BRITISH STANDARD

BS EN
50123-2:2003

Railway applications — Fixed installations — D.C. switchgear —

Part 2: D.C. circuit breakers

The European Standard EN 50123-2:2003 has the status of a British Standard

ICS 29.120.60; 45.020

BSI
British Standards

National foreword

This British Standard is the official English language version of EN 50123-2:2003. It supersedes BS EN 50123-2:1996 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/9, Railway electrotechnical applications, to Subcommittee GEL/9/3, Fixed equipment, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Foreword

This European Standard was prepared by SC 9XC, Electric supply and earthing systems for public transport equipment and ancillary apparatus (fixed installations), of the Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways.

The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50123-2 on 2002-09-01.

This European Standard supersedes EN 50123-2:1995 + A1:1996. It has been prepared taking into account IEC 61992-2 in order to align technically as much as possible this EN 50123-2 and IEC 61992-2. These documents are to be considered as technically equivalent except for those references and peculiarities which are due to the European standardization in the railway application field.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2003-09-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2005-09-01

This Part 2 is to be used in conjunction with EN 50123-1:2003.

Annexes designated “informative” are given for information only.
In this standard, annex A is informative.

Contents

1 Scope

This part of EN 50123 specifies requirements for d.c. circuit breakers for use in fixed installations of traction systems.

NOTE Switchgear assemblies, electromagnetic compatibility (EMC) and dependability are not covered in this part of EN 50123, but by other parts of this standard or by other standards, as indicated in EN 50123-1.

2 Normative references

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

See EN 50123-1:2003.

3 Definitions

For the purposes of this European Standard, the terms and definitions given in EN 50123-1 apply.

4 Service requirements

Environmental conditions applicable to the equipment discussed in this standard are covered in 4.1 of EN 50123-1.

5 Characteristics of the circuit breaker

5.1 Enumeration of the characteristics

The characteristics of a circuit breaker and its assigned designations and values (where applicable) are covered below as follows:

- type of circuit breaker (5.2);
- rated values and limit values of the main circuit and short-circuit characteristics (5.3);
- control circuits (5.4);
- auxiliary circuits (5.5);
- releases (5.6);
- arc voltages (5.7).

5.2 Type of circuit breaker

A circuit breaker is defined by the following details, as applicable.

NOTE 1 As far as applicable, the following requirements also apply to single-pole circuit breakers electrically or mechanically interlocked in multiple systems.

a) Interruption:
   - in air;
   - via a semiconductor.

   NOTE 2 In this standard only interruption in air or via a semiconductor is addressed. This standard may be used for other specified interrupting media, as far as applicable, where clearly specified by mutual agreement between purchaser and supplier.

b) Breaking characteristics (class designation):
   - high speed current limiting circuit breakers H;
   - very-high speed current limiting circuit breakers V;
   - semi-high speed circuit breakers S.

c) Use (installation point) in the system:
   - interconnector circuit breaker I (also called bus-section or section circuit breaker);
   - line circuit breaker L;
   - rectifier circuit breaker R.

d) Current interruption direction:
   - unidirectional U:
     - fitted with a series unidirectional release U_1;
     - fitted with a series bidirectional release U_2.

     NOTE 3 U_2 circuit breakers are used for application where the reverse fault current is low (distant fault current) and cannot operate the overload protection for normal discrimination purposes (i.e. substations where adjacent substations are a far distance away).
   - bidirectional B.

e) Duty of the main circuit

   NOTE 4 To be specified when different from 5.3.4.2 and Table 2.

f) Actuating of the closing and opening operations:
   - stored energy operation;
   - independent manual operation;
   - independent power operation;
   - use of magnet;
   - type of automatic tripping due to a release or relay;
   - interlocks for opening and/or closing operations;
   - trip-free provision;
   - anti-pumping device.

g) Relay or release type:
   - type of the relay(s) or release(s) involved.

h) Provision of an enclosure:
   - without provision of an enclosure O (see 3.3.16 of EN 50123-1);
   - with provision of an integral enclosure E (see 3.3.17 of EN 50123-1);
   - with provision of a separate protection enclosure P.

The purchaser shall indicate which characteristics are to be present in the required circuit breaker(s) and only those tests which relate to the chosen type are applicable to the selected type of circuit breaker.

The above designations are used in this standard and may be used elsewhere adopting the conventional grouping as given in Table 1:

Table 1 - Shortened type-designation

Items above	**b**	**c**	**d**[a]	**h**[a]
Options	H V S	/I /L /R	/U_1 /U_2 /B	/O /E /P
Examples	H/L/B/E V/I/P H /R and L/U_2 [b]		S/R/O	
NOTE When a circuit breaker is not suitable to perform all duties as given in 5.3.4.2, this fact will be indicated by means of the lower case letter(s) designating actual capability according to Table 2, first column (for example, H/Iff, fr/ P).				
[a] Optional designations. [b] When a circuit breaker is or shall be suitable for multiple alternate functions, the indication of these functions shall be preceded by an «and».				

Where semiconductor circuit breakers are only designed for use in rectifier equipped substations, they shall be clearly so marked. If they may also be used as track paralleling circuit breakers, when the substation rectifier circuit breakers are out of service, they shall also be clearly so marked.

5.3 Rated values and limit values for the main circuit

5.3.1 General

The rated characteristic values shall be specified by the purchaser. Nominal voltage values are to be selected from the values indicated in Table 1 of EN 50123-1; current values and track time constant (based on the track configuration which gives the largest track time constant) should have one of the preferred values listed in 5.1.2 of EN 50123-1.

