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

Essais de fiabilité – Plans d'essai de conformité pour un taux de défaillance constant et une intensité de défaillance constante

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Essais de fiabilité – Plans d’essai de conformité pour un taux de défaillance constant et une intensité de défaillance constante

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

FOREWORD

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

This fourth edition cancels and replaces the third edition published in 2012. This edition constitutes a technical revision.

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

a) The truncated sequential probability ratio test (SPRT) [1], [2], [3][1] has been significantly developed in recent years [4], [5], [6]. In this edition, type A test plans (optimally truncated SPRT) have been significantly changed, as follows:

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[1] Numbers in square brackets refer to the Bibliography.

– the tests are significantly truncated (the maximal test time is low) without substantially increasing the expected accumulated test time to decision (ETT);
– the true producer's and consumer's risks (α', β') are given and are very close to the nominal values;
– the range of the test parameters is wide (risks and discrimination ratio);
– the test plans include various risk ratios (not restricted to equal risks only);
– the values of the ETT are accurate and given in the relevant region (for practical use);
– guidelines for extension of the tests set (using accurate interpolation) are included.

b) Other ready-to-use test plans (types B, C, D) are not changed, only the form of presentation of the data on their border lines and the characteristics has been changed. This form is made unified for all types of test plans, which helps the comparison of different plans and, accordingly, to facilitate the selection of the most appropriate.

c) FTFT design procedures, to extend the set of test plans B, are significantly changed and make the design accurate and simple. The implementation of this design is given on a spreadsheet program. A unified approach to the calculation of the operational characteristics of all types of test plans is introduced.

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

Draft	Report on voting
56/1980/FDIS	56/1985/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

A compliance test is an essential part of the reliability assurance system [7], [8], [9]. Reliability is affected by many random factors, so its prediction is not accurate. The direct way to check if the item meets its reliability specifications is to perform a compliance test.

The tests described in this document can be applied to items that have a failure rate or failure intensity (denoted by λ) which can be considered as a constant. The procedures are based on the assumption that trials of the test are statistically independent. If it is necessary to test the constant failure rate and constant failure intensity assumption, the procedures given in IEC 60605-6 should be used.

The test serves to verify the compliance with a specified λ_0, that is, to verify that $\lambda \leq \lambda_0$.

The probability of making the correct decision in the test depends on the test duration and on the sample size (number of failures). The tests usually require a large sample size and, accordingly, a large consumption of time and funds. The consumptions are especially high for reliability testing. For this reason, sampling plans of the tests should be carefully planned in order to reduce the consumption.

This document is dedicated to sampling plans for the tests.

The tests are characterized by the operating characteristic (OC) and test duration until the test stops with the accept/reject decision on the compliance.

OC is the probability of accepting an item as meeting the requirements. In this document, the OC is represented by the coordinates of its two points (see ISO 3534-2 [10]):

– (λ_0, 1 – α) are the coordinates of the producer's risk point (PRP);
– (λ_1, β) are the coordinates of the consumer's risk point (CRP);

where α and β are producer's and consumer's risks, and $\lambda_1 > \lambda_0$.

The test duration (test time) is a random value and in this document is usually characterized by its expected (ETT) and maximum (MaxTT) values.

This document contains the following types of tests:

– optimally truncated sequential probability ratio test (SPRT, type A);
– maximally truncated SPRT (type C);
– fixed time/failure terminated test (FTFT, type B);
– FTFT – calendar time terminated test without replacement;
– combined test plan (type D).

The tests can be used for testing equipment (repaired or non-repaired) as well as for components (replaced or not replaced when failing).

All the plans in this document are sequential, that is, every time an event occurs during the test, a decision is made to continue or stop the test. An event occurs in two cases: when a failure occurs, or when the acceptance boundary is crossed, which means that there is compliance with the requirements. The decision can be one of three types:

- accept the compliance and stop the test;
- reject the compliance and stop the test;
- continue the test, because there is not enough information to stop it.

The difference between the types of tests is in the shape of border lines.

The FTFT is characterized by decision rules for accepting or rejecting compliance when the MaxTT has been reached, or the acceptable number of failures has been exceeded. This test has the smallest MaxTT among all tests with specified PRP and CRP. If, for a tested item $\lambda \le \lambda_0$, then ETT is close to MaxTT; otherwise, if $\lambda > \lambda_0$, then ETT decreases. In fact, the only advantage of the FTFT over the SPRT is the simplicity of designing new test plans. A detailed procedure for the design is provided in this document.

The optimally truncated SPRT (type A) has a MaxTT of 1,1 to 1,2 times greater than the FTFT with the same PRP and CRP. However, the ETT of the SPRT is significantly smaller than that of the corresponding FTFT, and for $\lambda \le \lambda_0$ it can be 1,4 to 1,8 times smaller. This is a great advantage of the SPRT. This document contains an extensive set of ready-to-use type A plans. The set also allows the design of additional tests by simple interpolation according to the procedure provided in this document.

The maximally truncated SPRT (type C) has a MaxTT, like the FTFT; however, its ETT is less than that of the FTFT, but greater than that of the type A SPRT.

In the combined test plan (type D), test items with early failures will not be rejected in the initial stages of the test.

Some of the ready-to-use tests listed in this document have a very large maximal acceptable number of failures, which is why they are likely to be rarely used. However, the data allows the user of this document to assess the economic benefit of the OC test requirements and, in general, to assess the advisability of performing the test.

Accumulated test time can be reduced by accelerated testing (see IEC 62506 [11]).

An example of objects covered by this document can be electronic equipment and its components, which usually have a failure rate or failure intensity that can be considered constant.

Clause 4 presents the requirements and area of application of the tests and recommendations for their selection. Clause 5 explains the general elements of the test procedure. Clause 6 explains the characteristics of the ready-to-use SPRT and the parameters of the border lines (their values are given in Annex A). Extension of the set of SPRT tests are given in Annex C. Clause 7 is devoted to the ready-to-use FTFT. Clause 8 presents the design of FTFT plans that are not covered in the tables of this document. Mathematical references and procedures of the design of FTFT plans are given in Annex E and in Annex F. Clause 9 is devoted to the calendar FTFT for non-replaced items (examples and mathematical references of their design are given in Annex G). Clause 10 is devoted to the combined test plans (parameters of their border lines are given in Annex B). Clause 11 explains how to perform the test and presentation of results. Annex D presents the approximation of OC by Wald's formula. Annex H is devoted to the mathematical reference for the test plans of GOST R 27.402 [12].