



SLOVENSKI STANDARD
oSIST prEN IEC 61124:2022
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**Preskušanje zanesljivosti - Ustreznostni preskusi za konstantno pogostost
odpovedi in konstantno intenzivnost odpovedi**

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

Prüfungen der Funktionsfähigkeit - Prüfpläne für konstante Ausfallrate und konstante Ausfalldichte

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21.020	Značilnosti in načrtovanje strojev, aparatov, opreme	Characteristics and design of machines, apparatus, equipment

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OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: <input type="checkbox"/> Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
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TITLE:

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

PROPOSED STABILITY DATE: 2024

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 183 **RELIABILITY TESTING –**
 184 **COMPLIANCE TESTS FOR CONSTANT FAILURE RATE**
 185 **AND CONSTANT FAILURE INTENSITY**

186
 187 **FOREWORD**

- 188 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising
 189 all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international
 190 co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and
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- 219 International Standard IEC 61124 has been prepared by IEC technical committee 56:
 220 Dependability.
- 221 This fourth edition of IEC 61124 cancels and replaces the third edition, published in 2012, and
 222 constitutes a technical revision.
- 223 The main changes with respect to the previous edition are as follows:
- 224 a) The truncated sequential probability ratio test (SPRT) [1, 2, 3]¹ has been significantly
 225 developed in recent years [4, 5, 6]. In this edition, type A test plans (optimally truncated
 226 SPRT) have been significantly changed, as follows:
- 227 – the tests are significantly truncated (the maximal test time is low) without substantially
 228 increasing the expected accumulated test time to decision (ETT);
 - 229 – the true producer's and consumer's risks (α' , β') are given and are very close to the
 230 nominal values;
 - 231 – the range of the test parameters is wide (risks and discrimination ratio);

¹ Numbers in square brackets refer to the bibliography.

- 232 – the test plans include various risk ratios (not restricted to equal risks only);
 233 – the values of ETT are accurate and given in the relevant region (for practical use);
 234 – guidelines for extension of the tests set (using accurate interpolation) are included.
- 235 b) Other ready-to-use test plans (types B, C, D) are not changed, only the form of
 236 presentation of the data on their border lines and the characteristics has been changed.
 237 This form is made unified for all types of test plans, which helps the comparison of
 238 different plans and, accordingly, to facilitate the selection of the most appropriate.
- 239 c) FTFT design procedures, to extend the set of test plans B, are significantly changed and
 240 make the design accurate and simple. The implementation of this design is given on a
 241 spreadsheet program. A unified approach to the calculation of the operational
 242 characteristics of all types of test plans is introduced.

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

FDIS	Report on voting
XX/XXXX/FDIS	XX/XXXX/RVD

244 Full information on the voting for the approval of this standard can be found in the report on
 245 voting indicated in the above table.
 246

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

248 The committee has decided that the contents of this publication will remain unchanged until the
 249 stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to
 250 the specific publication. At this date, the publication will be

- 251 • reconfirmed, <https://standards.iteh.ai/catalog/standards/sist/ce9dc306-2a9c-454d-a934-89454ae12ae8/osist-pren-iec-61124-2022>
- 252 • withdrawn,
- 253 • replaced by a revised edition, or
- 254 • amended.

255

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256

257

INTRODUCTION

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

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

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

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

272 This document is dedicated to sampling plans for the tests.

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

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

277 – $(\lambda_0, 1 - \alpha)$ are the coordinates of the producer's risk point (PRP);

278 – (λ_1, β) are the coordinates of the consumer's risk point (CRP);

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

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

282 This document contains the following types of tests:

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

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

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

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

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

298 The FTFT is characterized by decision rules for accepting or rejecting compliance when the
 299 MaxTT has been reached, or the acceptable number of failures has been exceeded. This test

300 has the smallest MaxTT among all tests with specified PRP and CRP. If for a tested object
301 $\lambda \leq \lambda_0$, then ETT is close to MaxTT; otherwise, if $\lambda > \lambda_0$, then ETT decreases. In fact, the only
302 advantage of the FTFT over the SPRT is the simplicity of designing new test plans. A detailed
303 procedure for the design is provided in this standard.

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

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

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

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

318 Accumulated test time can be reduced by accelerated testing (see IEC 62506 [12]).

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

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

334

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

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340 **1 Scope**

341 This International Standard gives a number of optimized test plans, the corresponding border
342 lines and characteristics. In addition the algorithms for designing test plans using a spreadsheet
343 program are also given, together with guidance on how to choose test plans.

344 This standard specifies procedures to test whether an observed value of

- 345 – failure rate,
- 346 – failure intensity,
- 347 – mean operating time to failure (MTTF),
- 348 – mean operating time between failures (MTBF),
- 349 conforms to a given requirement.

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

354 Four types of test plans are described as follows:

- 355 – truncated sequential probability ratio test (SPRT);
- 356 – fixed time/failure terminated test (FTFT);
- 357 – fixed calendar time terminated test without replacement;
- 358 – combined test.