These values should be confirmed by the supplier, who should indicate the rated values for the type of circuit breaker proposed and supply any other relevant data.

All these values are to be stipulated in accordance with 5.3.2 to 5.3.4. Definitions are given in EN 50123-1. Some data may be omitted by agreement.

5.3.2 Voltages

A circuit breaker is identified by the following voltages:

- system voltages and limits (see 3.2.1 and 5.1.3 of EN 50123-1);
- nominal voltage U_n (see EN 50163);
- rated voltage U_{Ne} (see 3.2.3 of EN 50123-1);
- rated insulation voltage U_{Nm} (see 3.2.2 of EN 50123-1). It shall be equal to or higher than U_{max};
- rated impulse withstand voltage U_{Ni} (see 3.2.4 of EN 50123-1);
- power-frequency voltage withstand level (dry) U_a (see 3.2.5 and Table 1 of EN 50123-1);
- maximum arc voltage (see 3.2.6.1 of EN 50123-1);
- rated auxiliary and control supply voltages (see 3.2.3.1 of EN 50123-1).

5.3.3 Currents

A circuit breaker is defined by the following currents:

- conventional thermal current I_{th}, I_{the} (see 3.2.8 and 3.2.9 of EN 50123-1);
- rated service current I_{Ne} (see 3.2.10 of EN 50123-1);
- rated short circuit current I_{Nss} (see 3.2.12.1 of EN 50123-1);
- rated short-time withstand current I_{Ncw} (see 3.2.11 of EN 50123-1).

  NOTE 1 Short-time ratings only apply to circuit breakers not fitted with series trip devices, or in a unidirectional device where a series trip is inoperative. In practice this would apply to a rectifier circuit breaker in the forward direction where a series trip only acts in the reverse direction.

  NOTE 2 Rated short-time currents donot need to have the same value as the rated short-circuit current I_{Nss}.

- overload capability: the purchaser shall inform the supplier of the load cycle requirements (see 3.2.10, note 2 of EN 50123-1).

5.3.4 Short-circuit characteristics

5.3.4.1 Rated short-circuit breaking and making capacities

These values are defined in 3.2.19 and 3.2.23 of EN 50123-1 and are associated with the rated voltage U_{Ne}, the rated service current I_{Ne}, the rated short-circuit current I_{Nss}, the rated track time-constant T_{Nc} and the class designation H or V or S.

The rated short-circuit making capacity is the prospective peak value of the rated short-circuit current I_{Nss} (see 3.2.12.1 of EN 50123-1).

A rated short-circuit breaking capacity requires the circuit breaker to be able to interrupt any short-circuit current of a value lower than or equal to this rated breaking capacity at the circuit time constant stipulated.

A circuit breaker having a breaking capacity at a rated track time constant T_{Nc} is capable of the same breaking capacity at all lower values of track time constant T_c.

The prospective maximum short-circuit current is the sum of the prospective short-circuit currents from all sources connected to the system, including rectifier converters and regenerative trains.

When fixing the maximum short-circuit current and the above track time constant, clause 5 of EN 50123-1 shall be considered.

5.3.4.2 Duties and test duty cycles

The duties required of a circuit breaker for each of the three uses are listed in Table 2. The test duty cycles applying to the duties are shown in Table 3.

NOTE Where the circuit breaker chosen by the manufacturer or offered by the supplier has been designed with short circuit breaking characteristics in excess of those actually required in the installation, it may be agreed between purchaser and supplier to perform additional tests in accordance with 8.3.8 for duties f) and/or e) and/or d) using the test current actually required. These tests may be performed either at a standard test duty cycle (duty 1 or duty 2) or at an agreed duty cycle and may be repeated a number of times upon agreement between purchaser and supplier.

Table 2 - Circuit breaker duties

Duty	Use	Conditions	Test current	Prospective peak	Time constant
f	L	Maximum fault	I_{Nss}	≥ 1,42 I_{Nss}	By consequence of other circuit parameters
e	L [a]	Maximum energy	0,5 I_{Nss}	By consequence of other circuit parameters	0,5 T_{Nc}
d	L	Distant fault	2 I_{Ne}	By consequence of other circuit parameters	T_{Nc}
l	L	Low current	I_c	Not applicable	≅ 0,01 s
ff	I	Maximum fault forward	I_{Nss}	≥ 1,42 I_{Nss}	By consequence of other circuit parameters
fr	I	Maximum fault reverse	I_{Nss}	≥ 1,42 I_{Nss}	By consequence of other circuit parameters
lr	I, R [b]	Forward low current after reverse short circuit	I_c	Not applicable	≅ 0,01 s
r	R	Max fault reverse with paralleled converters	I_{Nss}	≥ 1,42 I_{Nss}	
s	R	Short time current forward	I_{Ncw}	≥ 1,42 I_{Ncw}	

NOTE 1 For substations equipped with smoothing reactors of high value, the maximum energy condition may correspond to the maximum fault condition.

NOTE 2 I_{Nss} is to be determined for each type of actual circuit situation. Therefore I_{Nss} may be different for Line L, Interconnector I and Rectifier R circuit breakers.

[a] The factor affecting both I_{Nss} and T_{Nc} for maximum fault position is taken for practical reasons as 0,5. For low values of T_{Nc} , see Table 2 in 5.1.1.3 of EN 50123-1.

[b] R only when explicitly required by the purchaser.

