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Road vehicles — Circuit breakers —

Part 1: Definitions and general test requirements

Véhicules routiers — Coupe-circuits —

Partie 1: Définitions et exigences d'essais générales

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

This second edition cancels and replaces the first edition (ISO 10924-1:2009), which has been technically revised.

ISO 10924 consists of the following parts, under the general title *Road vehicles — Circuit breakers*:

— *Part 1: Definitions and general test requirements*

— *Part 2: User's guide*

— *Part 3: Miniature circuit breakers with tabs (Blade type), Form CB11*

— *Part 4: Medium circuit breakers with tabs (Blade type), Form CB15*

— *Part 5: Circuit breakers with bolt with rated voltage of 450 V*

Road vehicles — Circuit breakers —

Part 1:
Definitions and general test requirements

1 Scope

This part of ISO 10924 defines terms and specifies general test requirements for circuit breakers for use in road vehicles with a nominal voltage of 12 V d.c., 24 V d.c, 48 V d.c. and 450 V d.c.

This part of ISO 10924 is intended to be used in conjunction with other parts of ISO 10924. The numbering of its clauses corresponds to that of this part of ISO 10924 whose requirements are applicable, except where modified by requirements particular to this part of ISO 10924.

This part of ISO 10924 is not applicable to circuit breaker holders (electrical centres or fuse-holders) used in vehicles.

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.

ISO 6722–1, *Road vehicles — 60 V and 600 V single-core cables — Part 1: Dimensions, test methods and requirements for copper conductor cables*

ISO 8820–1, *Road vehicles — Fuse-links — Part 1: Definitions and general test requirements*

ISO 8820–3, *Road vehicles — Fuse-links — Part 3: Fuse-links with tabs (blade type) Type C (medium), Type E (high current) and Type F (miniature)*

ISO 16750–1, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

ISO 16750–3, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 3: Mechanical loads*

ISO 16750–4, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads*

ISO 16750–5, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 5: Chemical loads*

IEC 60068–2–70, *Environmental testing — Part 2: Tests — Test Xb: Abrasion of markings and letterings caused by rubbing of fingers and hands*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16750-1, ISO 8820-1 and the following apply.

3.1
absolute breaking capacity
value of prospective breaking current that a circuit breaker is capable of breaking at least once at U_{Smax} under prescribed conditions of use and behaviour

3.2
breaking capacity
I_B
value of prospective breaking current a circuit breaker is capable of breaking several times at U_{Smax} under prescribed conditions of use and behaviour

3.3
circuit breaker
overcurrent protection device that mechanically interrupts the circuit reversibly, responsive to electric current

Note 1 to entry: The test fixture for the circuit breaker may be identical to the test fixture as described in the appropriate part of ISO 8820; however, some circuit breaker designs do not require a separate test fixture as the cables are directly connected to the circuit breaker terminals.

3.4 Circuit breaker components

3.4.1
housing
electrically non-conductive mechanical support for conductive and non-conductive parts of the *circuit breaker* (3.3)

3.4.2
terminal
part of the *circuit breaker* (3.3) which makes the electrical connection in the electrical circuit

3.4.3
time delayed element
active part that acts depending on the current and causes the reversible interruption of the circuit in the case of an overcurrent

3.5 Circuit breaker features

3.5.1
reset mechanism
provides a user interface in a manual reset *circuit breaker* (3.3) for resetting the device after an overcurrent condition

3.5.2
snap-action mechanism
ensures that the contact closing speed by mechanical reset is independent of the speed of operation of the *reset mechanism* (3.5.1)

3.5.3
switching mechanism
provides the ability to switch off the *circuit breaker* (3.3) by mechanical means

3.5.4
trip mechanism
comprises a time delayed actuator and mechanical components

3.5.4.1
cycling trip free
circuit breaker mechanism that cycles to open and close the contact(s) repeatedly if the actuator is maintained in the "*ON*" position in case of overcurrent

3.5.4.2
fully trip free
circuit breaker mechanism that will cause the moving contact(s) to open and remain open, even if the actuator is maintained in the "*ON*" position in case of overcurrent

3.5.5
trip free mechanism
prevents the *switching mechanism* (3.5.3) from being defeated by forcibly holding the actuator "*ON*" position, i.e. cannot be held closed against an overload

