SLOVENSKI STANDARD
oSIST prEN IEC 62506:2023

01-januar-2023

Metode za pospešeno preskušanje proizvodov

Methods for product accelerated testing

Verfahren für beschleunigte Produktprüfungen

Méthodes d'essais accélérés de produits

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Ta slovenski standard je istoveten z: prEN IEC 62506:2022

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03.120.01	Kakovost na splošno	Quality in general
19.020	Preskuševalni pogoji in postopki na splošno	Test conditions and procedures in general
21.020	Značilnosti in načrtovanje strojev, aparatov, opreme	Characteristics and design of machines, apparatus, equipment

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FUNCTIONS CONCERNED: ☐ EMC	☐ ENVIRONMENT	☐ QUALITY ASSURANCE	☒ SAFETY
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TITLE:

Methods for product accelerated testing

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METHODS FOR PRODUCT ACCELERATED TESTING

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International Standard IEC 62506 has been prepared by IEC technical committee 56: Dependability.

Edition 2 correct a number of errors in Edition 1, mainly in Clause 5.7.2.3 and Annex B. A number of calculation errors in the examples in Annex B and F have been corrected. Further the references have been updated and the symbols have been revised.

Further the references have been updated.

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

FDIS	Report on voting
56/1503/FDIS	56/1513/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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INTRODUCTION

Many reliability or failure investigation test methods have been developed and most of them are currently in use. These methods are used to either determine product reliability or to identify potential product failure modes, and have been considered effective as demonstrations of reliability:

- fixed duration,
- sequential probability ratio,
- reliability growth tests,
- tests to failure, etc.

Such tests, although very useful, are usually lengthy, especially when the product reliability that has to be demonstrated was high. The reduction in time-to-market periods as well as competitive product cost, increase the need for efficient and effective accelerated testing. Here, the tests are shortened through the application of increased stress levels or by increasing the speed of application of repetitive stresses, thus facilitating a quicker assessment and growth of product reliability through failure mode discovery and mitigation.

There are two distinctly different approaches to reliability activities:

- the first approach verifies, through analysis and testing, that there are no potential failure modes in the product that are likely to be activated during the expected life time of the product under the expected operating conditions and usage profile;
- the second approach estimates how many failures can be expected after a given time under the expected operating conditions and usage profile.

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Accelerated testing is a method appropriate for both cases, but used quite differently. The first approach is associated with qualitative accelerated testing, where the goal is identification of potential faults that eventually might result in product field failures. The second approach is associated with quantitative accelerated testing where the product reliability may be estimated based on the results of accelerated simulation testing that can be related back to the use of the environment and usage profile.

Accelerated testing can be applied to multiple levels of items containing hardware or software. Different types of reliability testing, such as fixed duration, sequential test-to-failure, success test, reliability demonstration, or reliability growth/improvement tests can be candidates for accelerated methods. This standard provides guidance on selected, commonly used accelerated test types. This standard should be used in conjunction with statistical test plan standards such as IEC 61123, IEC 61124, IEC 61649 and IEC 61710.

The relative merits of various methods and their individual or combined applicability in evaluating a given system or item, should be reviewed by the product design team (including reliability engineering) prior to selection of a specific test method or a combination of methods. For each method, consideration should also be given to the test time, results produced, credibility of the results, data required to perform meaningful analysis, life cycle cost impact, complexity of analysis and other identified factors.

In this standard the term item is used as defined in IEC 60050-192 covering physical products as well as software. Services are however not covered by this standard.

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METHODS FOR PRODUCT ACCELERATED TESTING

Scope

This International Standard provides guidance on the application of various accelerated test techniques for measurement or improvement of item reliability. Identification of potential failure modes that could be experienced in the use of an item and their mitigation is instrumental to ensure dependability of an item.

The object of the methods is to either identify potential design weakness or provide information on item reliability, or to achieve necessary reliability/availability improvement, all within a compressed or accelerated period of time. This standard addresses accelerated testing of non-repairable and repairable systems. It can be used for probability ratio sequential tests, fixed duration tests and reliability improvement/growth tests, where the measure of reliability may differ from the standard probability of failure occurrence.

This standard also extends to present accelerated testing or production screening methods that would identify weakness introduced into the item by manufacturing error, which could compromise item reliability.

Normative references

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The following documents, in whole or in part, are normatively referenced in this document.

