IEC 60947-5-4

Edition 2.1 2019-05
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Low-voltage switchgear and controlgear –
Part 5-4: Control circuit devices and switching elements – Method of assessing the performance of low-energy contacts – Special tests

Appareillage à basse tension –
Partie 5-4: Appareils et éléments de commutation pour circuits de commande – Méthode d'évaluation des performances des contacts à basse énergie – Essais spéciaux

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IEC 60947-5-4:2002-10+AMD1:2019-05 CSV(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 29.130.20

ISBN 978-2-8322-6998-5

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 5-4: Control circuit devices and switching elements – Method of assessing the performance of low-energy contacts – Special tests

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60947-5-4 edition 2.1 contains the second edition (2002-10) [documents 17B/1228/FDIS and 17B/1254/RVD] and its amendment 1 (2019-05) [documents 121A/284/FDIS and 121A/301/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 60947-5-4 has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This second edition has the status of an International Standard.

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

Some slight modifications, mainly of an editorial nature, have been introduced since the first edition.

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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INTRODUCTION

General usage of control switches may not be suitable for use at very low voltages and therefore it is recommended to seek the advice of the manufacturer concerning any application with a low value of operational voltage, for example, below 100 V a.c. or d.c. (see IEC 60947-5-1:2016, note ~~2~~ of ~~4.3.1.1~~ 4.3.2.2).

However, the development of electronic systems and programmable controllers in industrial processes increases the use of switching elements in low-voltage circuit control.

It is thus necessary to define how predictional behaviour of contacts in this area should be established (with an acceptable confidence level), by using precise conventional testing methods, down to specified values (such as 24 V, 1 mA; 5 V, 10 mA).

The objective of this document is to ensure the availability of contacts used in this area, including normally-open contacts.

This document shall be used as a complement of IEC 60947-5-1 for low-energy contacts applications.

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 5-4: Control circuit devices and switching elements – Method of assessing the performance of low-energy contacts – Special tests

1 Scope and object

This part of IEC 60947 applies to separable contacts used in the utilization area considered, such as switching elements for control circuits.

This standard takes into consideration two typical rated voltage areas:

a) above (and including) 10 V (typically 24 V) where contacts are used for switching loads with possible electrical erosion, such as programmable controller inputs;

b) below 10 V (typically 5 V) with negligible electrical erosion, such as electronic circuits.

This standard does not apply to contacts used in:

– functional safety area. In case of contacts used in functional safety area, Annex N of IEC 60947-5-1:2016 applies;

– ~~the~~ very low energy area of measurement, for example, sensor or thermocouple systems.

The object of this standard is to propose a method of assessing the performances of low energy contacts giving

– useful definitions;

– general principles of test methods which are to monitor and record the behaviour of contacts at each operation;

– functional bases for the definition of a general testing equipment;

– preferred test values;

– particular conditions for testing contacts intended for specific applications (such as switching of PC inputs);

– information to be given in the test report;

– interpretation and presentation of the rest results.

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2 Normative references

The following referenced documents are indispensable for the application 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 60068-1:~~1988~~2013, *Environmental testing – Part 1: General and guidance*
~~Amendment 1 (1992)~~

IEC 60068-2 (all parts), *Environmental testing – Part 2: Tests*

IEC 60605-6:~~1997~~2007, *Equipment reliability testing – Part 6: Tests for the validity and estimation of the constant failure rate ~~or~~ and constant failure intensity ~~assumptions~~*

IEC 60947-1:~~1999~~2007, *Low-voltage switchgear and controlgear – Part 1: General rules*~~[1]~~
Amendment 1 (~~2000~~2010)
Amendment 2 (~~2001~~2014)

IEC 60947-5-1:~~1997~~2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*~~[2]~~
~~Amendment 1 (1999)~~
~~Amendment 2 (1999)~~

~~IEC 61131-2:1992, *Programmable controllers – Part 2: Equipment requirements and tests*~~

3 Definitions and list of symbols used

3.1 Definitions

For the purpose of this part of IEC 60947, the following definitions apply.

In this standard the term “time interval” is expressed as the “number of operating cycles”, as appropriate in definitions.

3.1.1
reliability
probability that an item can perform a required function, under given conditions, for a given time interval (t_1, t_2)

NOTE 1 It is generally assumed that the item is in a state to perform this required function at the beginning of the time interval.

NOTE 2 The term “reliability” is also used to denote the reliability performance quantified by this probability (see IEV 191-02-06).

[IEV 191-12-01]

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3.1.2
contact reliability
probability that a contact can perform a required function, under given conditions, for a given number of operating cycles

3.1.3
failure
termination of the ability of an item to perform a required function

NOTE 1 After a failure the item has a fault.

NOTE 2 “Failure” is an event, as distinguished from “fault”, which is a state.

NOTE 3 This concept as defined does not apply to items consisting of software only.

[IEV 191-04-01]

3.1.4
defect
non-fulfilment of an intended requirement or an expectation for an entity, including one concerned with safety

NOTE The requirement or expectation should be reasonable under the existing circumstances.

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~~[1] A consolidated version of this standard exists.~~

~~[2] A consolidated version of this standard exists.~~

3.1.5
observed failure rate λ_{ob}
for a stated period in the life of an item, ratio of the total number of failures in a sample to cumulated observed number of cycles on that sample. The observed failure rate is to be associated with particular and stated numbers of operating cycles (or summation of operating cycles) in the life of the item and with stated conditions

3.1.6
assessed failure rate λ_c
failure rate of an item determined by a limiting value or values of the confidence interval associated with a stated confidence level, based on the same data as the observed failure rate of nominally identical items

NOTE 1 The source of the data should be stated.

