

Reliability of systems, equipment and components —

Part 10: Guide to reliability testing —

Section 10.1 General requirements

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
- Institute of Quality Assurance
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- Mercury Communications Limited
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- Royal Institution of Chartered Surveyors
- 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

This British Standard, having been prepared under the direction of the Quality, Management and Statistics Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 February 1993

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The following BSI references relate to the work on this standard:
Committee reference QMS/23
Special announcement in *BSI News* August 1992

ISBN 0 580 21972 0

Amendments issued since publication

Amd. No.	Date	Comments

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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 605-1:1978 *Equipment reliability testing — Part 1: General requirements*, including amendment No. 1:1982, 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 which 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 that 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.

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.

NOTE Part 8 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 68	BS 2011 <i>Environmental testing</i>
IEC 271	BS 4778 <i>Quality vocabulary</i> Section 3.2:1991 <i>Glossary of international terms</i>
IEC 300 (1969)	BS 5760 <i>Reliability of systems, equipment and components</i> Part 1:1985 <i>Guide to reliability and maintainability programme management</i>
ISO R645	BS 5532 <i>Statistical terminology</i>
ISO R1786	Part 1:1978 <i>Glossary of terms relating to probability and general terms relating to statistics</i>

Additional information. IEC 272 is now withdrawn; comprehensive guidance on preliminary reliability considerations is contained in BS 5760-0 and BS 5760-1.

IEC 362 (1971) is currently being revised and it is envisaged that the revised version will be published as BS 5760-11. *Guide to the collection of reliability, maintainability and maintenance support data from the field.*

The Technical Committee has decided that IEC 362 (1971) is suitable meanwhile for use in conjunction with this standard.

NOTE 1 The definitions in IEC 271 are reproduced in IEC 50(191):1990, with which BS 4778-3.2 is identical.

NOTE 2 IEC 300(1969) has been superseded by IEC 300(1984) with which BS 5760-1 is technically equivalent.

NOTE 3 ISO Recommendations R645 and R1786 have been superseded by ISO 3534(1985) with which BS 5532-1 is identical.

References to Part of IEC 605

The text of this standard refers to other Parts of IEC 605 as they existed or were planned when IEC 605-1 was published in 1978. The current status of these Parts is as follows.

IEC 605 Part listed in text	Current corresponding IEC publication
<i>Part 2: Guidance for the design of test cycles for equipment reliability testing</i>	Approved for publication
<i>Part 3: Preferred test conditions for equipment reliability testing</i>	IEC 605-3-1 (1986) IEC 605-3-2 (1986) IEC 605-3-4 (1992)
<i>Part 4: Procedures for determining point estimates and confidence limits from equipment reliability determination tests</i>	IEC 605-4 (1986) [Amendment 1 (1989)]

<i>Part 5: Compliance test plans for success ratio</i>	IEC 1123 (1991)
<i>Part 6: Tests for the validity of a constant failure rate assumption</i>	IEC 605-6 (1986)
<i>Part 7: Compliance test plans for failure rate and mean time between failures assuming constant failure rate</i>	IEC 605-7 (1978) [Amendment 1 (1990)]
<i>Part 8: Test for the validity of a non-constant failure rate assumption</i>	Not published, no work in progress
<i>Part 9: Compliance test plans assuming Weibull distribution of times to failure</i>	Related work in progress
<i>Part 10: Compliance test plans assuming normal distribution of times to failure</i>	Related work in progress
<i>Part 11: Flow chart describing preparations for and execution of reliability tests</i>	Incorporated into IEC 605-1 (1978) as Amendment No. 1 (1982)

NOTE Further Sections of IEC 605-3 describing preferred test conditions for a range of equipment types are in the course of drafting and publication.

Textual errors. This standard is a guide and the use of the verbal forms “must” and “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.

Scope

This standard gives procedures for equipment reliability compliance and determination testing. Part 1 contains general requirements to be considered in the planning of the tests. Parts 2 to 11 inclusive contain specific procedures which are intended for use during the phases of planning, testing, data collecting and data analysing. Selection of the most appropriate procedures is made by the user of the standard.

