicting with the HD have to be withdrawn (dow) 1995-12-01

Appendices and annexes designated “normative” are part of the body of the standard. In this standard, Annex A and Appendix B and Annex ZA and Annex ZB are normative. Annex ZA and Annex ZB have been added by CENELEC.

## Contents

## 1 Scope

This standard applies to a.c. switchgear and controlgear, designed for indoor and outdoor installation and for operation at service frequencies up to and including 60 Hz on systems having voltages above 1 000 V.

This standard applies to all high-voltage switchgear and controlgear except as otherwise specified in the relevant IEC standards for the particular type of switchgear and controlgear.

## 2 Normal and special service conditions

Unless otherwise specified, high-voltage switchgear and controlgear, including the operating devices and the auxiliary equipment which form an integral part of it, is intended to be used at its rated characteristics under the normal service conditions listed in Sub-clause **2.1**.

If the actual service conditions differ from these normal service conditions, high-voltage switchgear and controlgear and associated operating devices and auxiliary equipment shall be designed to comply with any special service conditions required by the user, or appropriate arrangements shall be made (see Sub-clause **2.2**).

NOTE Appropriate action should also be taken to ensure proper operation under such conditions of other components, such as relays.

### 2.1 Normal service conditions

#### 2.1.1 *Indoor switchgear and controlgear*

a) The ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h, does not exceed 35 °C.

The minimum ambient air temperature is – 5 °C for class “minus 5 indoor” and – 25 °C for class “minus 25 indoor”.

b) The altitude does not exceed 1 000 m.

c) The ambient air is not significantly polluted by dust, smoke, corrosive or flammable gases, vapours or salt.

d) The conditions of humidity are under consideration but, in the meantime, the following figures can be used as a guide:

— the average value of the relative humidity, measured during a period of 24 h, does not exceed 95 %,

— the average value of the vapour pressure, for a period of 24 h, does not exceed 22 mbar,

— the average value of the relative humidity, for a period of one month, does not exceed 90 %,

— the average value of the vapour pressure, for a period of one month, does not exceed 18 mbar.

For these conditions, condensation may occasionally occur.

NOTE 1 Condensation can be expected where sudden temperature changes occur in periods of high humidity.
NOTE 2 To withstand the effects of humidity and occasional condensation, such as breakdown of insulation or corrosion of metallic parts, indoor switchgear, designed for such conditions and tested accordingly, or outdoor switchgear may be used.
NOTE 3 Condensation may be prevented by special design of the building or housing, by suitable ventilation and heating of the station or by the use of dehumidifying equipment.

e) Vibrations due to causes external to the switchgear and controlgear or earth tremors are negligible.

#### 2.1.2 *Outdoor switchgear and controlgear*

a) The ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h, does not exceed 35 °C.

The minimum ambient air temperature is – 25 °C for class “minus 25 outdoor” and – 40 °C for class “minus 40 outdoor”.

b) The altitude does not exceed 1 000 m.

c) Ambient air pollution (classification is under consideration).

d) The ice coating does not exceed 1 mm for Class 1, 10 mm for Class 10 and 20 mm for Class 20.

e) The wind pressure does not exceed 700 Pa (corresponding to 34 m/s wind speed).

f) Account should be taken of the presence of condensation or rain, rapid temperature changes, and the effects of solar radiation.

NOTE This does not imply that outdoor switchgear and controlgear will carry its rated normal current under all conditions of solar radiation without exceeding the specified temperature rise. When required, appropriate measures shall be taken, e.g. roofing, forced ventilation, etc.

g) Vibrations due to causes external to the switchgear and controlgear or earth tremors are negligible.

### 2.2 Special service conditions

By agreement between manufacturer and user, high-voltage switchgear and controlgear may be used under conditions different from the normal service conditions given in Subclause **2.1**. For any special service condition, the manufacturer shall be consulted.

NOTE 1 For internal insulation, the dielectric characteristics are identical at any altitude and no special precautions need be taken. For definitions of external and internal insulation see IEC Publication 71-1.
NOTE 2 For low-voltage auxiliary equipment, no special precautions need be taken if the altitude is lower than 2 000 m.

## 3 Definitions

For the definitions of general terms used in this publication, reference is made to IEC Publication 50(441). (To be replaced by Publication 50(443), under consideration.)

## 4 Rating

The common ratings of switchgear and controlgear including their operating devices and auxiliary equipment should be selected from the following:

a) Rated voltage.

b) Rated insulation level.

c) Rated frequency.

d) Rated normal current.

e) Rated short-time withstand current.

f) Rated peak withstand current.

g) Rated duration of short circuit.

h) Rated supply voltage of closing and opening devices and of auxiliary circuits.

i) Rated supply frequency of closing and opening devices and of auxiliary circuits.

j) Rated pressure of compressed gas supply for operation.

NOTE Other rated characteristics may be necessary and will be specified in the relevant IEC standards.

### 4.1 Rated voltage

The rated voltage indicates the upper limit of the highest voltage of systems for which the switchgear and controlgear is intended. Standard values of rated voltages are given below:

NOTE For editorial reasons, mainly due to the characteristics of the transient recovery voltages, the subdivision in voltage ranges differs from that in IEC Publication 38 and IEC Publication 71.

#### 4.1.1 *For rated voltages of 72.5 kV and below*

Series I 3.6 kV – 7.2 kV – 12 kV – 17.5 kV – 24 kV – 36 kV – 52 kV – 72.5 kV.

Series II 4.76 kV – 8.25 kV – 15 kV – 15.5 kV – 25.8 kV – 38 kV – 48.3 kV – 72.5 kV.

NOTE Series I 50 Hz and 60 Hz.
Series II 60 Hz, based on current practice in the United States of America and Canada.

#### 4.1.2 *For rated voltages above 72.5 kV*

100 kV – 123 kV – 145 kV – 170 kV – 245 kV – 300 kV – 362 kV – 420 kV – 525 kV – 765 kV.

NOTE The value 550 kV is also used, as well as values between 765 kV and 800 kV.

### 4.2 Rated insulation level

The rated insulation level shall be selected from the values given in the following Table I, Table II, Table III and Table IV. The withstand voltage values in Table I, Table II, Table III and Table IV apply at the standard reference atmosphere (temperature, pressure and humidity) specified in IEC Publication 60.

#### 4.2.1 *Rated voltages up to and including 72.5 kV*

In Table I and Table II, two series are given; Series I (Table I) is based on current practice in most European and several other countries. Series II (Table II) is mainly based on current practices in the United States of America and Canada.

The choice between lists 1 and 2 of Table I should be made by considering the degree of exposure to lightning and switching overvoltages, the type of system of neutral earthing and, where applicable, the type of overvoltage protective device (see IEC Publication 71).

**Table I — Series I (based on current practice in most European and several other countries)**

| Rated voltage *U* (r.m.s. value) | Rated lightning impulse withstand voltage (peak value) | | | | Rated 1 min power-frequency withstand voltage (r.m.s. value) | |
|---|---|---|---|---|---|---|
| | List 1 | | List 2 | | | |
| | To earth, between poles and across open switching device | Across the isolating distance | To earth, between poles and across open switching device | Across the isolating distance | To earth, between poles and across open switching device | Across the isolating distance |
| (kV) | (kV) | (kV) | (kV) | (kV) | (kV) | (kV) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 3.6 | 20 | 23 | 40 | 46 | 10 | 12 |
| 7.2 | 40 | 46 | 60 | 70 | 20 | 23 |
| 12 | 60 | 70 | 75 | 85 | 28 | 32 |
| 17.5 | 75 | 85 | 95 | 110 | 38 | 45 |
| 24 | 95 | 110 | 125 | 145 | 50 | 60 |
| 36 | 145 | 165 | 170 | 195 | 70 | 80 |
| 52 | — | — | 250 | 290 | 95 | 110 |
| 72.5 | — | — | 325 | 375 | 140 | 160 |

NOTE The withstand voltage values "across the isolating distance" in Table I are valid only for the switching devices where the clearance between open contacts is designed to meet the safety requirements specified for disconnectors.

**Table II — Series II (based on current practice in the United States of America and Canada, for 60 Hz only)**

Under consideration.

### 4.2.2 *Rated voltages from 100 kV to 245 kV*

The voltages shall be selected from values given in Table III using the lightning impulse withstand voltage and the power-frequency withstand voltage value of the same line.

For the choice between the alternative values for the same rated voltage, see IEC Publication 71.

**Table III**

| Rated voltage *U* (r.m.s. value) | Rated lightning impulse withstand voltage (peak value) | | Rated 1 min power-frequency withstand voltage (r.m.s. value) | |
|---|---|---|---|---|
| | To earth, between poles and across open switching device | Across the isolating distance | To earth, between poles and across open switching device | Across the isolating distance |
| (kV) | (kV) | (kV) | (kV) | (kV) |
| (1) | (2) | (3) | (4) | (5) |
| 100 | 380<br>450 | 440<br>520 | 150<br>185 | 175<br>210 |
| 123 | 450<br>550 | 520<br>630 | 185<br>230 | 210<br>265 |
| 145 | 550<br>650 | 630<br>750 | 230<br>275 | 265<br>315 |
| 170 | 650<br>750 | 750<br>860 | 275<br>325 | 315<br>375 |
| 245 | 850<br>950<br>1 050 | 950<br>1 050<br>1 200 | 360<br>395<br>460 | 415<br>460<br>530 |

NOTE The withstand voltage values "across the isolating distance" in Table III are valid only for the switching devices where the clearance between open contacts is designed to meet the safety requirements specified for disconnectors.

#### 4.2.3 *Rated voltage 300 kV and above*

The voltages shall be selected from values of Table IV using lightning impulse withstand voltage and switching impulse withstand voltage values of the same line.

For the choice between the alternative values for the same voltage, see IEC Publication 71.

