

Reliability of systems, equipment and components —

Part 10: Guide to reliability testing —

Section 10.3 Compliance test procedures for steady-state availability

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Quality, Management and Statistics Standards Policy Committee (QMS/-) to Technical Committee QMS/23, upon which the following bodies were represented:

- AEA Technology
- Association of Consulting Engineers
- Association of Project Managers
- British Gas plc
- British Railways Board
- City University
- Civil Aviation Authority
- Consumers' Association
- Cranfield Information Technology Institute
- Cranfield Institute of Technology
- Design Council
- EEA (the Association of Electronics, Telecommunications and Business Equipment Industries)
- Electricity Association
- Electronic Components Industry Federation
- Engineering Equipment and Materials Users' Association
- GAMBICA (BEAMA Ltd.)
- Institute of Petroleum
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- Safety and Reliability Society
- Society of British Aerospace Companies Limited
- Society of Environmental Engineers
- Society of Motor Manufacturers and Traders Limited
- University of Technology, Loughborough

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National foreword

This Part of BS 5760 has been prepared under the direction of the Quality, Management and Statistics Standards Policy Committee. It is identical with IEC 1070:1991 *Compliance test procedures for steady-state availability* published by the International Electrotechnical Commission (IEC).

Ten Parts of this standard have been published and these may be summarized as follows:

Part 0: Introductory guide to reliability. This Part provides guidance to directors of companies who need to know why reliability is important to them, to engineers not trained in quality and reliability to show how reliability should influence their technical decision making, and to middle management not specialized in engineering, to explain how measures to achieve reliability should be integrated with other aspects of project management to give optimum results.

Part 1: Guide to reliability and maintainability programme management. This Part discusses the essential features of a comprehensive reliability and maintainability programme for the planning, organization, direction and control of resources to produce systems, equipment and components that will be reliable and maintainable. It includes consideration of the specification and assessment of reliability and maintainability and of arrangements for the collection of reliability data.

Part 2: Guide to the assessment of reliability. This Part recommends general procedures for the assessment of reliability of hardware systems and contains guidance for the reliability practitioner on the quantitative and statistical aspects of reliability, such as reliability modelling, the provision of data, and the concepts of redundancy and simulation.

Part 3: Guide to reliability practices: examples. This Part contains authentic practical examples illustrating the principles established in Parts 1 and 2 of BS 5760.

Part 4: Guide to specification clauses relating to the achievement and development of reliability in new and existing items. This Part provides more detailed guidance on the specification of reliability.

Part 5: Guide to failure modes, effects and criticality analysis (FMEA) and (FMECA). This Part describes failure modes and effects analysis (FMEA) and failure modes, effects and criticality analysis (FMECA), and gives guidance on the application of these techniques.

Part 6: Guide to programmes for reliability growth. This Part describes procedures to expose and remove weaknesses in hardware and software items in order to achieve acceptable reliability in a product. It explains basic concepts, management and test procedures and describes techniques for analysis and correction of failures.

Part 7: Guide to fault tree analysis. This Part describes fault tree analysis and gives guidance on the application of this technique which may be used to identify factors affecting the reliability, performance and safety characteristics of a system.

Part 9: Guide to the block diagram technique. This Part describes the use of the block diagram technique for modelling and evaluating the reliability of both elementary and more complex systems. The extension of the method to calculate availability is also outlined.

Part 10: Guide to reliability testing:

Section 10.1 General requirements. This Section provides guidance on general principles, procedures and considerations for reliability testing in the laboratory and in the field.

Section 10.3 Compliance test procedures for steady-state availability. This Section provides guidance on techniques for availability performance testing, under defined conditions, of frequently maintained items.

NOTE Further Sections of Part 10 are planned based on other Parts of IEC 605 and related IEC standards. Further Parts of BS 5760 are envisaged in order to provide guidance on other techniques of reliability management. At present two further Parts are in the process of being drafted, and these are as follows:

Part 8: Guide to the assessment of reliability of systems containing software. This Part will provide guidance on the assessment of reliability of systems containing software. (This is currently published as DD 198:1991).

Part 11: Guide to the collection of reliability, maintainability, availability and maintenance support data from the field.

Guidance on specific aspects of maintainability is provided in the various Parts of BS 6548 *Maintainability of equipment*.

Cross-references

International standard	Corresponding British Standard
IEC 50(191):1990	BS 4778 <i>Quality vocabulary</i> Part 3 <i>Availability, reliability and maintainability terms</i> Section 3.2:1991 <i>Glossary of international terms</i> (Identical)
IEC 68-2	BS 2011 <i>Environmental testing</i> Part 2.1 <i>Tests</i> Part 2.2 <i>Guidance</i> BS 5760 <i>Reliability of systems, equipment and components</i>
IEC 300:1984	Part 1:1985 <i>Guide to reliability and maintainability programme management</i> (Technically equivalent)
IEC 605-1:1978	Part 10 <i>Reliability testing</i> Section 10.1:1993 <i>General requirements</i> (Identical) BS 6548 <i>Maintainability of equipment</i>
IEC 706-1:1982	Part 1:1984 <i>Guide to specifying and contracting for maintainability</i> (Identical)
IEC 706-3:1987	Part 3:1992 <i>Guide to maintainability verification and to the collection, analysis and presentation of maintainability data</i> (Identical)
IEC 721-1:1990	BS 7527 <i>Classification of environmental conditions</i> Part 1:1991 <i>Environmental parameters and their severities</i> (Identical)

The Technical Committee has reviewed the provisions of ISO 362, IEC 605-2, IEC 605-3 and IEC 605-6, to which normative reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

It is envisaged that the revised version of IEC 362 will be published as BS 5760-11. IEC 605-2, IEC 605-3 and IEC 605-6 are under consideration for publication as further sections of BS 5760-10.

This standard is a guide and the use of the verbal form “shall” in the text does not indicate mandatory requirements.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 20, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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.

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 50(191):1990, *International Electrotechnical Vocabulary (IEV), chapter 191: Dependability and quality of service*.

IEC 68-2, *Environmental testing — Part 2: Tests*.

IEC 300:1984, *Reliability and maintainability management*.

IEC 362:1971, *Guide for the collection of reliability, availability, and maintainability data from field performance of electronic items*.

IEC 605-1:1978, *Equipment reliability testing — Part 1: General requirements*.

IEC 605-2, *Equipment reliability testing — Part 2: Guidance for the design of test cycles. (In preparation.)*.

IEC 605-3, *Equipment reliability testing — Part 3: Preferred test conditions*.

IEC 605-6:1986, *Equipment reliability testing — Part 6: Tests for the validity of a constant failure rate assumption*.

IEC 706-1:1982, *Guide on maintainability of equipment — Part 1: Sections 1, 2 and 3. Introduction, requirements and maintainability programme.*

IEC 706-3:1987, *Guide on maintainability of equipment — Part 3: Sections 6 and 7: Verification and collection, analysis and presentation of data.*

IEC 721-1:1991, *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 specified 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 availability
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.