IEC 62506

Edition 2.0 2023-11

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

colour inside

## Methods for product accelerated testing

## Méthodes d'essais accélérés de produits



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# METHODS FOR PRODUCT ACCELERATED TESTING

## FOREWORD

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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. The main document types developed by IEC are described in greater detail at www.iec.ch/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- withdrawn, or
- revised.



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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 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 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 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 item reliability. Identification of potential failure modes that can 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 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 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 item by manufacturing error, which can compromise 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 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 61123:2019, *Reliability testing – Compliance test plans for success ratio*

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

IEC 61649:2008, *Weibull analysis*

IEC 61709, *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 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 60050-192 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 measures follow those of 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" (IEV 192-01-02) and "indenture level" (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" 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 60050-192:2015, 192-01-01, modified – Note 6 to entry has been added.]

**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 revealed faults



**3.1.10**
**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 60050-192:2015,192-09-10]

**3.1.11**
**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 60050-192:2015,192-09-09]

**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

### 3.2 Symbols and abbreviated terms

| | |
|---|---|
| ADT | accelerated degradation test(ing) |
| $AF$ | acceleration, acceleration factor |
| $AF_{\text{Test}}$ | 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 | compact disc player in a HiFi equipment |
| DL | destruct limit |
| DSL | design specification limit |
| 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 |
| $L_{\text{v}}$ | 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 |
| $P_{\text{A}}$ | acceptance probability |
| PDF | probability density functions |
| PWB | printed wiring board |
| $R(t)$ | reliability as a function of time; probability of survival to the time $t$ |
| RTL | reliability test level |
| S | strength |
| SL | specification limit |
| SPRT | sequential probability ratio test |
| $t_0$ | time denoted time 0 |
| $t_{\text{L}}$ | 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

# 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 item in its life cause progressive damage that accumulates throughout the item life. This damage can, or not, result in an 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. The 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 can, but not necessarily, quantify a probability of item survival for its life, and just provides 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), can 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 can produce the same or different failure modes in an item. To avoid clutter, the 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.