**Table IV**

| **Rated voltage** $U$ (r.m.s. value) (kV) | **Rated lightning impulse withstand voltage** (peak value) | | **Rated switching impulse withstand voltage** (peak value) | | | **1 min power-frequency test withstand voltage** (r.m.s. value) | |
|---|---|---|---|---|---|---|---|
| | **To earth** (kV) | **Across open switching device** (kV) | **To earth** (kV) | **Across open switching device** (kV) | | **To earth** (kV) | **Across open switching device** (kV) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 300 | 950<br>1 050 | 950 (+ 170)<br>1 050 (+ 170) | 750<br>850 | 850 | 700 (+ 245) | 380 | 435 |
| 362 | 1 050<br>1 175 | 1 050 (+ 205)<br>1 175 (+ 205) | 850<br>950 | 950 | 800 (+ 295) | 450 | 520 |
| 420 | 1 300<br>1 425 | 1 300 (+ 240)<br>1 425 (+ 240) | 950<br>1 050 | 1 050 | 900 (+ 345) | 520 | 610 |
| 525 | 1 425<br>1 550 | 1 425 (+ 300)<br>1 550 (+ 300) | 1 050<br>1 175 | 1 175 | 900 (+ 430) | 620 | 760 |
| 765 | 1 800<br>2 100 | 1 800 (+ 435)<br>2 100 (+ 435) | 1 300<br>1 425 | 1 550 | 1 100 (+ 625) | 830 | 1 100 |

NOTE 1 For column (1) it is permissible to adopt values between 765 kV and 800 kV provided that the test values for switching devices should be the same as defined by the IEC for 765 kV.

NOTE 2 For column (3), values in brackets are the peak values of the power-frequency voltage, $0.7\,U\sqrt{2}/\sqrt{3}$, applied to the opposite terminal.

For column (6), values in brackets are the peak values of the power-frequency voltage, $U\sqrt{2}/\sqrt{3}$, applied to the opposite terminal.

NOTE 3 For column (7), values applicable:

a) for type tests to earth,

b) for routine tests to earth, and across the open switching device.

For column (8), values applicable for type tests only across the open switching device.

NOTE 4 The withstand voltage values "between poles" are under consideration and will be given in IEC Publication 71-3.

NOTE 5 The choice between alternative values of rated switching impulse withstand voltage in columns (5) and (6) across the open switching device is given in the relevant IEC standards for the particular type of switching device.

### 4.3 Rated frequency

The standard values of the rated frequency for three-pole switchgear and controlgear are 50 Hz or 60 Hz.

### 4.4 Rated normal current and temperature rise

#### 4.4.1 *Rated normal current*

The rated normal current of a switching device is the r.m.s. value of the current which the switching device shall be able to carry continuously under specified conditions of use and behaviour.

The values of rated normal currents should be selected from the R 10 series, specified in IEC Publication 59.

NOTE Current ratings for temporary or for intermittent duty are subject to agreement between manufacturer and user.

#### 4.4.2 *Temperature rise*

The temperature rise of any part of a switching device for an ambient air temperature not exceeding 40 °C shall not exceed the temperature-rise limits specified in Table V under the conditions specified in the test clauses.

NOTE In this standard, the terms "contact" and "connection" are used according to the following definitions:
*Contact*: Two or more conductors designed to establish circuit continuity when they touch, and which, due to their relative motion during operation, open or close circuit or (in the case of hinged or sliding contacts) maintain circuit continuity.
*Connection (bolted or the equivalent)*: Two or more conductors designed to ensure permanent circuit continuity when forced together by means of screws, bolts or the equivalent.

**Table V — Limits of temperature and temperature rise for various parts, materials and dielectrics of high-voltage switching devices**

| Nature of the part, of the material and of the dielectric (see Notes 1, 2 and 3) | Maximum values | |
|---|---|---|
| | Temperature (°C) | Temperature rise at an ambient air temperature not exceeding 40 °C (K) |
| 1. Contacts (see Note 4) | | |
| Bare copper and bare-copper alloy | | |
| — in air | 75 | 35 |
| — in $SF_6$ (sulphur hexafluoride) | 90 | 50 |
| — in oil | 80 | 40 |
| Silver-coated or nickel-coated (see Note 5) | | |
| — in air | 105 | 65 |
| — in $SF_6$ | 105 | 65 |
| — in oil | 90 | 50 |
| Tin-coated (see Notes 5 and 6) | | |
| — in air | 90 | 50 |
| — in $SF_6$ | 90 | 50 |
| — in oil | 90 | 50 |
| 2. Connections, bolted or the equivalent (see Note 7) | | |
| Bare copper, bare-copper alloy or bare-aluminium alloy | | |
| — in air | 90 | 50 |
| — in $SF_6$ | 105 | 65 |
| — in oil | 100 | 60 |
| Silver-coated or nickel-coated | | |
| — in air | 115 | 75 |
| — in $SF_6$ | 115 | 75 |
| — in oil | 100 | 60 |
| Tin-coated | | |
| — in air | 105 | 65 |
| — in $SF_6$ | 105 | 65 |
| — in oil | 100 | 60 |
| 3. All other contacts or connections made of bare metals or coated with other materials | (see Note 8) | (see Note 8) |
| 4. Terminals for the connection to external conductors by screws or bolts (see Note 9) | | |
| — bare | 90 | 50 |
| — silver, nickel or tin-coated | 105 | 65 |
| — other coatings | (see Note 8) | (see Note 8) |
| 5. Oil for oil switching devices (see Notes 10 and 11) | 90 | 50 |
| 6. Metal parts acting as springs | (see Note 12) | (see Note 12) |
| 7. Materials used as insulation and metal parts in contact with insulation of the following classes (see Note 13) | | |
| — Y (for non-impregnated materials) | 90 | 50 |
| — A (for materials immersed in oil or impregnated) | 100 | 60 |
| — E | 120 | 80 |
| — B | 130 | 90 |
| — F | 155 | 115 |
| — Enamel: oil base | 100 | 60 |
| synthetic | 120 | 80 |
| — H | 180 | 140 |
| — C | (see Note 14) | (see Note 14) |
| 8. Any part of metal or of insulating material in contact with oil, except contacts | 100 | 60 |

*(See notes page 10.)*

NOTE 1 According to its function, the same part may belong to several categories as listed in Table V. In this case the permissible maximum values of temperature and temperature rise to be considered are the lowest among the relevant categories.

NOTE 2 For vacuum switching devices, the values of temperature and temperature-rise limits are not applicable for parts in vacuum. The remaining parts shall not exceed the values of temperature and temperature rise given in Table V.

NOTE 3 Care shall be taken to ensure that no damage is caused to the surrounding insulating materials.

NOTE 4 When contact parts have different coatings, the permissible temperatures and temperature rises shall be those of the part having the lower value permitted in Table V.

NOTE 5 The quality of the coated contacts shall be such that a layer of coating material remains at the contact area:

a) after making and breaking tests (if any);

b) after short-time withstand current test;

c) after the mechanical endurance test;

according to the relevant specifications for each equipment. Otherwise, the contacts shall be regarded as "bare".

NOTE 6 For fuse contacts, the temperature rise shall be in accordance with IEC publications on high-voltage fuses.

NOTE 7 When connection parts have different coatings, the permissible temperatures and temperature rises shall be those of the part having the higher value permitted in Table V.

NOTE 8 When other materials than those given in Table V are used, their properties shall be considered, notably in order to determine the maximum permissible temperature rises.

NOTE 9 The values of temperature and temperature rise are valid even if the conductor connected to the terminals is bare.

NOTE 10 At the upper part of the oil.

NOTE 11 Special consideration should be given when low flash-point oil is used in regard to vaporization and oxidation.

NOTE 12 The temperature shall not reach a value where the elasticity of the material is impaired.

NOTE 13 The following classes of insulating materials are those given in IEC Publication 85.

*Class Y:* Insulation consists of materials or combinations of materials such as cotton, silk and paper without impregnation. Other materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at Class Y temperatures.

*Class A:* Insulation consists of materials or combinations of materials such as cotton, silk and paper when suitably impregnated or coated or when immersed in a dielectric liquid such as oil. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at Class A temperatures.

*Class E:* Insulation consists of materials or combinations of materials which by experience or accepted tests can be shown to be capable of operation at Class E temperatures.

*Class B:* Insulation consists of materials or combinations of materials such as mica, glass fibre, asbestos, etc. with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if by experience or accepted tests they can be shown to be capable of operation at Class B temperatures.

*Class F:* Insulation consists of materials or combinations of materials such as mica, glass fibre, asbestos, with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if by experience or accepted tests they can be shown to be capable of operation at Class F temperatures.

*Class H:* Insulation consists of materials such as silicone elastomer and combinations of materials such as mica, glass fibre, asbestos, etc. with suitable bonding substances such as appropriate silicone resine. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at Class H temperatures.

*Class C:* Insulation consists of materials or combinations of materials such as mica, porcelain, glass and quartz with or without an inorganic binder. Other materials or combinations of materials may be included in this class if by experience or accepted tests they can be shown to be capable of operation at temperatures above the Class H limit. Specific materials or combinations of materials in this class will have a temperature limit which is dependent upon their physical, chemical and electrical properties.

NOTE 14 Limited only by the requirement not to cause any damage to surrounding parts.

### 4.5 Rated short-time withstand current

The r.m.s. value of the current which a mechanical switching device can carry in the closed position during a specified short time under prescribed conditions of use and behaviour.

The standard value of rated short-time withstand current should be selected from the R 10 series specified in IEC Publication 59, and shall be compatible with any other short-circuit rating assigned to the mechanical switching device.

NOTE The R 10 series comprises the numbers 1 – 1.25 – 1.6 – 2 – 2.5 – 3.15 – 4 – 5 – 6.3 – 8 and their products by $10^n$.

### 4.6 Rated peak withstand current

The peak current associated with the first major loop of the rated short-time withstand current which a mechanical switching device can carry in the closed position under prescribed conditions of use and behaviour.

The standard value of rated peak withstand current is equal to 2.5 times the rated short-time withstand current.

NOTE Values higher than 2.5 times the rated short-time withstand current may be required according to the characteristics of the system.