3.6 Circuit breaker types

3.6.1
type I – automatic reset
provides the reversal of an overcurrent condition after a cool-down period without any manual activity required by a user

3.6.2
type II – electrically reset
has a secondary heating circuit which, after an overcurrent condition occurs, creates heat internally upon the *time delayed element* (3.4.3) of the *circuit breaker* (3.3) to keep it from reversing as long as electrical system voltage and a small current flow (<1,0 A) is available, reset function is accomplished by removing all electrical power supplied to the circuit breaker until the internal thermal element cools down and returns to its conductive position

3.6.3
type III – manual reset
contains a *reset mechanism* (3.5.1) that the user is required to operate manually for reversal of a circuit interruption

3.6.4
type IV – switchable
mechanism like type III additionally capable of being switched off manually for user testing or maintenance

3.7
dielectric strength
strength measured between specified measuring points, as shown in the appropriate parts of ISO 10924, at a specified voltage without flash-over

3.8
nominal voltage
U_N
voltage value used to describe the electrical system of a vehicle

[SOURCE: ISO 16750-1:2006, 3.1]

3.9
operating time
time between the application of an overcurrent and the moment when the current drops below a value as specified in the appropriate part of ISO 8820

[SOURCE: ISO 8820-1:2014, 3.7]

3.10
operating time rating
operating time (3.9), as a function of the current under defined test conditions

[SOURCE: ISO 8820-1:2014, 3.8]

3.11
prospective current
I_P
current, which would flow in a circuit, if the *circuit breaker* (3.3) would be replaced by a conductor with negligible impedance

Note 1 to entry: See Figure B.1.

3.12
rated current
I_R
current used for identifying the *circuit breaker* (3.3), according to specified tests

Note 1 to entry: The continuous current can be lower than the rated current.

3.13
rated voltage
U_R
maximum supply voltage for which the circuit breaker is designed

[SOURCE: ISO 8820-1:2014, 3.10]

3.14
rerating factor
correction factor of *rated current* (3.14) that consider fluctuations in ambient temperature

3.15
resetting time
time elapsed between a *circuit breaker* (3.3) tripping due to an overcurrent and subsequently reaching the ability of the circuit breaker to be reset

3.16
selectivity
primary interruption of the *circuit breaker* (3.3) placed closest to faulty section

3.17
supply voltage maximum
U_{Smax}
highest supply voltage in the specified supply voltage range of the DUT performing class A

[SOURCE: ISO 16750-1:2006, 3.4]

3.18
time constant
time required for a physical quantity to rise from 0 to 1 – 1/*e* (that id 63,2 %) of its final steady value when it varies with time, *t*, as $1 - 1^{-kt}$

Note 1 to entry: The continuous current is lower than the *rated current* (3.14).

[SOURCE: ISO 8820-1:2014, 3.13]

3.19
test voltage
voltage(s) applied to the DUT during a test

[SOURCE: ISO 16750-1:2006, 3.7]

3.20
voltage drop
U_D
voltage measured between specified measuring points at a specified current

[SOURCE: ISO 8820-1:2014, 3.14]

4 Marking, labelling and colour coding

The circuit breakers shall be permanently marked with the following to be externally visible:

— rated current (I_R) in Ampere (A), the value of the rated current (I_R) without unit is accepted;

— supply voltage maximum (U_{Smax}) in (V);

— colour coding;

— manufacturer's name, trademark and/or symbol;

— part no. or identification.

5 Tests and requirements

5.1 General

5.1.1 General test conditions

If not otherwise specified, all tests shall be performed at room temperature (RT) (23 ± 5) °C at a relative humidity (RH) of 45 % to 75 % (standard condition).

At the beginning of the electrical tests, a direct current shall be fixed at the rated value. This current shall be measured with an appropriate method. If not otherwise specified, no further adjustments during the tests are allowed.

All electrical measurement equipment shall have a tolerance of less than ±2 %.

Mount the circuit breaker in a test fixture (holder) as specified in the applicable part of ISO 10924.

For appropriate cable sizes, see the applicable part of ISO 10924.

Temperature measurements shall be performed at no forced air flow.

Connections shall be made to the circuit breaker with copper cables according to ISO 6722-1. The cable length between the test fixture and the rest of the test set-up shall be (500 ± 50) mm, if not otherwise specified.

Measure the connection resistance using a dummy with dimensions as specified in the appropriate part of ISO 10924. Use a current as specified in the appropriate part of ISO 10924 for this measurement. For the used voltages, see Table 1.

