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INTERNATIONAL STANDARD

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colour inside

Electromechanical elementary relays – Part 2: Reliability

Relais électromécaniques élémentaires – Partie 2: Fiabilité

IEC 61810-2:2017-05(en-fr)

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Electromechanical elementary relays –
Part 2: Reliability

Relais électromécaniques élémentaires –
Partie 2: Fiabilité

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 7
3.21 Terms and definitions related to tests 10
4 General considerations 10
5 Test conditions 11
5.1 Sample items 11
5.2 Environmental conditions 12
5.3 Operating conditions 12
5.4 Test equipment 13
6 Failure criteria 13
7 Output data 13
8 Analysis of output data 13
9 Presentation of reliability measures 13
Annex A (normative) Data analysis 15
A.1 General 15
A.2 Abbreviations 15
A.3 Symbols and definitions 15
A.4 Weibull distribution 16
A.5 Procedure 17
A.5.1 Graphical methods 17
A.5.2 Numerical methods 22
A.5.3 Confidence Intervals 23
A.5.4 WeiBayes Approach 25
Annex B (informative) Example of data analysis 28
B.1 Graphical methods case study (cumulative hazard plot) 28
B.1.1 General 28
B.1.2 Procedure of cumulative hazard plot 28
B.1.3 Example applied to life test data 30
B.2 Numerical methods case study (Weibull probability) 33
B.2.1 General 33
B.2.2 Distribution parameters 33
B.2.3 Mean cycles to failure (MCTF) 33
B.2.4 Value of $\hat{B}_{10}$ 34
B.2.5 Mean time to failure (MTTF) 34
B.3 Confidence intervals case study 34
B.3.1 General 34
B.3.2 Interval estimation of β 34
B.3.3 Interval estimation of η 35
B.3.4 Lower confidence limit for B10 35
B.3.5 Lower confidence limit for R 36
B.4 WeiBayes case study 36
Annex C (informative) Statistical tables 38

C.1 Table of gamma function 38
C.2 Fractiles of the normal distribution 38
Annex D (informative) Success run – Test without failures 40
D.1 General 40
D.2 Confidence level and minimum reliability 40
D.3 Example 41
Bibliography 42

Figure A.1 – An example of Weibull probability paper 18
Figure A.2 – An example of cumulative hazard plotting paper 20
Figure A.3 – Plotting of data points and drawing of a straight line 20
Figure A.4 – Estimation of distribution parameters 21
Figure B.1 – Estimation of distribution parameters 30
Figure B.2 – Cumulative hazard plots 32
Figure B.3 – Type test versus WeiBayes analysed periodic test 37

Table A.1 – Confidence levels for WeiBayes without failures 26
Table B.1 – Worksheet for cumulative hazard analysis 28
Table B.2 – Example worksheet 31
Table B.3 – First twenty failures in this example 33
Table C.1 – Values of the gamma function 38
Table C.2 – Fractiles of the normal distribution 39
Table D.1 – Number of samples and life cycles 41

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMECHANICAL ELEMENTARY RELAYS –

Part 2: Reliability

FOREWORD

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International Standard IEC 61810-2 has been prepared by IEC technical committee 94: All-or-nothing electrical relays.

This third edition cancels and replaces the second edition published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) not only graphical but also numerical methods are added;
b) reduction of number of samples in specified cases;
c) new subclauses of confidence intervals are added;
d) the WeiBayes approach is added to facilitate compliance tests (routine test) with lower effort;

e) annexes have been restructured into an Annex A for data analysis (normative) and Annex B (informative) where various examples of the data analysis are given;

f) the former Annex C has been incorporated into the modified Annex B;

g) a new Annex C replaces the old Annex D.

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

FDIS	Report on voting
94/415/FDIS	94/418/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

This International Standard is to be used in conjunction with IEC 61649:2008.

A list of all parts in the IEC 61810 series, published under the general title *Electromechanical elementary relays*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

Within the IEC 61810 series of basic standards covering elementary electromechanical relays, IEC 61810-2 is intended to give requirements and tests permitting the assessment of relay reliability. All information concerning endurance tests for type testing have been included in IEC 61810-1.

NOTE According to IEC 61810-1, a specified value for the electrical endurance under specific conditions (e.g. contact load) is verified by testing 1 or 3 relays. None is allowed to fail. Within this document, a prediction of the reliability of a relay is performed using statistical evaluation of the measured cycles to failure of a larger number of relays (generally 10 or more relays).

This document is the base for IEC 61810-2-1 to determine reliability values for relays where enhanced requirements for the verification of reliability (B_{10} and B_{10D}) apply.

