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General purpose push-pull three-pole circuit-breakers for aircraft — Performance requirements

Disjoncteurs tripolaires à bouton-poussoir d'usage courant utilisés à bord des aéronefs — Caractéristiques

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Foreword

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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 document 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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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 1, *Aerospace electrical requirements*.

This second edition cancels and replaces the first edition (ISO 1509:1973), which has been technically revised.

The main changes are as follows:

— ambient temperature and altitudes have been updated;

— operation forces have been updated;

— time/current characteristics have been updated;

— mechanical shocks test have been updated;

— high voltage and insulation tests have been updated;

— tests of temperature rise and minimum and maximum limit of ultimate trip current have been updated;

— operating forces test have been updated;

— mechanical strength tests have been updated;

— overload and re-closure test have been updated.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides performance requirements of the general purpose push-pull three-pole circuit-breakers normal ratings up to and including 35 A for aircraft.

The purpose of this document are as follows:

a) To standardize the requirements for push-pull three-pole trip-free circuit-breakers that are physically and environmentally diversified.

b) To provide the applicable document for push-pull three-pole trip-free circuit-breakers.

In order to satisfy the purpose of this document, requirements such as those for physical, environmental and individual items are specified in accordance with the detail requirements that are issued individually.

General purpose push-pull three-pole circuit-breakers for aircraft — Performance requirements

1 Scope

This document specifies the performance requirements for push-pull, three-pole, trip-free circuit breakers having an inverse time/current characteristic of normal ratings up to and including 35 A for use in nominal 115 V/200 V three-phase 400 Hz a.c. circuits.

2 Normative references

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.

ISO 2635, *Aircraft — Conductors for general purpose aircraft electrical cables and aerospace applications — Dimensions and characteristics*

ISO 1033, *Aircraft — Dimensions for general purpose push-pull three-pole circuit-breakers*

ISO 1540, *Aerospace — Characteristics of aircraft electrical systems*

ISO 7137, *Aircraft — Environmental conditions and test procedures for airborne equipment*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
push-pull three-pole circuit-breaker
circuit-breaker with a single button to trip and reset the breaker, by pushing to make and pulling to break

3.2
trip-free circuit-breaker
Circuit-breaker so designed that holding the push-button in the closed position does not override the tripping mechanism and does not permit subsequent closure of the contacts, until the push-button has been returned to the open position and the tripping mechanism has reset

4 Design requirements

4.1 Ambient temperature and altitudes

The circuit-breaker shall be suitable for use at specified ambient temperatures and altitudes. There are two temperature ranges: −55 °C to +70 °C or −55 °C to +125 °C; and the maximum altitude according to the product standard shall not be less than 22 000 m.

4.2 Operation and instructions

The circuit-breaker shall be operated by a single button, perpendicular to the plane of the mounting panel, pushed to make and pulled to break the circuit. The portion of the button visible when the circuit-breaker is in the closed position shall be black. A white band on the button shall be exposed when the circuit-breaker is in the open position.

4.3 Fixing type

The circuit-breaker shall be suitable for through-panel mounting, preferably by single-hole fixing, and shall operate satisfactorily when mounted in any attitude.

4.4 Trip-free function

The circuit-breaker shall be trip-free and shall incorporate an automatic overload tripping device in each pole.

4.5 Working characteristics

The three sets of contacts shall open and close together when manually operated at normal load and shall open together when automatically tripped on overload current in one or more lines, when the push-button shall move to the open or off position. The difference in time between the making or breaking of the three sets of contacts shall be not more than 5 ms.

4.6 Re-close

The circuit-breaker shall be so designed that, after tripping on overload, it cannot re-close automatically.

5 Dimensions

The envelope and fixing dimensions for the circuit-breakers should conform to ISO 1033.

6 Construction

6.1 Push-button

The push-button shall be insulated from all current-carrying parts, and shall not remain in an intermediate position, or give a false indication.

6.2 Operation forces

The circuit-breaker shall be so constructed that the forces required to operate it manually do not exceed the following values:

— closing force: 8 N to 80 N;

— tripping force: 5 N to 30 N.

6.3 Surface treatment

The portion of the circuit-breaker visible when mounted shall have a non-glaring finish.

6.4 Rating inviolability

The circuit-breaker shall be so constructed that tampering with the calibration is not possible without dismantling the device or breaking a seat.