Other parts of this standard:

- *Part 2: Guidance for the Design of Test Cycles for Equipment Reliability Testing;*
- *Part 3: Preferred Test Conditions for Equipment Reliability Testing;*
- *Part 4: Procedures for Determining Point Estimates and Confidence Limits from Equipment Reliability Determination Tests;*
- *Part 5: Compliance Test Plans for Success Ratio;*
- *Part 6: Tests for the Validity of a Constant Failure Rate Assumption;*
- *Part 7: Compliance Test Plans for Failure Rate and Mean Time Between Failures Assuming Constant Failure Rate;*
- *Part 8: Tests for the Validity of a Non-constant Failure Rate Assumption;*
- *Part 9: Compliance Test Plans Assuming Weibull Distribution of Times to Failure;*
- *Part 10: Compliance Test Plans Assuming Normal Distribution of Times to Failure;*
- *Part 11: Flow Chart Describing Preparations for and Execution of Reliability Tests.*

1 Introduction

This standard provides general principles as well as specific recommendations on procedures for equipment reliability compliance and determination testing. The principles set forth are suitable for all types of equipment including electronic, electromechanical and mechanical. The term equipment is used here as being synonymous with equipment and/or system.

The tests provided in this norme are not intended to replace ordinary tests such as qualification tests, functional performance tests and environmental tests. It should be noted that equipment reliability testing is only one of the possible elements of a reliability programme with the objective to increase the reliability assurance in the design, development and production of new equipment.

The concepts of compliance and determination testing are defined as follows:

Reliability compliance test¹⁾, an experiment used to show whether or not the value of a reliability characteristic of an item meets its stated reliability requirements.

Reliability determination test¹⁾, an experiment used to determine the value of a reliability characteristic of an item.

NOTE Analysis of available data may also be used for reliability determination.

The reliability compliance test is normally used as a condition of acceptance of the equipment by the customer. The determination test is normally used to provide information where a specific reliability requirement has not been stated.

Equipment reliability testing may be accomplished by either laboratory or field testing. The definitions of these concepts are as follows:

Laboratory reliability test¹⁾, a reliability compliance or determination test made under prescribed and controlled operating and environmental conditions which may or may not simulate field conditions.

Field reliability test¹⁾, a reliability compliance or determination test made in the field where operating environmental, maintenance and measurement conditions are recorded.

For equipment reliability testing, the laboratory reliability test conditions should be related to the conditions of use in a known manner and the maintenance conditions shall be prescribed and controlled.

Whether reliability testing should be required at all in a contract or a general equipment specification depends upon many factors. Among the most important of these are:

- relevant history of equipment;
- the consequences of inferior equipment reliability with respect to safety and economy;
- the cost of reliability testing;
- the time required for testing;
- the possibility of obtaining reliability assurance by activities other than reliability testing, and
- the availability of representative samples.

The final conclusions drawn from a reliability compliance test should not be based solely upon the formal accept/reject decision reached. The causes and consequences of each failure observed during a reliability test should be analyzed in detail, and any possibility of taking effective corrective actions should be investigated.

¹⁾ See also IEC Publication 271A.

A reliability growth (or improvement) programme employs reliability testing, but with the principal object of upgrading the reliability. This takes place by successive analysis of failures and corrective modifications to the equipments under test. This process may therefore be an essential preliminary to compliance or determination testing whenever there is a reason to believe that the equipment reliability is inadequate.

Great care should be taken if the results of a reliability compliance or determination test are extrapolated to:

- other equipment populations;
- environmental conditions differing from the test conditions, or
- longer time of operation than used during the testing.

Also, due to the complexity and variability of usage environments for most equipment applications, strict correlation between the reliability figures obtained from laboratory reliability testing and those experienced in actual use should not be expected in each individual case.

A flow chart giving an overall description of preparations for and execution of reliability compliance tests is presented in Part 11.

2 Object of this standard

The object of this standard is to provide recommended methods and procedures for the purpose of equipment reliability testing. The recommendations include how to:

- specify reliability requirements for compliance testing;
- select test conditions for reliability tests;
- prepare detailed reliability test specifications;
- perform laboratory and field reliability tests;
- evaluate information from reliability testing;
- write reliability test reports.

3 Applicability of the methods given

The recommendations given in this standard are intended to be applied:

- 1) when it is considered desirable in an equipment *contract* to stipulate quantitative reliability requirements which are to be verified by reliability compliance testing;

- 2) when it is considered desirable in a *general equipment specification* to incorporate reliability requirements to be verified by reliability compliance testing. The standard is thus intended to be used by the various Technical Committees dealing with equipment standardization;

- 3) when an equipment manufacturer, test agency or user intends to ascertain *reliability information* based on reliability determination testing for the particular type or application of the equipment.

Although primarily intended for electronic equipment, the methods are also applicable to other types of equipment and systems containing electric, electromechanical, mechanical, pneumatic and hydraulic devices. The equipment may be repaired or not repaired in use and during the testing. The methods are also applicable to limited-life devices. The methods can be applied in any one or more of the product phases: development (prototype), pre-production, normal production and field use. The tests may be included in an initial qualification procedure, in a requalification procedure, and in an acceptance procedure during normal production. They are applicable for laboratory tests as well as for field tests.

