IEC 63522-48

Edition 1.0 2024-12

INTERNATIONAL STANDARD

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Electrical relays – Tests and measurements – Part 48: Contact failure rate test

Relais électriques – Essais et mesurages – Partie 48 : Essai de taux de défaillance des contacts

IEC 63522-48:2024-12(en-fr)

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Relais électriques – Essais et mesurages – Partie 48 : Essai de taux de défaillance des contacts

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ICS 29.120.70

ISBN 978-2-8327-0061-7

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ELECTRICAL RELAYS – TESTS AND MEASUREMENTS –

Part 48: Contact failure rate test

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

Draft	Report on voting
94/1039/FDIS	94/1084/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

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A list of all parts of IEC 63522 series, published under the general title *Electrical relays — Tests and measurements*, can be found on the IEC website.

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ELECTRICAL RELAYS – TESTS AND MEASUREMENTS –

Part 48: Contact failure rate test

1 Scope

This part of IEC 63522 is used for testing electromechanical elementary relays (electromechanical relays, reed relays, reed contacts, reed switches and technology combinations of these) and for evaluating their ability to perform under expected conditions of transportation, storage and all aspects of operational use.

This document defines a standard test method for contact failure rate test of electromechanical elementary relays applied to low-load applications (for example, CC 0, CC 1) and failure rates and failure rate levels at low loads under specified conditions.

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.

IEC 60605-4:2001, *Equipment reliability testing – Part 4: Statistical procedures for exponential distribution – Point estimates, confidence intervals, prediction intervals and tolerance intervals*

IEC 61810-1, *Electromechanical elementary relays – Part 1: General and safety requirements*

IEC 61810-2, *Electromechanical elementary relays – Part 2: Reliability*

IEC 61810-4, *Electromechanical elementary relays – Part 4: General and safety requirements for reed relays*

IEC 62246-1, *Reed switches – Part 1: Generic specification*

IEC 62246-1-1:2018, *Reed switches – Part 1-1: Generic specification – Blank detail specification*

IEC 62246-4:2023, *Reed switches – Part 4: Application in conjunction with magnetic actuator used for magnetic sensing devices*

IEC 63522-0:–, *Electrical relays – Tests and measurements – Part 0: General and guidance*[1]

IEC 63522-6, *Electrical relays – Tests and measurements – Part 6: Contact-circuit resistance (or voltage drop)*[2]

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[1] Under preparation. Stage at the time of publication: IEC CDV 63522-0:2024.

[2] Under preparation. Stage at the time of publication: IEC FDIS 63522-6:2024.

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IEC 63522-7, *Electrical relays – Tests and measurements – Part 7: Functional tests*[3]

IEC 63522-45:–, *Electrical relays – Tests and measurements – Part 45: Maximum frequency of operation*[4]

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61810-1, IEC 61810-2, IEC 63522-0, IEC 62246-1 and the following apply.

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

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

3.1 Terms and definitions related to failure rate

3.1.1
failure rate
number of failures relative to the number of cycles of service of the relay

Note 1 to entry: λ_c is the reciprocal of $MTBF_c$.

[SOURCE: IEC 60050-444:2002, 444-07-09]

3.1.2
failure rate level
accumulated number of non-conforming units under specified operating conditions and specified accumulated time (cycles), evaluated for a given confidence level

Note 1 to entry: Higher (lower) failure rate level: This term describes a failure rate level associated with a higher (lower) number of failures per unit time (cycle).

3.1.3
confidence level
probability expressed in percentage (%) that a lot with a failure rate in the failure rate level of will be rejected

3.1.4
total testing cycles
total number of operations
sum of test cycles or of numbers of operations spent or done on all DUTs

Note 1 to entry: Total test cycles is called component hour, sometimes.

[3] Under preparation. Stage at the time of publication: IEC BPUB 63522-7:2024.

[4] Under preparation. Stage at the time of publication: IEC FDIS 63522-45:2024.

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3.2 Terms and definitions related to conditions and operations

3.2.1
internal impedance
impedance that exists between the output terminal of the power supply and the internal power supply circuit

Note 1 to entry: Z_s < 0,02 $Z_{M,B}$ (AC), R_s < 0,02 $R_{M,B}$ (DC) at Contact category 0 and 1 (see Figure A.1 of IEC 63522-0:—[5]).

