SLOVENSKI STANDARD
SIST EN 60947-5-4:1999

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Nizkonapetostne stikalne in krmilne naprave – 5. del: Krmilne naprave in stikalni elementi -– 4. oddelek: Metode za oceno lastnosti nizkoenergijskih kontaktov – Posebni preskusi

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

Niederspannungsschaltgeräte -- Teil 5: Steuergeräte und Schaltelemente -- Hauptabschnitt 4: Verfahren zur Abschätzung der Leistungsfähigkeit von Schwachstromkontakten - Besondere Prüfungen

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

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29.130.20	Nizkonapetostne stikalne in krmilne naprave	Low voltage switchgear and controlgear

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English version

Low-voltage switchgear and controlgear
Part 5: Control circuit devices and switching elements
Section 4: Methods of assessing the performance of low energy contacts
Special tests
(IEC 947-5-4:1996)

Appareillage à basse tension
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(CEI 947-5-4:1996)

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Besondere Prüfungen
(IEC 947-5-4:1996)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

A draft for an amendment to EN 60947-5-1:1991, prepared by the Technical Committee CENELEC TC 17B, Low-voltage switchgear and controlgear including dimensional standardization, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as amendment A11 to EN 60947-5-1 on 1995-02-15.

As the same document was approved and published by IEC as IEC 947-5-4:1996, the Technical Board of CENELEC has decided to redesignate it EN 60947-5-4 on 1997-03-11.

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)	1997-10-01
- latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	1997-10-01

Annexes designated "normative" are part of the body of the standard.
In this standard, annexes A and ZA are normative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the Technical Report IEC 947-5-4:1996 was approved by CENELEC as a European Standard without any modification.

CONTENTS

INTRODUCTION

IEC 947-5-1 indicates (see note 2 of 4.3.1.1) that 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.

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

So it is 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).

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – Part 5: Control circuit devices and switching elements – Section 4: Methods of assessing the performance of low-energy contacts – Special tests

1 General

1.1 *Scope and object*

This report applies to separable contacts used in the utilisation area considered such as switching element for control circuits.

This report takes into consideration two 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 report does not apply to contacts used in the very low energy area of measurement, for example sensor or thermocouple systems.

The object of this report 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 reports;
- interpretation and presentation of the rest results.

1.2 *Normative references*

The following normative documents contain provisions which, through reference in this text, constitute provisions of this report. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this report are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 68-1: 1988, *Environmental testing – Part 1: General and guidance*

IEC 68-2, *Environmental testing – Part 2: Tests*

IEC 605-6: 1986, *Equipment reliability testing – Part 6: Tests for the validity of a constant failure rate assumption*

IEC 947-1: 1996, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 947-5-1: 1990, *Low-voltage switchgear and controlgear – Part 5: Control circuit devices and switching elements – Section one: Electromechanical control-circuit devices*

IEC 1131-2: 1992, *Programmable controllers – Part 2: Equipment requirements and tests*

ISO 8402: 1994, *Quality management and quality assurance – Vocabulary*

2 Definitions and lists of symbols used

2.1 *Definitions*

For the purpose of this technical report the following definitions apply.

In this report "time interval" is expressed as the "number of switching cycles", as appropriate in definitions.

2.1.1 **reliability**: The probability that an item can perform a required function, under given conditions, for a given time interval (t_1, t_2). [IEV 191-12-01, modified]

NOTES

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

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

2.1.2 **contact reliability**: The probability that a contact can perform a required function, under given conditions, for a given number of operating cycles.

2.1.3 **failure**: The termination of the ability of an item to perform a required function. [IEV 191-04-01]

NOTES

1 After a failure the item has a fault.

2 "Failure" is an event, as distinguished from "fault", which is a state.

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

2.1.4 **defect**: The non-fulfillment of an intended requirement or an expectation for an entity, including one concerned with safety. [ISO 8402: 1994, 2-11 modified]

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

2.1.5 **observed failure rate** λ_{ob}: For a stated period in the life of an item, the 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 number of switching cycles (or summation of switching cycles) in the life of the item, and with stated conditions.

2.1.6 **assessed failure rate** λ_c: The 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.

NOTES

1 The source of the data shall be stated.

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

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

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

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

2.1.7 **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.

2.1.8 **entity; item:** Any element that can be individually considered.

NOTES

1 An entity may be, for example:
- a physical item;
- a defined quantity of material;
- a service, an activity or a process, an organisation or a person;
- some combination thereof (ISO 8402: 1994, 1.1 modified).

2 In English, the term "unit" or "individual" should not be used instead of "entity" or "item".

3 In French, the term "individu" may be used instead of "entité" in statistics.

2.1.9 **controlling unit:** The equipment generating commands to run a specified test sequence controlling synchronisation and the flow of orders (such as starts, measurements, stops).

2.1.10 **steady state (of the contacts after closing):** State of the contact after mechanical stabilisation (after operation bounces).

2.1.11 **load:** Device which is to be controlled by the contact under test.

2.1.12 **duty ratio:** The radio, for a given time interval, of the on-load duration to the total time. [IEC 151-04-13]

2.1.13 **contact voltage drop U_k:** Voltage between the contact members in the steady state.

