SLOVENSKI STANDARD
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Mathematical expressions for reliability, availability, maintainability and maintenance support terms (IEC 61703:2001)

Mathematical expressions for reliability, availability, maintainability and maintenance support terms

Mathematische Ausdrücke für Begriffe der Funktionsfähigkeit, Verfügbarkeit, Instandhaltbarkeit und Instandhaltungsbereitschaft

Expressions mathématiques pour les termes de fiabilité, de disponibilité, de maintenabilité et de logistique de maintenance

Ta slovenski standard je istoveten z: **EN 61703:2002**

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

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EUROPEAN STANDARD **EN 61703**

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(IEC 61703:2001)

Expressions mathématiques pour les termes de fiabilité, de disponibilité, de maintenabilité et de logistique de maintenance (CEI 61703:2001)

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This European Standard was approved by CENELEC on 2001-12-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 56/747/FDIS, future edition 1 of IEC 61703, prepared by IEC TC 56, Dependability, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61703 on 2001-12-04.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2002-09-01

– latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2004-12-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annexes A, B, C and D are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61703:2001 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-191	1990	International Electrotechnical Vocabulary (IEV) Chapter 191: Dependability and quality of service	-	-
ISO 3534-1	1993	Statistics - Vocabulary and symbols Part 1: Probability and general statistical terms	-	-

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Expressions mathématiques pour les termes de fiabilité, de disponibilité, de maintenabilité et de logistique de maintenance

Mathematical expressions for reliability, availability, maintainability and maintenance support terms

International Electrotechnical Commission 3, rue de Varembé Geneva, Switzerland
Telefax: +41 22 919 0300 e-mail: inmail@iec.ch IEC web site http://www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MATHEMATICAL EXPRESSIONS FOR RELIABILITY, AVAILABILITY, MAINTAINABILITY AND MAINTENANCE SUPPORT TERMS

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61703 has been prepared by IEC technical committee 56: Dependability.

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

FDIS	Report on voting
56/747/FDIS	56/771/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 3.

Annexes A, B, C and D are for information only.

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

Part 1 of IEC 60050-191 provides definitions for dependability and its influencing factors, reliability, availability, maintainability and maintenance support, together with definitions of many other terms commonly used in this field. Some of these terms relate to specific measures of the individual performance characteristics, which can be expressed mathematically.

This standard, used in conjunction with IEC 60050-191, provides practical guidance essential for the quantification of those performance measures. For those requiring further information, for example on detailed statistical methods, reference should be made to the IEC 60605 series of standards.

Annex A provides a diagrammatic explanation of the relationships between some basic mathematical terms, related random variables, probabilistic descriptors and measures.

Annex B provides a summary of measures related to time to failure.

Annex C compares some dependability measures for continuously operating items.

Annex D explains some of the software dependability aspects.

The bibliography gives references for the mathematical basis of this standard.

MATHEMATICAL EXPRESSIONS FOR RELIABILITY, AVAILABILITY, MAINTAINABILITY AND MAINTENANCE SUPPORT TERMS

1 Scope

This International Standard provides mathematical expressions for reliability, availability, maintainability and maintenance support measures defined in IEC 60050-191. The following classes of items are considered separately in this standard:

– non-repaired items;
– repaired items with zero time to restoration;
– repaired items with non-zero time to restoration.

In order to keep the mathematical formulae as simple as possible, the following basic mathematical models are used to quantify dependability measures:

– random variable (time to failure) for non-repaired items;
– simple (ordinary) renewal process for repaired items with zero time to restoration;
– simple (ordinary) alternating renewal process for repaired items with non-zero time to restoration.

To facilitate location of the full definition, the IEC 60050-191 reference for each term is shown (in parenthesis) immediately following each term, for example:

mean time to restoration [191-13-08]

The application of each dependability measure is illustrated by means of a simple example.

NOTE This standard is mainly applicable to hardware dependability, but many terms and their definitions may be applied to items containing software. Some of the software dependability aspects are explained in annex D.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, 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. For undated references, the latest edition of the normative document referred to applies. 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*

ISO 3534-1:1993, *Statistics – Vocabulary and symbols – Part 1: Probability and general statistical terms*

3 Definitions

For the purpose of this International Standard, the terms and definitions of IEC 60050-191 and ISO 3534-1 apply. In addition, the following terms and definitions are used.

3.1
instantaneous restoration intensity $v(t)$
limit, if it exists, of the quotient of the mean number of restorations of a repaired item in the time interval (t, $t + \Delta t$) and the duration of this interval, Δt, when the duration of the time interval tends to zero

NOTE The instantaneous restoration intensity is expressed by the formula as

$$v(t) = \lim_{\Delta t \to 0+} \frac{E\left[N_R(t + \Delta t) - N_R(t)\right]}{\Delta t}$$

where

$N_R(t)$ is the number of restorations in the time interval (0, t);

E denotes the expectation.