Table 3 - Test duty cycles

Duties	Test cycle
f, e, d [a]	
Duty 1	O - 15 s - CO - 15 s - CO - 60 s - CO
Duty 2	O - 7 s - CO - 10 s - CO - 60 s - CO
ff, fr, r	O - 15 s - CO
l, lr	10 times (O - 120 s - CO)
s	Carrying for 0,25 s
NOTE 1 O = opening operation; C = closing operation. NOTE 2 First opening is made on a short circuit being established.	
[a] The choice of duty 1 or 2 is left to the purchaser. If no choice is made, then the duty cycle required is duty 1.	

Circuit breakers designed to comply with more than one duty shall be fully tested for each duty; unless otherwise agreed between purchaser and supplier, these tests are to be carried out on a single circuit breaker which may be maintained between duty cycles. Any further duty cycles on the same circuit breaker shall not be performed unless a sufficient time to cool down the circuit breaker components is allowed.

The tests shall be performed with the series overcurrent release set at the maximum setting, e.g. four times I_{Ne}, I_{th} or I_{the} for test duties f, e, ff, fr, and 0,5 times for test duties r and s.

For test duties d) and l), the circuit breaker shall be set to trip when the sustained value is reached. For test duty d), when the track time constants are long, the trip shall be initiated at 0,15 s.

5.4 Control circuits

The control circuits are identified by the following characteristics as a minimum:

- the voltage of the control circuits;
- the kind of current (d.c. or a.c.);
- the current frequency, in case of an a.c. current.

The voltage of the supply source and its frequency are the values on which the performances, the thermal behaviour and the insulation characteristics are based.

Unless otherwise required, the voltage shall be in accordance with 5.2 of EN 50123-1 and rated insulation voltage shall be in accordance with EN 50124-1.

The supply voltage shall be within a range between 80 % and 110 % of the voltage in accordance with 5.2 of EN 50123-1.

Where the control voltage is the same as in the main circuit, the same variations as in the main circuit apply.

The manufacturer shall indicate the value(s) of the current drawn by the control circuits at the rated voltage. In the case of control circuits which draw current intermittently, the duration of the current flow shall be given.

5.5 Auxiliary contacts and circuits

Auxiliary circuits are mainly defined by the number of contacts provided, by their rating (thermal current and voltage) and by their characteristics (NO, NC or commutation). Unless otherwise required, the rated voltage shall be in accordance with 5.2 of EN 50123-1, and the rated insulation voltage shall be in accordance with EN 50124-1.

The purchaser shall specify the minimum number of auxiliary contacts required.

The auxiliary wiring connected to a circuit at 1 000 V a.c. or at 1 500 V d.c. or above shall be physically separated from those connected to a circuit at a voltage below said limits.

For other characteristics of the auxiliary circuits, the requirements of 5.4 apply.

5.6 Releases

NOTE The following requirements apply for direct or indirect releases which are part of the circuit breaker.

5.6.1 Type

Classification of the releases comprises

- series (direct or indirect) overcurrent releases,
- shunt releases,
- under-voltage releases,
- other releases.

5.6.2 Characteristics

A release may be instantaneous, time-lagged or time-dependant, or a combination of all three. Other characteristics are as follows:

a) for overcurrent (d.c.) releases:
   - type (overcurrent direct or indirect);
   - rated current;
   - the setting current (or setting range);
   - the direction of the main carrying current in case of a unidirectional circuit breaker;
   - characteristics of the operating time which the release gives the circuit breaker as a function of the rate of rise of the current.

   The release shall be capable of withstanding this current under the test conditions specified in clause 8, without the temperature-rise exceeding the values specified in clause 6 of EN 50123-1.

   For circuit breakers provided with interchangeable or adjustable releases, the current setting (or the setting range, if applicable) shall be indicated on the release or on its setting scale. The indication may be either in ampere or in multiples of the current indicated on the release. The purchaser shall specify the required setting range. The ratio of the minimum and maximum values shall not exceed 1:2 in normal conditions.

b) for the shunt release:

- the rated voltage;
- the power taken at the rated voltage for a specified time.

5.7 Arc voltage

The manufacturer shall specify the maximum value of the arc voltage $\hat{U}_{arc}$ caused by the operation of the circuit breaker when it is tested in accordance with clause 8.

NOTE This maximum voltage is the peak voltage measured during any test duty and is not necessarily seen with maximum current.

This value shall not exceed both that of the rated impulse withstand voltage of the equipment and four times the nominal voltage. If lower arc voltages are required, these shall be specified by the purchaser.

6 Construction

6.1 General

All apparatus and connections required for the safe and satisfactory operation, control and protection of the equipment concerned shall be provided, whether or not specifically mentioned, unless otherwise agreed between the circuit breaker manufacturer and the switchgear assembly manufacturer. Unless otherwise specified, the equipment shall be earthed, insulated, screened or enclosed as may be appropriate to ensure the protection of the equipment and safety of those concerned in its operation and maintenance.

Control and auxiliary circuits and contacts shall comply with the requirements of 5.2 of EN 50123-1.

6.1.1 Materials

No materials containing asbestos shall be used in the construction of the circuit breaker.

NOTE Special attention is to be paid to the ability of the material used to resist moisture and fire: materials used should be of the self-extinguishing type, such that the risk of propagation of fire from one cubicle to another is minimised. See Annex B of EN 50123-1.

6.1.2 Arcing contacts

Arcing contacts, if any, which are liable to be consumed during arc interruption shall be easy to replace.

6.1.3 Clearances and creepage distances

Clearances and creepage distances shall not be lower than those indicated in Table 1 in EN 50123-1 and in Annex D of EN 50123-1 respectively.

NOTE Clearances and creepage distances may be increased to take into account the presence of foreign substances after the number of operations, in normal and short circuit conditions, that occur during the normal life-span between cleaning procedures.