Table 1 — Supply voltage maximum (U_{Smax})

Nominal voltage (U_N) V	Supply voltage maximum (U_{Smax}) V
12	16
24	32
48	58
450	480

5.1.2 General performance requirements

— Marking and/or labelling shall remain legible.

— Colour coding shall remain recognizable.

— After testing, the circuit breaker shall be removable from the test fixture by its intended method.

— Manual and switchable circuit breakers shall provide visible evidence of the switching status.

5.2 Voltage drop

5.2.1 Purpose

This test is to define and measure the energy consumption of the circuit breaker which creates temperature rise.

5.2.2 Test

If not otherwise specified, this test shall be performed at I_R. The voltage drop shall be measured at the points shown in the applicable part of ISO 8820 after the value of the measured voltage has not changed more than 2 % within a 10 min period.

5.2.3 Requirement

The maximum voltage drop shall not exceed the values as shown in the applicable parts of ISO 10924.

5.3 Maximum housing temperature

5.3.1 Purpose

This test is to evaluate the circuit breaker's maximum surface temperature during normal operation.

5.3.2 Test

Subject the circuit breaker to I_R and measure the housing temperature by using a thermocouple attached to the hottest point of the housing. After the current has been flowing for a minimum of 15 min and the measurement has been stabilized, record the maximum housing temperature. A measurement is considered to be stabilized when three successive records, taken in intervals of 10 % of the previously elapsed duration of the test, but not less than 10 min intervals, advise no change.

5.3.3 Requirement

Maximum housing temperature shall be less than 95 °C.

5.4 Environmental conditions

5.4.1 Purpose

These tests (mechanical and climatic loads) are to evaluate the circuit breakers' ability to function under environmental stresses.

5.4.2 Mechanical loads

5.4.2.1 Test

If mechanical load tests are required, appropriate tests shall be chosen from ISO 16750-3, which have to be agreed upon between circuit breaker manufacturer and vehicle manufacturer.

NOTE The rating values have to be taken into account.

5.4.2.2 Requirement

After the mechanical load tests, the circuit breaker shall meet the requirements as shown in the applicable parts of ISO 10924.

5.4.3 Climatic loads

5.4.3.1 Test

If climatic load tests are required, appropriate tests shall be chosen from ISO 16750-4, which have to be agreed upon between circuit breaker manufacturer and vehicle manufacturer.

5.4.3.2 Requirement

After a minimum of ten cycles, the circuit breaker shall meet the requirements as shown in the applicable parts of ISO 10924. Test methods and the definition of cycles are specified in the applicable parts of ISO 16750-4.

5.4.4 Chemical loads

5.4.4.1 Test

If chemical load tests are required, appropriate tests condition, procedures and performance shall be chosen from IEC 60068-2-70 and ISO 16750-5, which have to be agreed upon between circuit breaker manufacturer and vehicle manufacturer.

5.4.4.2 Requirement

After the test, the marking of the circuit breaker shall remain legible and colour coding shall remain recognizable.

5.5 Operating time rating

5.5.1 Purpose

This test is to evaluate the circuit breaker's ability to function when subjected to electrical overloads.

5.5.2 Test

The test fixture and circuit breaker shall be stabilized at RT before each test. The power supply shall be adjusted to the test current (multiple rated current) as specified in the applicable parts of ISO 10924. Then, the test currents shall be applied to the circuit breaker. A measurement is considered to be stabilized when three successive records, taken in intervals of 10 % of the previously elapsed duration of the test, but not less than 10 min intervals, advise no change.

The test voltage shall not exceed the supply voltage maximum of the circuit breaker.

NOTE Electrically reset circuit breakers (Type II) have a holding current after activation.

5.5.3 Requirement

The operating time of the circuit breaker shall be within the limits as shown in the applicable parts of ISO 10924.

5.6 Current steps

5.6.1 Purpose

This test is to evaluate the circuit breaker's ability to withstand the heating due to prolonged low level overloads.

5.6.2 Test

First, a current equivalent in value to the rating of the circuit breaker under test shall be applied for duration of 5 min. Then, the current shall be sequentially increased in steps of 2,5 % of the circuit breaker rating in 5 min intervals until the circuit breaker trips.

