IEC 62271-101

Edition 2.0 2012-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

High-voltage switchgear and controlgear – Part 101: Synthetic testing

Appareillage à haute tension – Partie 101: Essais synthétiques

IEC 62271-101:2012

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

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
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.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,…).
It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

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.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,…).
Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 62271-101

Edition 2.0 2012-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

High-voltage switchgear and controlgear –
Part 101: Synthetic testing

Appareillage à haute tension –
Partie 101: Essais synthétiques

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.130.10

ISBN 978-2-83220-421-4

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 101: Synthetic testing

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 62271-101 has been prepared by subcommittee 17A: High-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This second edition cancels and replaces the first edition published in 2006 and its Amendment 1 published in 2010. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the first edition:

- addition of the new rated voltages of 1 100 kV and 1 200 kV;
- revision of Annex F regarding circuit-breakers with opening resistors;
- alignment with the second edition of IEC 62271-100:2008 and its Amendment 1 (2012).

The text of this standard is based on the first edition of IEC 62271-101 and the following documents:

FDIS	Report on voting
17A/1015/FDIS	17A/1024/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 publication shall be read in conjunction with IEC 62271-100, published in 2008, to which it refers. The numbering of the subclauses of Clause 6 is the same as in IEC 62271-100. However, not all subclauses of IEC 62271-100 are addressed; merely those where synthetic testing has introduced changes.

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 stability 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 101: Synthetic testing

1 Scope

This part of IEC 62271 mainly applies to a.c. circuit-breakers within the scope of IEC 62271-100. It provides the general rules for testing a.c. circuit-breakers, for making and breaking capacities over the range of test duties described in 6.102 to 6.111 of IEC 62271-100:2008, by synthetic methods.

It has been proven that synthetic testing is an economical and technically correct way to test high-voltage a.c. circuit-breakers according to the requirements of IEC 62271-100 and that it is equivalent to direct testing.

The methods and techniques described are those in general use. The purpose of this standard is to establish criteria for synthetic testing and for the proper evaluation of results. Such criteria will establish the validity of the test method without imposing restraints on innovation of test circuitry.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62271-100:2008, *High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*
Amendment 1:2012

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62271-100, as well as the following, apply.

3.1
direct test
test in which the applied voltage, the current and the transient and power-frequency recovery voltages are all obtained from a circuit having a single-power source, which may be a power system or special alternators as used in short-circuit testing stations or a combination of both

3.2
synthetic test
test in which all of the current, or a major portion of it, is obtained from one source (current circuit), and in which the applied voltage and/or the recovery voltages (transient and power frequency) are obtained wholly or in part from one or more separate sources (voltage circuits)

3.3
test circuit-breaker
circuit-breaker under test

SEE: 6.102.3 of IEC 62271-100:2008.

3.4
auxiliary circuit-breaker
circuit-breaker forming part of a synthetic test circuit used to put the test circuit-breaker into the required relation with various circuits

3.5
current circuit
that part of the synthetic test circuit from which all or the major part of the power-frequency current is obtained

3.6
voltage circuit
that part of the synthetic test circuit from which all or the major part of the applied voltage and/or recovery voltage is obtained

3.7
prospective current (of a circuit and with respect to a circuit-breaker)
current that would flow in the circuit if each pole of the test and auxiliary circuit-breakers were replaced by a conductor of negligible impedance

[SOURCE: IEC 60050-441:1984, 441-17-01, modified]

3.8
actual current
current through the test circuit-breaker (prospective current modified by the arc voltage of the test and auxiliary circuit-breakers)

3.9
distortion current
calculated current equal to the difference between the prospective current and the actual current

3.10
post-arc current
current which flows through the arc gap of a circuit-breaker when the current and arc voltage have fallen to zero and the transient recovery voltage has begun to rise

3.11
current-injection method
synthetic test method in which the voltage circuit is applied to the test circuit-breaker before power-frequency current zero

3.12
initial transient making current
ITMC
transient current which flows through the circuit-breaker at the moment of voltage breakdown prior to the initiation of current from the current circuit during making

3.13
injected current
current supplied by the voltage circuit of a current injection circuit when it is connected to the circuit-breaker under test

3.14
voltage-injection method
synthetic test method in which the voltage circuit is applied to the test circuit-breaker after power frequency current zero

3.15
reference system conditions
conditions of an electrical system having the parameters from which the rated and test values of IEC 62271-100 are derived

3.16
time delay of making device
t_m
time interval, during synthetic making test, between the instant of breakdown of the applied voltage and the initiation of current from the current circuit

3.17
minimum clearing time
sum of the minimum opening time, minimum relay time (0,5 cycle), and the minimum arcing time at current interruption after the minor loop of the first-pole-to-clear, during test duty T100a only, as declared by the manufacturer

NOTE This definition should be used only for the determination of the test parameters during short-circuit breaking tests according to test duty T100a.

[SOURCE: 3.7.159 of IEC 62271-100:2008]

3.18
pre-strike
voltage breakdown between the contacts during a making operation which initiates current flow

4 Synthetic testing techniques and methods for short-circuit breaking tests

4.1 Basic principles and general requirements for synthetic breaking test methods

4.1.1 General

Any particular synthetic method chosen for testing shall adequately stress the test circuit-breaker. Generally, the adequacy is established when the test method meets the requirements set forth in the following subclauses.

A circuit-breaker has two basic positions: closed and open. In the closed position a circuit-breaker conducts full current with negligible voltage drop across its contacts. In the open position it conducts negligible current but with full voltage across the contacts. This defines the two main stresses, the current stress and the voltage stress, which are separated in time.