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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IEC **60050-192**:2015/AMD1:2016 Standard | Amendment 1 - International Electrotechnical Vocabulary (IEV) - Part 192: Dependability.

IEC 60068 (all parts), *Environmental testing*

IEC 60300-3-4, *Dependability management – Part 3: Application guide-Section 4: Guide to the specification of dependability requirements*

IEC 60300-3-5, *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 Standard | Equipment reliability testing - Part 4: Statistical procedures for exponential distribution - Point estimates

IEC 60605-6: 2007 *Equipment reliability testing - Part 6: Tests for the validity and estimation of the constant failure rate and constant failure intensity*

IEC 60721 (all parts), *Classification of environmental conditions*

IEC 60812, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*

IEC 61014:2003, *Programmes for reliability growth*

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IEC 61123:2019 *Reliability testing - Compliance test plans for success ratio*

IEC 61124:2012, *Reliability testing – Compliance tests for constant failure rate and constant failure intensity*

IEC 61163-1, *Reliability stress screening – Part 1:Repairable assemblies manufactured in lots.*

IEC 61163-2, *Reliability stress screening – Part 2: Electronic components*

IEC 61164:2004, *Reliability growth – Statistical test and estimation methods*

IEC 61649:2008, *Weibull analysis*

IEC 61709, *Electronic components – Reliability – Reference conditions for failure rates and stress models for conversion*

IEC 61710, *Power law model – Goodness-of-fit tests and estimation methods*

IEC 62740:2015 *Root cause analysis (RCA)*

IEC/TR 62380, *Reliability data handbook – Universal model for reliability prediction of electronics components, PCBs and equipment*

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IEC 62429, *Reliability growth – Stress testing for early failures in unique complex systems*

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Terms, definitions, symbols and abbreviations

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For the purposes of this document, the term and definitions given in IEC 60050-192, as well as the following, apply.

NOTE Symbols for reliability, availability and maintainability measures follow those of IEC 60050-192:2015, where available.

3.1 Terms and definitions

3.1.1
activation energy
E_a
empirical factor for estimating the acceleration caused by a change in absolute temperature

Note 1 to entry: Activation energy is usually measured in electron volts per degree Kelvin.

3.1.2
detection screen
low stress level exposure to detect intermittent faults

3.1.3
event compression
increasing stress repetition frequency to be considerably higher levels than it is in the field

3.1.4
highly accelerated limit test
HALT
test or sequence of tests intended to identify the most likely failure modes of the product in a defined stress environment

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Note 1 to entry: HALT is sometimes spelled out as the highly accelerated life test (as it was originally named in error). However, as a non-measurable accelerated test, it does not provide information on life duration, but on the magnitude of stress which represents the limit of the design.

3.1.5
highly accelerated stress audit
HASA
process monitoring tool where a sample from a production lot is tested to detect potential weaknesses in a product caused by manufacturing

3.1.6
highly accelerated stress screening
HASS
screening intended to identify latent defects in a product caused by manufacturing process or control errors

3.1.7
item
subject being considered

Note 1 to entry: The item may be an individual part, component, device, functional unit, equipment, subsystem, or system.

Note 2 to entry: The item may consist of hardware, software, people or any combination thereof.

Note 3 to entry: The item is often comprised of elements that may each be individually considered. See "sub-item", definition 192-01-02 and "indenture level", definition 192-01-05.

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Note 4 to entry: IEC 60050-191:1990 (now withdrawn; replaced by IEC 60050-192:2015) identified the term “entity” as an English synonym, which is not true for all applications.

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Note 5 to entry: The definition for item in IEC 60050-191:1990 (now withdrawn; replaced by IEC 60050-192:2015) is a description rather than a definition. This new definition provides meaningful substitution throughout this document. The words of the former definition form new note 1.

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[SOURCE: IEC 60050-192:—, definition 192-01-01]

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3.1.9
life time, <of a non-repairable item / component>
time interval from first use until user requirements are no longer met

NOTE 1 to entry: The end of life time is usually called failure of the component.

NOTE 2 to entry: The end of life is often defined as the time where a specified percentage of the components have failed, for example stated as a B_{10} or L_{10} value for 10% accumulated failures.

3.1.10
precipitation screen
screening profile to precipitate, through failure, conversion of latent into revealed faults

3.1.11

step stress test
step stress test
test in which the applied stress is increased, after each specified interval, until failure occurs or a predetermined stress level is reached

Note 1 to entry: The ‘intervals’ could be specified in terms of number of stress applications, durations, or test sequences.