The methods are applicable when reliability is expressed in terms of the following reliability characteristics:

- failure rate, mean time between failures, mean time to first failure or other parameters of the distribution of times to or between failures;
- success ratio for a given time interval or number of operations (trials).

The applicability is not restricted to any particular distribution of times to failure.

Wherever “time” is used in this standard, this variable may be replaced by distance, cycles or other quantities or units as may be appropriate.

In case of conflict between this standard and the relevant contract or equipment specification(s), the latter shall apply.

4 Definitions and related documents

The meaning of terms, not explicitly defined in this standard, is in accordance with the definitions in IEC publication 271 and/or ISO Recommendations R645 and R1786. These and other related publications are listed below:

IEC Publication 68: Basic Environmental Testing Procedures, (issued in several parts).

Reliability, issued 1974.

IEC Publication 271: List of Basic Terms, Definitions and Related Mathematics for

IEC Publication 272: Preliminary Reliability Considerations, issued 1968.

IEC Publication 300: Managerial Aspects of Reliability, issued 1969.

IEC Publication 362: Guide for the Collection of Reliability, Availability and Maintainability Data from Field Use of Electronic Items, issued 1971.

ISO Recommendation R645: Statistical vocabulary and symbols, first series, issued 1967.

ISO Recommendation R1786: Statistical vocabulary and symbols, second series, issued 1970.

5 Principles of reliability compliance testing

5.1 Reliability requirements

Operational reliability requirements for a particular equipment should be derived from total system considerations and expressed in usage-oriented terms. The requirements should refer to the whole range of use conditions (operating, environmental and maintenance conditions) and the total period of time for which satisfactory performance is required.

For compliance testing reliability requirements should be specified in test-oriented terms and be designed to achieve good correspondence between the value of the reliability characteristic resulting from testing and the value of the operational reliability under use conditions. It must be realized, however, that close correspondence between test and use reliability is difficult to achieve. The usage-oriented operational reliability requirements should always be converted into suitable requirements for reliability compliance testing whenever reliability requirements are to be verified by testing.

5.2 Requirements for reliability compliance testing

Any requirement for reliability compliance testing of equipment should be included in or enforced by the equipment contract or specification.

They should be complete enough to define all particular details of the reliability compliance test. When reliability compliance testing is specified in accordance with this standard, information is required on the items listed in Sub-clauses 5.2.1 to 5.2.5, if applicable.

5.2.1 Test items and type of test

- 1) Identification of the (type of) equipment to be tested.
- 2) Type of test to be performed: laboratory or field test. See Sub-clause 5.3.

- 3) Population of the equipment from which the test sample shall be drawn and where appropriate, any special procedure of test item selection. See Sub-clause 7.1.

5.2.2 Reliability characteristic and statistical test plans

- 1) Applicable reliability characteristic and statement of the acceptable value.

When the reliability characteristic refers to a system and is to be derived from separately verified reliability characteristics for individual sub-units, the derivation procedure to be applied shall also be specified and shall include the applicable reliability block diagram.

- 2) The compliance test plan to be used.

The plan used should preferably be chosen from the applicable Part 5, 7, 9 or 10 of this standard. See Clause 7.

- 3) Tests to be used for the validity of distribution assumption, if desired. See Sub-clause 7.2.2 and Parts 6 to 8 for validity tests to be used and possible risk considerations.

5.2.3 Test conditions and test cycle

- 1) Operating and environmental test conditions including load and supply conditions and actual manipulation. See Sub-clause 8.2 and Clause 11.
- 2) Preventive maintenance to be applied during the test. See Sub-clause 8.3 and Clause 11.
- 3) Test cycle for the sequence and combinations of 1) and 2) above. See Sub-clause 8.1.

5.2.4 Test item performance and failure

- 1) Functional parameters to be monitored during the test and criteria for test item failures. See Sub-clauses 9.1 and 9.2.
- 2) Types of failures demanding immediate reject decision. See Sub-clause 9.4.1.
- 3) Types of failures to be considered as non-relevant test item failures. See Sub-clause 9.3.
- 4) Periods of test time to be considered as relevant test time. See Sub-clause 9.5.
- 5) Minimum and/or maximum relevant test time or number of operations for each test item. See Sub-clause 9.5.

5.2.5 Pre-test conditions and corrective maintenance

- 1) Tests, adjustments, calibrations and operation time (burn-in) of the test items prior to the reliability test. See Sub-clauses 7.1 and 10.1.
- 2) Corrective maintenance procedures to be applied, including any permitted replacement of failed parts or items. See Sub-clause 10.2.