If closer attention is paid to the voltage and current stresses during the interrupting process (Figure 1), three main intervals can be recognized:

– High-current interval

  The high-current interval is the time from contact separation to the start of the significant change in arc voltage. The high-current interval precedes the interaction and high-voltage intervals.

– Interaction interval

  The interaction interval is the time from the start of the significant change in arc voltage prior to current zero to the time when the current including the post-arc current, if any, ceases to flow through the test circuit-breaker (see also Clause B.2).

– High-voltage interval

  The high-voltage interval is the time from the moment when the current including the post-arc current, if any, ceases to flow through the test circuit-breaker to the end of the test.

4.1.2 High-current interval

During the high-current interval the test circuit-breaker shall be stressed by the test circuit in such a way that the starting conditions for the interaction interval, within tolerances to be specified, are the same as under reference system conditions.

In synthetic test circuits the ratio of the power-frequency voltage of the current circuit to the arc voltage is low in comparison with tests at reference system conditions due to:

– the voltage of the current circuit being a fraction of the system voltage;

– the fact that the arc voltages of the test circuit-breaker and of the auxiliary circuit-breaker are added.

As a result the duration of the current loop and the peak value of the current will be reduced. This distortion of the current is outlined in Annex A.

Considerations with respect to the arc energy released in the test circuit-breaker lead to a maximum permissible influence in terms of tolerances on two characteristic values of the shape of the current, i.e. current-peak value and current-loop duration (see Annex A).

The tolerance on the amplitude and the power frequency of the prospective breaking current is given in 6.103.2 and 6.104.3 of IEC 62271-100:2008. Therefore, the following conditions concerning the actual current through the test circuit-breaker shall be met:

– for symmetrical testing the current amplitude and final loop duration shall not be less than 90 % of the required values based on rated current;

– for asymmetrical testing, the current amplitude and final loop duration shall be between 90 % and 110 % of the required values, based on rated current and time constant (see Tables 15 to 22 of IEC 62271-100:2008).

Adjustment measures:

The amplitude and duration of the last current loop may be adjusted by several means, such as

– increasing or decreasing of the r.m.s. value of the short-circuit test current,

– changing of the frequency of the test current,

– using pre-tripping or delayed tripping,

– changing the instant of current initiation (initial d.c. component).

4.1.3 Interaction interval

During the interaction interval, the short-circuit current stress changes into high-voltage stress and the circuit-breaker performance can significantly influence the current and voltages in the circuit. As the current decreases to zero, the arc voltage may rise to charge parallel capacitance and distort current passing through the arc. After the current zero the post-arc conductivity may result in additional damping of the transient recovery voltage and thus influence the voltage across the circuit-breaker and the energy supplied to the ionized contact gap. The interaction between the circuit and the circuit-breaker immediately before and after current zero (i.e. during the interaction interval) is of extreme importance to the interrupting process.

During the interaction interval, the current and voltage waveforms shall be the same for a synthetic test as under reference system conditions (see 3.15), taking into account the possible deviations of the current and voltage from the prospective values due to the interaction between the circuit-breaker and the circuit.

The interaction interval presents the critical time for the thermal failure mode of the circuit-breaker. Therefore, it is of extreme importance that the shape and magnitude of the prospective transient recovery voltage (TRV) corresponds to that associated with the prospective current of the relevant test duty.

The above implies strict requirements for the test circuit. The requirements are given for the current injection method in 4.2.1 and for the voltage injection method in 4.2.2.

Depending on the test circuit used, the interaction between circuit and test circuit-breaker may be disturbed by the behaviour of the auxiliary circuit-breaker during the critical interval around current zero.

The arc voltage of the auxiliary circuit-breaker should be less than or equal to the arc voltage of the test circuit-breaker.

If an auxiliary circuit-breaker with a higher arc voltage is used, a higher power-frequency voltage of the current circuit may be necessary.

4.1.4 High-voltage interval

During the high-voltage interval, the gap of the test circuit-breaker is stressed by the recovery voltage.

The prospective TRV shall comply with the requirements of 4.102, 4.105, 4.106 and 6.104.5 of IEC 62271-100:2008.

Suitable methods for determining the prospective TRV in synthetic test circuits can be selected from Annex F of IEC 62271-100:2008.

The impedance of the voltage circuit shall be low enough to give clear evidence of breakdown, if any.

If the test circuit-breaker is fitted with opening resistors, a special procedure may be necessary (see Annex F).

If the TRV is obtained from more than one source the overall waveshape should not show any appreciable discontinuity.

In principle, the power-frequency recovery voltage for the basic short-circuit test duties should preferably be a.c. and shall equate with the requirements of 6.104.7 of IEC 62271-100:2008. In synthetic testing, the recovery voltage is supplied from a voltage circuit, either directly or in series with the current circuit. This gives an a.c. voltage, or a combined a.c. and d.c. voltage, or a d.c. voltage, which in most cases decays due to the limited energy of the voltage source. It may thus not be possible to maintain the recovery voltage for at least 0,3 s as specified in 6.104.7 of IEC 62271-100:2008. Deviations from the specified recovery voltage are acceptable if the following conditions are met:

– The instantaneous value of the recovery voltage during a period equal to 1/8 of a cycle of the rated frequency of the circuit-breaker shall be not less than the equivalent instantaneous value of the power-frequency recovery voltage specified in 6.104.7 of IEC 62271-100:2008 which, for a test with symmetrical current, starts with a minimum peak value of $0{,}95 \times k_{pp} \times U_r\sqrt{2}/\sqrt{3}$

  where

  k_{pp} is the first pole-to-clear factor;

  U_r is the rated voltage of the circuit-breaker.