3.2
asymptotic failure intensity $z(\infty)$
for modelling purposes, limit, if it exists, of the instantaneous failure intensity $z(t)$, when time t tends to infinity

3.3
up-time distribution function $F_U(t)$
function giving, for every value of t, the probability that an up time will be less than, or equal to, t

3.4
complement to the up-time distribution function $R_U(t)$
function giving, for every value of t, the probability that an up time will be greater than t

For convenience, this function is referred to as the **up-time survival function** in this standard.

NOTE 1 $R_U(t) = 1 - F_U(t)$.

NOTE 2 If the up time is exponentially distributed, then

$$R_U(t) = \exp(-t/\text{MUT})$$

where MUT is the mean up time.

In this case, the reciprocal of MUT is denoted by λ_U:

$$\lambda_U = 1/\text{MUT}$$

4 Glossary of symbols and abbreviations

NOTE The symbols given below are widely used and recommended but are not mandatory.

4.1 Non-repaired items

COI	Continuously operating item
IOI	Intermittently operating item
MTTF	Mean time to failure
$\hat{MTTF}$	Point estimate of the mean time to failure
$R(t)$	Reliability function, i.e. the probability of survival until time t: $R(t) = R(t_1, t_2)$ for $t_1 = 0$ and $t_2 = t$
$\hat{R}(t)$	Point estimate of the reliability function at time t
$R(t_1, t_2)$	Reliability for the time interval (t_1, t_2)
$R(t, t+x \mid t)$	Conditional reliability for the time interval $(t, t + x)$, assuming that the item survived to time t
TTF_i	Observed time to failure of item i
$f(t)$	Probability density function of the (operating) time to failure
$\hat{f}(t)$	Point estimate of the probability density function of the (operating) time to failure at time t
n	Number of (non-repaired) items in the population that are operational at the instant of time $t = 0$
$n_S(t)$	Number of (non-repaired) items that are still operational at the instant of time t ($n_S(0) = n$)
$n_S(t) - n_S(t + \Delta t)$	Number of items that fail in the time interval $(t, t + \Delta t)$
λ	Constant failure rate, i.e. the reciprocal of the mean time to failure (MTTF) when the times to failure are exponentially distributed
$\hat{\lambda}$	Point estimate of the constant failure rate
$\lambda(t)$	Instantaneous failure rate
$\hat{\lambda}(t)$	Point estimate of the instantaneous failure rate at time t
$\bar{\lambda}(t_1, t_2)$	Mean failure rate for the time interval (t_1, t_2)

4.2 Repaired items with zero time to restoration

COI	Continuously operating item
IOI	Intermittently operating item
MTBF	Mean operating time between failures
MTTF	Mean time to failure
$\hat{\text{MTTF}}$	Point estimate of the mean time to failure
MUT	Mean up time
$N(t)$	Number of failures in the time interval (0, t)
$R(t)$	Reliability function, i.e. the probability of survival until time t: $R(t) = R(t_1, t_2)$ for $t_1 = 0$ and $t_2 = t$
$R_U(t)$	Up-time survival function, i.e. the distribution function of the up times is $1 - R_U(t)$
$R(t_1, t_2)$	Reliability for the time interval (t_1, t_2)
$\hat{R}(t_1, t_2)$	Point estimate of the reliability for the time interval (t_1, t_2)
$Z(t)$	Expected number of failures in the time interval (0, t) $Z(t) = E[N(t)]$, where E denotes the expectation
$f(t)$	Probability density function of the (operating) times to failure
$f_U(t)$	Probability density function of the up times NOTE For COIs, $f_U(t) = f(t)$.
$h^{(n)}_{CTTF}(t)$	Probability density function of calendar time to the nth failure, $n \geq 1$
k_F	Number of failures during a given period of observation
n	Number of items in the population
$n_F(t, t + \Delta t)$	Number of failures observed in the time interval (t, $t + \Delta t$)
$n_F(t_1, t_2)$	Number of failures observed in the time interval (t_1, t_2)
$n_S(t_1, t_2)$	Number of items that were operational at the instant of time t_1 and operated without failure during the time interval (t_1, t_2)
$z(t)$	Instantaneous failure intensity
$z(\infty)$	Asymptotic failure intensity
$\hat{z}(t)$	Point estimate of the instantaneous failure intensity at time t
$\bar{z}(t_1, t_2)$	Mean failure intensity for the time interval (t_1, t_2)
$\hat{\bar{z}}(t_1, t_2)$	Point estimate of the mean failure intensity for the time interval (t_1, t_2)
λ	Constant failure rate, i.e. the reciprocal of the mean time to failure (MTTF) when the times to failure are exponentially distributed
λ_U	Constant rate of transition from an up state to a down state, i.e. the reciprocal of the mean up time (MUT) when the up time is exponentially distributed