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Reliability testing – Compliance tests for constant failure rate and constant failure intensity

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Essais de fiabilité – Plan d’essais de conformité d’un taux de défaillance constant et d’une intensité de défaillance constante

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International Standard IEC 61124 has been prepared by IEC technical committee 56: Dependability.

This third edition of IEC 61124 cancels and replaces the second edition, published in 2006, and constitutes a technical revision.

The main changes with respect to the previous edition are as follows:

- A number of new test plans have been added based on the Russian standard GOST R 27.402 [1]¹, and it is intended to align the new edition of MIL-HDBK-781 [2] with this edition. Algorithms for optimizing test plans using a spreadsheet program are given and a number of optimized test plans are listed. Furthermore, emphasis is laid on the fact that the test should be repeated following design changes.

¹ Figures in square brackets refer to the bibliography.

- Discrepancies in test plans A, B as well as Annexes A and B that originated in IEC 60605-7 [3], now withdrawn, have been corrected so these test plans differ from those given in previous editions of IEC 61124. As requested by the National Committees, mathematical background material and spreadsheet program information has been moved to informative annexes. In addition, the symbol lists have been divided, so that some annexes have separate lists of symbols.
- Guidance on how to choose test plans has been added as well as guidance on how to use spreadsheet programs to create them. Test plans A.1 to A.9 and B.1 to B.13 have been corrected.
- Subclauses 8.1, 8.2, 8.3, Clause 9, Annex C, Clauses G.2, I.2, I.3 and Annex J are unchanged, except for updated terminology and references.
- Corrections to the second edition proposed by National Committees have been implemented.

The text of this standard is based on the following documents:

FDIS	Report on voting
56/1461/FDIS	56/1468/RVD

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

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

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The contents of the corrigendum of January 2013 have been included in this copy.

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RELIABILITY TESTING – COMPLIANCE TESTS FOR CONSTANT FAILURE RATE AND CONSTANT FAILURE INTENSITY

1 Scope

This International Standard gives a number of optimized test plans, the corresponding operating characteristic curves and expected test times. In addition the algorithms for designing test plans using a spreadsheet program are also given, together with guidance on how to choose test plans.

This standard specifies procedures to test whether an observed value of

- failure rate,
- failure intensity,
- mean time to failure (MTTF),
- mean operating time between failures (MTBF),

conforms to a given requirement.

It is assumed, except where otherwise stated, that during the accumulated test time, the times to failure or the operating times between failures are independent and identically exponentially distributed. This assumption implies that the failure rate or failure intensity is constant.

[IEC 61124:2012](https://standards.iteh.ai/catalog/standards/sist/1b51cfbb-4d78-49fb-acc1-c5a9a59cc2/iec-61124-2012)

Four types of test plans are described as follows:

- truncated sequential tests;
- time/failure terminated tests;
- fixed calendar time terminated tests without replacement;
- combined test plans.

This standard does not cover guidance on how to plan, perform, analyse and report a test. This information can be found in IEC 60300-3-5.

This standard does not describe test conditions. This information can be found in IEC 60605-2 and in IEC 60300-3-5.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-191, *International Electrotechnical Vocabulary (IEV) – Chapter 191: Dependability and quality of service*

IEC 60300-3-5:2001, *Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles*

IEC 60605-2, *Equipment reliability testing – Part 2: Design of test cycles*

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

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

IEC 61123:1991, *Reliability testing – Compliance test plans for success ratio*

3 Terms, definitions, abbreviations and symbols

3.1 Terms and definitions

For the purposes of this document the terms and definitions given in IEC 60050-191 apply.

The terms "failure rate" and "failure intensity" are used as meaning constant failure rate and constant failure intensity.

3.2 Abbreviations and symbols

3.2.1 Abbreviations

MTBF	mean operating time between failures
MTTF	mean time to failure
OC	operating characteristic
SPRT	sequential probability ratio test (in some literature called probability ratio sequential test (PRST)).

3.2.2 Symbols

The generic symbol λ is used in the following for failure rate and failure intensity.

The symbol m is used to denote both the following reliability measures:

- mean operating time between failures, MTBF;
- mean time to failure, MTTF.

