

Compliance test procedures for steady-state availability

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Approved as an American National Standard by:

American Society for Quality

AMERICAN NATIONAL STANDARD

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Contents

	Page
Foreword.....	1
Introduction.....	2
Clause	
1 Scope	3
2 Normative references	3
3 Definitions	4
4 Symbols	4
5 Conditions for availability performance testing	5
5.1 Dependability management and specification	5
5.2 Statistical process conditions	6
5.3 Definition of states	6
5.4 Classification of times	7
5.5 Classification of failures	7
5.6 Test conditions	8
6 Data collection	9
7 Time distributions	10
7.1 Distribution assumptions	10
7.2 Trend test	11
7.3 Decision alternatives in case of non-validity of assumptions	12
8 Compliance testing planning	12
9 Compliance test plans	12
9.1 Test plan 1—Fixed number of failures	12
9.2 Test plan 2—Fixed time longer than 15 mean up times	13
9.3 Test plan 3—Fixed time ($U < 0.05$)	13
9.4 Test plan 4—Sequential test	14
10 Test report	15
10.1 Test logs and data records	15
10.2 Failure reports	16
10.3 Failure summary record	17
10.4 Replacement units and spare parts inventory (optional)	18
10.5 Final report	18

Annexes

A	Tables A.1 to A.4	19
B	Numerical examples	25
C	Bibliography	27

Compliance Test Procedures for Steady-State Availability

Foreword

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

This International Standard has been prepared by IEC Technical Committee No. 56: Dependability.

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

DIS	Report on Voting
56(CO)166	56(CO)187

Full information on the voting for the approval of this standard can be found in the Voting Report indicated in the above table.

Annex A forms an integral part of this International Standard.

Annexes B and C are for information only.

Introduction

Requirements on dependability may be expressed either in terms of measures of the individual characteristics reliability performance, maintainability performance and maintenance support performance, or by measures of availability performance.

Availability performance measures include, but are not limited to, instantaneous, mean, asymptotic, asymptotic mean and steady-state versions of availability, and mean accumulated down time, as defined in IEC 50(191). The preference for and application of these measures vary from one industry sector to another and from one product to another, inter alia depending on product application and end user needs.

A requirement expressed by one kind of measure may often be possible to convert to another. For example a requirement for mean accumulated down time under steady-state conditions may be translated into a requirement for steady-state availability.

Validation of a specified requirement is often done by means of compliance testing under simulated or actual field conditions.

Compliance Test Procedures for Steady-State Availability

1 Scope

This International Standard specifies techniques for availability performance testing of frequently maintained items when the availability performance measure used is either steady-state availability or steady-state unavailability. It is applicable to compliance testing of the steady-state availability of items attaining only two states, up-state and down-state, under the following conditions:

- 1) One single repaired item.
- 2) All up times have the same exponential distribution.

NOTE—This usually implies the need for operation to reach the constant failure intensity period before the compliance test is begun.

- 3) Preventive maintenance time is not included in down time although it is recognized as having possible impact on availability performance.
- 4) All contributors to down time need to be explicitly stated in the requirement or test specification.
- 5) Very reliable items may require an extremely long test time to determine compliance.

NOTE—With a highly reliable item, few or even zero failures may occur within a designated period of time. In such a case, there will be little or (possibly) zero quantitative information on the availability performance since there may be no repair actions. Parties (supplier and customer) applying this standard should agree on the decision to be made in such an eventuality. In general it is recommended that before the parties invoke this standard in a contract they calculate, or simulate, the results to be obtained from the compliance test. In this way both parties will be knowledgeable regarding the risks they are facing.

- 6) The compliance test procedures use the complementary measure steady-state unavailability.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(191): 1990, *International Electrotechnical Vocabulary (IEV), chapter 191: Dependability and quality of service*.

IEC 60082-2: *Environmental testing—Part 2: Tests*.

IEC 60300: 1984, *Reliability and maintainability management*.

IEC 60362: 1971, *Guide for the collection of reliability, availability, and maintainability data from field performance of electronic items.*

IEC 60605-1: 1978, *Equipment reliability testing—Part 1: General requirements.*

IEC 60605-2: *Equipment reliability testing—Part 2: Guidance for the design of test cycles. (In preparation.)*

IEC 60605-3: *Equipment reliability testing—Part 3: Preferred test conditions.*

IEC 60605-6: 1986, *Equipment reliability testing—Part 6: Tests for the validity of a constant failure rate assumption.*

IEC 60706-1: 1982, *Guide on maintainability of equipment—Part 1: Sections One, Two and Three. Introduction, requirements and maintainability programme.*

IEC 60706-3: 1987, *Guide on maintainability of equipment—Part 3: Sections Six and Seven: Verification and collection, analysis and presentation of data.*

IEC 60721-1: 1991, *Classification of environmental conditions—Part 1: Environmental parameters and their severities.*

3 Definitions

For the purposes of this International Standard the terms and definitions of IEC 50(191) apply.