6.5 Electrical connections

Each terminal screw or stud shall be size M4 X 0,7 or No. 6 UNC and shall be capable of accepting two tag-type terminations.

6.6 Fasteners

The circuit-breaker shall be mounted by means of a threaded bush suitable for use with the panel mounting hole specified in ISO 1033. Two hexagon mounting nuts, one locating washer and one internal shakeproof washer shall be provided with each circuit-breaker.

7 Voltage and current ratings

7.1 Voltage

The circuit-breaker shall be suitable for operation in a nominal 115 V/200 V three-phase 400 Hz a.c. supply having the characteristics described in ISO 1540.

7.2 Current ratings

The preferred normal current ratings of the circuit-breakers are 1 A, 2 A, 3 A, 5 A, 7,5 A, 10 A, 15 A, 20 A, 25 A, 30 A or 35 A.

8 Environment

The circuit-breakers shall conform to the requirements of ISO 7137, including vibration, acceleration, crash-landing, climatic, explosion proofness and magnetic influence. They shall not support mould growth and shall not deteriorate even after storage for long periods in the tropics.

9 Time/current characteristics

The time/current characteristics of each circuit-breaker can be within the limits shown in Table 1, or the product standard.

Table 1 — Time/current characteristics

Nominal current rating	Ambient temperature	Tripping current	Tripping time
A	°C	%normal current	s
1 to 35	23 ± 2	200 500 1 000	1,5 to 60 0,15 to 7,5 0,035 to 1,2
1 to 5	−55 ± 2	200 500 1 000	1,5 to 350 0,15 to 15 0,035 to 2
7,5 to 35	−55 ± 2	200 500 1 000	1,5 to 200 0,15 to 12 0,035 to 1,75
1 to 35	+70/+125 ± 2	200 500 1 000	1,5 to 45 0,15 to 7 0,035 to 1

10 Making and breaking capacity

The circuit-breaker shall have a making and breaking capacity appropriate to the relevant categories shown in Table 2, when tested under the conditions described in 13.15.

Table 2 — Making and breaking categories

Rupturing capacity category	Calibrated test current (A) (prospective current)			
1 A	—	—	1 000 [a]	750 [b]
2 A	—	—	1 000 [b]	750 [b]
3,5 A	3 500 [a]	2 000 [b]	1 000 [b]	750 [b]

[a] 0,4 to 0,5 lagging power factor.

[b] Unity power factor.

11 Endurance

The circuit-breaker, when carrying current, shall be capable of withstanding 10 000 cycles of manual close and open operations or some other number of cycles of operations which the manufacturer may declare, at the fastest practical rate, but at not less than two complete cycles per minute, with a ratio of time open of approximately 1:1, under the conditions described in 13.14.

12 Tests

12.1 General

Evidence shall be available to the purchaser that circuit-breakers have satisfactorily passed type tests conducted in accordance with Clause 13. In order that a consistent standard of quality be maintained, the manufacturer shall conduct production tests in accordance with Clause 14 and quality tests in accordance with Clause 15.

12.2 Requirements

The tests shall be made with the cover on. With the exception of the making and breaking capacity test (see 13.15), for which the test circuit is prescribed, all tests shall be performed with the circuit-breaker connected on each side by copper-cored cable conforming to ISO 2635, of the appropriate size, as given in Table 3.

Table 3 — Cable size

Circuit-breaker rating A	Cable size
1 to 5	22
7,5	20
10	18
15	16
20	14
25 and 30	12
35	10

Each cable shall be at least 915 mm in length and shall be attached to the circuit-breaker by a crimped termination of approved design.

12.3 Test conditions

Unless otherwise stated:

a) before each individual calibration check, the circuit-breaker and its connected cables shall be maintained at the appropriate temperature for 1 h prior to the commencement of the test;

b) except for the calibration checks, the tests in 13.3, 13.4, 13.6, 13.7, 13.8, 13.10, 13.11, 13.14, 13.15, 15.3 and 15.5 shall be made at a temperature between 15 °C and 30 °C.

13 Type tests

13.1 General

The tests shall be made on representative samples of each particular design and rating of circuit-breaker unless an agreement has been obtained to omit specific tests on intermediate ratings.

