IEC 62271-110

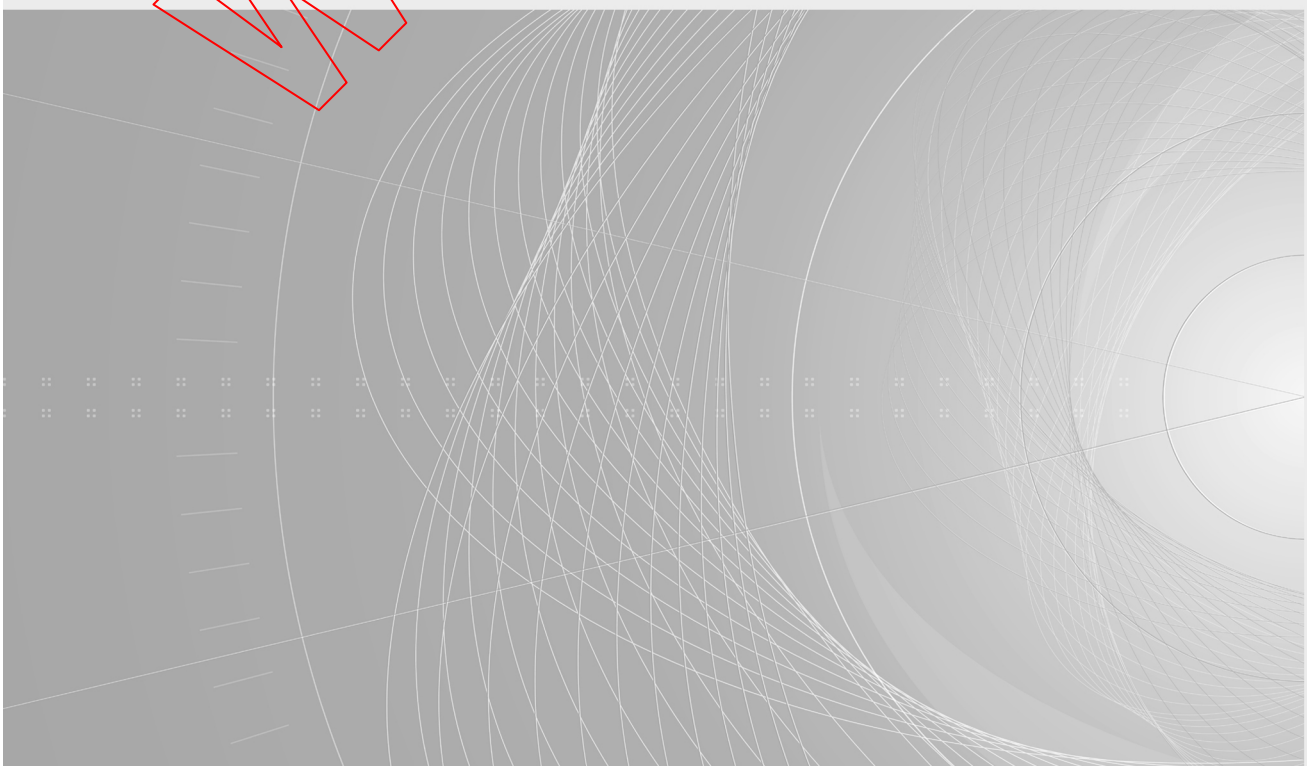
Edition 2.0 2009-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

High-voltage switchgear and controlgear –
Part 110: Inductive load switching

Appareillage à haute tension –
Partie 110: Manœuvre de charges inductives



IEC 62271-110:2009

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.
- IEC Just Published: www.iec.ch/online_news/justpub
Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.
- Electropedia: www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.
- Customer Service Centre: www.iec.ch/webstore/custserv
If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm
Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.
- Just Published CEI: www.iec.ch/online_news/justpub
Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.
- Electropedia: www.electropedia.org
Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.
- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:
Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 62271-110

Edition 2.0 2009-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

High-voltage switchgear and controlgear – Part 110: Inductive load switching

Appareillage à haute tension – Partie 110: Manœuvre de charges inductives

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX T

ICS 29.130.10

ISBN 978-2-88910-656-1

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 110: Inductive load switching

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62271-110 has been prepared by subcommittee 17A: High-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This second edition cancels and replaces the first edition dated 2005 and constitutes an editorial revision. The main changes from the first edition are that all references to IEC 60694 have been replaced with IEC 62271-1.

