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Methods for product accelerated testing

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IEC 62506

Edition 2.0 2023-11  
COMMENTED VERSION

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INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 03.120.01, 21.020

ISBN 978-2-8322-7828-4

**Warning! Make sure that you obtained this publication from an authorized distributor.**

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## METHODS FOR PRODUCT ACCELERATED TESTING

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**This commented version (CMV) of the official standard IEC 62506:2023 edition 2.0 allows the user to identify the changes made to the previous IEC 62506:2013 edition 1.0. Furthermore, comments from IEC TC 56 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.**

**A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.**

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

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

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

- a) references have been updated;
- b) symbols have been revised;
- c) errors in 5.7.2.3 and Annex B, mainly, have been corrected;
- d) calculation errors in the examples of Annex B and Annex F have been corrected.

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

Draft	Report on voting
56/2000/FDIS	56/2016/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

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- reconfirmed,
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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 is 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.

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~~ can 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~~ and software. Different types of reliability testing, such as fixed duration, sequential test-to-failure, success test, reliability demonstration, or reliability growth ~~or~~ improvement tests can be candidates for accelerated methods. This document provides guidance on selected, commonly used accelerated test types. This document 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 ~~dependability~~ 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 document the term "item" is used as defined in IEC 60050-192 covering physical products as well as software. Services and people are however not covered by this document.

# METHODS FOR PRODUCT ACCELERATED TESTING

## 1 Scope

This document provides guidance on the application of various accelerated test techniques for measurement or improvement of ~~product~~ item reliability. Identification of potential failure modes that ~~could~~ can be experienced in the use of ~~a product/~~ 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 ~~dependability~~ reliability, or to achieve necessary reliability/ and availability improvement, all within a compressed or accelerated period of time. This document 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~~ can differ from the standard probability of failure occurrence.

This document also extends to present accelerated testing or production screening methods that would identify weakness introduced into the ~~product~~ item by manufacturing error, which ~~could~~ can compromise ~~product dependability~~ item reliability. Services and people are however not covered by this document.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-192 – *International Electrotechnical Vocabulary (IEV) – Part 192: Dependability*, available at <http://www.electropedia.org>

~~IEC 60068 (all parts), *Environmental testing*~~

~~IEC 60300-3-1:2003, *Dependability management – Part 3-1: Application guide – Analysis techniques for dependability – Guide on methodology*~~

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

~~IEC 61014:2003, *Programmes for reliability growth*~~

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

IEC 61124:2012/2023, *Reliability testing – Compliance tests for constant failure rate and constant failure intensity*

~~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~~ Electric 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 62303, Radiation protection instrumentation – Equipment for monitoring airborne tritium~~

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

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

### 3 Terms, definitions, symbols and abbreviated terms

#### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ~~IEC 60050-191:\_\_\_\_\_~~ IEC 60050-192 and the following, apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

NOTE Symbols for reliability, availability and maintainability ~~and safety~~ measures follow those of ~~IEC 60060-191:1990~~ IEC 60050-192, where available.

##### 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 at 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

Note 1 to entry: HALT is sometimes spelt 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 191-41-02~~ (IEV 192-01-02) and "indenture level"; ~~definition 191-41-05~~ (IEV 192-01-05).

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.

Note 5 to entry: The definition for "item" ~~given in the first edition~~ 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 the new Note 1 to entry.

Note 6 to entry: In this document people and services are excluded.

[SOURCE: ~~IEC 60050-191:—, definition 191-41-01~~ [1] IEC 60050-192:2015, 192-01-01, modified – Note 6 to entry has been added.]

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**3.1.8****life time**

<of a non-repairable item> 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.

**3.1.9****precipitation screen**

screening profile to precipitate, through failure, conversion of latent faults into ~~permanent~~ revealed faults

**3.1.10**~~step stress~~**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 'interval' 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 60050-191:—, definition 191-49-10~~ IEC 60050-192:2015, 192-09-10]

**3.1.11****test acceleration factor**

~~ratio between the item failure distribution characteristics or reliability measures (e.g. failure intensities) of an item when it is subject to stresses in expected use and those the item acquires when the higher level stresses are applied for achieving a shorter test duration~~

~~Note 1 to entry: For a test to be effectively accelerated, the acceleration factor is >1.~~

~~Note 2 to entry: When the failure distribution Poisson is assumed with constant failure rate, then the acceleration factor corresponds to the ratio of time under stress in use vs. time under increased stress in test.~~

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 60050-192:2015, 192-09-09]

**3.1.12****time compression**

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

**3.1.5****highly accelerated stress test****HAST**

~~test where applied stresses are considerably increased in order to reduce duration of their application~~

**3.2 Symbols and abbreviated terms**

~~ADT~~ ~~accelerated degradation testing~~ 62506:2023

ADT accelerated degradation test(ing) 10c5-0dd8-4cb9-b4da-f4c424649ca1/iec-62506-2023

*AF* acceleration, acceleration factor

*AF*<sub>Test</sub> overall acceleration in a test

~~AF~~ ~~acceleration factor~~

CALT calibrated accelerated life testing

*B*<sub>10</sub> life time, the time where 10 % of the items have failed

*C* confidence

CD compact disc player in a HiFi equipment

DL destruct limit

DSL design specification limit

FIT failure ~~to~~ in time (failure per 10<sup>9</sup> 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*<sub>v</sub> life time 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
$P_A$	acceptance probability
PDF	probability density functions
PWB	printed wiring board
<del>RG</del>	<del>reliability growth</del>
$R(t)$	reliability as a function of time; probability of survival to the time $t$

~~NOTE 1 IEC 60050-191:1990, definition 191-12-01 uses the general symbol  $R(t, z)$ . Time may be substituted by cycles, measure of distance, etc.~~

~~NOTE 2 In reliability growth testing, the same symbol normally used for the instantaneous failure rate can be used for variable failure intensity.~~

RTL	reliability test level
S	strength
SL	specification limit
SPRT	sequential probability ratio test
<del>SPRT</del>	<del>sequential probability ratio tests</del>
<del><math>t_0</math></del>	<del>start of a period of indetermination of product destruct life test</del>
$t_0$	time denoted time 0
<del><math>t_L</math></del>	<del>duration of a predetermined</del> 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

## 4 General description of the accelerated test methods

### 4.1 Cumulative damage model

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