[SOURCE: IEC 60050-312:2001, 312-06-19, modified – modified output impedance of the term to internal impedance, rewording of the definition and addition of Note 1 to entry.]

3.3 Terms and definitions related to contact faults

3.3.1
contact fault due to increased contact-circuit resistance
occurrence of a contact-circuit resistance of a closed contact exceeding the maximum value specified

[SOURCE: IEC 60050-444:2002, 444-07-13]

3.3.2
contact fault due to non-opening of the contact circuit
occurrence of a resistance across an open contact falling below the minimum value specified

[SOURCE: IEC 60050-444:2002, 444-07-14]

4 Test procedure

4.1 Purpose

This test is intended to investigate the failure rates or failure rate levels of the DUTs at low loads under specified conditions.

NOTE 1 The failure data typically shows an exponential distribution.

NOTE 2 With respect to the establishment and assessment for relays of reliability data which typically show a Weibull distribution, reference is made to IEC 61810-2.

The contact failure rate test evaluates random failures including those occurring in the range of minimum operational voltage and current to clarify low-load application limits.

NOTE 3 For example, the intended use of low-level current switching and measurement signals in telecom and network devices, test and measurement equipment, security devices, communications, security, automotive devices, railway signalling system, etc.

4.2 Procedure

4.2.1 General

The test circuit, contact load, test current and test voltage, test cycle, monitoring methods (according to 4.2.2 to 4.2.6), sample size and acceptable number of failures during the test shall be specified by the manufacturer, if not otherwise specified by the detail specification or the manufacturer.

Examples of test procedures for electromechanical elementary relays are given in Annex A.

[5] Under preparation. Stage at the time of publication: IEC CDV 63522-0:2024.

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Additional and/or alternative contact failure rate test procedures for the particular types of relays are stated in Annex B. Particular reed switch (reed contact) types and similar products are given in Annex B.

The number of DUTs shall be at least 10, unless otherwise specified by a detail specification.

4.2.2 Test circuit

Test circuits with monitoring equipment using relays and a monitoring device with capability of storing measurement results are given in Figure C.1 and Figure C.2, respectively, in Annex C based on IEC 63522-0:–[6], Figure A.1.

The wiring of the control, the measuring and indicating devices shall not effectively influence the current through and the voltage across the contacts during operation.

The source for input energization shall be a voltage source with low internal impedance.

The mounted relay coils shall be energized individually or in parallel, with precautions against interactions. When coil suppression (electrical components to suppress or reduce unwanted transients) is used, it shall be described in the test report.

4.2.3 Contact load

The contact load shall be as shown in Table 1. Contact categories CC 0 and CC 1 apply.

The values of test current and test voltage shall be selected from Table 2 and Table 3 respectively, and the making current and breaking current shall have the same value. The detail specification shall specify the test voltage and test current.

Table 1 – Contact load characteristics

Contact load	
AC	Resistive load (cos φ 0,95 to 1,0)
DC	Resistive load (L/R is ≤ 10^{-7} s)

Table 2 – Recommended test current

Test current[a]
1 µA; 5 µA; 10 µA; 50 µA; 100 µA; 500 µA; 1 mA; 5 mA; 10 mA; 50 mA; 100 mA
[a] The tolerances are ±5 %.

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Table 3 – Recommended test voltage

Classification	Test voltage[a]
AC	1 µV; 5 µV; 10 µV; 50 µV; 100 µV; 500 µV; 1 mV; 10 mV; 30 mV; 50 mV 0,1 V; 0,5 V; 1 V; 1,5 V; 4,5 V; 5 V; 6 V; 9 V; 12 V; 24 V; 36 V; 42 V; 48 V
DC[b]	1 µV; 5 µV; 10 µV; 50 µV; 100 µV; 500 µV; 1 mV; 10 mV; 30 mV; 50 mV 0,1 V; 0,5 V; 1 V; 1,5 V; 3,3 V; 4,5 V; 5 V; 6 V; 9 V; 10 V; 12 V; 24 V; 48 V; 60 V
[a] The tolerances are ±10 %. [b] The ripple rate is less than 2 %.	