### 4.7 Rated duration of short-circuit

The interval of time for which a mechanical switching device can carry, in the closed position, a current equal to its rated short-time withstand current.

The standard value of rated duration of short circuit is 1 s.

If a value of more than 1 s is necessary, the value of 3 s is recommended.

By agreement between manufacturer and user, a value lower than 1 s may be chosen.

### 4.8 Rated supply voltage of closing and opening devices and auxiliary circuits

The supply voltage of closing and opening devices and auxiliary circuits shall be understood to mean the voltage measured at the circuit terminals of the apparatus itself during its operation, including, if necessary, the auxiliary resistors or accessories supplied or required by the manufacturer to be installed in series with it, but not including the conductors for the connection to the electricity supply.

The rated supply voltage should be selected from the standard values given in Table VI and Table VII.

**Table VI — Direct current voltage**

| (V) |
|---|
| 24 |
| 48 |
| 60 |
| 110 or 125 |
| 220 or 250 |

**Table VII — Alternating current voltage**

| Three-phase, three-wire or four-wire systems (V) | Single-phase three-wire systems (V) | Single-phase two-wire systems (V) |
|---|---|---|
| — | 120/240 | 120 |
| (220/380) | — | (220) |
| 230/400 | — | 230 |
| (240/415) | — | (240) |
| 277/480 | — | 277 |

The lower values in the first column of Table VII are voltages to neutral and the higher values are voltages between phases. The lower value in the second column is the voltage to neutral and the higher value is the voltage between lines.

NOTE 1 The value 230/400 V indicated in Table VII will be, in future, the only IEC standard voltage and its adoption is recommended, in new systems. The voltage variations of existing systems at 220/380 V and 240/415 V should be brought within the range 230/400 V ± 10 %. The reduction of this range will be considered in a later stage of standardization.

NOTE 2 The secondary voltages of protective and measuring transformers are not subject to this standard.

The operating device shall be capable of closing and opening the switching device for any value of supply voltage between 85 % and 110 % of the rated value. For operation of releases, see Sub-clause **5.7**.

### 4.9 Rated supply frequency of operating devices and auxiliary circuits

The standard values of rated supply frequency are 50 Hz and 60 Hz.

### 4.10 Rated pressure of compressed gas supply for operation

The standard values of rated pressure are:

0.5 MPa – 1 MPa – 1.6 MPa – 2 MPa – 3 MPa – 4 MPa.

The pneumatic operation device shall be capable of opening and closing the switching device when the compressed gas pressure is between 85 % and 110 % of the rated pressure, unless otherwise specified by the manufacturer.

## 5 Design and construction

### 5.1 Requirements for liquids in switchgear and controlgear

It shall be possible to fill and drain liquid-filled switching devices easily, the main circuit being dead and earthed.

The requirements of Sub-clauses **5.1.1** and **5.1.2** do not apply to the oil used for control devices.

**5.1.1** ***Liquid level***

A device for checking the liquid level, even during service, with indication of minimum and maximum limits admissible for correct operation, shall be provided.

**5.1.2** ***Liquid quality***

Liquid for use in liquid-filled switchgear and controlgear shall comply with the instructions of the manufacturer.

For oil-filled switchgear and controlgear, new insulating oil shall comply with IEC Publication 296.

**5.2 Requirements for gases in switchgear and controlgear**

The manufacturer shall specify the type and the required quantity, quality and density of the gas to be used in switchgear and controlgear and provide the user with necessary instructions for renewing the gas and maintaining its required quantity and quality.

For sulphur hexafluoride-filled switchgear and controlgear, new sulphur hexafluoride shall comply with IEC Publication 376.

**5.3 Earthing of switching devices**

The frame of each switching device shall be provided with a reliable earthing terminal having a clamping screw for connection to an earthing conductor, suitable for specified fault conditions. The diameter of the clamping screw shall be at least 12 mm.

The connecting point shall be marked with the symbol for protective earth, No. 5019 of IEC Publication 417: *Graphical Symbols for Use on Equipment*. Index, Survey and Compilation of the Single Sheets.

**5.4 Auxiliary equipment**

Auxiliary switches and auxiliary circuits shall be capable of carrying the current of the circuits to be controlled, particulars of which should be specified to the manufacturer. In the absence of such specifications they shall be capable of carrying a current of at least 10 A continuously. The temperature rises shall not exceed the limits specified.

Auxiliary switches shall be capable of making and breaking the current of the circuits to be controlled. Where auxiliary switches are associated with external equipment, details should be provided to the manufacturer. In the absence of such a specification, they shall be capable of making and breaking at least 2 A at 220 V d.c. with a circuit time-constant of not less than 20 ms.

Auxiliary switches which are operated in conjunction with the main contacts shall be positively driven in both directions.

Auxiliary switches which are installed on the frame of switching devices shall be suitably protected against accidental arcing from the main circuit.

The insulation of auxiliary switches and terminals of auxiliary circuits which are to be used under outdoor conditions shall have suitable non-tracking and non-hygroscopic properties.

Unless otherwise specified in the relevant IEC standards, control and auxiliary equipment shall be segregated by earthed metallic partitions from the main circuit.

The wiring of auxiliary circuits shall, with the exception of short lengths of wire at terminals of instrument transformers, tripping coils, auxiliary contacts etc., also be either segregated from the main circuit by earthed metallic partitions (e.g. tubes) or separated by partitions (e.g. tubes) made of insulating material.

Low-voltage fuses of auxiliary circuits, terminals and other auxiliary apparatus requiring attention while the equipment is in service, shall be accessible without exposing high-voltage conductors.

**5.5 Dependent power closing**

A switching device arranged for dependent power closing with external energy supply shall be capable of making its rated short-circuit making current when the voltage or the pressure of the power supply of the closing device is at the lower of the limits specified under Sub-clauses **4.8** and **4.10** (the term "closing device" here embraces intermediate control relays and contractors where provided). At the upper limit it shall be capable of closing on no-load without suffering undue mechanical deterioration. If a maximum make-time is stated by the manufacturer, this shall not be exceeded.

### 5.6 Stored energy closing

A switching device arranged for stored energy closing shall be capable of making its rated short-circuit making current, when the energy store is suitably charged in accordance with Sub-clause **5.6.1** or **5.6.2**. It shall also be capable of closing on no-load without suffering undue mechanical deterioration. If a maximum make-time is stated by the manufacturer, this shall not be exceeded.

#### 5.6.1 *Energy storage in gas receivers or hydraulic accumulators*

When the energy store is a gas receiver or hydraulic accumulator, the requirements of Sub-clause **5.6** apply at operating pressures between the limits specified in Items a) and b):

a) *External pneumatic or hydraulic supply*

Unless otherwise specified by the manufacturer, the limits of the operating pressure are between 85 % and 110 % of rated pressure.

These limits do not apply where receivers also store compressed gas for interruption.

b) *Compressor or pump integral with the switching device or the operating device*

The limits of operating pressure shall be stated by the manufacturer.

#### 5.6.2 *Energy storage in springs (or weights)*

When the energy store is a spring (or weight), the requirements of Sub-clause **5.6** apply when the spring is charged (or the weight lifted). It shall not be possible for the moving contacts to move from the open position unless the charge is sufficient for satisfactory completion of the closing operation.

#### 5.6.3 *Manual charging*

If a spring (or weight) is charged by hand, the direction of motion of the handle shall be marked unless it is evident. A device indicating when the spring (or weight) is charged shall be mounted on the switching device except in the case of an independent manual closing operation.

#### 5.6.4 *Motor charging*

Motors, and their electrically operated auxiliary equipment for charging a spring (or weight) or for driving a compressor or pump, shall operate satisfactorily between 85 % and 110 % of the rated supply voltage (Sub-clause **4.8**), the frequency, in the case of a.c., being the rated supply frequency (Sub-clause **4.9**).

NOTE For electric motors the limits do not imply the use of non-standard motors, but only the selection of a motor which at these values provides the necessary effort, and the rated voltage of the motor need not coincide with the rated supply voltage of the closing device.

### 5.7 Operation of releases

The operation limits of release shall be as follows:

#### 5.7.1 *Shunt closing release*

A shunt closing release shall operate correctly between 85 % and 110 % of the rated supply voltage of the closing device (Sub-clause **4.8**), the frequency, in the case of a.c., being the rated supply frequency of the closing device (Sub-clause **4.9**).

#### 5.7.2 *Shunt opening release*

A shunt opening release shall operate correctly under all operating conditions of the switching device up to its rated short-circuit breaking current, and between 70 % in the case of d.c. — or 85 % in the case of a.c. — and 110 % of the rated supply voltage of the opening device (Sub-clause **4.8**), the frequency, in the case of a.c., being the rated supply frequency of the opening device (Sub-clause **4.9**).

#### 5.7.3 *Capacitor operation of shunt releases*

When, for stored energy operation of a shunt release, a rectifier-capacitor combination is provided as an integral part of the switching device, the charge of the capacitors to be derived from the voltage of the main circuit, the capacitors shall retain a charge sufficient for satisfactory operation of the release 5 s after the voltage supply has been disconnected from the terminals of the combination and replaced by a short-circuiting link. The voltages of the main circuit before disconnection shall be taken as the lowest voltage of the system associated with the rated voltage of the switching device (see IEC Publication 38 for the relation between “highest voltage for equipment” and system voltages).

**5.7.4** ***Under-voltage release***

An under-voltage release shall operate to open the switching device when the voltage at the terminals of the release falls below 35 % of its rated voltage, even if the fall is slow and gradual. On the other hand it shall not operate the switching device when the voltage at its terminals exceeds 70 % of its rated supply voltage.

The closing of the switching device shall be possible at values of the voltage at the terminals of the release equal to, or higher than, 85 % of its rated voltage. Its closing shall be impossible when the voltage at the terminals is lower than 35 % of its rated supply voltage.