2.1.14 **defect contact voltage drop U_{kd}:** The value of the voltage drop for which a defect is registered if it is exceeded for a time more than t_d.

2.1.15 **defect time t_d:** The minimum time during which a contact voltage drop greater than U_{kd} is considered as a defect.

2.1.16 **ON voltage U_{ON}:** The minimum voltage necessary for activating the load from the OFF to the ON state.

2.1.17 **ON time t_{ON}:** The corresponding minimum duration of the application of voltage U_{ON} for activating the load from the OFF to the ON state.

2.1.18 **OFF voltage U_{OFF}:** The maximum voltage necessary for deactivating the load from the ON to the OFF state.

2.1.19 **OFF time t_{OFF}:** The corresponding minimum time to change from the ON to the OFF state when the voltage drops to U_{OFF} or below.

2.2 *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 8.2.1)
N	number of operating cycles (see 8.2.1)
N_i	number of operating cycles for item i (see 8.2.1)
N^*	cumulative number of operating cycles (see 8.2.1)
r	number of failures (see 8.2.1)
t_b	time to reach steady state conditions (see figure 4)
t_d	defect time (see definition 2.1.15)
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 delay (see definition 2.1.19)
t_{ON}	ON delay (see definition 2.1.17)
t_p	time of current flowing (see figure 4)
t_s	time of steady state of the test contact (see definition 2.1.10 and figure 4)
U	supply voltage of the test circuit
U_k	contact voltage drop (see definition 2.1.13)
U_{kd}	defect contact voltage drop (see definition 2.1.14)
U_L	voltage across the load (see figure 3)
U_{OFF}	OFF voltage (see definition 2.1.18)
U_{ON}	ON voltage (see definition 2.1.16)
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 definition 2.1.7).

3 General principles

The purpose of this report is to provide a method of assessing the performances of low-energy contacts by special tests. As the failures of such contacts are of a random nature, the method is based on a continuous monitoring of the contacts under tests.

For the basic method (see 5.1.1), the voltage drop between the terminals of the closed contacts (mechanically stable – see 2.1.10) is measured for each operation and compared to a specified threshold.

In an 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 7. 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 5.1.2).

In the basic and alternative methods recommended here (see 5.1.1 and 5.1.2) 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. Therefore the testing equipment for this purpose should be designed accordingly.

It may be possible to test the contact(s) in specific environments (dry heat, dust, damp heat, H_2S, etc.). Such environments shall be agreed between the user and the manufacturer and chosen from those defined in the IEC 68-2 series (see clause 7).

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

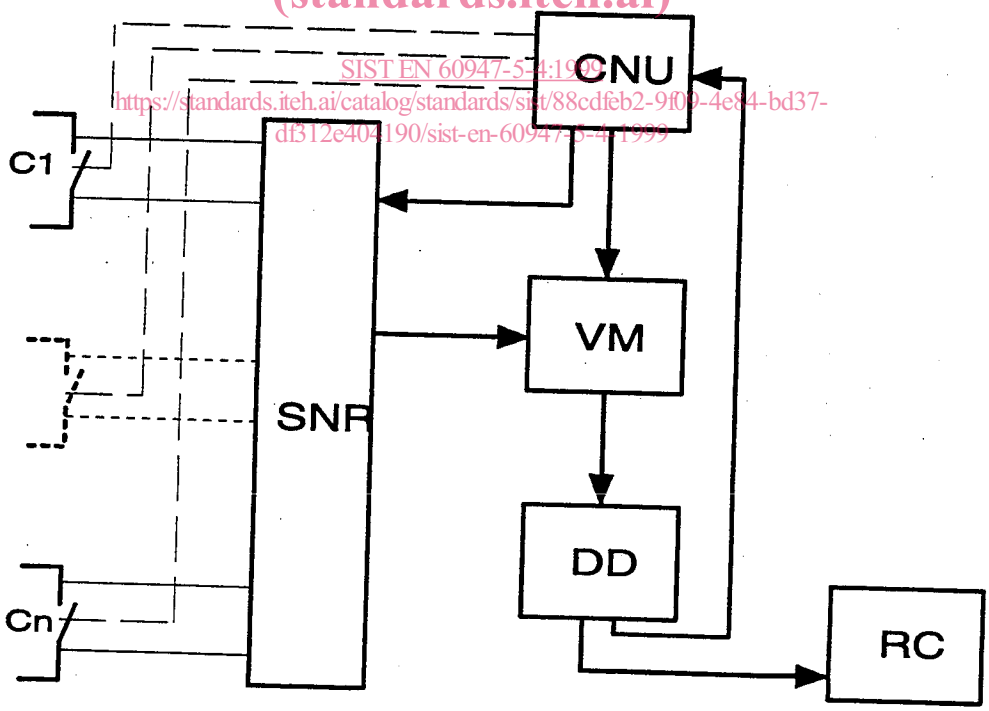
When the test is performed on a load, care shall be taken to avoid voltage drops other than contact voltage drop (use of stabilised power supply).

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

4 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.



C1,.., Cn: contacts under test
SNR: scanner
DD: detection of defects
CNU: controlling unit
VM: voltage measuring device
RC: recording of results

Figure 1 – Functional diagram of the testing equipment