When used, the relationship between the above quantities, under the given assumptions, is:

$$\lambda = \frac{1}{m}$$

Sequential test plans (see Clause 6) and fixed time/failure terminated test plans (see Clause 7) are based on m as a reliability measure, thus in these cases:

$$m = \frac{1}{\lambda}$$

c	acceptable number of failures during the test
D	discrimination ratio; $D = m_0/m_1$ or $D = \lambda_1/\lambda_0$
k	summation variable for failures

MTBF	mean operating time between failures
MTTF	mean time to failure
m	true MTBF or MTTF
m_0	specified MTTF or MTBF $m_0 = 1/\lambda_0$ (design goal)
m_1	lower limit for MTTF or MTBF $m_1 = 1/\lambda_1$
n	number of test items at the beginning of the test
P_a	probability of acceptance
p_0	acceptable failure ratio
q_0	acceptable success ratio, $q_0 = 1 - p_0$
$R(t)$	reliability at time t
r	observed number of failures during the test
r_0	test truncation failure number for sequential tests (SPRT)
T^*	accumulated test time
T_a^*	accumulated test time stated as accept criterion
$T_{a, \min}^*$	minimum test time for $r = 0$ stated as accept criterion
T_e^*	expected accumulated test time to decision
$T_e^*(+)$	expected accumulated test time to acceptance
T_r^*	accumulated test time stated as reject criterion
T_t^*	accumulated test time stated as termination criterion
t	test time
t^*	test truncation time
t_t^*	test time for each test item (assumed here to be the same for all test items)
t_i	life time of failed item i
$t_{cal, t}^*$	calendar test time stated as termination criterion
$P(r)$	probability of r failures
$\Delta\mu_0$	auxiliary quantity for determination of c , $\Delta\mu_0 = c - \mu_0$
α	nominal producer's risk (type I risk)
α'	true producer's risk (type I risk)
β	nominal consumer's risk (type II risk)
β'	true consumer's risk (type II risk)
λ	true failure rate per item
λ_0	expected failure rate per item (design goal)
λ_1	upper limit for constant failure rate per item

μ expected number of failures during the test at the true λ

NOTE μ is not necessarily an integer.

μ_0 expected number of failures during the test at the specified λ_0 as parameter of the Poisson distribution $\mu_0 = T_t^* / m_0 = \lambda_0 T_t^*$

4 General requirements and area of application

4.1 Requirements

It is assumed, except where otherwise stated, that during the accumulated test time the times to failure or the operating times between failures are independent, and identically exponentially distributed. This assumption implies that the failure rate or failure intensity is constant. Under this assumption there is no difference between failure rate and failure intensity. Therefore they are both called λ and referred to in the following as failure rate.

It is assumed that the requirement is specified in one of the terms: the acceptable constant failure rate λ_0 , or the acceptable mean number of failures per time unit, λ_0 or the acceptable mean time to failure or mean operating time between failures, m_0 .

If it is necessary to test the constant failure rate/constant failure intensity assumption, the procedures given in IEC 60605-6 should be used.

4.2 Applicability to replaced and repaired items

The sequential test plans (see Clause 6), the time/failure terminated test plans (see Clause 7) and the combined test plans (see Clause 10) are applicable to the following:

- replacement of failed items;
- without replacement of failed items;

under the assumption that

- an item can be replaced by repair of the item itself;
- the accumulated test time is calculated as elapsed operating item-time, in accordance with 5.4;
- replaced items belong to the same population as the original items;
- repaired items can be considered to have the same failure intensity after repair as they had before they failed.

The calendar time/failure terminated test plans in Clause 9, however, are applicable to cases where failed items are not replaced and where a fixed number of items are placed on test for a fixed calendar time. This means that the test is running, even though the number of items under test may not remain constant because some items may not survive.

4.3 Types of test plans

4.3.1 General

Test plans are given for four types of tests:

- truncated sequential tests (see Clause 6);
- time/failure terminated tests (for fixed time/failure terminated tests see Clause 7, and for alternative time/failure terminated tests, see Clause 8);
- calendar time terminated tests without replacement (see Clause 9);
- combined test plans (see Clause 10).