4 Symbols

The following symbols are used in this International Standard.

NOTE—Symbols that are used only locally are explained as they appear and are not included in this symbol list.

α	the nominal producer's risk (type I risk)
β	the nominal consumer's risk (type II risk)
$Ac(r)$	the acceptance limit in a sequential test
$Re(r)$	the rejection limit in a sequential test
D	the discrimination ratio, $D = U_1 / U_0$
U_0	the specific acceptable value of steady-state unavailability, $U_0 = 1 - A_0$
U_1	the unacceptable value of steady-state unavailability, $U_1 = 1 - A_1$
U_{lim}	the rejection limit in a compliance test
$U_{1-\alpha}$	the $1 - \alpha$ fractile of the standardized normal distribution
A_0	the specified acceptable value of steady-state unavailability
A_1	the unacceptable value of steady-state availability
$F_{1-\alpha}(v_1, v_2)$	the $1 - \alpha$ fractile of the F -distribution with degrees of freedom v_1 and v_2 . Table A.1 of annex A contains fractiles of the F -distribution

m_d	the mean down time
m_u	the mean up time
n	the sample size, i.e. the number of failures, for a fixed time test
r	the number of failures in a sequential test
T	the accumulated up time, $T = \sum t_i$
T^*	the duration for a fixed time test
t_i	up time No. i , $i = 1, 2, 3, \dots$
Y	the accumulated down time, $Y = \sum y_i$
y_i	down time No. i , $i = 1, 2, 3, \dots$

Probability density functions, $f(t)$, and expectations $E(t)$, $E(t^2)$, for the distributions used:

Gamma distribution:

$$f(t) = s(st)^{p-1} \exp(-st) / \Gamma(p)$$

$$E(t) = p/s$$

$$E(t^2) = p/s^2$$

p is the shape parameter

s is the scale parameter

$$\Gamma(p) = \int_0^\infty y^{p-1} \exp(-y) dy \text{ is the gamma function}$$

$$\Gamma(p) = (p-1)! \text{ for integer } p$$

Exponential distribution (special case of gamma distribution with $p = 1$):

$$f(t) = s \exp(-st)$$

$$E(t) = 1/s$$

$$E(t^2) = 1/s^2$$

5 Conditions for availability performance testing

5.1 Dependability management and specification

The process of reaching a desired availability performance goal for an item may contain several steps, for example:

- specification of availability performance requirements for the item to be acquired;
- analysis of the predicted availability performance. This may be applied during the design of the item, and may include an allocation of the overall availability performance requirements to requirements on sub-items;

- testing the steady-state availability of the completed item to verify that the specified requirement has been fulfilled. Test methods are presented in this standard.

As indicated above, the purpose of an availability compliance test is generally to verify that a specified requirement has been met. The test procedure thus depends heavily on what is stated in the specification. If a test is to be part of the acquisition procedure, it is recommended that the basic outline of the test be included in the specification. The following topics should be considered:

- availability performance measure to be used;

NOTE—Availability performance requirements for direct application in this standard may be expressed as the steady-state mean availability or the steady-state unavailability. An availability compliance test should be based on the measure that is used in the requirement specification.

- definitions of states, times and failures;

- test conditions;

- type of test to be performed, e.g. fixed number of failures, fixed time test or sequential test;

- consequences in case of rejection. Monetary penalties (and incentives) or requirements for redesign may be drawn up.

When referring to this standard in an agreement between a supplier and a customer, it should be explicitly stated if all or only a selection of clauses are applicable.

5.2 Statistical process conditions

The test plans of this standard presuppose all up times are independent observations from the same homogeneous Poisson process (all up times are realizations of the same exponential distribution) and all down times are independent realizations from the same gamma (or exponential) distribution. Methods for verification of a lack of trend in the data are included in 7.2. If a trend exists, test results may still be informative, provided precautions are taken to consider reliability growth, learning curve of maintenance personnel, etc.

5.3 Definition of states

The test plans are intended for a continuously operated item, where the availability performance measure is expressed in relation to the total time. If they are applied to items used intermittently, due consideration shall be given to the problem of repairs performed during non-required time.

Availability performance measures generally require that the acceptable functional modes of the item are defined, i.e. that up and down states are specified. The test methods of this standard can only treat items with two states (up/down).

NOTE—For complex items several functional modes may be defined, each with a different availability performance requirement. If this is the case, the test plans may be applied to one functional mode at the time. In such cases it is necessary to define in advance how the situation of conflicting test outcomes for different functional modes is to be handled.