Where applicable, ribs shall be provided in order to break the continuity of conducting deposit which occurs during operation.

6.1.4 Primary connections

The circuit breakers shall be equipped with fixed, removable (bolted or clamped) or plug-in coupling connections.

6.1.5 Location of the primary connections

For non-withdrawable circuit breakers, the terminals for the primary connections shall be accessible with the circuit breaker in its normal operating position. The position of the terminals shall be agreed between purchaser and supplier, unless covered by a European standard.

For withdrawable circuit breakers, the terminals for the primary connections shall be accessible in the conditions detailed in EN 50123-6.

6.1.6 Earthing terminal

The frames, the structure and the fixed parts of the metallic enclosures shall be connected to each other and to a suitable earthing terminal, placed in an accessible position, in order to allow earthing.

NOTE 1 This condition may be fulfilled by normal construction elements, ensuring an adequate electric continuity.

For withdrawable circuit breakers, the earth connection shall be made before the shutters are opened, and the shutters shall be closed before the earth connection is disconnected.

NOTE 2 The purchaser may require a dedicated earth connection for this purpose. For a non-dedicated earth connection, where bolts or similar fixings are used for earth continuity, the maintenance instructions should state the requirements for cleaning the surfaces and ensuring tightness.

The earthing terminal shall be protected against corrosion. The standard earth symbol shall be permanently marked.

The earth terminal shall be capable of carrying the rated earth fault current I_{Ncwe} for 0,25 s.

6.1.7 Manual operation for maintenance

NOTE A handle may be required by the purchaser or provided by the supplier for closing during maintenance. The handle may be fixed or removable.

Where a fixed handle is provided, it shall not be accessible to the operator until the circuit breaker is fully withdrawn from its enclosure, if any, or until all primary connections are opened.

6.2 Circuit breaker enclosures

Circuit breaker enclosures shall conform to EN 50123-6.

6.3 Temperature-rises

6.3.1 Limits

The temperature shall not rise by more than the values given in clause 6 of EN 50123-1.

6.3.2 Main circuit

The main circuit of a circuit breaker, including the series releases and the associated relays, shall withstand its rated currents I_{Ne}, I_{th} or I_{the}. It shall also comply with the load cycle which may be specified by the purchaser, see note 2 in 3.2.10 of EN 50123-1.

6.3.3 Control circuit

The control circuits, as well as the control devices, used for the opening and closing operations of a circuit breaker shall not exceed the rated temperature-rise limits, during their operation.

6.3.4 Auxiliary circuits

The auxiliary circuits, as well as the auxiliary devices, shall withstand their conventional thermal current (for switching devices) or their rated service current (for other equipment), without exceeding the rated temperature-rise limits.

6.4 Dielectric strength

Dielectric strength shall conform to the values stipulated in Table 1 in EN 50123-1.

6.5 Electrical and mechanical endurance

The circuit breaker shall be capable of carrying out the following number of operations when tested in accordance with 7.3.2 and 7.3.3 of EN 50123-1:

a) for checking of mechanical endurance, without current in the main circuit, the following operating cycles shall be performed:

   L circuit breaker: 20 000 or 10 000;

   I and R circuit breakers: 4 000;

   NOTE When L circuit breakers are only required for duties of approximately one operation per day, then the figure of 10 000 operating cycles is acceptable and should be specified by the purchaser. If no figure is specified then the standard is 20 000 operating cycles.

b) for checking of electrical endurance, with the rated service current I_{Ne} in the main circuit, the following operating cycles shall be performed:

   L circuit breaker: 200;

   I and R circuit breakers: 100.

The test shall consist of carrying out the above number of operating cycles in groups of no less than 20 CO operations at no greater than 180 s intervals. For current ratings higher than 4 000 A, the group number may be reduced subject to agreement between purchaser and supplier.

6.6 Operation

6.6.1 Closing operation

The closing device, including the auxiliary control relays, if any, shall operate correctly for any voltage value of the supply source as given in 5.4 and in any operating condition of the circuit breaker.

6.6.2 Opening operation

6.6.2.1 General

The circuit breakers shall be, unless otherwise specified, trip-free.

Relays are covered by this subclause only if fitted to the circuit breaker.

6.6.2.2 Opening due to overcurrent relay or release

For a new circuit breaker, the release or relay shall operate with a minimum accuracy of ± 5 % of the set operating point, if electronic, and of ± 10 % of the set operating point, if electromagnetic, for any value of its current range.

6.6.2.3 Opening due to shunt release

A shunt release shall correctly operate for any supply voltage value of the supply source as given in 5.4, and with a further decrease of the minimum voltage by 15 % of the rated operating voltage, and for any operating condition of the circuit breaker up to the breaking capacity of the circuit breaker itself.

6.6.2.4 Opening due to undervoltage relay or release

An undervoltage relay or release, if provided, shall cause the opening of a circuit breaker, when the voltage is decreasing slowly, when the voltage is between 70 % and 35 % of its rated value.

An undervoltage relay or release shall not allow the circuit breaker to close when the supply voltage is lower than 35 % of its rated voltage; it shall not prevent the circuit breaker from closing for a supply voltage equal to or higher than 85 %.

NOTE A relay or release for loss of voltage is a particular type of undervoltage relay or release for which the operating voltage is between 35 % and 10 % of the rated supply voltage.

6.7 Corrosion protection

Steelwork and other materials of the equipment shall be treated in accordance with an approved type of corrosion protection except for arc-extinguishing sheets in the arc chute.

Purchasers may have their own specification, in which case the supplier shall either comply or offer an equivalent specification.