**5.8 Low and high pressure interlocking devices**

Where low-pressure or high-pressure interlocking devices are provided, they shall be such that they can be set to operate at, or within, the appropriate limits of pressure stated by the manufacturer, in accordance with Sub-clause **5.6.1** and with relevant IEC specifications.

**5.9 Nameplates**

Switchgear and controlgear and their operating devices shall be provided with nameplates which contain the necessary information specified in the relevant IEC standards.

For outdoor switchgear and controlgear, the nameplates shall be weather-proof and corrosion-proof.

If the switchgear and controlgear consist of several independent poles, each pole shall be provided with a nameplate.

For an operating device combined with a switching device, it may be sufficient to use only one combined nameplate. If the operating device is removable, it shall have a separate nameplate.

**5.10 External creepage distances of insulators under polluted conditions**

IEC 815 gives general rules that assist in choosing insulators which should give satisfactory performance under polluted conditions.

The procedure to determine the minimum creepage distances is described in Annex A.

## 6 Type tests

The type tests are for the purpose of proving the characteristics of switchgear and controlgear, their operating devices and their auxiliary equipment.

The type tests are:

— dielectric tests including lightning and switching impulse tests, power-frequency voltage withstand tests, artificial pollution tests, partial discharge tests and power-frequency voltage withstand tests on auxiliary and control circuits (see Sub-clause **6.1**);

— radio interference voltage (r.i.v.) test (see Sub-clause **6.2**);

— temperature-rise tests (see Sub-clause **6.3**);

— measurement of the resistance of the main circuit (see Sub-clause **6.4**);

— short-time withstand current and peak withstand current tests (see Sub-clause **6.5**).

All the above tests shall be made in principle on complete switchgear and controlgear (filled with the specified types and quantities of liquid or gas at specified pressure), on their operating devices and their auxiliary equipment. Where single pole testing is permitted in certain cases, it is indicated in the relevant clauses.

The results of all type tests shall be recorded in type-test reports containing sufficient data to prove compliance with this specification, and sufficient information shall be included so that the essential parts of the switchgear and controlgear tested can be identified.

General information concerning the supporting structure of the switching device or enclosed switchgear, of which the switching device forms an integral part, shall be included in the type-test report.

Information regarding the operating devices employed during the tests shall, where applicable, be recorded in the type-test report.

The switchgear and controlgear for test shall truly conform in all essential details to drawings of its type.

Additional type tests may be necessary and will be specified in the relevant IEC standards.

### 6.1 Dielectric tests

#### 6.1.1 *Ambient air conditions during tests*

Reference is made to IEC 60-1 regarding standard reference atmospheric conditions and atmospheric correction factors.

No humidity correction factor shall be applied for wet tests and for artificial pollution tests.

For switchgear and controlgear where external insulation in free air is of principal concern, the correction factor $K_t$ shall be applied.

For switchgear and controlgear having external and internal insulation, the correction factor $K_t$ shall be applied if its value is between 0,95 and 1,05. However, in order to avoid overstressing of internal insulation, the application of the correction factor $K_t$ may be omitted where the satisfactory performance of external insulation has been established. In the case when the correction factor is outside the range of 0,95 and 1,05, details of dielectric tests shall be subject to agreement between manufacturer and user.

For switchgear and controlgear having internal insulation only, the ambient air conditions are of no influence and the correction factor $K_t$ shall not be applied.

#### 6.1.2 *Wet test procedure*

The external insulation of outdoor switchgear and controlgear shall be subjected to wet withstand tests under the test procedure given in IEC 60-1.

NOTE The method of wetting extremely large switchgear and controlgear is under consideration.

#### 6.1.3 *Condition of switchgear and controlgear during dielectric tests*

Dielectric tests shall be made on switchgear and controlgear completely assembled, as in service; the outside surfaces of insulating parts shall be carefully cleaned.

The switchgear and controlgear shall be mounted for test with minimum clearances and height as specified by the manufacturer.

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

When the distance between the poles of switchgear and controlgear 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 necessity of erecting large three-pole switchgear and controlgear for test purposes alone, the artificial pollution and the radio-interference voltage tests may be made on a single pole and, if the minimum 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.

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 gradient distribution, they shall remain in position for the test.

For switchgear and controlgear using compressed gas for insulation, dielectric tests shall be performed at minimum operating density.

The minimum operating density may be expressed as the pressure at the reference temperature of 20 °C. If, at the time of the test, the temperature differs from 20 °C, the pressure must be adjusted to correspond to the minimum operating density. The temperature and pressure of the gas during the tests shall be noted and recorded in the test report.

NOTE *Caution*. In the dielectric testing of switchgear and controlgear incorporating vacuum switching devices, precautions 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.

#### 6.1.4 *Application of test voltage and test conditions*

With reference to Figure 1, page 28, which shows a diagram of connection of a three-pole switching device, the test voltage shall be applied according to the following tables.

**Table VIII — Impulse voltage tests and power-frequency voltage tests where the terminal opposite the energized terminal is earthed when testing the open switching device**

| Test condition No. | Switching device | Voltage applied to | Earth connected to |
|---|---|---|---|
| 1 | Closed | Aa | BCbcF |
| 2 | Closed | Bb | ACacF |
| 3 | Closed | Cc | ABabF |
| 4 | Open | A | BCabcF[a] |
| 5 | Open | B | ACabcF[a] |
| 6 | Open | C | ABabcF[a] |
| 7 | Open | a | ABCbcF[a] |
| 8 | Open | b | ABCacF[a] |
| 9 | Open | c | ABCabF[a] |

[a] When the test voltage across the open switching device is higher than the test voltage to earth it may be necessary to insulate suitably the base F and the terminals of the switching device, except the terminal opposite the energized terminal.

Test conditions Nos. 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 Nos. 7, 8 and 9 may be omitted if the arrangement of the terminals of each pole is symmetrical with respect to the base.

**Table IX — Power-frequency voltage tests using two voltage sources where the voltage is applied to both terminals when testing the open switching device**

| Test condition No. | Switching device | Voltage applied to | Earth connected to |
|---|---|---|---|
| 1 | Closed | Aa | BCbcF |
| 2 | Closed | Bb | ACacF |
| 3 | Closed | Cc | ABabF |
| 4 | Open | A and a | BCbcF |
| 5 | Open | B and b | ACacF |
| 6 | Open | C and c | ABabF |

Test conditions Nos. 3 and 6 may be omitted if the arrangement of the outer poles is symmetrical with respect to the centre pole and the base.

**Table X — Impulse voltage tests where the impulse is applied on the terminal opposite the terminal energized by the power-frequency voltage when testing the open switching device**

| Test condition No. | Switching device | 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 |

Test conditions Nos. 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 Nos. 7, 8 and 9 may be omitted if the arrangement of the terminals of each pole is symmetrical with respect to the base.

**6.1.5** ***Test voltages***

The rated withstand voltages to be used for the tests prescribed in Sub-clauses **6.1.6** and **6.1.7** and in the relevant IEC publications shall be in accordance with Sub-clauses **4.2.1**, **4.2.2** and **4.2.3**.

In the following sub-clauses, $U$ indicates the rated voltage of the switchgear and controlgear.

**6.1.6** ***Lightning and switching impulse voltage tests***

The switchgear and controlgear 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 IEC 60-1.

Switchgear and controlgear having rated voltages of 300 kV and above shall be subjected to switching impulse voltage tests. The tests shall be performed with voltages of both positive and negative polarity using the standard switching impulse 250/2 500, according to IEC 60-1. Wet tests shall be performed for outdoor switchgear and controlgear only.

When testing open switching devices where power-frequency voltage shall be applied on the opposite terminal, each lightning or switching impulse shall be synchronized so that it is applied approximately in correspondence to the peak value of the opposite polarity of the power-frequency voltage.

Fifteen consecutive lightning or switching impulses at the rated withstand voltage shall be applied for each test condition and each polarity. The switching device shall be considered to have passed the test if the number of the disruptive discharges on self-restoring insulation does not exceed two for each series of 15 impulses and if no disruptive discharge on non-self-restoring insulation occurs.

If it is proved that tests for one polarity give the most unfavourable results, it is permissible to perform the test for this polarity only.

NOTE 1 To take into account the problem of the influence of the impulse on the power-frequency voltage wave caused by capacitive coupling between the two voltage circuits, the following test requirements shall be fulfilled: When testing open switching devices having rated voltages of 300 kV and above, the voltage drop on the power-frequency wave, applied to one terminal, shall 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 $U\sqrt{2}/\sqrt{3}$ for the lightning impulse test and $U\sqrt{2}/\sqrt{3}$ for the switching impulse test.

To achieve such a condition, the power-frequency voltage can be increased up to, but not more than $U\sqrt{2}/\sqrt{3}$ for the lightning impulse test and not more than 1.2 $U\sqrt{2}/\sqrt{3}$ for the switching impulse test.

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 The above tests are not intended to ensure the co-ordination of the insulation to earth with respect to the insulation across the open switching device. To achieve such a co-ordination the use of suitable protective devices, such as surge arresters and spark gaps, should be considered, particularly for installations having a rated voltage of 100 kV and above.

NOTE 3 Some insulating materials retain a charge after an impulse test and for 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.

NOTE 4 By agreement between manufacturer and user, the conventional impulse withstand test may be applied as an alternative to the fifteen impulses withstand test. In this case, the test shall be performed by applying three consecutive impulses for each polarity. The switching device shall be considered to have passed the test if no disruptive discharge occurs.

**6.1.7** ***Power-frequency voltage withstand tests***

Switchgear and controlgear shall be subjected to 1 min power-frequency voltage withstand tests in accordance with IEC 60-1.

For switchgear and controlgear having a rated voltage lower than 300 kV, the tests shall be performed in dry conditions, and for outdoor switching devices, the tests shall also be performed in wet conditions. The test voltage shall be raised, for each test condition to the rated withstand voltage as specified in Sub-clauses **4.2.1** and **4.2.2** and shall be maintained for 1 min.