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

FDIS	Report on voting
17A/843/FDIS	17A/856/RVD

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

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

This standard is to be read in conjunction with IEC 62271-1, first edition, published in 2007, and with IEC 62271-100, second edition, published in 2008, to which it refers and which are applicable, unless otherwise specified. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1 and IEC 62271-100. Additional subclauses are numbered from 101.

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 110: Inductive load switching

1 General

1.1 Scope

This International Standard is applicable to a.c. circuit-breakers designed for indoor or outdoor installation, for operation at frequencies of 50 Hz and 60 Hz on systems having voltages above 1000 V and applied for inductive current switching with or without additional short-circuit current breaking duties. The standard is applicable to circuit-breakers in accordance with IEC 62271-100 that are used to switch high-voltage motor currents and shunt reactor currents and also to high-voltage contactors used to switch high-voltage motor currents [2].

Switching unloaded transformers, i.e. breaking transformer magnetizing current, is not considered in this standard. The reasons for this are as follows:

a) due to the non-linearity of the transformer core, it is not possible to correctly model the switching of transformer magnetizing current using linear components in a test laboratory. Tests conducted using an available transformer, such as a test transformer, will only be valid for the transformer tested and cannot be representative for other transformers;

b) as detailed in CIGRE Technical Brochure 305 [1], the characteristics of this duty are usually less severe than any other inductive current switching duty. It should be noted that such a duty may produce severe overvoltages within the transformer winding(s) depending on the circuit-breaker re-ignition behaviour and transformer winding resonance frequencies.

Short-line faults, out-of-phase current making and breaking and capacitive current switching are not applicable to circuit-breakers applied to switch shunt reactors or motors. These duties are therefore not included in this standard.

Subclause 1.1 of IEC 62271-100 is otherwise applicable.

1.2 Normative references

Subclause 1.2 of IEC 62271-100 is applicable with the following addition:

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

2 Normal and special service conditions

Clause 2 of IEC 62271-1 is applicable.

3 Definitions

For the purposes of this document, the definitions of IEC 60050(441) and IEC 62271-1 apply.

4 Ratings

Clause 4 of IEC 62271-100 is applicable except for the references to short-line faults, out-of-phase making and breaking, capacitive current switching and as noted in specific subclauses below.

4.1 Rated voltage (U_r)

Subclause 4.1 of IEC 62271-1 is applicable.

4.2 Rated insulation level

Subclause 4.2 of IEC 62271-1 is applicable with the following addition:

The rated values stated in Tables 1a and 1b and Tables 2a and 2b of IEC 62271-1 are applicable with the exception of column (8) in the latter two tables.

NOTE 1 The reason for this exception is the passive nature of the shunt reactor load circuit.

NOTE 2 In some cases (high chopping overvoltage levels, or where a neutral reactor is present or in cases of shunt reactors with isolated neutral), it may be necessary to specify an appropriate insulation level which is higher than the rated values given in Tables 1a, 1b, 2a and 2b.

4.3 Rated frequency (f_r)

Subclause 4.3 of IEC 62271-1 is applicable with the following addition:

The standard values for the rated frequency of high voltage circuit-breakers are 50 Hz and 60 Hz.

4.4 Rated normal current (I_r) and temperature rise

Subclause 4.4 of IEC 62271-1 is applicable.

4.5 Rated short-time withstand current (I_k)

Subclause 4.5 of IEC 62271-100 is applicable.

4.6 Rated peak withstand current (I_p)

Subclause 4.6 of IEC 62271-100 is applicable.

4.7 Rated duration of short-circuit (t_k)

Subclause 4.7 of IEC 62271-100 is applicable.

4.8 Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a)

Subclause 4.8 of IEC 62271-1 is applicable.

4.9 Rated supply frequency of closing and opening devices and auxiliary circuits

Subclause 4.9 of IEC 62271-1 is applicable.

4.10 Rated pressure of compressed gas supply for insulation, operation and/or interruption

Subclause 4.10 of IEC 62271-1 is applicable.