6.8 Noise emission

Noise emission from all equipment shall be minimised. The level of the noise emission during the breaking of its rated service current I_{Ne} shall be given by the supplier, if required by the purchaser.

6.9 Cooling

Unless otherwise agreed between purchaser and supplier, all equipment is expected to be naturally cooled.

6.10 Servo-control (where applicable)

The servo-control shall be mounted either on the circuit breaker or on a structure on which the circuit breaker is also mounted. The structure shall be earthed.

It shall not be possible for a fault in the servo-control to prevent the opening of the circuit breaker by a manual, electric or automatic control.

6.11 Other facilities

Circuit breakers shall have the following facilities:

a) a latching device, either electrical, magnetic or mechanical;

b) a mechanical indicator coupled to the moving contact, or an equivalent means to indicate the "closed" and the "open" conditions of the circuit breaker. Symbols "I" and "O" or "ON" and "OFF" shall be used to indicate the closed and open positions respectively;

c) means for earthing the circuit breaker structure either through a moving contact or a terminal.

Circuit breakers shall have the following facilities, when specified by the purchaser:

a) means of closing manually for maintenance;

b) operation counter;

NOTE These facilities may be supplied as standard by the manufacturer.

In addition to the number of auxiliary switch contacts required for normal operating circuits of the circuit breaker, the manufacturer shall provide an additional two for remote control and monitoring circuits. The number and type of contacts in addition to these shall be subject to agreement between purchaser and supplier.

7 Information and marking

7.1 Information

Purchaser and supplier shall exchange any necessary information in order to assure that the circuit breaker is suitable for the intended duty. This information is given in general in clause 5, and with regard to particular features or alternative choices for the contents, in clause 6. A summary of this information is provided in Annex A.

7.2 Marking

Each circuit breaker shall be indelibly marked.

The following indications shall be placed on the circuit breaker itself or on one or more rating plates attached to the circuit breaker:

a) name of the manufacturer or trade mark;

b) the reference to this European Standard corresponding to the National Standard which the manufacturer declares compliance with;

c) type designation (examples are given in Table 1);

d) serial number designation;

e) year of manufacture;

f) rated voltage(s) U_{Ne};

g) rated auxiliary and control supply voltages;

h) rated service/thermal currents I_{Ne}, I_{th} or I_{the};

i) rated short-circuit breaking capacity;

j) rated track time-constant T_{Nc};

k) rated short-time withstand current I_{Ncw} if applicable;

l) input and output terminals, unless they can be connected either way;

m) earth terminal, if applicable, by the symbol;

n) range of setting for releases (A or V);

o) compliance to service requirements differing from those indicated as normal (see clause 4 of EN 50123-1) (on a separate label if convenient).

All necessary labelling shall be provided for the purposes of safety, identification, instruction and information. Lifting attachments shall be marked.

The serial number and type designation shall be visible after installation of the circuit breaker when in the test position. The other markings shall be visible at least before installation. The manufacturer may fit an additional rating plate containing the prominent data for the circuit breaker on the corresponding circuit breaker enclosure.

8 Tests

8.1 General

General requirements concerning tests are shown in clause 7 of EN 50123-1.

NOTE For procedural matters not covered either in this standard or in EN 50123-1, reference may be made to other European or IEC publications covering similar equipment.

Unless otherwise indicated, the tests shall be performed at the rated service values of current, voltage, frequency (if applicable) and air pressure (if applicable). This applies to the complete circuit breaker (main, control and auxiliary) and in accordance with the values indicated in clause 5.

The test variables shall be within the tolerances indicated in Table 6 of EN 50123-1.

8.2 Applicable tests and test sequence

The applicable tests are summarised in Table 4, and tests shall be performed in the order given in Table 4 for each sequence group.

Table 4 - List of applicable tests and sequence

Group	Test description	Kind	Reference to subclause
1	General operating characteristics		
	Verification of conformity to the manufacturing drawings and to characteristics of the circuit breaker	Type and routine	8.3.1
	Mechanical operation	Type and routine	8.3.2
	Dielectric withstand	Type and routine	8.3.3
	Temperature-rise	Type	8.3.4
	Verification of the adjustment of the relays and releases	Routine	8.3.5
	Electrical endurance	Type	8.3.6
	Mechanical endurance	Type	8.3.7
2	Short circuit behaviour		
	Verification of the making and breaking characteristics in short circuit conditions and of the H, V or S characteristic	Type	8.3.8
	Verification of the short-time withstand current of rectifier circuit breakers R	Type	8.3.9
	Verification of the adjustment of the relays and releases	Type	8.3.5
3	Search for critical currents and low current test duty	Type	8.3.10

8.3 Performance of tests

8.3.1 Verification of the conformity to the manufacturing drawings and the characteristics of the circuit breaker

8.3.1.1 Verification of the conformity to the manufacturing drawings

The circuit breaker to be tested shall respect in all essential details the drawings of the represented type.

8.3.1.2 Measurement of the resistance of the main circuit

Resistance measurements of the main circuit shall be made with the circuit breaker at ambient temperature.

NOTE This measurement is also required both before and after each short circuit test (see 8.3.8 and 8.3.9).

8.3.1.3 Measurement of the resistance of the coils at ambient temperature

Measurements shall be taken at ambient temperature and shall be corrected to a measurement for a temperature of 35 °C.

8.3.2 Mechanical operation test

This test is carried out at the laboratory ambient temperature, in accordance with 7.3.1 of EN 50123-1.

