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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INTRODUCTION

The Saudi Standards and Quality Organization (SASO) has adopted the International Standard IEC 60947-5-4/2002 “LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – Part 5-4: Control circuit devices and switching elements –Method of assessing the performance of flow-energy contacts–Special tests” issued by the International Electrotechnical Commission (IEC). It has been adopted without any technical modifications with a view to its approval as a Saudi standard.
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 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 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 test results.

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, Environmental testing – Part 1: General and guidance
Amendment 1 (1992)

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

IEC 60605-6:1997, Equipment reliability testing – Part 6: Tests for the validity of the constant failure rate or constant failure intensity assumptions
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]

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.

3.1.5

**observed failure rate** \( \lambda_{ob} \)

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** \( \lambda_c \)

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 underlying 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 \( \lambda \) is constant, that is that the times to failure are distributed exponentially.

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)

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)
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).

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.

It may be possible to test the contact(s) in particular environments (dry heat, dust, damp heat, $\text{H}_2\text{S}$, 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.

![Functional diagram of the testing equipment](image)

**Key**

| 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**

To ensure an adequate statistical estimate of the failure rate, eight or more contacts of the type to be tested shall be tested.

**NOTE** Where applicable, both make and break contacts should be tested.
The number of operating cycles of the test shall be at least 25 %, and not more than 100 %, of the durability with the number of operating cycles at low energy stated by the manufacturer. Unless otherwise stated, this stated number is the mechanical durability.

Means of verification of the operating sequence, with special attention to the state of the contacts under test, and calibration of measuring devices shall be included in the test equipment.

6 General characteristics

6.1 Measurement methods

6.1.1 Measurement on the contact (basic method)

The measurement (detection of contact voltage drop) is made directly on the contact terminals according to figure 2.

![Figure 2 – Typical test circuit for the basic method](image)

**Key**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Contact under test</td>
</tr>
<tr>
<td>U</td>
<td>Supply voltage d.c.</td>
</tr>
<tr>
<td>R</td>
<td>Resistive load</td>
</tr>
<tr>
<td>VM</td>
<td>Voltage measuring device</td>
</tr>
<tr>
<td>AX</td>
<td>Auxiliary contact used for making and breaking current when not switching the load by the contact under test</td>
</tr>
<tr>
<td>AT</td>
<td>Actuation function of contact under test</td>
</tr>
</tbody>
</table>

a AX shall be chosen with low mechanical bounce and stable contact voltage drop.

6.1.2 Monitoring the load (alternative method)

In this method the contact is tested by monitoring the behaviour of the load according to figure 3.

This method corresponds to normal service conditions and gives results which depend on the load characteristics. The results can only be compared if the tests are performed on loads with identical characteristics.
The behaviour of the supply voltage has a direct influence on the performance of the load.
Therefore it is necessary to use a stable (better than \( \pm 1\% \)) uninterruptible power supply (see 6.3.1 for maximum ripple content of supply).

![Test circuit for monitoring a load](image)

**Key**

- **C**: Contact under test
- **AT**: Actuation function of contact under test
- **U**: Supply voltage (d.c. or a.c.)
- **AX**: Auxiliary contact
- **U_L**: Voltage across the load

**NOTE** One AX contact may be used for more contacts under test, as long as the AX contact rating is not exceeded, each contact being monitored including an individual resistance load \( R \).  

\(^a\) AX shall be chosen with low mechanical bounce and stable contact voltage drop.

**Figure 3 – Test circuit for monitoring a load**

### 6.2 Sequences of operations

For these recommended tests (basic method or alternative method), the contact under test switches the load and AX (see figures 2 and 3) is permanently closed during the test. The sequential diagram is given in figure 4.

For specific applications, the contact under test does not switch the load. An example of a sequential diagram is given in figure 5.

