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colour inside

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

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CONTENTS

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 110: Inductive load switching

FOREWORD

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

This fourth edition cancels and replaces the third edition published in 2012 and constitutes a technical revision.

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

– all switching devices are now covered, not only circuit-breakers;
– a limited number of T10 tests no longer covers shunt-reactor switching tests below 52 kV;
– evaluation and reporting of a re-ignition-free arcing time window has been added.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
17A/1151/FDIS	17A/1155/RVD

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

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

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

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

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- withdrawn,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

The contents of the corrigenda of December 2017 and February 2018 have been included in this copy.

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 publication using a colour printer.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 110: Inductive load switching

~~1 General~~

1 Scope

This part of IEC 62271 is applicable to AC ~~circuit-breakers~~ switching devices designed for indoor or outdoor installation, for operation at frequencies of 50 Hz and 60 Hz on systems having voltages above 1 000 V and applied for inductive current switching ~~with or without additional short-circuit current breaking duties~~. It is applicable to switching devices (including 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 as covered by IEC 62271-106. ~~For circuit-breakers applied to switch shunt reactor currents at rated voltages according to IEC 62271-1:2007 Tables 2a and 2b, combined voltage tests across the isolating distance are not required (refer to 4.2).~~

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

a) Owing 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 IEC TR 62271-306~~[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 of the switching device 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 62271-100:2008 is otherwise applicable.~~

NOTE 1 The switching of tertiary reactors from the high-voltage side of the transformer is not covered by this document.

NOTE 2 The switching of shunt reactors earthed through neutral reactors is not covered by this document. However, the application of test results according to this document, on the switching of neutral reactor earthed reactors (4-leg reactor scheme), is discussed in IEC TR 62271-306.

2 Normative references

~~Subclause 1.2 of IEC 62271-100:2008 is applicable with the following addition:~~

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

_____

~~1 To be published.~~

IEC 60050-441, *International Electrotechnical Vocabulary – Chapter 441: Switchgear, controlgear and fuses* (available at www.electropedia.org)

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-100:2008, *High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*
IEC 62271-100:2008/AMD1:2012

IEC 62271-106:2011, *High-voltage switchgear and controlgear – Part 106: Alternating current contactors, contactor-based controllers and motor-starters*

~~2 Normal and special service conditions~~

~~Clause 2 of IEC 62271-1:2007 is applicable.~~

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-441, IEC 62271-1 and the following ~~specific to inductive load switching~~ apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
inductive current
power-frequency current ~~through a circuit-breaker~~ drawn by an inductive circuit having a power factor 0,5 or less

~~**3.102**~~
~~**small inductive current**~~
~~inductive current having a steady state value considerably less than the rated short-circuit breaking current~~

3.2
current chopping
abrupt current interruption in ~~the circuit-breaker~~ a switching device at a point-on-wave other than the natural power-frequency current zero ~~of the circuit connected to the circuit-breaker~~

3.3
virtual current chopping
current chopping in one of the three phases in a three-phase circuit originated by transients in ~~(parts of) the circuit~~ another phase of the circuit

~~**3.105**~~
~~**chopping current**~~
~~current interruption prior to the natural power-frequency current zero of the circuit connected to the switching device~~

~~**3.106**~~
~~**chopping level**~~
~~maximum recorded value of the chopping current due to true current chopping in a specific circuit under rated voltage and normal operating conditions~~

~~**3.107**~~
~~**load side oscillation**~~
~~oscillation of the interrupted load side network after current chopping or natural current zero~~

3.4
suppression peak
first peak of the transient voltage to earth on the load side of the ~~circuit-breaker~~ switching device following current interruption

Note 1 to entry: Suppression peak is not necessarily the absolute maximum of the transient recovery voltage. Previous breakdowns may have appeared at higher voltage values.

3.5
recovery peak
maximum value of the voltage across the ~~circuit-breaker~~ switching device occurring ~~after definite polarity change of~~ when the polarity of the recovery voltage is equal to the polarity of the power-frequency voltage

Note 1 to entry: ~~Suppression peak and~~ Recovery peak ~~are~~ is not necessarily the absolute ~~maxima in~~ maximum of the transient recovery voltage. Previous breakdowns may have appeared at higher voltage values.

~~**3.110**~~
~~**voltage escalation**~~
~~increase in the amplitude of the prospective recovery voltage of the load circuit, produced by the accumulation of energy due to repeated re-ignitions~~

3.6
re-ignition
resumption of current between the contacts of a mechanical switching device during a breaking operation with an interval of zero current of less than a quarter cycle of power frequency

Note 1 to entry: In the case of inductive load switching the initiation of the re-ignition is a high-frequency event, which can be of a single or multiple nature and may in some cases be interrupted without power frequency follow current.

~~[SOURCE: IEC 60050-441:1998, 441-17-45]~~

3.7
re-ignition-free arcing time window
period of arc duration during a breaking operation during which the contacts of a mechanical switching device reach sufficient distance to exclude re-ignition

~~4 Ratings~~

~~Clause 4 of IEC 62271-100:2008 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. Circuit-breakers do not normally have inductive load switching ratings. However, circuit-breakers applied for this purpose should meet the requirement of this standard part.~~

~~4.2 Rated insulation level~~

~~Subclause 4.2 of IEC 62271-1:2007 is applicable with the following addition:~~

~~The rated values stated in Tables 1a and 1b and Tables 2a and 2b of IEC 62271-1:2007 are applicable with the exception of columns (6) and (8) in Table 2a and column (7) in Table 2b.~~

~~5 Design and construction~~

~~Clause 5 of IEC 62271-100:2008 is applicable.~~

4 Type tests

4.1 General

~~Subclause 6.1 of IEC 62271-100:2008 is applicable with the following addition:~~

Circuit-breakers according to IEC 62271-100 and contactors according to IEC 62271-106 do not have dedicated inductive switching ratings. However, switching devices applied for this purpose shall meet the requirements of this document.