13.2 Requirements

With the exception that a separate circuit-breaker may be used for the fungus growth test (see 13.5), the tests prescribed in 13.3, 13.4.1 and 13.5 shall be performed on the same circuit-breaker in the order stated. The tests in 13.4.2 and 13.7 to 13.16 may be performed on another circuit-breaker or other circuit-breakers, except that the tests in 13.10 and 13.14.2 shall be made on one circuit-breaker. Every circuit-breaker used for type test purposes shall previously have passed the production tests (see Clause 14). At the end of the test, or group of type tests, to which each circuit-breaker is subjected, it shall be tested in accordance with 13.6.2 and shall then be stripped and examined in accordance with 15.6.

13.3 Vibration test

The circuit-breaker shall be subjected to the appropriate vibration tests described in ISO 7137.

The resonance tests shall be conducted with the circuit-breaker in both the open and closed positions with normal rated voltage or current applied, as appropriate; and in each case oscilloscopic methods shall be used to check that there is no inadvertent opening or closing of the contacts throughout the test. 10 % of the vibration endurance tests (fatigue tests) shall be performed with the circuit-breaker in the open position, and 90 % with the circuit-breaker in the closed position and carrying 100 % normal rated current. At intervals of not greater than 3 h during the latter test, the voltage drop across the circuit-breaker terminals shall be measured and shall not exceed the limits shown in Table 5.

At the end of the test a cooling period of not less than 2 h shall be allowed, followed by a calibration check at 200 % rated current. Tripping shall occur within the time limit shown in Table 1 for 23 °C.

13.4 Acceleration and mechanical shocks tests

13.4.1 Acceleration test

The circuit-breaker shall be subjected to the appropriate acceleration tests described in ISO 7137, for a period of not less than 1 min, with the circuit-breaker in both the open and closed positions with normal rated voltage or current applied, as appropriate. A check shall be made to ensure that there is no inadvertent opening or closing of the contacts throughout the tests.

At the end of the test, a cooling period of 2 h in free air shall be allowed, followed by a calibration check at 200 % normal rated current. Tripping shall occur within the time limit shown in Table 1 for 23 °C.

13.4.2 Mechanical shocks test

The circuit-breaker shall be subjected to the appropriate crash condition tests described in ISO 7137, both in the closed position and carrying normal rated current, and in the open condition. In addition, it shall remain closed or open, as appropriate, during this test.

At the end of the test, a cooling period of 2 h in free air shall be allowed, followed by a calibration check at 200 % normal rated current. Tripping shall occur within the time limit shown in Table 1 for 23 °C.

13.5 Climatic test

The circuit-breaker shall be subjected to the appropriate climatic tests described in ISO 7137.

Functioning tests as described in a), b) and c) below shall be made during the course of climatic testing. At the conclusion of the tropical exposure and fungus growth tests, tests a), b) and c) shall be made.

a) A calibration check at 200 % rated current. Tripping shall occur within the time limits shown in Table 1 appropriate to the particular ambient temperature.

b) Ten make-and-break operations shall be performed over a period of 1 min at rated voltage and 100 % rated current, or declared current when the test is made at 70 °C/125 °C, with a resistive load. The voltage drop across the circuit-breaker terminals shall be measured carrying 100 % rated current and shall not exceed the limits shown in Table 5.

c) The circuit-breaker shall carry the declared current at an ambient temperature of 70 °C/125 °C for 1 h without tripping.

13.6 High voltage and insulation tests

13.6.1 High voltage test

A test voltage of not less than 1 500 V r.m.s. 50 Hz or 60 Hz at sea level, and a test voltage of not less than 500 V r.m.s 50 Hz or 60 Hz at 22 000 m or the maximum altitudes according to the product standard, shall be applied for a period of between 5 s and 10 s between:

a) the terminals with the circuit-breaker in the open position;

b) phases with the circuit-breaker in the open and closed position;

c) the terminals connected and a metallic mounting plate to which the circuit-breaker is fastened by its normal mounting arrangement, with the circuit-breaker in the open and closed positions;

d) the terminals connected and all exposed metal parts;

e) the tip of the actuating device(s) and the terminals connected with the circuit-breaker in the open and closed positions.

The voltage should be increased and decreased gradually.