In these diagrams, the represented functions (C, I, etc.) are those indicated in figures 2 and 3. The function \( M \) is actually the measurement of the contact voltage drop for the basic method. It can also be the monitoring or the recording of the state of the load in the alternative method.
Key

- **C**: Contact under test
- **I**: Test current
- **M**: Measurement of voltage drop or monitoring of the load
- **T**: Period of the test cycle
- **AX**: Auxiliary contact

- **$t_b$**: Time to reach steady-state conditions (bouncing has ceased) and at least 10 ms
- **$t_c$**: Final time without surveillance before breaking current (for example, $t_c = 10\%$ of $t_p$)
- **$t_i$**: Initial time without surveillance after initiation of current $t_i \leq 40\%$ of $t_p$ and at least 10 ms
- **$t_m$**: Time of measurement of contact voltage drop ($U_k$), or monitoring of the load
- **$t_p$**: Time of current flowing
- **$t_s$**: Time of steady state of the tested contact

Figure 4 – Sequential diagram with load-switching contacts
Key

- **C**: Contact under test
- **I**: Test current
- **M**: Measurement of voltage drop or monitoring of the load
- **T**: Period of the test cycle
- **AX**: Auxiliary contact
- **t_b**: Time to reach steady-state conditions (bouncing has ceased) and at least 10 ms
- **t_i**: Initial time without surveillance after initiation of current \( t_i \leq 40 \% \) of \( t_p \) and at least 10 ms
- **t_m**: Time of measurement of contact voltage drop \( (U_k) \), or monitoring of the load
- **t_p**: Time of current flowing
- **t_s**: Time interval between the opening of AX and C
- **t_c**: Final time without surveillance before breaking current (for example, \( t_c = 10 \% \) of \( t_p \))
- **t_s**: Time of steady state of the tested contact

**Figure 5 – Sequential diagram without load-switching contacts**

6.3 Electrical characteristics

6.3.1 Characteristics of the supply for basic method

6.3.1.1 Supply voltage

The supply voltage for test circuits (see figure 2) shall be

- d.c. 24 V ± 5 % (ripple included), or
- d.c. 5 V ± 5 % (ripple included).

**NOTE** When testing contacts, it is recommended to reverse the direction of the current through the contacts at regular intervals during the test. This should be recorded in the test report.
6.3.1.2 Current

For the basic method with negligible contact resistance (short-circuited terminals), the prospective current for test shall be chosen from the following values: 1 mA, 5 mA, 10 mA, 100 mA; 10 mA is the preferred value.

The current shall not exceed the rating of the contacts under the stated test conditions.

The tolerance is ±5 % of the nominal value (when setting at the actual voltage $U$).

6.3.2 Supply for alternative method

The supply depends on the load requirements. In every case, the stability shall be better than ±1 % of the adjusted voltage (see figure 3).

6.3.3 Characteristics of active load

6.3.3.1 General

The load is characterized by the following values:

<table>
<thead>
<tr>
<th>Voltage Type</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON Voltage</td>
<td>$U_{ON}$</td>
</tr>
<tr>
<td>OFF Voltage</td>
<td>$U_{OFF}$</td>
</tr>
<tr>
<td>ON Delay</td>
<td>$t_{ON}$</td>
</tr>
<tr>
<td>OFF Delay</td>
<td>$t_{OFF}$</td>
</tr>
</tbody>
</table>

The load will be activated (ON state) when $U_L \geq U_{ON}$ for a time $t \geq t_{ON}$ and will return to OFF state when $U_L \leq U_{OFF}$ for a time $t \geq t_{OFF}$.

6.3.3.2 Input of programmable controller (PC system as defined in IEC 61131-2)

Manufacturer’s name and type designation of the PC system used for the test shall be recorded in the test report.

6.3.3.3 Contactor or relay

As the test corresponds to a practical application, the power supply can be a.c. or d.c. as appropriate.

The load shall be used as recommended by the manufacturer. If a suppressor is used, it shall be mentioned in the test report. The type of suppressor used (diode, varistor, RC link, etc.) shall also be mentioned.

The load, in this case being an electromechanical device, is subject to mechanical wear. Consequently, the load (contactor or relay) shall be replaced before reaching its stated mechanical life.

The manufacturer’s name and type designation of the load shall be recorded in the test report.

6.4 Characteristics of operation

The operating cycle shall be chosen following 4.3.4.3 of IEC 60947-1, appropriate to the device and load under test.

Duty ratio for the contacts under test: 50 %.
In some cases, an operating machine is necessary for actuating the tested contacts.

Operating conditions of the machine shall be as defined in 8.3.2.1 of IEC 60947-5-1.

7 Characterization of defects

7.1 Basic method

7.1.1 General

The test equipment shall be adequate to detect contact voltage drops greater than $U_{kd}$ persisting for a time $t \geq t_d$. The value of $t_d$ required depends on the application and shall be recorded in the test report; preferred values of $t_d$ are 1 ms and 5 ms.

The value for $U_{kd}$ depends on the application. Preferred values are: 1 %, 10 %, 25 % of $U$.