5.6.3 Requirement

After the current step test, the current through the circuit breaker shall not exceed the value specified in the appropriate part of ISO 10924 at the supply voltage maximum, U_{Smax}. The circuit breaker shall be removable from the test fixture by its intended method after returning to RT. The devices subjected to the current step test shall additionally be subjected to operating time rating test as described in 5.5.2.

5.7 No current trip and reset temperature

5.7.1 Purpose

This test is to evaluate the circuit breaker's design variations and ambient temperature compensation.

5.7.2 Test

The circuit breaker shall be placed into a climate chamber for 30 min at a temperature as follows:

— for rated current of 10 A and less: 72 ± 2 °C;

— for rated current above 10 A: 102 ± 2 °C.

After the 30 min, the temperature shall be raised at a rate not exceeding 1 °C/min and the temperature at which the circuit breaker opens shall be recorded. After the circuit breaker has opened, the temperature at a rate not exceeding 1 °C/min shall be decreased and the temperature at which the circuit breaker closes shall be recorded. If more than one circuit breaker is tested at one time, they shall all open before the temperature is decreased.

If a circuit breaker does not trip up to a maximum ambient temperature depending on the plastic material, but not less than 180 °C, the test shall be terminated. In this case, the circuit breaker shall be

loaded with two times rated current. Once the circuit breaker has opened, the temperature at a rate not exceeding 1 °C/min shall be decreased and the temperature at which the circuit breaker closes shall be recorded. For type III/IV circuit breakers, activate the reset mechanism once per minute until the breaker recloses.

5.7.3 Requirement

Circuit breakers rated 10 A or less shall not open at less than 82 °C and shall reclose before the temperature is below 70 °C. Circuit breakers rated greater than 10 A shall not open at less than 112 °C and shall reclose before the temperature is below 70 °C.

5.8 Absolute breaking capacity

5.8.1 Purpose

This test is to evaluate the circuit breaker's ability to withstand the absolute breaking current.

5.8.2 Test

The test circuit shall be in accordance with Figure B.1. A short circuit line or a dummy shall be connected at point SL. The switch SW shall be closed and the d.c. current adjusted. The time constant of the circuit shall be adjusted with the variable resistor R and/or the inductor L to achieve the prospective current I_P with a tolerance of $\begin{pmatrix} +5 \\ 0 \end{pmatrix}$ % and a time constant of (2,0 ± 0,5) ms, as specified in the appropriate part of ISO 10924. The voltage at the source Q shall be U_{Smax} $\begin{pmatrix} +2 \\ 0 \end{pmatrix}$ V. Then the switch SW shall be opened and the short circuit line or dummy removed.

The circuit breaker under test shall be inserted at point C1/C2. After interruption, U_{Smax} for 30 s shall be held at type III and type IV circuit breakers only. For type I and type II circuit breakers, the hold time shall be long enough to see the voltage in the test circuit rise to $U_{Smax.}$

5.8.3 Requirement

The following conditions shall not occur during the test:

— permanent arcing;

— no breakage of the circuit breaker casing shall be apparent;

— welding of the contacts and/or terminals.

After the test, the circuit breaker shall meet the requirements as specified in the appropriate part of ISO 10924 and the circuit breaker shall be removable from the test fixture by its intended method.

It shall be acceptable, if the results of the breaking capacity test are such, that the device is rendered inoperable, but is otherwise intact as described in the appropriate part of ISO 10924.

5.9 Breaking capacity

5.9.1 Purpose

This test is to evaluate the circuit breakers ability to withstand the breaking current and remain functional after 1 1/2 cycles, and non-functional (fail-safe) after additional cycles at breaking current.

5.9.2 Test

The test circuit shall be in accordance with Figure B.1. A short circuit line or a dummy shall be connected at point SL. The switch SW shall be closed and the d.c. current adjusted. The time constant of the circuit shall be adjusted with the variable resistor R and/or the inductor L to achieve the prospective current I_P with a tolerance of $\begin{pmatrix} +5 \\ 0 \end{pmatrix}$ % and a time constant of (2,0 ± 0,5) ms as specified in the appropriate part of ISO 10924. The voltage at the source Q shall be U_{Smax} $\begin{pmatrix} +2 \\ 0 \end{pmatrix}$ V. Then, the switch SW shall be opened and the short circuit line or dummy removed.

The circuit breaker under test shall be inserted at point C1/C2. After each interruption, a minimum idle time of 3 min is required before the start of the next cycle. The test current shall be applied for at least 1 s.