For switchgear and controlgear having a rated voltage of 300 kV and above, the tests shall be performed in dry conditions only. The test voltage shall be raised, for each test condition, to the value specified in Sub-clause **4.2.3** and shall be maintained for 1 min.

The switchgear and controlgear shall be considered to have passed the test if no disruptive discharge occurs.

**6.1.8** ***Artificial pollution tests***

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

These tests apply only to outdoor switchgear and controlgear and shall be performed only by special agreement between manufacturer and user. Unless otherwise specified in the relevant standards, tests shall be performed on one single pole of the switching device in closed position, for earthing switches in open position only, to provide information on the behaviour of insulation to earth.

Since the most appropriate testing method for switchgear and controlgear 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 manufacturer and user, shall be chosen from those described by the relevant IEC report, Publication 507 (see also IEC 60-1).

**6.1.9** ***Partial discharge tests***

Partial discharge tests, if required, are prescribed in the relevant IEC standards. For partial discharge measurement, see IEC Publication 270.

**6.1.10** ***Test on auxiliary and control circuits***

Auxiliary and control circuits of switchgear and controlgear shall be subjected to 1 min power-frequency voltage withstand tests:

a) between the auxiliary and control circuits connected together as a whole and the base of the switching device;

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

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

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 apparatus has already been tested in accordance with the appropriate specification, it may be disconnected for these tests.

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

**6.1.11** ***Power frequency voltage test as condition check after type tests***

When the insulating properties across open contacts of a switching device after type tests (making and breaking tests, mechanical/electrical endurance tests) cannot be verified by visual inspection with sufficient reliability, a power frequency withstand voltage test in dry condition according to **6.1.7** shall be performed across the open switching device at the following value of power frequency voltage:

For equipment with rated voltages up to and including 72,5 kV:

80 % of the value in Table I, column (7) for disconnectors and switch-disconnectors (equipment with safety requirements) and column (6) for other equipment.

For equipment with rated voltages from 100 kV up to and including 245 kV:

80 % of the value in Table III, column (5) for disconnectors and switch-disconnectors (equipment with safety requirements) and column (4) for other equipment.

For equipment with rated voltage 300 kV and above:

100 % of the value in Table IV, column (8), for disconnectors and switch-disconnectors (equipment with safety requirements).

80 % of the value in Table IV, column (8) for other equipment.

NOTE 1 The reduction of the test voltage is motivated by the safety margin in the rated withstand voltage values, which takes ageing, wear and other normal deterioration into account, and by the statistical nature of the flashover voltage.

NOTE 2 Condition checking tests of the insulation to earth may be required for enclosed devices of certain design. In that case a power frequency test with 80 % of the values in column (6), (4) and (7) of Table I, Table III and Table IV, respectively, should be performed.

NOTE 3 The relevant apparatus standard can specify that this condition checking test is mandatory for certain types of equipment.

**6.2 Radio interference voltage (r.i.v.) test**

These tests apply only to switchgear and controlgear having a rated voltage of 123 kV and above, and shall be made when specified in the relevant IEC standards.

The test voltage shall be applied as follows:

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

b) in open position, between one terminal and the other terminals connected to the earthed base and then with the connections reversed if the switching device is not symmetrical.

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

The switchgear and controlgear 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 h prior to the present test.

The test connections and their ends shall not be a source of radio interference voltage of higher values than those indicated below.

The measuring circuit (see Figure 2, page 29) shall comply with International Special Committee on Radio Interference (C.I.S.P.R.) Publication 16. The measuring circuit shall preferably be tuned to a frequency within 10 % of 0.5 MHz but other frequencies in the range 0.5 MHz to 2 MHz may be used, the 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. Therefore, a 300 Ω resistance is recommended for switchgear and controlgear with bushings with earthed flanges (e.g. dead tank circuit-breakers).

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 switchgear and controlgear under test. This filter also reduces circulating radio-frequency currents in the test circuit, generated by the high-voltage transformer or picked up from extraneous sources. A suitable value for its impedance has been found to be 10 000 Ω to 20 000 Ω at the measuring frequency.

It shall 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 at least 6 dB and preferably 10 dB below the specified radio interference level of the switchgear and controlgear to be tested. Calibration methods for the measuring instrument are given in C.I.S.P.R. Publication 16. Calibration methods for the measuring circuit are under consideration by C.I.S.P.R.

As the radio interference level may be affected by fibres or dust settling on the insulators, it is permitted to wipe the insulators with a clean cloth before taking 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 test may be open to doubt if the relative humidity exceeds 80 %.

The following test procedure shall be followed:

A voltage 1.1 $U/\sqrt{3}$ shall be applied to the switchgear and controlgear and maintained for at least 5 min, $U$ being the rated voltage of the switchgear and controlgear. The voltage shall then be decreased by steps down to 0.3 $U/\sqrt{3}$, raised again by steps to the initial value and finally decreased by steps to 0.3 $U/\sqrt{3}$. At each step a radio interference measurement shall be taken and the radio interference level, as recorded during the last series of voltage reductions, shall be plotted versus the applied voltage; the curve so obtained is the radio interference characteristic of the switchgear and controlgear. The amplitude of voltage steps shall be approximately 0.1 $U/\sqrt{3}$.

NOTE This procedure is under consideration by C.I.S.P.R.

The switchgear and controlgear shall be considered to have passed the test if the radio interference level at 1.1 $U/\sqrt{3}$ does not exceed 2 500 μV.

### 6.3 Temperature-rise tests

#### 6.3.1 *Conditions of the switching device to be tested*

Unless otherwise specified in the relevant publications, the temperature-rise test of the main circuits shall be made on a new switching device in the closed position with clean contacts.

#### 6.3.2 *Arrangement of the equipment*

The test shall be made indoors in an environment substantially free from air currents, except those generated by heat from the switching device being tested. In practice, this condition is reached when the air velocity does not exceed 0.5 m/s.

For temperature-rise tests of parts other than auxiliary equipment, the switching device and its accessories shall be mounted in all significant respects as in service, including all normal covers of any part of the switching device, and shall be protected against undue external heating or cooling.

When the switching device, according to the manufacturer's instructions, may be installed in different positions, the temperature-rise test shall be made in the most unfavourable position.

These tests shall be made in principle on three-pole switching devices but may be made on a single-pole or on a single unit provided the influence of the other poles or units is negligible. This is the general case for non-enclosed switchgear. For three-pole switching devices with a rated current not exceeding 630 A, the tests may be made with all poles connected in series.

For switching devices, particularly large switching devices, for which the insulation to earth has no significant influence on temperature rises, that insulation may be appreciably reduced.

Temporary connections to the main circuit shall be such that no significant amount of heat is conducted away from, or conveyed to, the switching device during the test. The temperature rise at the terminals of the main circuit, and at the temporary connections at a distance of 1 m from the terminals, shall be measured. The difference of temperature rise shall not exceed 5 °C. The type and sizes of the temporary connections shall be recorded in the test report.

NOTE To make the temperature-rise test more reproducible, type and/or sizes for the temporary connections may be specified in relevant publications.

For three-pole switching devices, the test shall be made in a three-phase circuit with the exceptions mentioned above.

The test shall be made with the rated normal current of the switching device. The supply current shall be practically sinusoidal.

Switching devices with the exception of d.c. auxiliary equipment are tested at rated frequency with a tolerance of + 2 % and – 5 %. The test frequency shall be recorded in the test report.

NOTE For convenience of testing, wider tolerances may be necessary. If these deviations are appreciable, i.e. when switching devices rated for 50 Hz are tested at 60 Hz and vice versa, care should be taken in the interpretation of results.

The test shall be made over a period of time sufficient for the temperature rise to reach a constant value. This condition is usually obtained when the increase of temperature rise does not exceed 1 K in 1 h. Special attention shall be paid to equipment with large thermal time constant.

The time for the whole test may be shortened by preheating the circuit with a higher value of current, except where the measurement of thermal time constant is required.

**6.3.3** ***Measurement of the temperature and the temperature rise***

Precautions shall be taken to reduce the variations and the errors due to the time lag between the temperature of the switching device and the variations in the ambient air temperature.

For coils, the method of measuring the temperature rise by variation of resistance shall normally be used. Other methods are permitted only if it is impracticable to use the resistance method.

The temperature of the various parts other than coils for which limits are specified shall be measured with thermometers or thermocouples, of any suitable type, placed at the hottest accessible point. The temperature rise shall be recorded at regular intervals throughout the test when the calculation of the thermal time constant is needed.

The surface temperature of a component immersed in a liquid dielectric shall be measured only by thermocouples attached to the surface of this component. The temperature of the liquid dielectric itself shall be measured in the upper layer of the dielectric.

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

a) the bulbs of the thermometers or thermocouples shall be protected against cooling from outside (dry clean wool, etc.). The protected area shall, however, be negligible compared with the cooling area of the apparatus under test.

b) good heat conductivity between the thermometer or thermocouple and the surface of the part under test shall be ensured;

c) when bulb thermometers are employed in places where there is any varying magnetic field, it is recommended to use alcohol thermometers in preference to mercury thermometers, as the latter are more liable to be influenced under these conditions.

**6.3.4** ***Ambient air temperature***

The ambient air temperature is the average temperature of the air surrounding the switching device (for enclosed switching devices, it is the air outside the enclosure). It shall be measured during the last quarter of the test period by means of at least three thermometers, thermocouples or other temperature-detecting devices equally distributed around the switching device at about the average height of its current-carrying parts and at a distance of about 1 m from the switching device. The thermometers or thermocouples shall be protected against air currents and undue influence of heat.

In order to avoid indication errors because of rapid temperature changes, the thermometers or thermocouples may be put into small bottles containing about half a litre of oil.

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

The ambient air temperature during tests shall be more than + 10 °C but less than + 40 °C. No correction of the temperature-rise values shall be made for ambient air temperatures within this range.

**6.3.5** ***Temperature-rise test of the auxiliary equipment***

The test is made with the specified supply (a.c. or d.c.) and for a.c. at its rated frequency (tolerance + 2 %, – 5 %).