Note 2 to entry: The test should not alter the basic failure modes, failure mechanisms, or their relative prevalence.

[SOURCE: IEC 60050-192:—, definition 192-09-10]

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3.1.12
test acceleration factor
ratio of the stress response rate of the test specimen under the accelerated conditions, to the stress response rate under specified operational conditions

Note 1 to entry: Both stress response rates refer to the same time interval in the life of the tested items.

Note 2 to entry: Measures of stress response rate are, for example, operating time to failure, failure intensity, and rate of wear.

[SOURCE: IEC 60050-192:—, definition 192-09-09]

3.1.13
time compression
removal of exposure time at low or deemed non damaging stress levels from a test for purpose of acceleration

3.2 Symbols and abbreviated terms

Symbol/ Abbreviation	Description
ADT	accelerated degradation test(ing)
AF	acceleration, acceleration factor
AF_{test}	overall acceleration in a test
CALT	calibrated accelerated life testing
B_{10}	life time, the time where 10% of the items have failed
C	Confidence
CD	CD player in a HiFi equipment
DL	destruct limit
DSL	design specification limit
DVL	design verification level
FIT	failure in time (failure per. 10^9 hours)
HALT	highly accelerated limit test
HASA	highly accelerated stress audit
HASS	highly accelerated stress screening test
HAST	highly accelerated stress test
L	Load
L_v	Lifetime ratio
LDL	lower destruct limit
LDT	lower destruct temperature
LOL	lower operating limit
LOT	lower operating temperature
LRTL	lower reliability test limit
MTBF	mean operating time between failures
MTTF	mean operating time to failure
OL	operating limit
OVL	operation vibration limit
PWB	Printed wireing board
R(*t*)	reliability as a function of time; probability of survival to the time *t*
RTL	reliability test level

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S	Strength
SL	specification limit
SPRT	sequential probability ratio test
t_0	time denoted time 0
t_L	a specified time, e. g. life
THB	temperature humidity bias test
TTF	time to failure
UDL	upper destruct limit
UDT	upper destruct temperature
UOL	upper operating limit
UOT	upper operating temperature
URTL	upper reliability test limit
UUT	unit under test
VDL	Vibration Destruct Limit
$\lambda(S)$	failure rate as a function of a stress
$\lambda(t)$	failure rate as a function of time

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General description of the accelerated test methods

4.1 Cumulative damage model

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Accelerated testing of any type is based on the cumulative damage principle. The stresses of the item in its life cause progressive damage that accumulates throughout the item life. This damage may or may not result in a item's failure in the field.

The strategy of any type of accelerated testing is to produce, by increasing stress levels during testing, cumulative damage equivalent to that expected in the item's life for the type of expected stress. Determination of item destruct limits, without reliability estimation, provides information on whether there exists a sufficient margin between those destruct limits and item specification limits, thus providing assurance that the item will survive its predetermined life period without failure related to that specific stress type. This technique may or may not necessarily quantify a probability of item survival for its life, just assurance that the necessary adjustments in item strength would help eliminate such failure in item use. Where sufficient margins are determined unrelated to the probability of survival, the type of test is qualitative. In tests where this probability of survival is determined, the magnitude of the stress is correlated to the probability that the item would survive that stress type beyond the predetermined life, and this test type is quantitative.

Figure 1 depicts the principle of cumulative damage in both qualitative and quantitative accelerated tests.

In Figure 1, for simplicity, all stresses, operating limits, destruct limits, etc. are shown as absolute values. The specification values for an item are usually given in both extremes, upper and lower, thus the upper and lower (or low) specification limit, USL and LSL with the corresponding design limits (DSL), UDL and LDL, the upper and lower operating limits, UOL and LOL, and also the reliability test limits, URTL and LRTL. The rationale is that the opposite (negative stresses), may also cause cumulative damage probably with a different failure mechanism, thus the relationship between the expected and specified limits can be illustrated in the same manner as for the high or positive stress. As an example, cold temperature extremes might produce the same or different failure modes in a item. To avoid clutter, the

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positive and the negative thermal or any other stresses are not separately shown in Figure 1, thus the magnitudes of stresses are either positive or negative, and thus represented as absolute values only as upper or lower limits.