13.6.2 Insulation resistance tests

Immediately following the tests described in 13.6.1, the insulation resistance shall be measured at a potential of 500 V d.c. between the same points as in 13.6.1 a) to e); and the results shall conform to the relevant requirements of ISO 7137.

13.7 Test of explosion-proofness

The circuit-breaker shall be subjected to the test described in ISO 7137, for explosion-proof equipment.

13.8 Measurement of magnetic influence

The compass safe distance relative to the circuit-breaker when carrying 100 % rated current shall be measured in the manner described in ISO 7137.

13.9 Tests of temperature rise and minimum and maximum limit of ultimate trip current

The circuit-breaker, in conditions of still air, shall be submitted to the tests detailed in Table 4. Immediately on completion of the final test, with the circuit-breaker still hot at an ambient temperature of 70 °C/125 °C, the circuit-breaker shall be subjected to a test in accordance with 13.6.2.

Table 4 — Tripping currents and tripping times

Ambient temperature	Tripping current	Tripping time
°C	%normal current	
+23 ± 2	115	>1 h
+23 ± 2	140	≤1 h
−55 ± 2	115	>1 h
−55 ± 2	160	≤1 h
+70/+125 ± 2	100	>1 h
+70/+125 ± 2	140	≤1 h

For this test the temperature rise of external parts shall be measured.

The temperature rise in the attached cable (measured with a suitable thermocouple, when the temperature reading becomes stable, at the surface of the conductor beneath the insulation at a point 25 mm from the end of the insulation) shall not exceed 75 °C.

13.10 Operating forces test

The maximum and minimum forces necessary for the operation of the circuit-breaker to both the open and closed positions shall be determined and declared. The force shall be applied in the line of travel of the push-button. The force required to operate the circuit-breaker shall not exceed the relevant value specified in 6.2.

During this test it shall be established that the circuit-breaker has a positive action and will not remain with the button in an intermediate position when operating to the open and closed positions.

13.11 Mechanical strength tests

13.11.1 Strength of terminations

All terminations shall be subjected for not less than 1 min to:

a) a 45 N pull in each of the following directions:

— parallel to the long axis of the terminal screw;

— at right angles to the long axis of the terminal screw;

b) a torque of 1,8 N.m applied to the terminal screw.

13.11.2 Strength of push-button

A force of 110 N shall be applied to the push-button for not less than 1 min under each of the following conditions, during which the circuit-breaker shall be connected electrically to check contact operation:

a) perpendicular to the axis of travel of the push-button in both directions along the major and minor axes of the body of the circuit-breaker in both open and closed positions;

b) co-axial with the push-button axis toward and away from the circuit-breaker body throughout the entire range of push-button travel.

For the test in a) the load shall be applied 3 mm from the end of the push-button.

13.11.3 Strength of panel mounting bush

A tightening torque of 3,6 N.m shall be applied for not less than 1 min to the mounting nut with the circuit-breaker mounted in a panel and located by means of the locating washer and key-way.

13.11.4 Tests

There shall be no damage or distortion to the threads, key-way, locating washer, locknut or circuit-breaker as a result of the tests in 13.11.1, 13.11.2 and 13.11.3 immediately, following which the circuit-breaker shall:

a) satisfy the requirements of the insulation resistance test (13.6.2);

b) carry 100 % normal rated current in a temperature of 23 °C ± 2 °C for 1 h without tripping;

c) trip within the time limits shown in Table 1 for 23 °C ± 2 °C when carrying 200 % normal rated current.

13.12 Test of calibration of overload trip

13.12.1 General

The circuit-breaker shall be subjected to a series of tripping tests at ambient temperatures of 23 °C ± 2 °C, −55 °C ± 2 °C and 70 °C/125 °C ± 2 °C, to confirm its conformity to the performance requirements stated in Table 1. The tests shall be made:

a) with the three poles connected in series (in order to obtain equal currents in the three poles);

b) on each pole with the other two poles disconnected.

13.12.2 Additional requirements

In addition, to determine this characteristic completely, tripping times shall be recorded and declared for currents of 20 and 30 times normal current on circuit-breakers rated 1 A to 10 A.

Each tripping time shall be measured at least three times, a cooling period of not less than 2 h being allowed between checks.