NOTE For convenience of testing, wider tolerances may be necessary. If the deviations are appreciable, i.e. when auxiliary equipment rated for 50 Hz is tested at 60 Hz and vice versa, care should be taken in the interpretation of results.

The auxiliary equipment shall be tested at its rated supply voltage or at its rated current. The a.c. supply voltage shall be practically sinusoidal.

Continuously rated coils shall be tested over a period of time sufficient for the temperature rise to reach a constant value. This condition is usually obtained when the variation does not exceed 1 K in 1 h.

For circuits energized only during switching operations, the tests shall be made under the following conditions:

a) when the switching device has an automatic breaking device for interruption of the auxiliary circuit at the end of the operation, the circuit shall be energized ten times, for either 1 s or until the automatic breaking device operates, the interval between the instant of each energizing being 2 s or, if the construction of the switching device does not permit this, the lowest interval possible;

b) when the switching device has no automatic breaking device for interruption of the auxiliary circuit at the end of the operation, an additional test shall be made after cooling down by energizing the circuit once for a duration of 15 s.

**6.3.6** ***Interpretation of the temperature-rise tests***

The temperature rise of the various parts of the switching device or auxiliary equipment for which limits are specified, shall not exceed the values specified in Table V. Otherwise, the switching device shall be considered to have failed the test.

When the arcing contacts are bare copper contacts and are separate from but in parallel with the main contacts, the temperature rise of the main contacts shall not exceed the values given for them in Table V and the temperature rise of the arcing contacts shall not be so great as to cause damage to surrounding parts or impair the elasticity of the arcing contacts. If any doubt exists in this case that the current passing through the arcing contacts is small in comparison with the current in the main contacts, a second test is carried out by electrically insulating the arcing contacts. During this test the temperature rise of the main contacts shall not exceed the values given for them in Table V.

If the insulation of a coil is made of several different insulating materials, the permissible temperature rise of the coil shall be taken as that for the insulating material with the lowest limit of temperature rise.

If the switching device is fitted with various equipment complying with particular standards (for example, rectifiers, motors, low-voltage switches, etc.), the temperature rise of such equipment shall not exceed the limits specified in the relevant publications.

### 6.4 Measurement of the resistance of the main circuit

This measurement of the resistance of the main circuit shall be made for comparison between the switching device type tested for temperature rise and all other switching devices of the same type subjected to routine tests.

The measurement shall be made with d.c. by measuring the voltage drop or resistance across the terminals of each pole. Special consideration shall be given to enclosed switchgear (see the relevant publications).

The current during the test shall have any convenient value between 50 A and the rated normal current.

The measurement of the d.c. voltage drop or the resistance shall be made before the temperature-rise test, with the switching device at the ambient air temperature and after the temperature-rise test when the switching device has cooled to a temperature equal to the ambient air temperature. The measured resistances in these two tests shall not differ by more than 20 %.

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

### 6.5 Short-time withstand current and peak withstand current tests

Main circuits and, where applicable, the earthing circuits of the mechanical switching device shall be subjected to a test to prove their ability to carry the rated peak withstand current and the rated short-time withstand current.

The test shall be made at the rated frequency with a tolerance of ± 10 % at any suitable voltage and starting at any convenient ambient temperature.

NOTE For convenience of testing, wider tolerances of the rated frequency may be necessary. If the deviations are appreciable, i.e. when mechanical switching devices rated for 50 Hz are tested at 60 Hz and vice versa, care should be taken in the interpretation of results.

#### 6.5.1 *Arrangement of the mechanical switching device and of the test circuit*

The mechanical switching device shall be mounted on its own support or on an equivalent support and installed with its own operating device as far as necessary to make the test representative. It shall be in the closed position and fitted with clean contacts in new condition.

Each test shall be preceded by a no-load operation of the mechanical switching device.

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

— on a three-pole mechanical switching device, the test shall be made on two adjacent poles;

— in the case of a mechanical switching device with separate poles, the test may be made either on two adjacent poles or on one pole with the return conductor at phase distance. If the distance between poles is not fixed by the design, the test shall be made at the minimum distance indicated by the manufacturer;

— above a rated voltage of 72.5 kV, unless otherwise specified in the relevant publications, the return conductor need not be taken into account, but in no case shall it be located closer to the tested pole than the minimum distance indicated for phase centres by the manufacturer.

The connections to the terminals of the mechanical switching device shall be arranged in such a way as to avoid unrealistic stressing of the terminals. The distance between the terminals and the nearest supports of the conductors on both sides of the mechanical switching device shall be in accordance with the instructions of the manufacturer.

The test arrangement shall be noted in the test report.

#### 6.5.2 *Test current and duration*

The a.c. component of the test current shall in principle be equal to the a.c. component of the rated short-time withstand current of the mechanical switching device. The peak current (for a three-phase circuit, the highest value in one of the outer phases) shall be not less than the rated peak withstand current and shall not exceed it by more than 5 % without the consent of the manufacturer.

For three-phase tests, the current in any phase shall not vary from the average of the currents in the three phases by more than 10 % of the average.

The test current $I_t$ shall in principle be applied for a time $t_t$ equal to the rated duration $t$ of short circuit. The value of $I_t^2 t_t$ shall be determined from the oscillogram using the method of determining $I_t$ given in Appendix B or by an equivalent. The value of $I_t^2 t_t$ on test shall be not less than the rated value $I^2t$ and shall not exceed this value by more than 10 % without the consent of the manufacturer.

When, however, the characteristics of the test plant are such that the peak and r.m.s. values of test current specified above cannot be obtained in a test of the specified duration, the following deviations are permitted:

a) if the decrement of the short-circuit current of the test plant is such that the specified r.m.s. value, measured in accordance with Appendix B, or by an equivalent cannot be obtained for the rated duration without applying initially an excessively high current, the r.m.s. value of the test current may be permitted to fall below the specified value during the test and the duration of the test may be increased appropriately, provided that the value of the peak current is not less than that specified and the time is not more than 5 s;

b) if, in order to obtain the required peak current, the r.m.s. value of the current is increased above the specified value, the duration of the test may be reduced accordingly;

c) if neither a) nor b) is practicable, separation of the peak withstand current test and the short-time withstand current test is permissible. In this case two tests are made:

For the peak withstand current test, the time during which the short-circuit current is applied shall be not less than 0.3 s.

For the short-time withstand current test, the time during which the short-circuit current is applied shall be equal to the rated duration. However, deviation in time according to Item a) is permitted.

#### 6.5.3 *Behaviour of mechanical switching device during test*

All mechanical switching devices shall be capable of carrying their rated peak withstand current and their rated short-time withstand current without causing mechanical damage to any part or separation of the contacts.

It is recognized that, during the test, the temperature rise of current-carrying and adjacent parts of the mechanical switching device may exceed the limits specified in Table V. No temperature-rise limits are specified for the short-time current withstand tests but the maximum temperature reached should not be sufficient to cause significant damage to adjacent parts.

#### 6.5.4 *Conditions of mechanical switching device after test*

After the test, the mechanical switching device shall not show significant deterioration, shall be capable of operating normally, carrying its rated normal current continuously without exceeding the temperature-rise limits specified in Table V and withstanding the voltage specified under dielectric tests.

If the mechanical switching device has a rated making and/or breaking current, then the condition of the contacts shall not be such as to affect the performance materially at any making and/or breaking current up to its rated value.

No-load operation of the mechanical switching device immediately after the test followed by visual inspection of the contacts is usually sufficient to check these requirements.

## 7 Routine tests

The routine tests are for the purpose of revealing faults in material or construction. They do not impair the properties and reliability of a test object. These tests shall be carried out on each apparatus manufactured. By agreement, any routine test may be made on site.

The routine tests given in this standard comprise:

a) power-frequency voltage dry tests of the main circuit in accordance with Sub-clause **7.1**;

b) voltage tests on control and auxiliary circuits in accordance with Sub-clause **7.2**;

c) measurement of the resistance of the main circuit in accordance with Sub-clause **7.3**.

Additional routine tests may be necessary and will be specified in the relevant IEC standards.

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

### 7.1 Power-frequency voltage withstand dry tests on the main circuit

The test shall be made according to IEC 60-1, and to Sub-clause **6.1.1** on complete apparatus or on separate poles in new, clean and dry conditions.

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

The application of the test voltage is given in the relevant IEC standards. The test voltage shall be raised to the withstand value specified and maintained for 1 min.

The switchgear and controlgear shall be considered to have passed the test if no disruptive discharge occurs.

For switchgear and controlgear having a rated voltage lower than 300 kV, the test voltage shall be that specified in Table I, column 6 or 7, Table II and Table III, column 4 or 5 of Sub-clauses **4.2.1** and **4.2.2**, according to the relevant IEC standards.

For switchgear and controlgear having a rated voltage 300 kV and above, the test voltage shall be that specified in Table IV, column 7 of Sub-clause **4.2.3**, according to the relevant IEC standards.

### 7.2 Voltage withstand tests on auxiliary and control circuits

These tests shall be performed under the same conditions as prescribed in Sub-clause **6.1.10**.

For convenience of testing, the duration may generally be reduced to 1 s by agreement between manufacturer and user.

### 7.3 Measurement of the resistance of the main circuit

For the routine test, the d.c. voltage drop or resistance of each pole of the main circuit shall be measured under conditions as nearly as possible similar with regard to ambient air temperature and points of measurement to those under which the corresponding type test was made. The test current should be within the range stated above.

The measured resistance shall not exceed 1.2 $R_u$, where $R_u$ is equal to the resistance measured before the temperature-rise test.

## 8 Guide to the selection of switching devices for service

To be specified in the relevant IEC standards for switchgear and controlgear.

## 9 Information to be given with enquiries, tenders and orders

To be specified in the relevant IEC standards for switchgear and controlgear.

## 10 Rules for transport, storage, erection and maintenance

It is essential that the transport, storage and erection of switchgear and controlgear, as well as their maintenance in service, are performed in accordance with instructions given by the manufacturer.