For a defective operation only one defect shall be counted, even if several defects of conduction (intermittent contact) occur during $t_m$.

NOTE The characterization of a defect given in this standard is conventional. In practice, it might be possible that such a defect never causes a malfunction.

7.1.2 Calibration of the detection threshold

For fixed values of $U$ and $I$, a calibration resistor replaces the contact to be tested and is adjusted to obtain $U_{kd}$. The detector (or the recorder) is adjusted to operate within the specified tolerances of measurement.

7.1.3 Monitoring (during $t_m$)

– By analogue measurement: for the measuring time $t_m$, see figures 4 and 5.
– By sampling at high frequency: the measuring time $t_m$ shall be as shown in figures 4 and 5, and the time between two samplings shall be less than $t_d/2$.

7.2 Monitoring the load (figure 3)

7.2.1 Voltage drop measurement

The first method of monitoring can use the same principle as in 7.1: analogue or sampling measurement of $U_L$. In this case, there is a defect when $U_L < U_{ON}$ for a time $t \geq t_{OFF}$ (see 6.3.3).

7.2.2 Analysis of the state of the load

This is made by counting the number of operations of the output. In this case, the number of defects to be considered is the difference between the number of contact operations and the number of output changes.

8 Ambient conditions

8.1 Normal conditions

These are defined in 5.3 of IEC 60068-1, for temperature (15 °C to 35 °C), relative humidity (25 % to 75 %), and pressure (86 kPa to 106 kPa).
8.2 Preconditioning

The contacts to be tested should be exposed to the environmental testing conditions, stated in 8.1, for 24 h. If, however, the preconditioning is different from the above, it shall be mentioned in the test report, and a description of the preconditioning procedure shall be added.

8.3 Particular conditions

For particular applications, special tests may be required in controlled environments. Such environments should be chosen from IEC 60068-2 series.

9 Methods of reporting

9.1 Failure criterion

A failure of a contact is considered to have occurred after three defects.

The failure of a contact and the number of operating cycles at the occurrence of the failure for that contact are registered.

The time-terminated test is recommended.

After one failure (three defects), the contact shall not be considered for further statistical evaluation. It may be removed from test and replaced by a new contact whose performance is taken into consideration in the statistical analysis (see 9.2, test with replaced failed item).

9.2 Reporting the failure rate

9.2.1 General

In the case where it can be assumed that the failure rate is constant during the test (see IEC 60605-6), the confidence limits which give the assessed values may be derived from the $\chi^2$ distribution.

For the one-sided interval, at confidence level $c$, the upper limit of the failure rate is $\lambda_c$ for the assessed failure rate, with

$$0 < \lambda < \lambda_c$$

The assessed number of operating cycles to failure is: $m_c = 1/\lambda_c$

The failure rate is expressed by using the value $\lambda_c$ at a given confidence level, $c$.

The preferred values of the confidence level $c$ are 60 % and 90 %.

For a time-terminated test, the way of estimating $\lambda_c$ or $m_c$ is given below:

- for non-replaced failed items;
- for replaced failed items.

9.2.2 Estimation of $\lambda_c$ when failed items are not replaced

$$\lambda_{ob} = \frac{r}{N^*}$$

$$\lambda_c = \frac{r}{N^*}$$
where
\[ N^* = N_1 + N_2 + \ldots + N_r + (n - r)N \]

\( N_1, N_2, \ldots, N_r \) are the operating cycles of items failed during the test
\[ \lambda_c = \frac{K_c}{N^*} \]

Even when no failure arises during the test, an upper value of the failure rate \( \lambda_c \) can be estimated when using a time-terminated test.

**EXAMPLE**
- 20 contacts under test \((n = 20)\)
- test duration: \(N = (5 \times 10^6)\) operating cycles (time-terminated test)
- contact No. 1 failed at 100 000 operating cycles
- contact No. 2 failed at 400 000 operating cycles
- contact No. 3 failed at \((1,5 \times 10^6)\) operating cycles
- contact No. 4 failed at \((2,5 \times 10^6)\) operating cycles
- contacts No. 5 and No. 6 failed at \((4 \times 10^6)\) operating cycles
- contact numbers 7 to 20 completed \((5 \times 10^6)\) operating cycles without failure.