Circuit breakers shall be subjected to 1 1/2 cycles of breaking current as specified in appropriate part of ISO 10924 and the diagram as shown in Figure A.3.

After the number of cycles as specified below, the circuit breaker shall be subjected to 70 % I_R for 30 min without tripping.

— **Type I circuit breakers**

  The circuit breaker shall be cycled for 30 min or up to its failure.

— **Type II circuit breaker**

  As the circuit breaker does not reset after 1/2 cycle due to the normal operation, the power shall be removed to allow the circuit breaker to reset. The test shall proceed with the voltage drop test. Following the voltage drop test, the operating time-rating test at 200 % I_R shall be performed. The circuit breaker shall be subjected to 100 cycles or up to its failure.

— **Type III and IV circuit breake**r

  The circuit breaker shall be subjected to 100 cycles or up to its failure.

5.9.3 Requirement

The following conditions shall not occur during the test:

— permanent arcing;

— no breakage of the circuit breaker casing shall be apparent;

— welding of the contacts and/or terminals.

After this test, the circuit breaker shall meet the subsequent tests as specified in the appropriate part of ISO 10924 and the circuit breaker shall be removable from the test fixture by its intended method.

It shall be acceptable, if the results of the breaking capacity test are such, that the device is rendered inoperable, but is otherwise intact as described in the appropriate part of ISO 10924.

5.10 Strength of terminals

5.10.1 Purpose

This test is to evaluate the circuit breaker's ability to withstand mechanical stress during insertion and removal.

5.10.2 Test

Forces shall be applied to the terminals of the circuit breaker as specified in the appropriate part of ISO 10924.

5.10.3 Requirement

See ISO 8820-3.

5.11 Endurance

5.11.1 Purpose

This test is to evaluate the circuit breakers ability to withstand a normal cycling during its life.

5.11.2 Test

The test shall be performed at $U_{Smax}\begin{pmatrix}+2\\0\end{pmatrix}$ V with a (2,0 ± 0,5) ms time constant. Test sequences and cycling profiles are shown in the applicable parts of ISO 10924. Perform this test at standard conditions and ambient temperature as specified in the appropriate part of ISO 10924.

— **Type I circuit breakers**

A multiple I_R shall be applied to the circuit breaker for a length of time allowing it to cycle continuously as specified in the appropriate part of ISO 10924. See Figure A.1 for the cycling profile.

— **Type II circuit breakers**

A multiple I_R shall be applied to the circuit breaker for the numbers of cycles as specified in the appropriate part of ISO 10924. The test current shall be applied for 60 s each cycle. Multiple interruptions are possible with this type of CB and allowed during this time. The resetting time shall be long enough for the circuit breaker to reclose the circuit. At the last cycle, the circuit shall remain on at a voltage level of 0,94 U_{Smax} for a period of 12 h. After 12 h, the circuit breaker shall be switched off to cool down to reclose the circuit. After that, the test shall be repeated as specified in the appropriate part of ISO 10924. See Figure A.2 for the cycling profile.

— **Type III circuit breakers**

A multiple I_R shall be applied to the circuit breaker for numbers of cycles as specified in the appropriate part of ISO 10924 utilizing the reset mechanism on the circuit breaker. See Figure A.1 for the cycling profile.

— **Type IV circuit breakers**

The circuit breaker shall be mechanically cycled utilizing the trip mechanism and subsequently, the reset mechanism for numbers of cycles as specified in the appropriate part of ISO 10924 while I_R shall be applied to the circuit breaker. See Figure A.1 for the cycling profile.

5.11.3 Requirement

After the test, the current through the circuit breaker shall not exceed the value as specified in the appropriate part of ISO 10924 at the rated voltage. The following shall not occur:

— permanent arcing;

— ruptures to the external surfaces shall not be visible to the naked eye;

— welding together of the contacts or terminals;

— circuit breaker shall be removable in one piece from the test fixture by its intended method.

5.12 Dielectric strength

5.12.1 Purpose

This test is to evaluate the circuit breaker's ability to withstand a specific test voltage without flash-over.