Consequently, the manufacturer should provide instructions for the transport, storage, erection and maintenance of switchgear and controlgear. The instructions for the transport and storage should be given at a convenient time before delivery, and the instructions for the erection and maintenance should be given by the time of delivery at the latest.

It is impossible, here, to cover in detail the complete rules for the erection and maintenance of each of the different types of apparatus manufactured, but the following information is given relative to the most important points to be considered for the instructions provided by the manufacturer.

### 10.1 Conditions during transport, storage and erection

A special agreement should be made between manufacturer and user if the temperature and humidity conditions defined in the order, cannot be guaranteed during transport, storage and erection. Special precautions may be essential for the protection of insulation during transport, storage and erection, and prior to energizing, to prevent moisture absorption due, for instance, to rain, snow or condensation. Appropriate instructions should be given.

### 10.2 Erection

For each switchgear and controlgear the instructions provided by the manufacturer should at least include the items listed below:

#### 10.2.1 *Unpacking and lifting*

Required information for unpacking and lifting safely, including details of any special lifting and positioning devices which are necessary.

#### 10.2.2 *Assembly*

When the switchgear and controlgear is dismantled for transport, all parts should be clearly marked. Drawings showing assembly of these parts should be provided with the switchgear and controlgear.

#### 10.2.3 *Mounting*

Instructions for mounting of switchgear and controlgear, operating device and auxiliary equipment should include sufficient details of locations and foundations to enable site preparation to be completed.

These instructions should also indicate:

— the total mass of the apparatus inclusive of extinguishing or insulating fluids;

— the mass of extinguishing or insulating fluids;

— the mass of the heaviest part of the apparatus to be lifted separately if it exceeds 100 kg.

#### 10.2.4 *Connections*

Instructions should include information on:

a) connection of conductors, comprising the necessary advice to prevent overheating and unnecessary strain on the switchgear and controlgear and to provide adequate clearance distances;

b) connection of auxiliary circuits;

c) connection of liquid or gas systems, if any, including size and arrangement of piping;

d) connection for earthing.

#### 10.2.5 *Final installation inspection*

Instructions for inspection and tests which should be made after the switchgear and controlgear has been installed and all connections have been completed.

NOTE Special care should be taken if the switchgear and controlgear is not commissioned immediately after erection.

### 10.3 Maintenance

The manufacturer shall give information regarding the maintenance measure to be observed. The manufacturer should indicate the number of operations, time intervals or other appropriate criteria after which certain parts of the switchgear and controlgear shall be maintained.

The instructions given by the manufacturer should at least include items as listed below.

#### 10.3.1 *Main circuit*

Information should be given on the following items: the inspection, adjustment and renewal of contacts, the permissible arcing contact burning for switching devices having a rated short-circuit making or breaking current, the resistance value of the main circuit and the tolerances on the opening and closing times.

#### 10.3.2 *Liquid or gas for insulation or arc extinction*

Recommendations should be given for the following items: procedures for sampling, testing, drying and refilling, quality and freedom from contamination and an indication of the required quantity (for sulphur hexafluoride-filled equipment, see IEC Publication 480).

NOTE The instructions should include safety requirements, if any.

#### 10.3.3 *Operating device*

Maintenance procedures and adjustment values and tolerances should be provided for the operating device.

#### 10.3.4 *Auxiliary circuits, auxiliary equipment*

Instructions shall indicate which parts of the auxiliary circuits and auxiliary equipment should be checked.

#### 10.3.5 *Bearings*

Instructions shall indicate which bearings should be checked.

**10.3.6** ***Connections***

The manufacturer shall indicate which connections should be checked.

**10.3.7** ***Pneumatic and hydraulic systems***

The manufacturer shall indicate which pneumatic and hydraulic components should be checked.

**10.3.8** ***Lubrication and greasing***

Specifications for quality of oil and grease shall be given by the manufacturer.

**10.3.9** ***Pollution and corrosion***

Instructions for methods of cleaning and prevention of corrosion shall be given by the manufacturer.

**10.3.10** ***Spare parts and materials***

A list of recommended spare parts and materials which should be kept in stock by the user shall be provided by the manufacturer.

**10.3.11** ***Special tools***

A list of special tools, if any, necessary for assembly or overhaul, shall be provided by the manufacturer.

## Annex A (normative)
## Determination of minimum external creepage distances of outdoor insulators

The following procedure is recommended for outdoor ceramic or glass insulators used in high-voltage switchgear and controlgear:

The pollution severity level is defined according to Table I of IEC 815. A parameter "$I_f$" is introduced to represent the minimum nominal specific creepage distance for each pollution level according to Table A.1:

**Table A.1**

| Pollution level | | Minimum nominal specific creepage distance $I_f$, mm/kV |
|---|---|---|
| I | Light | 16 |
| II | Medium | 20 |
| III | Heavy | 25 |
| IV | Very heavy | 31 |

The minimum nominal specific creepage distance "$I_f$" is the ratio of the creepage distance measured between phase and earth over the r.m.s. phase-to-phase value of the highest voltage for the equipment (see IEC 71-1). It is the lowest value of specific creepage distance which is recommended for a particular pollution level.

The required creepage distance is determined as follows: the minimum nominal creepage distance of an insulator situated between phase and earth, between phases or across the terminals of a pole of a circuit-breaker or a switch, is determined by the relation:

$$L = a \cdot I_f \cdot U \cdot k_D$$

where

$L$ is the minimum nominal creepage distance in millimetres;

$a$ is an application factor selected in relation to the type of insulation according to Table A.2;

$I_f$ is the minimum nominal specific creepage distance according to Table A.1;

$U$ is the highest system voltage phase-to-phase for the equipment;

$k_D$ is the correction factor due to diameter according to **5.3** of IEC 815.

**Table A.2**

| Application of insulation | Application factor, $a$ |
|---|---|
| Between phase and earth | 1,0 |
| Between phases | $\sqrt{3}$ |
| Across open contacts of a circuit-breaker or a switch | 1,0 |

NOTE 1 Circuit-breakers in synchronizing applications may need somewhat longer creepage distance across the open contact. An application factor $a$ = 1,15 has been suggested for such applications.
NOTE 2 Horizontal insulators covered with melting polluted snow may require a longer creepage distance.
NOTE 3 For the actual creepage distance, the specified manufacturing tolerances are applicable. See IEC 273 and IEC 233.

## Appendix B Determination of the equivalent r.m.s. value of a short-time current during a short-circuit of a given duration

The method illustrated in Figure 5, page 78, should be used to determine the short-time current.

The total time $t_t$ of the test is divided into ten equal parts by verticals 0 to 10 and the r.m.s. value of the a.c. component of the current is measured at these verticals.

These values are designated

$Z_0, Z_1 \ldots Z_{10}$

where:

$Z = X/\sqrt{2}$

and $X$ = peak value of a.c. component of current.

The equivalent r.m.s. current during the time $t_t$ is given by:

$$\sqrt{1/30\,[Z_0^2 + 4\,(Z_1^2 + Z_3^2 + Z_5^2 + Z_7^2 + Z_9^2) + 2\,(Z_2^2 + Z_4^2 + Z_6^2 + Z_8^2) + Z_{10}^2]}$$

The d.c. component of current represented by $CC'$ is not taken into account.