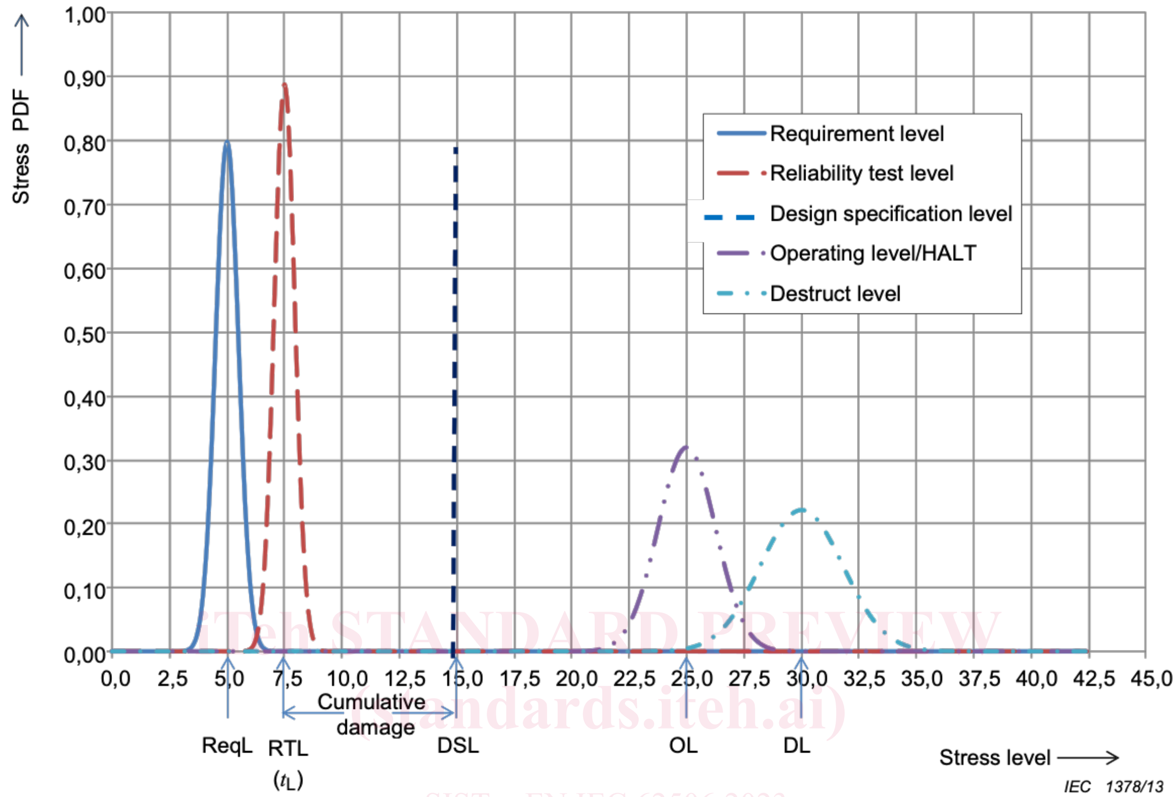

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Figure 1 – Probability density functions (PDF) for cumulative damage, degradation, and test types

The graph in Figure 1 shows the required strength of a item regarding a stress for the duration of its lifetime, from beginning of life (e.g. time when the item is made), t_0 through the end of life, t_L. The strength and stresses in tests are also assumed to have a Gaussian distribution.

The different types of accelerated tests can now be illustrated using Figure 1 as a conceptual model.

Functional testing is carried out within the range of the requirement specification and at the level of the specification. In this area no failures should occur during the test; design is validated to allow operation within the upper and lower specification limits. Accelerated testing of Type B and C (4.2.3 and 4.2.4), i.e. accelerated degradation testing (ADT) or cumulative damage testing can be illustrated as the distance between the design specification level (DSL) and the level where the reliability demonstration test should be performed (RTL). When the degradation reduces the performance below the requirement specifications the item can be declared as failed, if this behaviour is defined as a failure. When testing the item at time t_0 no failures should be expected for stress levels up to and including the design specification level (DSL).

The item design specification should take into consideration certain degradation during the item's life which is resultant from the cumulative damage of the stresses expected in life, thus its limit is the design specification limit (DSL) which is higher than the requirement limit (RL) in order to provide the necessary margin. After item degradation resultant from the cumulative damage caused by expected stresses, the reliability test provides information on the existing margin between the test level (the remaining strength) and the requirement. This margin is a measure of reliability at the end of required period, t_L.