5.12.2 Test

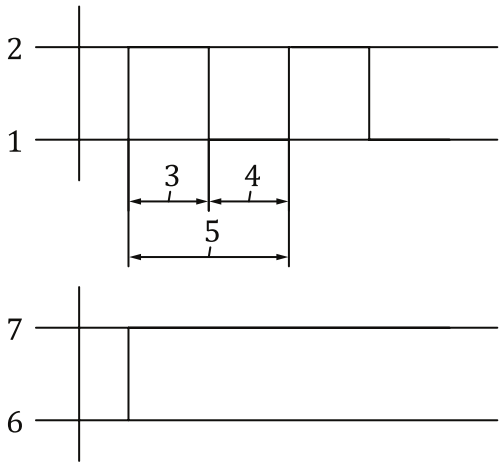
The test shall be performed in OFF-position. Measuring points, specific test voltage and duration are shown in the applicable part of ISO 10924.

5.12.3 Requirement

During the test, the requirements given in the applicable part of ISO 10924 shall apply.

Annex A
(informative)

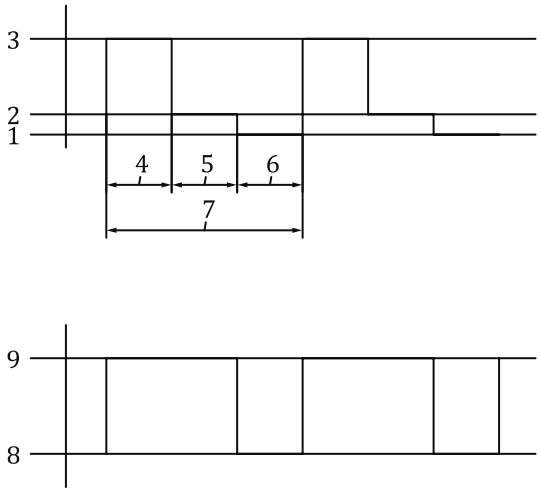
Cycling profiles



Key

1 0 * I_R
2 I_R or multiple I_R
3 current load time
4 resetting time
5 one cycle
6 no voltage
7 voltage applied

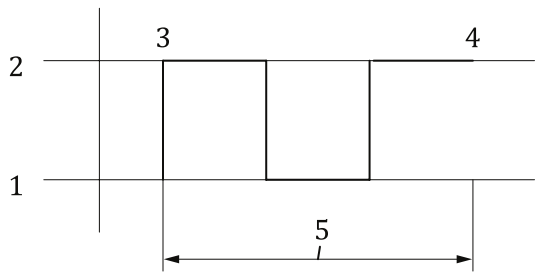
Figure A.1 — Cycle test profile for type I, type III and type IV circuit breakers



Key

1 0 x I_R
2 low current
3 multiple I_R
4 operating time
5 low current time
6 resetting time
7 one cycle
8 no voltage
9 voltage applied

Figure A.2 — Cycle test profile type II circuit breakers



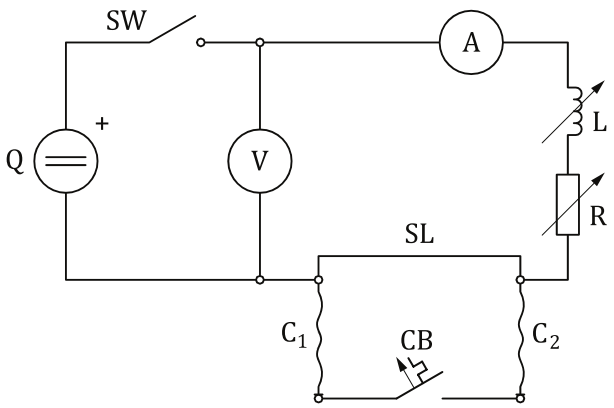
Key

1 open circuit I_{test} = 0, U_{Smax}
2 test (breaking) current
3 start test
4 end 1 1/2 cycle test
5 1 1/2 cycles

Figure A.3 — Breaking capacity current cycle test

Annex B
(informative)

Test circuit



Key

SW	switch bounce-free
V	voltmeter
A	current meter
L	adjustable inductor
R	adjustable resistor
C1, C2	test cables
Q[a]	power supply
SL	short circuit line/dummy according to ISO 8820-3
CB	circuit breaker in test fixture
a	Storage battery shall be used with Cold Cranking Amperage ≥ 600 A. U_{Smax} shall be maintained by a battery charger or appropriate power supply.

Figure B.1 — Test circuit

ICS 43.040.10

Price based on 15 pages