NOTE 2 Results can be accumulated (combined) only when all conditions are similar.

NOTE 3 The assumed underlaying distribution of failures against time should be stated.

NOTE 4 It should be stated whether a one-side or a two-side interval is being used.

NOTE 5 Where only one limiting value is given, this is usually the upper limit.

3.1.7
constant failure rate period
that period, if any, in the life of a non-repaired item during which the failure rate is approximately constant

[IEV 191-10-09]

NOTE In reliability engineering, it is often assumed that the failure rate λ is constant, that is that the times to failure are distributed exponentially.

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3.1.8
controlling unit
equipment generating commands to run a specified test sequence controlling synchronization and the flow of orders (such as starts, measurements, stops)

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3.1.9
steady state (of the contacts after closing)
state of the contact after mechanical stabilization (after operation bounces)

3.1.10
load
device which is to be controlled by the contact under test

3.1.11
duty ratio
ratio, for a given time interval, of the on-load duration to the total time

[IEV 151-04-13]

3.1.12
contact voltage drop U_k
voltage between the contact members in the steady state

3.1.13
defect contact voltage drop U_{kd}
value of the voltage drop for which a defect is registered if it is exceeded for a time more than t_d

3.1.14
defect time t_d
minimum time during which a contact voltage drop greater than U_{kd} is considered as a defect

3.1.15
ON voltage U_{ON}
minimum voltage necessary for activating the load from the OFF to the ON state

3.1.16
ON time t_{ON}
corresponding minimum duration of the application of voltage U_{ON} for activating the load from the OFF to the ON state

3.1.17
OFF voltage U_{OFF}
maximum voltage necessary for deactivating the load from the ON to the OFF state

3.1.18
OFF time t_{OFF}
corresponding minimum time to change from the ON to the OFF state when the voltage drops to U_{OFF} or below

3.2 List of symbols used

AX auxiliary contact (see figure 2)
B coefficient used for statistical analysis (see table 1)
c confidence level
C contact under test (see figure 2)
I test current
m_c statistical assessed constant mean number of operating cycles to failure (lower limit) at confidence level *c* ($m_c = 1/\lambda_c$)
M measurement of voltage drop or monitoring the load (see figure 4)
n number of tested items at the commencement of the test (see 9.2.2)
N number of operating cycles (see 9.2.2)
N_i number of operating cycles for item i (see 9.2.2)
*N** cumulative number of operating cycles (see 9.2.2)
r number of failures (see 9.2.2)
t_b time to reach steady-state conditions (see figure 4)
t_d defect time (see 3.1.14)
t_c final time without surveillance before breaking current (see figure 4)
t_e time interval between the opening of AX and C (see figure 5)
t_i initial time without surveillance after initiation of current (see figure 4)
t_m time of measurement of contact voltage drop U_k or monitoring the load (see figure 4)
t_{OFF} OFF time (see 3.1.18)
t_{ON} ON time (see 3.1.16)
t_p time of current flowing (see figure 4)
t_s time of steady state of the test contact (see 3.1.9 and figure 4)
U supply voltage of the test circuit
U_k contact voltage drop (see 3.1.12)
U_{kd} defect contact voltage drop (see 3.1.13)
U_L voltage across the load (see figure 3)
U_{OFF} OFF voltage (see 3.1.17)

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U_{ON} ON voltage (see 3.1.15)

T period of the test cycle (see figure 4)

λ true constant failure rate

λ_c assessed failure rate (upper limit) at confidence level c

λ_{ob} observed failure rate (calculated from test) (see 3.1.5)

4 General principles

A method of assessing the performances of low-energy contacts by special tests is proposed. As the failures of such contacts are of a random nature, the method is based on a continuous monitoring of the contacts under test.

For the basic method (see 6.1.1), the voltage drop between the terminals of the closed contact (steady state – see 3.1.9) is measured for each operation and compared to a specified threshold.

In the alternative method, the behaviour of the load is monitored at each operating cycle.

The measurement is performed under constant voltage U (see figures 2 and 3). The contact(s) under test is (are) mounted and connected as in normal service and under ambient conditions as defined in clause 8. The measurement of the voltage drop is made directly on the connecting terminals of the contact(s) or on the connecting terminals of the load (see 6.1.2).

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In the basic and alternative methods recommended here (see 6.1.1 and 6.1.2), the contacts under test switch (make and break) the load.

For tests without switching the load, the analysis may be performed on the same equipment. The testing equipment for this purpose should, therefore, be designed accordingly.

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It may be possible to test the contact(s) in particular environments (dry heat, dust, damp heat, H_2S, etc.). Such environments shall be agreed between the user and the manufacturer, and shall be chosen from those defined in the IEC 60068-2 series (see clause 8).

In the basic method, tests are made with direct current. Precautions concerning measurement of low voltage shall be taken (for example, the use of shielded cables).

When the test is performed on a load, care must be taken to avoid voltage drops other than contact voltage drop (use of stabilized power supply).

Any external influence liable to affect the results (such as vibrations) shall be avoided.

5 General test method

The equipment used for the test (see figure 1) controls

– the operation of contacts under test;

– the electrical supply for contact circuits;

– the measurement of contact voltage drop for the basic method or the monitoring of the state of the load for the alternative method;

– the detection and recording of defects and failures for each of the contacts under test.