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

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

363 **2 Normative references**

364 The following documents are referred to in the text in such a way that some or all of their content
365 constitutes requirements of this document. For dated references, only the edition cited applies.
366 For undated references, the latest edition of the referenced document (including any
367 amendments) applies.

368 IEC 60050-192, *International Electrotechnical Vocabulary (IEV) – Chapter 192: Dependability.*

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

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

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

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

376 IEC 61123:2019, *Reliability testing – Compliance test plans for success ratio.*

377 3 Terms, definitions, abbreviations and symbols

378 3.1 Terms and definitions

379 For the purposes of this document the terms and definitions given in IEC 60050-192 apply.

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

382 3.2 Abbreviations and symbols

383 3.2.1 Abbreviations

384 ADT accept decision time – time that the test was terminated with accept decision

385 CDF cumulative distribution function

386 CRP consumer's risk point

387 ETT expected accumulated test time to accept/reject decision

388 FTFT fixed time/failure terminated test

389 MaxTT maximal accumulated test time and accumulated truncation time of the test

390 MTBF mean operating time between failures

391 MTTF mean operating time to failure

392 OC operating characteristic

393 PDF probability density function

394 PRP producer's risk point

395 RDS reject decision segment – segment of time/failure line when the test was terminated
396 with reject (see Figure 2)

397 SPRT truncated sequential probability ratio test (in some literature called probability ratio
398 sequential test (PRST))

399 3.2.2 Symbols

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

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

402 – mean operating time between failures, MTBF;

403 – mean operating time to failure, MTTF.

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

$$405 \lambda = 1/m$$

406 Test plans are based on m as a reliability measure; thus in these cases:

$$407 m = 1/\lambda$$

c acceptable number of failures during FTFT

D discrimination ratio; $D = m_0/m_1$ or $D = \lambda_1/\lambda_0$

m true MTBF or MTTF

m_j indexed m , where $j = L, 1, M, 0, H$ (as in Figure 1 and in Table 3)

m_0 specified MTTF or MTBF, $m_0 = 1/\lambda_0$

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 function
r	observed number of failures during the test
r_0	maximum number of failures where an “accept” decision is possible (see Figure 2)
r_e	expected number of failures to reach a decision
T^*	accumulated test time
T_a^*	accumulated test time stated as accept criterion (ADT)
$T_{a,min}^*$	minimum test time for $r = 0$ stated as accept criterion
T_e^*	expected accumulated test time to decision
$T_{e,j}^*$	indexed T_e^* , where $j = L, 1, M, 0, H$ (which are related to the five values of m_j as in Figure 1)
$T_e^*(+)$	expected accumulated test time to acceptance
T_r^*	accumulated test time stated as reject criterion
T_t^*	accumulated test time stated as termination criterion for FTFT and MaxTT for A, C and D tests
t	test time
t^*	test time for each tested item
t_e^*	expected test time to decision
t_t^*	test truncation time
t_i	test time of failed item i
$t_{cal,t}^*$	calendar test time stated as termination criterion
R_D	optimization criterion, Formula (E.11)
R_R	optimization criterion, Formula (E.12)
$P(r)$	probability of r failures
α	producer’s risk (type I risk)
α'	true producer’s risk (type I risk)
β	consumer’s risk (type II risk)
β'	true consumer’s risk (type II risk)
λ	true failure rate per item
λ_0	specified expected failure rate per item (design goal)
λ_1	upper limit for constant failure rate per item

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408 4 General requirements and area of application

409 4.1 Requirements and characteristics

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

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

418 The tests are characterized by an operating characteristic (OC) and test time to decision.

419 The OC of a test is the probability of accepting an item as meeting the requirements (see
420 example in Figure 3). The OC is a function of the true value of m , or of λ . In this standard, the
421 OC is represented by the coordinates of its two points (by ISO 3534-2):

- 422 • $(m_0, 1 - \alpha)$ are the coordinates of the producer's risk point (PRP), or $(\lambda_0, 1 - \alpha)$;
- 423 • (m_1, β) are the coordinates of the consumer's risk point (CRP), or (λ_1, β) .

424 The test time to reaching a decision regarding the test is a random value and in this standard
425 is usually characterized by its expected (ETT) and maximum (MaxTT) values (see example in
426 Figure 1). ETT is a function of the true value of m , or λ .

427 It is possible that special treatments will be required to ensure the constant failure rate or failure
428 intensity, for example, screening for the elimination of early life failure period.

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

431 4.2 Applicability to replaced and repaired items

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

- 435 – replacement of failed items;
- 436 – without replacement of failed items;
- 437 under the assumption that
 - 438 – an item can be replaced by repair of the item itself;
 - 439 – the accumulated test time is calculated as elapsed operating item-time, in accordance with
440 Clause 5.4;
 - 441 – replaced items belong to the same population as the original items;
 - 442 – repaired items can be considered to have the same failure intensity after repair as they had
443 before they failed.

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

448 4.3 Types of test plans

449 4.3.1 General

450 Test plans are given for the following test types:

- 451 – optimally truncated SPRT (type A ready-to-use plans, see Clause 6);