4.101 Rated short-circuit breaking current (I_{sc})

Subclause 4.101 of IEC 62271-100 is applicable.

4.102 Transient recovery voltage related to the rated short-circuit breaking current

Subclause 4.102 of IEC 62271-100 is applicable.

4.103 Rated short-circuit making current

Subclause 4.103 of IEC 62271-100 is applicable.

4.104 Rated operating sequence

Subclause 4.104 of IEC 62271-100 is applicable.

4.108 Inductive load switching

This standard is applicable.

4.109 Rated time quantities

Subclause 4.109 of IEC 62271-100 is applicable.

4.110 Number of mechanical operations

Subclause 4.110 of IEC 62271-100 is applicable.

5 Design and construction

Clause 5 of IEC 62271-100 is applicable.

6 Type tests

6.1 General

Subclause 6.1 of IEC 62271-100 is applicable with the following addition:

Inductive current switching tests performed for a given current rating and type of application may be considered valid for another current rating and same type of application as detailed below:

a) for high-voltage shunt reactor switching at rated voltage 52 kV and above, tests at a particular current rating are to be considered valid for applications up to the tested current value +20 %;

b) for shunt reactor switching at rated voltage below 52 kV, no type testing is required and reference should be made to the guide [1];

c) for high-voltage motor switching, no further type testing is considered necessary for stalled motor currents between 100 A and 300 A or for stalled motor currents between 300 A and the current associated with the short-circuit current of test duty T10 according to 6.106.1 of IEC 62271-100.

6.2 Dielectric test

Subclause 6.2 of IEC 62271-100 is applicable with the following addition:

Refer to 4.2 of this standard.

6.3 Radio interference voltage (r.i.v.) tests

Subclause 6.3 of IEC 62271-1 is applicable.

6.4 Measurement of the resistance of the main circuit

Subclause 6.4 of IEC 62271-1 is applicable.

6.5 Temperature-rise tests

Subclause 6.5 of IEC 62271-1 is applicable.

6.6 Short-time withstand current and peak withstand current tests

Subclause 6.6 of IEC 62271-1 is applicable.

6.7 Verification of protection

Subclause 6.7 of IEC 62271-1 is applicable.

6.8 Tightness tests

Subclause 6.8 of IEC 62271-1 is applicable.

6.9 Electromagnetic compatibility (EMC) tests

Subclause 6.9 of IEC 62271-1 is applicable.

6.101 Mechanical and environmental tests

Subclause 6.101 of IEC 62271-100 is applicable.

6.102 Miscellaneous provisions for making and breaking tests

Subclause 6.102 of IEC 62271-100 is applicable with the following addition:

High-voltage motor current and shunt reactor switching tests shall be performed at rated auxiliary and control voltage or, where necessary, at maximum auxiliary and control voltage to facilitate consistent control of the opening and closing operation according to 6.102.3.1 of IEC 62271-100 and at rated functional pressure for interruption and insulation. For gas circuit-breakers shunt reactor switching tests shall also be performed at the minimum functional pressure for interruption and insulation.

6.103 Test circuits for short-circuit making and breaking tests

Subclause 6.103 of IEC 62271-100 is applicable.

6.104 Short-circuit test quantities

Subclause 6.104 of IEC 62271-100 is applicable.

6.105 Short-circuit test procedures

Subclause 6.105 of IEC 62271-100 is applicable.

6.106 Basic short-circuit test duties

Subclause 6.106 of IEC 62271-100 is applicable.

6.107 Critical current tests

Subclause 6.107 of IEC 62271-100 is applicable.

6.108 Single-phase and double-earth fault tests

Subclause 6.108 of IEC 62271-100 is applicable.

NOTE Subclauses 6.109 to 6.112 of IEC 62271-100 are not applicable to this standard.

6.114 High-voltage motor current switching tests

6.114.1 Applicability

This subclause is applicable to three-phase alternating current circuit-breakers having rated voltages above 1 kV and up to 17,5 kV, which are used for switching high-voltage motors. Tests may be carried out at 50 Hz with a relative tolerance of ±10 % or 60 Hz with a relative tolerance of ±10 %, both frequencies being considered equivalent.