The technical committee responsible for dependability has developed IEC 61649 dealing with Weibull-distributed test data. It contains both numerical and graphical methods for the evaluation of Weibull-distributed data as well as WeiBayes estimation.

On the basis of this basic reliability standard, this document was developed. It comprises test conditions and an evaluation method to obtain characteristic reliability values for electromechanical elementary relays. The life of relays as non-repairable items is primarily determined by the number of operations. For this reason, the reliability is expressed in terms of mean cycles to failure (MCTF).

Commonly, equipment reliability is calculated from mean time to failure (MTTF) figures. With the knowledge of the frequency of operation (cycling rate) of the relay within a piece of equipment, it is possible to calculate an effective MTTF value for the relay in that application.

Such calculated MTTF values for relays can be used to calculate respective reliability, probability of failure, and availability (e.g. MTBF (mean time between failures)) values for equipment into which these relays are incorporated.

Generally, it is not appropriate to state that a specific MCTF value is “high” or “low”. The MCTF figures are used to make comparative evaluations between relays with different styles of design or construction, and as an indication of product reliability under specific conditions.

ELECTROMECHANICAL ELEMENTARY RELAYS –

Part 2: Reliability

1 Scope

This part of IEC 61810 covers test conditions and provisions for the evaluation of endurance tests using appropriate statistical methods to obtain reliability characteristics for relays.

This document applies to electromechanical elementary relays considered as non-repaired items (i.e. items which are not repaired after failure).

The lifetime of a relay is usually expressed in number of cycles (CTF). Therefore, whenever the terms "time" or "duration" are used in IEC 61649, they carry the meaning "cycles". However, with a given frequency of operation, the number of cycles can be transformed into respective times (e.g. times to failure (TTF)).

The failure criteria and the resulting characteristics of elementary relays describing their reliability in normal use are specified in this document. A relay failure occurs when the specified failure criteria are met.

As the failure rate for elementary relays cannot be considered as constant, particularly due to wear-out mechanisms, the cycles to failure of tested items typically show a Weibull distribution. This document provides numerical and graphical methods to calculate approximate values for the two-parameter Weibull distribution, as well as lower confidence limits and a method for confirmation of reliability values with the WeiBayes method.

This document does not cover procedures for electromechanical elementary relays where enhanced requirements for the verification of reliability apply.

NOTE 1 Such reliability test procedures are specified in IEC 61810-2-1. In particular, when electromechanical elementary relays are intended to be incorporated in safety-related control systems of machinery in accordance with IEC 62061 and ISO 13849-1, IEC 61810-2-1 defines procedures for the manufacturer to provide B_{10D} values.

NOTE 2 Electromechanical elementary relays with forcibly guided (mechanically linked) contacts according to IEC 61810-3 offer the possibility of a high diagnostic coverage according to 4.5.3 of ISO 13849-1:2015.

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 61649:2008, *Weibull analysis*

IEC 61810-1:2015, *Electromechanical elementary relays – Part 1: General and safety requirements*

3 Terms and definitions

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

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

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

3.1
item
any component that can be individually considered

Note 1 to entry: For the purpose of this document, items are electromechanical elementary relays.

3.2
non-repaired item
item which is not repaired after a failure

3.3
sample
one or more sampling items intended to provide information on the population

[SOURCE: IEC 60050-151:2001, 151-16-19, modified – The words "or on the material" have been deleted from the definition.]

3.4
sample item
one of the individual items in a population of similar items and taken from one place and at one time

[SOURCE: IEC 60050-151:2001, 151-16-18, modified – The words "or a portion of material forming a cohesive entity" have been deleted from the definition.]

3.5
cycle
<elementary relays> operation and subsequent release/reset

[SOURCE: IEC 60050-444:2002, 444-02-11]

3.6
frequency of operation
number of cycles per unit of time

[SOURCE: IEC 60050-444:2002, 444-02-12]

3.7
reliability
ability of an item to perform a required function under given conditions for a given number of cycles or time interval

Note 1 to entry: 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 to entry: The term “reliability” is also used as a measure of reliability performance (see IEC 60050-312:2001, 312-07-06).

[SOURCE: IEC 60050-395:2014, 395-07-131, modified – The words "number of cycles or" have been added to the definition, and the second note has been replaced by a new note.]

3.8
reliability test
experiment carried out in order to measure, quantify or classify a reliability measure or property of an item

[SOURCE: IEC 60300-3-5:2001, 3.1.27, modified – The notes have been deleted.]

3.9
life test
test with the purpose of estimating, verifying or comparing the lifetime of the class of items being tested

[SOURCE: IEC 60300-3-5:2001, 3.1.17, modified – The note has been deleted.]