13.13 Overload and re-closure test

13.13.1 General

The circuit-breaker shall be connected to control a resistive load carrying 200 % normal rated current, and shall be operated as follows:

Close -- trip automatically -- re-close within 20 s of automatic trip.

These operations shall be repeated 100 times.

13.13.2 Requirement

Immediately following re-closing of the circuit-breaker at the end of the last operation in 13.13.1, the load shall be reduced to 115 % normal rated current and shall then be carried for a period of 1 h without automatic tripping.

The voltage drop across the circuit-breaker terminals shall be measured at the end of this test carrying 100 % rated current and shall not exceed the limits specified in 13.14.

13.13.3 Tests

At the end of the tests described in 13.13.1 and 13.13.2 a cooling period of not less than 2 h shall be allowed, followed by calibration checks on the same circuit-breaker at 200 % and 500 % normal rated current. Tripping shall occur within the time limits shown in Table 1.

13.14 Endurance tests

13.14.1 General

A single circuit-breaker shall be checked for conformity to the requirements for the limits of ultimate trip (see 13.9) and the operating forces test (13.10) and shall be subjected to 10 000 cycles of manual close and open operations at the fastest practical rate, but not less than two complete cycles per minute, divided as stated in 13.14.2. The time closed shall be approximately equal to the time open.

The manual operation may be performed mechanically but shall simulate normal correct manual operation of the circuit-breaker, including overtravel where this is a feature of the design.

No adjustment to the mechanism or contacts shall be made at any time during the tests.

13.14.2 Test conditions

a) 2 500 cycles at 100 % normal rated current resistive load at sea level;

b) 2 500 cycles at 100 % normal rated current in a circuit of 0,75 power factor lagging at sea level.

The test supply shall be three-phase and shall be maintain at 200 V to 210 V, 380 Hz to 420 Hz a,c. throughout.

13.14.3 Requirements

During the tests in 13.14.2 the voltage drop across the terminals of each pole of the circuit-breaker shall be measured, at 100 % normal rated direct current, prior to commencement of the test, at every 500 cycles of operation, and on completion of the test and shall at no time exceed the limits shown in Table 5. During the test a check shall be made to ensure that interphase arcing does not occur and that the difference between making or breaking of the three sets of contacts does not exceed 5 ms.

Table 5 — Voltage drop

Normal rated current A	Voltage drop across terminals max. mV
1	1 500
2	1 000
3	750
5	300
7,5	300
10	300
15	225
20	200
25	200
30	180
35	160

At the conclusion of the endurance test, the circuit-breaker shall be subjected to a check calibration of minimum and maximum limits of ultimate trip current as in 13.9. The tripping time shall also be checked at 200 % rated current, and shall be within the limits shown in Table 1 for 23 °C.

13.14.4 Tests

Upon completion of the tests described in 13.14.1 to 13.14.3, the circuit-breaker shall be retested in accordance with 13.10.

13.15 Making and breaking capacity tests

13.15.1 General

Tests shall be performed at the prospective test currents stated in Table 2 appropriate to the declared rupturing capacity of the circuit-breaker under test.

More than one circuit-breaker may be used for these tests, but tests at a particular test current and air pressure shall be made on the same sample.

The circuit-breaker shall be test at an air pressure corresponding to sea level and at an air pressure corresponding to an altitude of 22 000 m or the maximum altitudes according to the product standard by inserting it into the calibrated test circuit and testing as follows:

Break test current -- make and break test current - make and break test current.

Sufficient force shall be applied to the operating button to achieve normal closing of the circuit-breaker; the minimum rate of travel of the button should be 12,7 mm/s.

The circuit-breaker shall be tested with a fault current applied as a balanced three-phase fault, and as a fault across the terminals of any one pole of the circuit-breaker, the other two carrying normal rated current.

During the calibration tests the cable terminations normally connected to the circuit-breaker under test shall be clamped together without an intermediate link. A fine fuse wire (0,122 mm diameter) shall be connected between the circuit-breaker mounting face and the system neutral or negative. A typical test circuit is shown in Figure 1.