The checks shall include:

- one satisfactory opening of the circuit breaker, while the closing device is energised (trip-free operation, see 3.4.11 of EN 50123-1) (if this feature is provided);
- that the closing operation is not completed when the closing operation is initiated while the opening device is under operation.

The opening and closing times (when indicated) shall be verified.

When required by the purchaser, this test is repeated as a type test, for abnormal environmental and/or operating conditions (7.3.1 of EN 50123-1).

8.3.3 Dielectric tests

Dielectric tests shall be in accordance with 7.5 of EN 50123-1, with the following qualifications.

8.3.3.1 Test conditions

Dielectric tests shall be carried out on a new circuit breaker, mounted as in service conditions. Where the supporting structure of the circuit breaker is made of insulating material, metallic pieces shall be inserted on the fixing point simulating the installation conditions.

8.3.3.2 Impulse withstand voltage test

This test is a type test only for circuit breakers having U_{Nm} above 2 500 V and is an investigation test in all other cases.

The test shall be performed in accordance with the requirements of 7.5.1 of EN 50123-1 both in the open and closed positions.

8.3.3.3 Power-frequency voltage withstand test

These tests are routine tests.

8.3.3.3.1 Main circuit

This test shall be carried out in accordance with 7.5.2 of EN 50123-1 both in the open and closed positions.

8.3.3.3.2 Control and auxiliary circuits

The test voltage is applied for 60 s in the following conditions:

a) application of the voltage between all the interconnected auxiliary and control circuits, which are not normally connected to the main circuit, and the circuit breaker metallic frame;

b) if an auxiliary circuit is intended to be physically segregated or fully isolated from the remaining auxiliary circuits, then the test is between this circuit and the remainder;

c) all equipment having previously satisfactorily passed this test may be disconnected.

NOTE Semiconductors should be short-circuited during the test.

8.3.3.4 Test values

R.M.S. test values are specified in accordance with Table 1 of EN 50123-1.

The level required for the test between the contacts may be selected at the level just below that for the main circuits and earth. Similarly, different voltage levels may be chosen for auxiliary and control circuits to earth and between themselves.

Repeated tests are carried out at 75 % of the voltage value stipulated for a new circuit breaker submitted for the first time to dielectric tests.

8.3.4 Temperature-rise tests

General provisions concerning temperature-rise tests are given in 7.4 of EN 50123-1. Temperature-rises specified in clause 6 of EN 50123-1 shall not be exceeded.

When the mutual heating between the main circuit, the control circuit and the auxiliary circuit may be important, the temperature tests detailed under 7.4.3 and 7.4.4 of EN 50123-1 shall be carried out simultaneously.

8.3.5 Verification of the adjustment of the relays and releases

8.3.5.1 Overcurrent relays or releases

Check that the current in the circuit breaker (in the correct direction for unidirectional circuit breakers) causes the opening within the limits stated in 6.6.2.2 for each indicated value of the setting range.

For circuit breakers whose operation is affected by the rate of rise of the current, in the vicinity of the setting values, 200 A/s shall not be exceeded.

8.3.5.2 Shunt release and undervoltage relay or release

Check that these devices cause opening of the circuit breaker within the limits given in 6.6.2.3 and 6.6.2.4 respectively.

8.3.6 Electrical endurance test

This test is a type test and is carried out in laboratory conditions.

The test procedure shall follow the requirements of 7.3.2 of EN 50123-1. The number of cycles to be carried out shall be as indicated in 6.5.

The test shall be carried out on a circuit breaker with its own closing device, energised at its rated voltage U_{Ne}, and during the test, the temperature-rises given in clause 6 of EN 50123-1 shall not be exceeded.

8.3.7 Mechanical endurance test

The test is a type test and is carried out in laboratory conditions.

The test procedure shall follow the requirements of 7.3.3 of EN 50123-1. The number of cycles to be carried out shall be as indicated in 6.5.

The test shall be made on a circuit breaker equipped with a closing device, which shall be supplied at a voltage within the limits set out in 5.2 of EN 50123-1, and the test shall be arranged in such a way that the temperature-rises given in clause 6 of EN 50123-1 are not exceeded.

All operating cycles, for I and R circuit breakers, and the first 4 000 operating cycles, for L circuit breakers, shall be carried out without maintenance; further operating cycles, for L circuit breakers, may be carried out with maintenance in accordance with the manufacturer's instructions, but shall not involve the replacement of any component.

The circuit breaker shall be deemed to have passed this test if, after the test, it is capable of operating normally, without any need of maintenance other than cleaning and greasing, or in accordance with the provisions set out in this subclause.

8.3.8 Verification of the making and breaking capacity in short-circuit conditions and of the H, V or S characteristic

8.3.8.1 Tolerance on the test values

This test is carried out at the values indicated by the manufacturer in 5.3.1 to 5.3.3 in accordance with 5.3.4. The test is considered valid if the reported values differ from stated values within the limits stated in Table 6 of EN 50123-1.

For laboratory reasons these tolerances may be revised by mutual agreement.

8.3.8.2 Test conditions

The circuit breaker shall be a complete assembly. The control device, except for control motors, shall be supplied at its minimum voltage value, as stated in 5.4.

The circuit breaker should be tested in an enclosure having the minimum volume and dimensions as declared by the manufacturer, or in open air when intended for cell use, using screens to simulate the closest proximity of cell walls and ceiling. These screens or cubicle shall be metal and connected to the circuit breaker earthed frame. Screens and cubicles may be lined with insulation if this is the manner in which the circuit breaker operates in service.