3.10
cycles to failure
CTF
total number of cycles of an item, from the instant it is first put in an operating state until failure

3.11
mean cycles to failure
MCTF
expectation of the number of cycles to failure

3.12
time to failure
TTF
total time duration of operating time of an item, from the instant it is first put in an operating state until failure

3.13
mean time to failure
MTTF
expectation of the time to failure

[SOURCE: IEC 60050-192:2015, 192-05-11, modified – The word "operating" has been deleted from the term and the definition, and the notes have been deleted.]

3.14
useful life
number of cycles or time duration until a certain percentage of items have failed

Note 1 to entry: In this document, this percentage is defined as 10 %.

3.15
failure
termination of the ability of an item to perform a required function as defined in the failure criteria

[SOURCE: IEC 60050-603:1986, 603-05-06, modified – The words "as defined in the failure criteria" have been added to the definition.]

3.16
malfunction
event when an item does not perform an expected function

3.17
contact failure
occurrence of break and/or make malfunctions of a contact under test, exceeding a specified number

3.18
failure criteria
specified conditions to judge if a fault or malfunction is a failure

3.19
contact load category
classification of relay contacts dependent on wear-out mechanisms

Note 1 to entry: Various contact load categories are defined in IEC 61810-1.

3.20
fault
deviation of the existing condition from the expected condition

3.21 Terms and definitions related to tests

3.21.1
type test
conformity test made on sample relays representative of the production to get basic performance data or to verify that these relays comply with the specified requirements

3.21.2
routine test
conformity test made on sample without any modifications and specification changes during or after mass production with specified repetition

4 General considerations

The provisions of this document are based on the relevant publications on dependability. In particular, the following documents have been taken into account: IEC 60050-191, IEC 60300-3-5 and IEC 61649.

The aim of reliability testing as given in this document is to obtain objective and reproducible data on reliability performance of relays representative of standard production quality. The tests described and the related statistical tools to gain characteristic reliability values can be used for the estimation of such characteristic reliability values, as well as for the verification of stated characteristic values.

NOTE 1 Examples for the application of characteristic reliability values are:

- establishment of characteristic reliability values for a new relay type;
- comparison of relays with similar characteristics, but produced by different manufacturers;
- evaluation of the influence, on a relay, of different materials or different manufacturing processes;
- comparison of a new relay with a relay which has already worked for a specific period of time;
- calculation of the reliability of an equipment or system incorporating one or more relays.

According to Clauses 8 and 9 of IEC 60300-3-5:2001, for non-repaired items showing a non-constant failure rate, the Weibull model is the most appropriate statistical tool for evaluation of reliability measures. This analysis procedure is described in IEC 61649.

Relays within the scope of this document are considered as non-repaired items. They generally do not exhibit a constant failure rate but a failure rate increasing with number of

cycles, being tested until wear-out mechanisms become predominant. The cycles to failure of a random sample of tested items typically show the Weibull distribution.

NOTE 2 In cases where no wear-out mechanisms prevail, random failures with constant failure rate can be assumed. Then the shape parameter β of the Weibull distribution equals 1, and the reliability function becomes the well-known exponential law.

The first step in the analysis of the recorded cycles to failure (CTF) of the tested relays is the determination of the two distribution parameters of the Weibull distribution. In a second step, the mean cycles to failure (MCTF) is calculated as a point estimate. In a third step, the useful life is determined as the lower confidence limit of the number of cycles by which 10 % of the relay population will have failed (B_{10}) (see 10.5 and 10.6 of IEC 61649:2008).

With a given frequency of operation, these reliability measures expressed in number of cycles (MCTF) can be transformed into respective times (MTTF); see Annex B for an example.

The statistical procedures require some appropriate computing facility. Software for evaluation of Weibull-distributed data is commercially available on the market. Such software may be used for the purpose of this document provided it shows equivalent results when the data given in Annex B are used.

Since the number of cycles to failure highly depends on the specific set of test conditions (particularly the electrical loading of the relay contacts), values for MCTF and useful life derived from test data apply only to this set of test conditions, which have to be stated by the manufacturer together with the reliability measures.

Upon explicit specification of the manufacturer, the test may be performed with even less than 10 relays, provided the uncertainty of the estimated Weibull parameters is acceptable to him. In such a case, the minimum number of tested relays shall be specified; this number then replaces the minimum number of 10 relays wherever prescribed in this document. This reduction of relay specimens is acceptable in both numerical and graphical methods. Here, the number of failures or specimens may be determined, being concerned with confidence interval, which can be calculated by A.5.3. On the other hand, the reduction due to WeiBayes approach shown in A.5.4 is also acceptable if the shape parameter, β, is assumed from historical data from prior experiments, or from engineering knowledge of the physics of the failure.