4.2.4 Test cycle

The DUTs shall be energized with the rated coil voltage or an appropriate value within the rated coil voltage range or operative range or as otherwise specified, and the test shall be conducted at ambient room temperature or as otherwise specified.

The switching action shall not be synchronous with the source of the load circuit, if this is AC. The frequency of operation shall be as specified; the relay shall, however, attain both the operate and release/reset condition within one cycle.

The frequency of operation shall be either one of those given in Table 2 of IEC 63522-45:–[7].

The pulse pattern shall be a rectangular waveform with a duty cycle of 50 % (see IEC 63522-0:–[8], C.1.3 Duty type S3), unless otherwise specified in the detail specification.

The number of testing cycles shall be either one of those given in Table 4, as specified in the detail specification.

Table 4 – Recommended number of testing cycles

Number of testing cycles
10 000; 20 000; 30 000; 50 000; 1×10^5; 2×10^5; 3×10^5; 5×10^5; 1×10^6; 2×10^6; 3×10^6; 5×10^6; 1×10^7; 2×10^7; 3×10^7; 5×10^7; 1×10^8; 2×10^8; 3×10^8; 5×10^8; 1×10^9

4.2.5 Method 1: Continuous monitoring

The DUTs shall be monitored electrically, using a contact load as specified. The selected contact load shall ensure reliable monitoring of the performed cycles to clarify the limits of application to digital circuits.

Each contact shall be tested for malfunction to make and malfunction to break at each operation by measuring the voltage across the contacts and/or the load according to Figure C.1 or Figure C.2: timing portion of the ON check and OFF check and the comparators is given in Figure C.3.

By comparing the voltage between contacts with the fault level voltage of the comparator, it is determined whether the contact is malfunction to make or malfunction to break.

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7 Under preparation. Stage at the time of publication: IEC FDIS 63522-45:2024.

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The maximum value of contact-circuit resistance shall be selected from Table 5 by the manufacturer to set the fault level voltage(s).

The failure criteria shall be as follows:

- If the voltage across contacts exceeds the fault level voltage when the coil is energized, it is judged as a failure;
- If the contact is not opened when the coil is not energized, it is judged as a failure;
- The first detected malfunction is defined as a failure.

Table 5 – Recommended value of contact-circuit resistance

Contact-circuit resistance
1 Ω; 5 Ω; 10 Ω; 20 Ω; 50 Ω; 100 Ω; 500 Ω; 1 kΩ; 1,2 kΩ; 5 kΩ; 10 kΩ; 50 kΩ; 100 kΩ; 500 kΩ; 1 MΩ

The fault level voltage(s) is based on the following principles:

- The ON-check pulse is applied after the complete closing of the contact, when the voltage between contacts is above 5 % of the test voltage, it can be considered as the contact fault due to increased contact-circuit resistance and the sequence is stopped at the ON state, unless otherwise specified;
- When the contact completes its breaking operation and the cut-off time has passed sufficiently, then the OFF-check pulse is applied. When the voltage between contacts is less than 95 % of the test voltage, it can be considered as the contact fault due to non-opening of the contact circuit and the sequence is stopped at the OFF state, unless otherwise specified.

4.2.6 Method 2: Intermediate monitoring

The intermediate monitoring (periodic test) shall be performed in regular intervals as specified by the manufacturer.

The measured intermediate parameters shall be in accordance with IEC 63522-6 [9] and IEC 63522-7 [10] within the limits defined by the manufacturer product specification at any time during the contact failure rate test:

- If the measured parameters exceed the limits, the DUT shall be rejected;
- If not otherwise specified, the 1 kΩ contact-circuit resistance shall be selected for contact category.

4.3 Conditions to be specified

The conditions to be specified are the following:

a) test circuit (see Figure C.1 and Figure C.2);

b) contact load, test current and test voltage (see Table 1, Table 2 and Table 3);

c) ambient conditions (if deviating from 4.4 of IEC 63522-0:– [11]);

d) sample size;

e) total number of operations or test cycles for each contact (see Table 4);

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[9] Under preparation. Stage at the time of publication: IEC FDIS 63522-6:2024.

[10] Under preparation. Stage at the time of publication: IEC BPUB 63522-7:2024.