8.3.8.3 Procedure

The test, as specified in 5.3.4, consists of a number of duties particular to a class of circuit breaker with an appropriate duty cycle and release setting. Each duty cycle is required to be performed once and, because of the severe nature of the test, the circuit breaker may be maintained between duty cycles.

Where a circuit breaker can have applications of either of its primary terminals connected to the positive supply, then the test duties f), e) and d) shall be repeated for both connections.

After each test duty, a dielectric test is required in accordance with 7.6.3 of EN 50123-1.

8.3.8.4 Test circuit

A typical arrangement of the test circuits is shown in Annex A of EN 50123-1.

Details of the test circuit are given in 7.6.1 of EN 50123-1.

For test duties e and d, where insufficient impedance can be added to the load side, then the test duty shall be repeated with the live connection to the opposite terminal. Thus both terminals of the circuit breaker are stressed to earth during arc interruption.

For V type circuit breakers, test duty d should be performed with the circuit impedances all on the load side to stress the free wheeling diode of the circuit breaker, and then repeated with all the impedances on the supply side to stress the overvoltage absorbing devices.

Test duty e should also be performed in this way if the V type circuit breaker can be located at the maximum energy position.

8.3.8.5 Time-constant of the test circuit

For maximum faults, the time constant is not measured and is assumed correct if the ratio of peak to steady state is not less than 1,42. For the maximum energy test duty, the circuit time constant shall not be less than 0,5 times the rated track time constant T_{Nc} (see 5.1.1.3 of EN 50123-1 for actual values). For the distant fault condition, the circuit time constant t_c should be the rated track time constant T_{Nc}. For electrical endurance test, the circuit time constant t_c should be 0,01 s and for critical current test the circuit time constant t_c should be a practical value as close as possible to 0,01 s.

The time constant of the test circuit shall be measured during the calibration test and the measurement is that of the test current (see Figure A.2 - calibration 2 - of EN 50123-1).

8.3.8.6 Recovery voltage

For the test, the average value of the recovery voltage shall not be lower than the rated voltage U_{Ne}.

8.3.8.7 Details for the conduct of the tests

These shall be in accordance with the conditions specified in 7.6.2 of EN 50123-1.

8.3.8.7.1 Calibration of the test circuit

The test shall be performed at the rated voltage U_{Ne} , calibrated with the test unit A replaced by a provisional connection B of negligible impedance in respect to the test circuit.

Adjust resistors R and reactors L in order to obtain both the sustained short-circuit current and the rated time constant. These values are for the prospective current and shall be those declared by the manufacturer, within the tolerances stated in 7.2 of EN 50123-1 (see also 8.3.8.1).

Where the short circuit requires a peak value, it shall be not less than 1,42 I_{SS}.

NOTE The value of I_{SS} may have to be adjusted to achieve the required peak value.

8.3.8.7.2 Performance of the test

Replace the provisional connection B by the test unit A, with the terminals of the circuit breaker connected as required by the test duty. The test shall comply with 8.3.8.3.

After the current interruption, the recovery voltage shall be maintained for 0,1 s.

8.3.8.7.3 Behaviour of the circuit breaker during the making and breaking short circuit tests

During the test the circuit breaker shall break the short-circuit current; there shall be no re-ignition after current zero. The short circuit current shall be the rated short circuit current.

The circuit breaker shall achieve the values given in Table 5.

Table 5 - Verification of the behaviour of the circuit breaker when performing test duties f, ff and fr

Type	Opening time ms	Total break time ms	Ratio of I_{Nss} to setting	di/dt at $t = 0$ kA/ms
H	≤ 5	≤ 20	≥ 7	≥ 5
V	≤ 1	≤ 4	Not applicable	Not applicable
S	≤ 15	≤ 30	≥ 3,5	≥ 1,7
See 3.4.7 and 3.4.8 of EN 50123-1.				

The fuse element in the protection device D shall not blow during the test.

The cut-off current shall be verified.

8.3.8.7.4 Conditions of the circuit breaker after the above test

These shall be in accordance with the conditions specified in 7.6.3 of EN 50123-1.

8.3.8.8 Verification of the H, V or S characteristic for test duties f, ff and fr

During the maximum fault test for test duties f, ff and fr, the behaviour of the circuit breaker in meeting its class designation of either H, V and S shall be verified only if the test currents and settings are as given in Table 5.

The opening time and total break time of each type of circuit breaker shall be as given in Table 5.

Where the test currents have values of ratio and di/dt less than the requirements in Table 5 for the type category during the standard type tests, and give opening and total break times greater than required, a single opening test at a reduced circuit breaker setting, within the setting range of the circuit breaker, shall be performed to demonstrate compliance with the required opening and total break times of Table 5.

8.3.9 Verification of behaviour under short-time withstand current for test duty s

8.3.9.1 Test values

These shall be in accordance with the conditions specified in 7.7.1 of EN 50123-1.

8.3.9.2 Test conditions

The unit shall be subject to the conditions specified in 8.3.8.2 and 7.7.2 of EN 50123-1.

8.3.9.3 Behaviour of the circuit breaker during test

These shall be in accordance with the conditions specified in 8.3.8.3 and 7.7.3 of EN 50123-1 (where applicable).

8.3.9.4 Condition of the circuit breaker after completion of the test

After the test, mechanical parts and insulation parts shall conform to 7.7.4 of EN 50123-1 (where applicable).

8.3.10 Searching for critical currents and performing test duty l) and lr)

Searching for critical currents is a type test for all types of circuit breakers to provide the value of current to be used for the low current test duty l and lr of Table 2 in 5.3.4.2.

Annex C of EN 50123-1 gives the procedures for searching for critical currents.