However, the WeiBayes approach applies only for routine test.

5 Test conditions

5.1 Sample items

For useful life estimation, a minimum of 10 failures need to be recorded to perform the analysis described in this document, 10 or more items (relays) should be submitted to the test. However, at least 2/3 of the tested relays shall fail physically. This allows the test to be carried out with 10 relays only, even when the test is stopped before all relays have physically failed (with a minimum of 7 physical failures recorded). When the test is stopped at a specific number of cycles, all relays that have not yet failed shall be considered as suspended or censored at that number of cycles.

Upon explicit specification of the manufacturer, less than 10 items can be tested to determine the basic Weibull parameters (B_{10} and β), but the minimum number of samples to be tested is 5. The requirement to truncate a test still remain with 2/3 of the number of samples. The results with less than 10 samples shall be published in conjunction with the confidence level and number of samples. The evaluation method in this specific case shall be the numeric method.

For a WeiBayes test, the number of samples and failures shall be selected according to the desired confidence level.

The items shall be selected at random from the same production lot and shall be of identical type and construction. No action is allowed on the sample items from the time of sampling until the test starts.

Where any particular burn-in procedure or reliability stress screening is employed by the manufacturer prior to sampling, this shall apply to all production. The manufacturer shall describe and declare such procedures, together with the test results.

Unless otherwise specified by the manufacturer, all contacts of each relay under test shall be loaded as stated and monitored continuously during the test.

The test starts with all items and is stopped at a certain number of cycles. At that instant, a certain number of items have failed. The number of cycles to failure of each of the failed items is recorded.

Items failed during the test are not replaced once they fail.

5.2 Environmental conditions

The testing environment shall be the same for all items.

– The items shall be mounted in the manner intended for normal service; in particular, relays for mounting onto printed circuit boards are tested in the horizontal position, unless otherwise specified.
– The ambient temperature shall be as specified by the manufacturer.
– All other influence quantities shall comply with the values and tolerance ranges given in Table 1 of IEC 61810-1:2015, unless otherwise specified.

5.3 Operating conditions

The set of operating conditions

– rated coil voltage(s),
– coil suppression (if any),
– frequency of operation,
– duty factor,
– contact load(s),

shall be as specified by the manufacturer.

Recommended values should be chosen from those given in Clause 5 of IEC 61810-1:2015.

The test is performed on each contact load and each contact material as specified by the manufacturer.

All specified devices (for example, protective or suppression circuits), if any, which are part of the relay or stated by the manufacturer as necessary for particular contact loads, should be operated during the test.

The contacts shall be continuously monitored to detect malfunctions to open and malfunctions to close, as well as unintended bridging (simultaneous closure of make and break side of a changeover contact).

The contacts are connected to the load(s) in accordance with Table 12 of IEC 61810-1:2015 as specified and indicated by the manufacturer.

5.4 Test equipment

The test circuit described in Annex C of IEC 61810-1:2015 shall be used, unless otherwise specified by the manufacturer and explicitly indicated in the test report.

6 Failure criteria

Whenever any contact of a relay under test fails to open or fails to close or exhibits unintended bridging, this shall be considered as a malfunction.

Three severity levels are specified:

– severity A: the first detected malfunction is defined as a failure;

– severity B: the sixth detected malfunction or two consecutive malfunctions are defined as a failure;

– severity C: as specified by the manufacturer.

The severity level used for the test shall be as prescribed by the manufacturer and stated in the test report.

Faults occurring during test like insulation fault, dielectric test fault, thermal deformation of enclosure, burning and others, shall be judged as failure.

7 Output data

The data to be analysed consists of cycles to failure (CTF) for each of the items put on test. These CTF values have to be known exactly. However, it is not necessary to gather the CTF values for all items under test, under the conditions described under 5.1.

8 Analysis of output data

The evaluation of the CTF values obtained during the test shall be carried out in accordance with the procedures given in Annex A.

9 Presentation of reliability measures

The basic reliability measures applicable to relays as described in this document and obtained from the data analysis shall be provided.

However, since the values obtained for these reliability measures using the procedures of Annex A depend to a great extent on the basic design characteristics of the relay, on the test conditions of Clause 5 and on the failure criteria of Clause 6, the following information shall also be provided together with the test results:

– relay type for which the results are valid:
  a) contact material;
  b) deviations from standard types (if any);
  c) type of termination.
– set of operating conditions (see 5.3):
  a) rated coil voltage(s);