[11] Under preparation. Stage at the time of publication: IEC CDV 63522-0:2024.

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f) number of cycles per hour and duty factor (refer to IEC 63522-45);
g) maximum reference value of contact-circuit resistance (see Table 5);
h) acceptable number of failures;
i) monitoring times (see Figure C.3);
j) periodic measurements (see 4.2.6);
k) final tests;
l) any other measurement, if required.

5 Evaluation

5.1 General

5.1.1 Acceptance criteria

The DUTs are decided acceptable for the established failure rate level if the total number of failures observed does not exceed the established acceptance number of failures during the test (see D.4).

The DUTs shall operate and release, and the contact-circuit resistance and operating functions shall be within specified limits.

Assessment of test results is given in Annex D.

A practical example is given in Annex E.

5.1.2 Final tests (if applicable)

Immediately after the contact failure rate test, the DUTs shall pass the following tests:

- Contact-circuit resistance in accordance with IEC 63522-6 shall be measured;
- Functional test in accordance with IEC 63522-7 shall be measured;
- Any other measurement, if required.

5.1.3 Visual inspection (if applicable)

Subsequently for all DUTs a visual inspection shall verify the contact surfaces of the DUTs. For this purpose, it is necessary to open the DUTs.

The visual inspection shall show absence of:

– mechanical defects
– insulating material.

NOTE SEM-EDX (Scanning Electron Microscope – Energy Dispersive Spectroscopy) and EPMA (Electron Probe Micro Analyzer) photographs are effective for investigating the contact surfaces.

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5.2 Test report

If this part of the IEC 63522 series is executed as a part of a test record of another standard, then the results shall be reported as required in the other standard.

Otherwise, it is recommended to issue a dedicated test report according to this document.

The test report should contain all the information necessary to reproduce the test. In particular, the following should be recorded:

a) identification of the device, e.g., brand name, product type, serial number;
b) reference value of cycle-related failure rate based on a confidence level of 60 % or failure rate level;
c) test circuit;
d) contact load, test voltage and test current;
e) sample size;
f) energizing voltage;
g) number of cycles per hour and duty factor;
h) total number of failures;
i) total number of operations;
j) maximum reference value of contact-circuit resistance;
k) monitoring times;
l) periodic measurements and final tests;
m) ambient conditions.

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Annex A
(informative)

Test procedures for electromechanical elementary relays

For electromechanical elementary relays, examples of the test procedures are given in Table A.1.

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Table A.1 – Test procedures for electromechanical elementary relays

Type of relays		Electromechanical elementary relays		
Test circuit		Figure C.2		
Switching load		Resistive load		
Test current		50 µA	0,1 mA	10 mA
Test voltage		50 mV	1 VDC	10 VDC
Sample size		10		
Energizing voltage		Test coil voltage: 100 % of rated-operate value		
Switching frequency of operation per h		Not more than 45 000	Not more than 18 000	
Limit for malfunction to make		≥ 5 mV DC (100 Ω max.) [a]	≥ 0,1 V DC (1 kΩ max.) [a]	≥ 0,5 V DC (50 Ω max.) [a]
Limit for malfunction to break		≤ 45 mV DC	≤ 0,9 V DC	≤ 9,5 V DC
Test cycles		Min. 1×10^6		
Monitoring times [b]		t_1 = 16 ms τ_1 = 20 ms t_2 = 16 ms τ_2 = 20 ms	t_1 = 40 ms τ_1 = 50 ms t_2 = 40 ms τ_2 = 50 ms	
Periodic measurements	Contact-circuit resistance (mΩ) [c]	≤1 000	≤200	
	Must-operate value [c]	≤80 % rated coil voltage		
	Must-release value [c]	≥10 % (DC coil) / 15 % (AC coil) rated coil voltage (monostable relay) ≤80 % rated coil voltage (bistable relay)		

[a] Contact-circuit resistance value conversion (Monitoring contact resistance or contact voltage drop is considered acceptable).

[b] Monitoring shall start after the contact has reached stable closed condition, or after at least 40 % of the closed part of each cycle has elapsed, whichever is later.

[c] The relevant limits can be specified by the manufacturer.

Documents
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Full document details: IEC 63522-48 2024