For shunt reactor switching test of circuit-breakers, the rated insulation level values stated in Tables 1a, 1b, 3 and 4 of IEC 62271-1:2017 are applicable with the exception of combined voltage tests across the isolating distance (columns (6) and (8) in Table 3 and column (7) in Table 4).

The type tests are in addition to those specified in the relevant product standard, with the exception of short-line faults, out-of-phase switching and capacitive current switching.

NOTE 1 The reason for this exception is the source-less 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 can be necessary to specify an appropriate insulation level which is higher than the rated values stated above.

Inductive current switching tests performed for a given current ~~rating~~ level 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 voltages of 52 kV and above, tests at a particular current ~~rating~~ level are to be considered valid for applications with a higher current level up to 150 % of the tested current value;

b) for shunt reactor switching at rated voltages below 52 kV, type testing is required ~~but short circuit test duties T30 and T10 will cover the requirements provided that the TRV values of T30 and T10 are equal to or higher than the reactor switching TRV values~~;

c) for high-voltage motor switching, type testing for stalled motor currents at 100 A and 300 A is considered to cover stalled motor currents in the range 100 A to 300 A and up to the current associated with the short-circuit current of test duty T10 according to 6.106.1 of IEC 62271-100:2008 for circuit-breakers and up to the rated operational current for contactors.

With respect to a) the purpose of type testing is also to determine a re-ignition-free ~~zones~~ arcing time window for controlled switching purposes (refer to IEC TR 62271-302) and caution should be exercised when considering applications at higher currents than the tested values since the re-ignition-free arcing window can increase at higher current.

Annex B of IEC 62271-100:2008 ~~is applicable~~ can be used with respect to tolerances on test quantities.

~~6.2 Dielectric tests~~

~~Subclause 6.2 of IEC 62271-100:2008 is applicable with the following addition:~~

~~Refer to 4.2.~~

~~**6.3 Radio interference voltage (r.i.v.) test**~~

~~Subclause 6.3 of IEC 62271-1:2007 is applicable.~~

~~**6.4 Measurement of the resistance of circuits**~~

~~Subclause 6.4 of IEC 62271-1:2007 is applicable.~~

~~**6.5 Temperature-rise tests**~~

~~Subclause 6.5 of IEC 62271-1:2007 is applicable.~~

~~**6.6 Short-time withstand current and peak withstand current tests**~~

~~Subclause 6.6 of IEC 62271-1:2007 is applicable.~~

~~**6.7 Verification of protection**~~

~~Subclause 6.7 of IEC 62271-1:2007 is applicable.~~

~~**6.8 Tightness tests**~~

~~Subclause 6.8 of IEC 62271-1:2007 is applicable.~~

~~**6.9 Electromagnetic compatibility tests (EMC)**~~

~~Subclause 6.9 of IEC 62271-1:2007 is applicable.~~

~~**6.101 Mechanical and environmental tests**~~

~~Subclause 6.101 of IEC 62271-100:2008 is applicable.~~

4.2 Miscellaneous provisions for ~~making and breaking~~ inductive load switching tests

Subclause 6.102 of IEC 62271-100:2008+IEC 62271-100:2008/AMD1:2012 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 62271-100:2008~~ and at rated functional pressure for interruption and insulation~~.

~~For gas circuit-breakers, a shunt reactor switching test shall also be performed at the minimum functional pressure for interruption and insulation. This requirement applies for test duty 4 only (see 6.114.9).~~

For gas filled switching devices (including vacuum switching devices using gaseous media for insulation), tests shall be performed at the rated functional pressure for interruption and insulation, except for test-duty 4, where the pressure shall be the minimum functional pressure for interruption and insulation.

~~**6.103 Test circuits for short-circuit making and breaking tests**~~

~~Subclause 6.103 of IEC 62271-100:2008 is applicable.~~

~~**6.104 Short-circuit test quantities**~~

~~Subclause 6.104 of IEC 62271-100:2008 is applicable.~~

~~**6.105 Short-circuit test procedure**~~

~~Subclause 6.105 of IEC 62271-100:2008 is applicable.~~

~~**6.106 Basic short-circuit test-duties**~~

~~Subclause 6.106 of IEC 62271-100:2008 is applicable.~~

~~**6.107 Critical current tests**~~

~~Subclause 6.107 of IEC 62271-100:2008 is applicable.~~

~~**6.108 Single-phase and double-earth fault tests**~~

~~Subclause 6.108 of IEC 62271-100:2008 is applicable.~~

~~Subclauses 6.109 to 6.112 of IEC 62271-100:2008 are not applicable to this part of IEC 62271 series.~~

4.3 High-voltage motor current switching tests

4.3.1 Applicability

Subclause 4.3 is applicable to three-phase alternating current ~~circuit-breakers~~ switching devices 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~~ switching devices 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~~ switching device 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~~ switching device and motor. When tests are required, they shall be made in accordance with 4.3.2 to 4.3.9.

When overvoltage limitation devices are mandatory for the tested equipment, the voltage limiting devices may be included in the test circuit provided that the devices are an intrinsic part of the equipment under test.

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.

4.3.2 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~~ switching device 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~~ switching device's performance in other motor circuits. Tests performed with the test currents defined in 4.3.3 and 4.3.4 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~~ switching device and motor. However, the results of such field tests are only valid for ~~circuit-breakers~~ switching devices working in circuits similar to those during the tests.

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

NOTE 1 Overvoltages can be produced when switching running motors. This condition is not represented by the substitute circuit and is generally considered to be less severe than the stalled motor case.

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 can exceed that of the motor.~~