For L circuit breakers, the test duty l is performed to the requirements for unidirectional circuit breakers in a similar manner as described in C.2 of EN 50123-1.

NOTE 1 This applies to both U_1 and U_2 circuit breakers.

For R and I circuit breakers, the test duty lr is performed to the requirements for bidirectional circuit breakers in a similar manner as described in C.3 of EN 50123-1.

NOTE 2 R circuit breakers have a unidirectional reverse trip release and break low currents in the forward direction.

Annex A
(informative)

Information required

A.1 General

This annex gives a summary of the information which may be used as guidance to fulfil clause 7.

A.2 Procurement specification

The following items should be included, where applicable, within the procurement specification issued by the purchaser in order to provide the precise technical requirements for particular installations:

a) service conditions differing from those defined as "normal" (see clause 4 of EN 50123-1);

b) detail of the types (including duties use and categories) of circuit breakers;

c) the data mentioned in clause 5 to be provided by the purchaser;

d) particular features concerning clause 6 and terminal details;

e) continuous rating of circuit breakers and load cycle;

f) test duty cycle - duty 1 or duty 2;

g) calibration range and increments for overcurrent protection;

h) maximum and minimum voltage of auxiliary supply;

i) details and arrangements for transport and delivery to site including the maximum packing dimensions;

j) lower mechanical operation cycles for L circuit breaker if required by the purchaser (see 6.5a).

A.3 Manufacturer's specification

The following information should be given by the manufacturer:

a) identification
   1) name of the manufacturer or trademark;
   2) type designation;
   3) reference to the National Standard corresponding to this European Standard, which the manufacturer declares compliance with;
   4) manufacturing year and serial number;
   5) marking of all connections (primary and auxiliary).

b) characteristics

1) confirmation of the type, use and duties (see 5.2b and c and 5.3.4);
2) suitability to use service requirements differing from normal (as defined as normal in clause 4 of EN 50123-1);
3) rated voltage(s) U_{Ne};
4) range of voltage(s) at which the circuit breaker operates satisfactorily;
5) rated current(s) at the rated voltage(s) of the equipment I_{Ne};
6) rated track time constant T_{Nc};
7) current interruption direction, U_1, U_2 or B;
8) circuit breaker test duty cycle;
9) circuit breaker use, L, I or R;
10) restriction of V to rectifier substation use only, if applicable;
11) maximum arc voltage in test conditions;
12) conventional thermal current and enclosed thermal current, if applicable I_{th}, I_{the};
13) contact(s) material;
14) rated insulation voltage U_{Nm};
15) rated impulse withstand voltage level U_{Ni}, if applicable;
16) power required at rated control voltage to close circuit breaker;
17) power required at rated control voltage for shunt trip coil or equivalent device;
18) confirmation of the suitability to the load cycle specified by the purchaser
19) resistance in the circuit breaker main circuit;
20) guaranteed temperature-rises (see clause 6 of EN 50123-1) at rated service current in the various parts of the circuit breaker and temperature-rises in overload conditions;
21) rated short-circuit making and/or breaking capacities at the various duties specified I_{Nss};
22) break time as a function of rate of rise of current (di/dt);
23) closing time;
24) cut-off current as a function of rate of rise of current (di/dt);
25) critical current;
26) type of arc chute;
27) whether the circuit breaker is held closed electrically, magnetically or mechanically;
28) IP code in the case of an enclosed equipment (according to EN 60529);
29) characteristics of the overcurrent protection relay and releases;
30) rated voltage(s) of the control circuit(s), nature (and frequency) of the current(s);
31) nature of the current (rated frequency) and supply voltage of the control, if different from those of the control coil;
32) rated air pressure and pressure variation limits (for devices with pneumatic control);

33) weights of the complete circuit breaker and of the withdrawable part if any;

34) minimum size of the enclosure and, if applicable, data concerning ventilation, to which the rated characteristics apply;

35) minimum distance between the circuit breaker and metal parts connected to earth for circuit breakers which are intended for use without an enclosure;

36) rated voltage of the control circuit of the shunt release and/or undervoltage release (or no-voltage release);

37) rated current of overcurrent releases;

38) setting range(s) of the overcurrent release;

39) method for varying current calibration;

40) method of tripping;

41) effect, if any, of temperature variation on current calibration;

42) type and power consumption of the anti-pumping device;

43) type and power consumption of interposing relays;

44) type and power consumption of all built-in control equipment;

45) number and type of auxiliary contacts and nature of the current, rated frequency (if applicable) and rated voltage(s) of auxiliary switches;

46) continuous rating and breaking capacity of each auxiliary contact;

47) method of fixing the circuit breaker;

48) details of arrangements for manoeuvrability of circuit breaker truck, if any;

49) details of draw-out space required;

50) details of access required at rear;

51) manufacturer's recommended period for routine maintenance (contacts, arc chute and whole circuit breaker) taking into account the number of operations at rated service current INe and maximum short-circuit current INss.

NOTE The above characteristics are only used where they specifically apply to the application.

c) drawings

1) general arrangement and sectional elevations of circuit breaker showing overall dimensions, required space for removing arc chute, required space to insulated and/or earthed parts (if applicable) and space required for circuit breaker withdrawal, maximum shipping dimensions, shipping weight and estimated gross weights and shock loading for floors;

2) schematic diagram of control;

3) general arrangement of any floor irons and area to be left unscreened for the contractor to finish, and loading details;

4) characteristics (i2t or break time or cut-off current) of the circuit breaker;

5) oscillographic records showing circuit breaker performance under the specific interrupting conditions;

6) installation, operation and maintenance manuals.

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