\[ n = 20 \]
\[ r = 6 \]
\[ N^* = 10^5 + (0,4 \times 10^6) + (1,5 \times 10^6) + (2,5 \times 10^6) + [2 \times (4 \times 10^6)] + [14 \times (5 \times 10^6)] \]
\[ = 82,5 \times 10^6 \]
\[ \lambda_{ob} = 6/82,5 \times 10^6 = 0,7 \times 10^{-7} \text{ failure/operating cycles} \]

At the confidence level of 90 \%, \( K_c = 10,55 \) (from table 1)

\[ \Rightarrow \lambda_c = 10,55 / (82,5 \times 10^6) = 1,3 \times 10^{-7} \text{ failure/operating cycles} \]

or
\[ m_c = 7,7 \times 10^6 \text{ operating cycles} \]

### 9.2.3 Estimation of \( \lambda_c \) when failed items are replaced

When an item fails, it is replaced by a new one. All the failures which appear during the test are counted.

\[ \hat{\lambda}_{ob} = \frac{r}{N^*} \]

where
\[ r = \text{total number of failures} \]
\[ N^* = n \times N \]
\[ \hat{\lambda}_c = \frac{K_c}{N^*} \]

**EXAMPLE**

Same conditions as in the previous example, that is:
- 20 contacts under test and spare contacts available for replacing any failed ($n = 20$)
- Test duration: $N = (5 \times 10^6)$ operating cycles (time-terminated test)
– contact No. 1 failed at \((0.1 \times 10^6)\) operating cycles. It was replaced by a new one which ran until the end of the test without failure.

– contact No. 2 failed at \((0.4 \times 10^6)\) operating cycles. It was replaced by a new one which ran until the end of the test without failure.

– contact No. 3 failed at \((1.5 \times 10^6)\) operating cycles. It was replaced by a new one which failed after \((3 \times 10^6)\) operating cycles (that is at the \((4.5 \times 10^6)\)th operating cycle). It was then replaced by a new contact which ran until the end of the test without failure.

– contact No. 4 failed at \((2.5 \times 10^6)\) operating cycles. It was replaced by a new one which ran until the end of the test without failure.

– contacts No. 5 and No. 6 failed at \((4 \times 10^6)\) operating cycles. They were each replaced by a new one which ran until the end of the test without failure.

– contact numbers 7 to 20 completed \((5 \times 10^6)\) operating cycles without failure.

\[ N = 20 \]
\[ R = 7 \]
\[ N^* = 20 \times (5 \times 10^6) = 10^8 \]
\[ \lambda_{ob} = 7 / 10^8 \quad \lambda_{ob} = 0.7 \times 10^{-7} \text{ failure/operating cycles} \]

At the confidence level of 90 %, \( K_c = 11.75 \) (from table 1)

\[ \Rightarrow \]
\[ \lambda_c = 11.75 / 10^8 = 1.2 \times 10^{-7} \text{ failure/operating cycles} \]

or

\[ m_c = 8.3 \times 10^6 \text{ operating cycles} \]

10 Information to be provided in the test report

The test report shall indicate

– chosen normative characteristics for the basic method: \( U, I, U_{kd}, t_d; \)

– characteristics of loads when studying on active load: \( U_{ON}, U_{OFF}, t_{ON}, t_{OFF}, \) etc;

– wiring and mounting conditions;

– operating conditions: frequency of operations; mean velocity of actuating device if any; number of significant interruptions and their duration (and state of contact, open or closed, during these interruptions); particular ambient conditions;

– when the test is made on active load, the variations of functional characteristics shall be noted (including thermal stabilization). The characteristics (operating time, sensibility, etc.) of counters shall be given.

A recommended tabular form of report is given in annex A.
Table 1 – Coefficient $K_c$ for a time-terminated test

<table>
<thead>
<tr>
<th>Number of failures</th>
<th>Value of $K_c$ at confidence level $c$ %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$c = 60$ %</td>
</tr>
<tr>
<td>0</td>
<td>0.915</td>
</tr>
<tr>
<td>1</td>
<td>2.020</td>
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<td>14.60</td>
</tr>
<tr>
<td>14</td>
<td>15.65</td>
</tr>
<tr>
<td>15</td>
<td>16.70</td>
</tr>
<tr>
<td>16</td>
<td>17.70</td>
</tr>
<tr>
<td>17</td>
<td>18.75</td>
</tr>
<tr>
<td>18</td>
<td>19.80</td>
</tr>
<tr>
<td>19</td>
<td>20.75</td>
</tr>
<tr>
<td>20</td>
<td>21.85</td>
</tr>
<tr>
<td>21</td>
<td>22.85</td>
</tr>
<tr>
<td>22</td>
<td>23.90</td>
</tr>
<tr>
<td>23</td>
<td>24.90</td>
</tr>
<tr>
<td>24</td>
<td>25.95</td>
</tr>
</tbody>
</table>