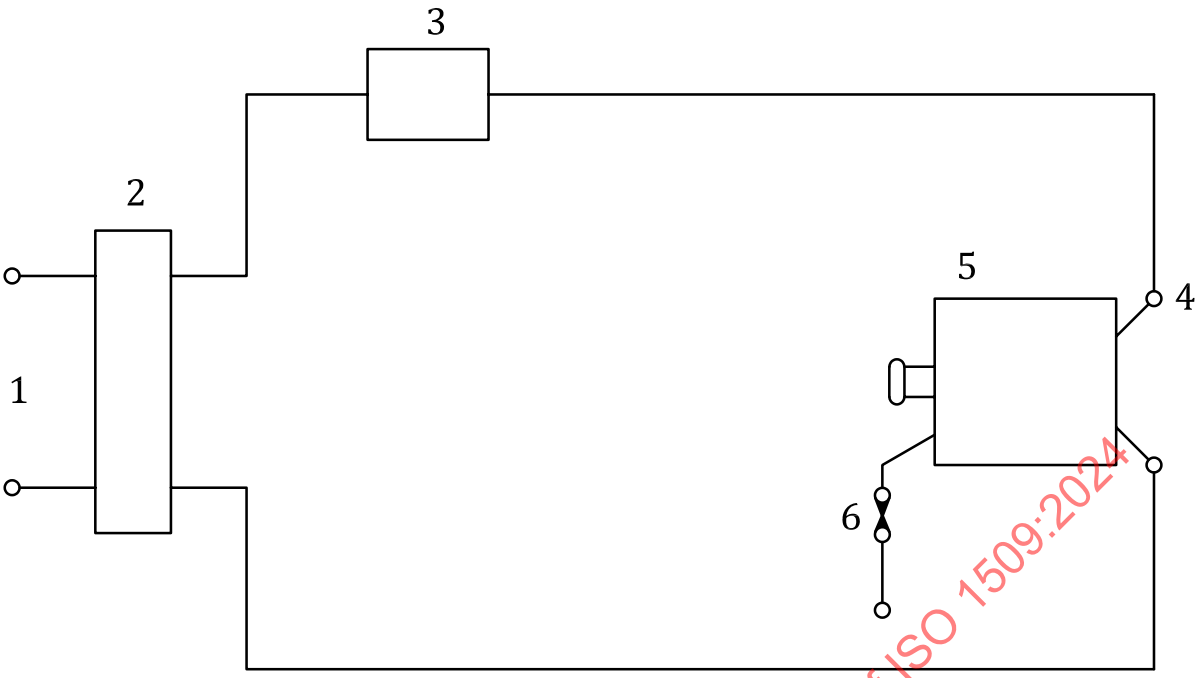
The actual time of rise of the test current shall be recorded during the calibration tests and this value shall be stated in the test reports.

Oscillograph records of the test current during these tests shall be made.

The open circuit voltage shall be maintained across the circuit-breaker terminals for a minimum period of 5 s after recovery to stable conditions; and there shall be no current flow or arcing between the contacts during this period.

During the test, there shall be no leakage current as indicated by melting of the fine fuse wire.

All connections shall be as short as possible and of very low resistance. The system circuit-breaker shall be capable of making and breaking repeatedly and without deterioration the maximum specified test current.



Key

1 power source
2 system circuit-breaker
3 shunt or current transformer for measuring test current
4 line terminal
5 circuit-breaker under test
6 fuse wire 0,122 mm diameter connected to system neutral or negative

Figure 1 — Typical test circuit for breaking capacity test

13.15.2 Test conditions

A source of power capable of providing balanced three-phase currents of the values specified in Table 4 shall be calibrated to conform to the following requirements:

a) the open circuit voltage shall be 200 V to 210 V r.m.s at 400 Hz ± 20 Hz;

b) the transient open circuit recovery voltage after interruption of the test current shall be 205 V within three cycles, 260 V within six cycles, and shall not exceed 285 V;

c) for currents up to 2 000 A, the relevant prospective current shall be reached within five cycles and for currents up to 3 000 A, the relevant prospective current shall be reached between 10 and 25 cycles;

d) the frequency during the test shall be within 350 Hz to 450 Hz.

13.15.3 Tests

At the conclusion of the tests described in 13.15.2 and after a cooling period of not less than 1 h, each circuit-breaker shall carry 115 % rated current for 1 h without tripping. When carrying 200 % rated current the circuit-breaker shall have a tripping time within 120 % of the maximum and 80 % of the minimum times specified in Table 1. The high voltage and insulation resistance tests specified in 13.6 shall then be repeated.