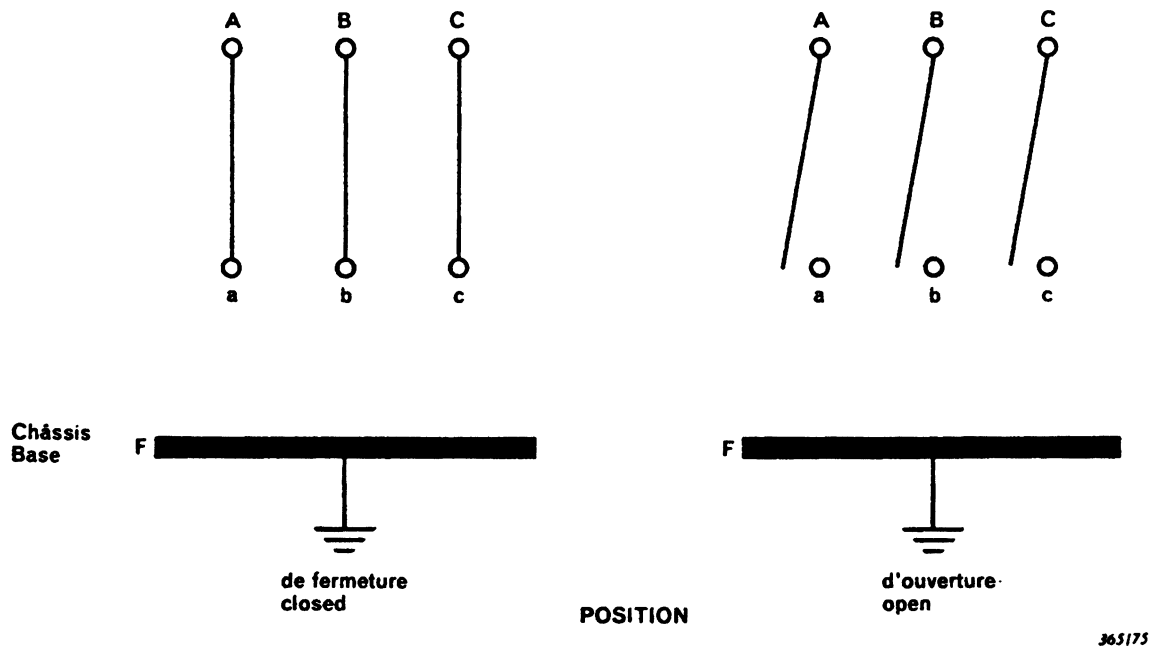
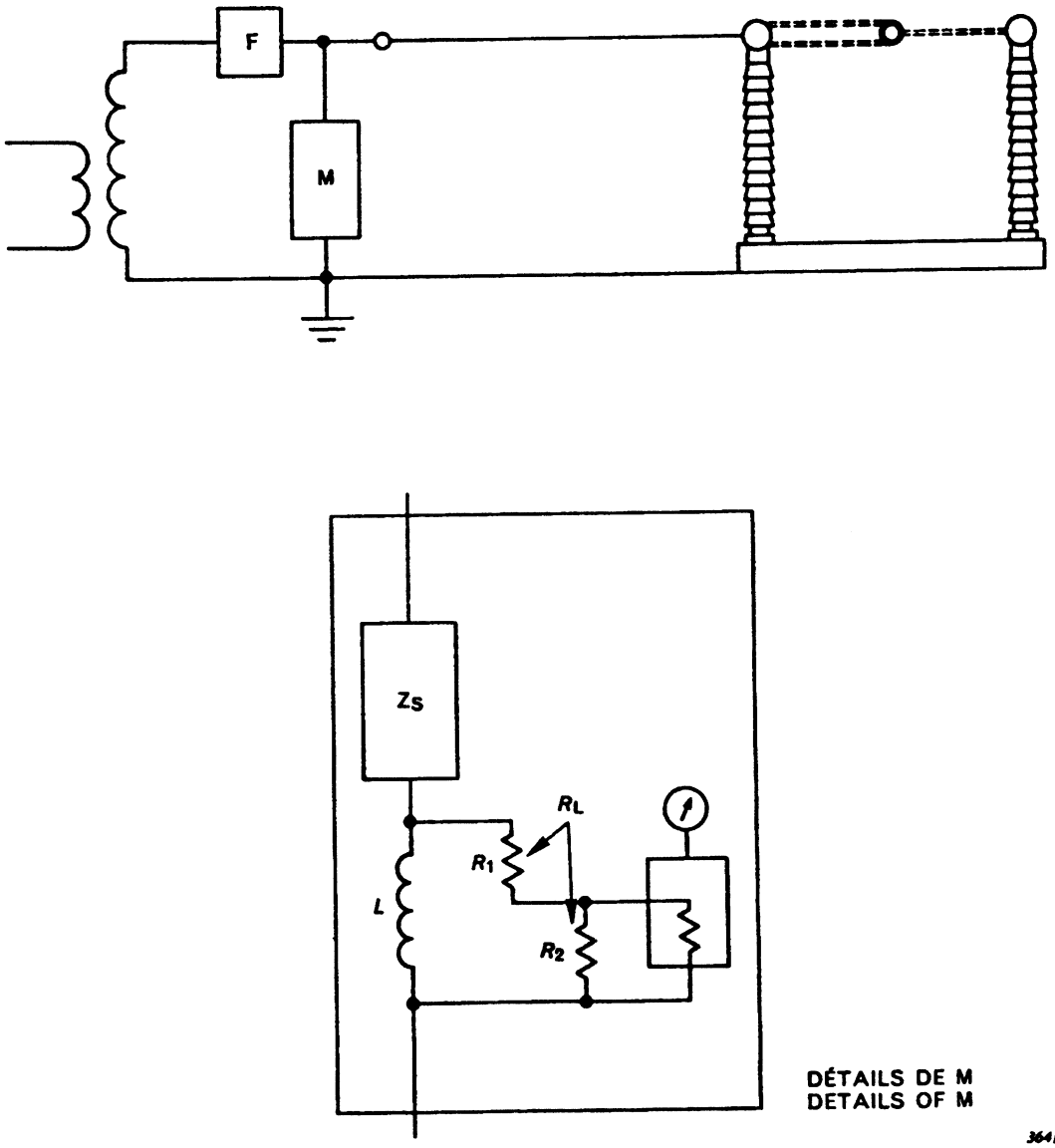



**Figure 1 — Diagram of connections of a three-pole switching device**



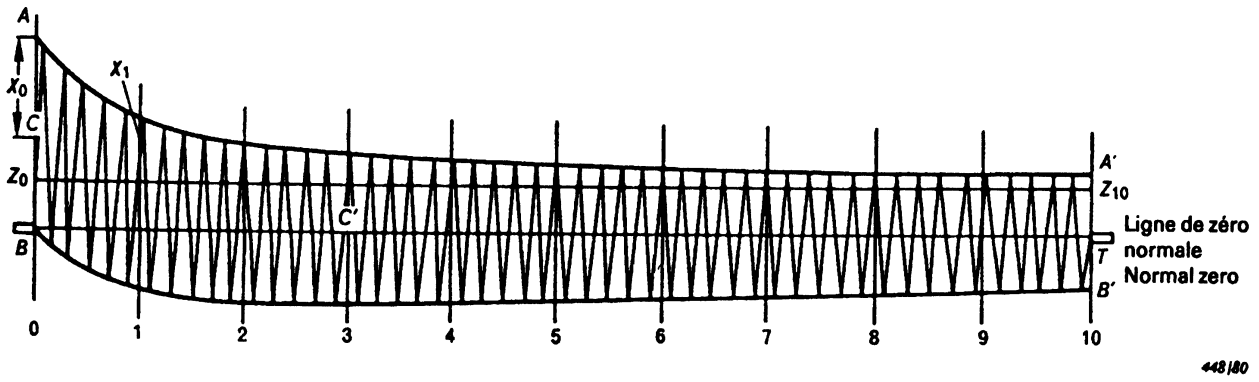

F = filter

$R_L$ = the equivalent resistance of $R_1$ in series with the parallel combination of $R_2$ and the equivalent resistance of the measuring set

$Z_S$ = may be either a capacitor or a circuit composed of a capacitor and an inductor in series

$L$ = the impedance used to shunt power-frequency currents and to compensate for stray capacitance at the measuring frequency

**Figure 2 — Diagram of a test circuit for the radio-interference voltage test of switching devices**




$AA'$ } = Envelope of current wave
$BB'$ }

$CC'$ = Displacement of current wave zero line from normal zero line at any instant.

$Z_1\ Z_{10}$ = R.M.S. value of a.c. component of current at any instant measured from normal zero; d.c. component is neglected.

$X_0$ = Peak value of a.c. component of current at instant of initiating short-circuit.

$X_1$ = Peak value of a.c. component of current at time division 1.

$t_t = BT'$ = Duration of short-circuit.

**Figure 3 — Determination of short-time current**

## Annex ZA (normative)
## Special national conditions

**Special national condition**: National characteristic or practice that cannot be changed even over a long period, e.g. climatic conditions, electrical earthing conditions. If it affects harmonization, it forms part of the European Standard or Harmonization Document.

For the countries in which the relevant special national conditions apply these provisions are normative, for other countries they are informative.

**Belgium**

*Rated voltages*

These are appreciable discrepancies between actual network voltages and the next highest IEC rated voltages, two additional rated voltages are permitted, those being 41,5 kV and 82,5 kV.

The rated lightning impulse withstand voltage and the rated one minute power-frequency withstand voltage related to these values are given in the table below.

| **Rated voltage** *U* (r.m.s. value) (kV) | **Rated lightning impulse withstand voltage** (peak value) | | | | **Rated 1 min power-frequency withstand voltage** (r.m.s. value) | |
|---|---|---|---|---|---|---|
| | **List 1** | | **List 2** | | | |
| | **To earth, between poles and across open switching device** (kV) | **Across the isolating distance** (kV) | **To earth, between poles and across open switching device** (kV) | **Across the isolating distance** (kV) | **To earth, between poles and across open switching device** (kV) | **Across the isolating distance** (kV) |
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
| 41,5 | 170 | 195 | 200 | 230 | 80 | 92 |
| 82,5 | 380 | 440 | 380 | 440 | 150 | 175 |

## Annex ZB (normative)
## Other international publications quoted in this standard with the references of the relevant European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For publications apply to this European Standard only when incorporated in it by amendment or revision. For dated references, subsequent amendments to or revisions of any of these undated references the latest edition of the publication referred to applies.

NOTE When the international publication has been modified by CENELEC common modifications, indicated by (mod), the relevant EN/HD applies.

| IEC publication | Date | Title | EN/HD | Date |
|---|---|---|---|---|
| 38 | 1975[a] | *IEC standard voltages* | — | — |
| 50(441) | 1974 | *International Electrotechnical Vocabulary* (IEV) Chapter 441: *Switchgear, controlgear and fuses* | — | — |
| 59 | 1938 | *IEC standard current ratings* | — | — |
| 60 | series | *High-voltage test techniques* | HD 588.1 S1<br>EN 60060-2 | 1991<br>1994 |
| 71-1 | 1976 | *Insulation co-ordination* Part 1: *Terms, definitions, principles and rules* | — | — |
| 71-2 | 1976 | Part 2: *Application guide* | HD 540.2 S1 | 1991 |
| 71-3 | 1982 | Part 3: *Phase-to-phase insulation co-ordination — Principles, rules and application guide* | HD 540.3 S1 | 1991 |
| 85 | 1957[b] | *Recommendations for the classification of materials for the insulation of electrical machinery and apparatus in relation to their thermal stability in service* | — | — |
| 117-1 | 1960 | *Recommended graphical symbols* Part 1: *Kind of current, distribution systems, methods of connection and circuit elements* | — | — |
| 270 | 1968 | *Partial discharge measurements* | — | — |
| 296 | 1969 | *Specification for new insulating oils for transformers and switchgear* | — | — |
| 376 | 1971 | *Specification and acceptance of new sulphur hexafluoride* | — | — |
| 480 | 1974 | *Guide to the checking of sulphur hexafluoride (SF6) taken from electrical equipment* | — | — |
| 507 | 1975[c] | *Artificial pollution tests on high-voltage insulators to be used on a.c. systems* | — | — |

**Other publication:**

CISPR 16 — CISPR *Specification for radio interference measuring apparatus and measuring methods*

[a] IEC 38:1983 is harmonized as HD 472 S1:1989. The title of HD 472 S1 is: *Nominal voltages for low public electricity supply systems*
[b] IEC 85:1984 is harmonized as HD 566 S1:1990.
[c] IEC 507:1991 is harmonized as EN 60507:1993.

# List of references

See national foreword.

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