If the number of failures is more than 24, use the formula: $K_c = 0.25 \left[(4r+1)^{\frac{1}{2}} + B\right]^2$

where $B$ has the following values:

- for $c = 60$ %, $B = 0.253$
- for $c = 90$ %, $B = 1.28$
Annex A
(normative)

Information to be supplied by the manufacturer

<table>
<thead>
<tr>
<th>Contacts under test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer's name:</td>
</tr>
<tr>
<td>Type designation of contacts:</td>
</tr>
<tr>
<td>Form of contacts (see figure 4 of IEC 60947-5-1):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Active load (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of the load:</td>
</tr>
<tr>
<td>Manufacturer's name:</td>
</tr>
<tr>
<td>Type designation:</td>
</tr>
<tr>
<td>Mounting conditions:</td>
</tr>
</tbody>
</table>
Method of monitoring the load:
(for example, counter, digital voltmeter, logical output):

- operating time:
- sensibility:

Load characteristics
- ON voltage:  \( U_{ON} = \ldots \ldots \ldots \) V
- ON time:  \( t_{ON} = \ldots \ldots \ldots \) ms
- OFF voltage:  \( U_{OFF} = \ldots \ldots \ldots \) V
- OFF time:  \( t_{OFF} = \ldots \ldots \ldots \) ms

Environment

Normal (5.3 of IEC 60068-1): yes – no
If no, specify:
# Type test

<table>
<thead>
<tr>
<th>Reference to standards and subclauses</th>
<th>Test description and requirements</th>
<th>Test values and results</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1.1 Basic method</td>
<td></td>
<td>yes – no</td>
</tr>
<tr>
<td>6.1.2 Alternative method</td>
<td></td>
<td>yes – no</td>
</tr>
</tbody>
</table>

## Electrical characteristics

<table>
<thead>
<tr>
<th>6.3.1.1 Voltage: $U$ d.c or a.c</th>
<th>........... $V$</th>
</tr>
</thead>
<tbody>
<tr>
<td>if d.c, $U$ inverted: yes – no</td>
<td></td>
</tr>
</tbody>
</table>

| 6.3.1.2 Current: $I$            | ........... mA |

<table>
<thead>
<tr>
<th>IEC 60947-1, 4.3.4.3</th>
<th>Operating cycle</th>
<th>....... cycle/hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Defect contact voltage drop $U_{kd}$</td>
<td>........... $V$</td>
</tr>
</tbody>
</table>
7.1 | Defect time | $t_d$ | ............ ms

<table>
<thead>
<tr>
<th>Mechanical characteristics</th>
</tr>
</thead>
</table>
| IEC 60947-5-1, 8.3.2.1     | Velocity of actuating device, if any | ............ m/s
|                             | (angular velocity for rotary switches) |
### Characteristics of the test – Results

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tested item at commencement of test</td>
<td>( n )</td>
<td>..........</td>
</tr>
<tr>
<td>Number of operating cycles</td>
<td>( N )</td>
<td>..........</td>
</tr>
<tr>
<td>Replacement of failed contacts</td>
<td></td>
<td>yes – no</td>
</tr>
<tr>
<td>Number of failures</td>
<td>( r )</td>
<td>..........</td>
</tr>
<tr>
<td>Cumulative number of operating cycles (see 9.2.2 and 9.2.3)</td>
<td>( N^* )</td>
<td>..........</td>
</tr>
<tr>
<td>Confidence level</td>
<td>( c )</td>
<td>60 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90 %</td>
</tr>
<tr>
<td>Coefficient ( K_c ) (from table 1)</td>
<td>( K_c )</td>
<td>..........</td>
</tr>
<tr>
<td>Assessed constant failure rate (failure/operating cycles)</td>
<td>( \lambda_c )</td>
<td>..........</td>
</tr>
</tbody>
</table>
Assessed number of operations to fail (operating cycles)

\[ m_c = \frac{1}{\lambda_c} \]

\[ m_c = \ldots \ldots \ldots \]
Bibliography


  Amendment 1 (1999)
  Amendment 2 (2002)