Motor switching tests are applicable to all three-pole circuit-breakers having rated voltages equal to or less than 17,5 kV, which may be used for the switching of three-phase asynchronous squirrel-cage or slip-ring motors. The circuit-breaker may be of a higher rated voltage than the motor when connected to the motor through a stepdown transformer. However, the more usual application is a direct cable connection between circuit-breaker and motor. When tests are required, they shall be made in accordance with 6.114.2 to 6.114.9.

No limits to the overvoltages are given as the overvoltages are only relevant to the specific application. Overvoltages between phases may be as significant as phase-to-earth overvoltages.

6.114.2 General

The switching tests can be either field tests or laboratory tests. As regards overvoltages, the switching of the current of a starting or stalled motor is usually the more severe operation.

Due to the non-linear behaviour of the motor iron core, it is not possible to exactly model the switching of motor current using linear components in a test station. Tests using linear components to simulate the motors can be considered to be more conservative than switching actual motors.

For laboratory tests a standardized circuit simulating the stalled condition of a motor is specified (refer to Figure 1). The parameters of this test circuit have been chosen to represent a relatively severe case with respect to overvoltages and will cover the majority of service applications.

The laboratory tests are performed to prove the ability of a circuit-breaker to switch motors and to establish its behaviour with respect to switching overvoltages, re-ignitions and current chopping. These characteristics may serve as a basis for estimates of the circuit-breaker performance in other motor circuits. Tests performed with the test currents defined in 6.114.3 and 6.114.4 demonstrate the capability of the switching device to switch high-voltage motors up to its rated interrupting current.

For field tests, actual circuits are used with a supply system on the source side and a cable and motor on the load side. There may be a transformer between the circuit-breaker and

motor. However, the results of such field tests are only valid for circuit-breakers working in circuits similar to those during the tests.

The apparatus under test includes the circuit-breaker with overvoltage protection devices if they are normally fitted.

NOTE 1 Overvoltages may be produced when switching running motors. This condition is not represented by the substitute circuit, but is regarded as less severe.

NOTE 2 The starting period switching of a slip-ring motor is generally less severe due to the effect of the starting resistor.

NOTE 3 The rated voltage of the circuit-breaker may differ from that of the motor.

6.114.3 Characteristics of the supply circuits

6.114.3.1 General

A three-phase supply circuit shall be used. The tests shall be performed using two different supply circuits A and B as specified in 6.114.3.2 and 6.114.3.3, respectively. Supply circuit A represents the case of a motor connected directly to a transformer. Supply circuit B represents the case where parallel cables are applied on the supply side.

6.114.3.2 Supply circuit A

The three-phase supply may be earthed through a high ohmic impedance so that the supply voltage is defined with respect to earth. The impedance value shall be high enough to limit a prospective line-to-earth fault current to a value below the test current.

The source inductance L_s shall not be lower than that corresponding to the rated short-circuit breaking current of the tested circuit-breaker. Its impedance shall also be not higher than 0,1 times the impedance of the inductance in the load circuit (see 6.114.4).

The supply side capacitance C_s is represented by three capacitors connected in earthed star. Their value, including the natural capacitance of the circuit shall be 0,04 µF ± 0,01 µF. The inductance L_{b1} of the capacitors and connections shall not exceed 2 µH.

The busbar inductance is represented by three bars forming a busbar each 6 m ± 1 m in length and spaced at a distance appropriate to the rated voltage.

6.114.3.3 Supply circuit B

As supply circuit A with the value of the supply side capacitance increased to 1,75 µF ± 0,25 µF.

6.114.4 Characteristics of the load circuit

6.114.4.1 General

A three-phase load circuit shall be used. The motor substitute circuit is connected to the circuit-breaker under test by 100 m ± 10 m of screened cable. It is recommended that the cable be connected directly to the terminals of the motor or substitute circuit.

The inductance of any intermediate connection should not exceed 3 µH. The shield of the cable shall be earthed at both ends. The tests shall be performed using two different motor substitute circuits as specified in 6.114.4.2 and 6.114.4.3. The inductance L_{b2} of the connections between the circuit-breaker and cable shall not exceed 5 µH.

6.114.4.2 Motor substitute circuit 1

Series-connected resistance and inductance shall be arranged to obtain a current of 100 A ± 10 A at a power factor less than 0,2 lagging. The star point shall not be connected to earth. Resistance R_p shall be connected in parallel with each phase impedance and capacitance C_p between each phase and earth so that the motor substitute circuit has a natural frequency of 12,5 kHz ± 2,5 kHz and an amplitude factor of 1,7 ± 0,1 measured in each phase with the other two phases connected to earth. The prospective transient recovery voltages values shall be determined in accordance with Annex F of IEC 62271-100. A transformer may be introduced at the load end of the cable. This shall be considered as part of the motor substitute circuit.

6.114.4.3 Motor substitute circuit 2

As motor substitute circuit 1, but with the series resistance and inductance reduced to obtain a current of 300 A ± 30 A at a power factor less than 0,2 lagging. The prospective transient recovery voltage shall be as specified for motor substitute circuit 1.

6.114.5 Test voltage

a) The average value of the applied voltages shall be not less than the rated voltage U_r divided by $\sqrt{3}$ and shall not exceed this value by more than 10 % without the consent of the manufacturer.

   The differences between the average value and the applied voltages of each pole shall not exceed 5 %.

   The rated voltage U_r is that of the circuit-breaker when using the substitute circuit, but is that of the motor when an actual motor is used.

b) The power frequency recovery voltage of the test circuit may be stated as a percentage of the power frequency recovery voltage specified below. It shall not be less than 95 % of the specified value and shall be maintained in accordance with Subclause 6.104.7 of IEC 62271-100.

   The average value of the power frequency recovery voltages shall not be less than the rated voltage U_r of the circuit-breaker divided by $\sqrt{3}$.

   The power frequency recovery voltage of any pole should not deviate by more than 20 % from the average value at the end of the time for which it is maintained.

   The power frequency recovery voltage shall be measured between terminals of a pole in each phase of the test circuit. Its r.m.s. value shall be determined on the oscillogram within the time interval of one half cycle and one cycle of test frequency after final arc extinction, as indicated in Figure 44 of IEC 62271-100. The vertical distance (V_1, V_2 and V_3 respectively) between the peak of the second half-wave and the straight line drawn between the respective peaks of the preceding and succeeding half-waves shall be measured, and this, when divided by $2\sqrt{2}$ and multiplied by the appropriate calibration, gives the r.m.s. value of the recorded power frequency recovery voltage.

6.114.6 Test duties

The motor current switching tests shall consist of four test duties as specified in Table 1.

Table 1 – Test duties at motor current switching tests

Test duty	Supply circuit	Motor substitute circuit
1	A	1
2	A	2
3	B	1
4	B	2

The number of tests for each test duty shall be:

– 20 tests with the initiation of the closing and tripping impulses distributed at intervals of approximately 9 electrical degrees.

The above tests shall be make-breaks or separate makes and breaks except that when using an actual motor they shall only be make-breaks. When tests are made using the motor substitute circuit, the contacts of the circuit-breaker shall not be separated until any d.c. component has become less than 20 %. When switching an actual motor, a make-break time of 200 ms is recommended.

6.114.7 Test measurements

At least the following quantities shall be recorded by oscillograph or other suitable recording techniques with bandwidth and time resolution high enough to measure the following:

– power frequency voltage;
– power frequency current;
– phase-to-earth voltage, at the motor or motor substitute circuit terminals, in all three phases.

6.114.8 Behaviour and condition of circuit-breaker

The criteria for successful testing are as follows:

a) the behaviour of the circuit-breaker during the motor switching tests fulfils the conditions given in 6.102.8 of IEC 62271-100 as applicable;
b) voltage tests shall be performed in accordance with 6.2.11 of IEC 62271-100;
c) re-ignitions shall take place between the arcing contacts.

6.114.9 Test report

In addition to the requirements of Annex C of IEC 62271-100, the test report shall include a thorough description of the circuit, including the following details:

– main dimensions and characteristics of the bus and connections to the circuit-breaker;
– the characteristics of the cable:
  – length;
  – rated values;
  – type;
  – main insulation dielectric – XLPE, paper/oil, etc.;
  – earthing;
  – capacitances;
  – surface impedance.
– the parameters of the substitute motor circuit: