

Reliability of systems, equipment and components —

Part 10: Guide to reliability testing —

Section 10.2 Design of test cycles

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee QMS/23, Reliability and maintainability systems, upon which the following bodies were represented:

- AEA Technology
- Association of Consulting Engineers
- Association of Project Managers
- British Gas plc
- British Railways Board
- British Telecommunications plc
- City University
- Civil Aviation Authority
- Consumers' Association
- Cranfield University
- Design Council
- Electricity Association
- Federation of the Electronics Industry
- GAMBICA (BEAMA Ltd.)
- Institute of Quality Assurance
- Institute of Risk Management
- Institution of Electrical Engineers
- Institution of Mechanical Engineers
- Institution of Plant Engineers
- London Underground Ltd.
- Mercury Communications Limited
- Ministry of Defence
- National Computing Centre Ltd.
- Railtrack
- Railway Industry Association
- Royal Institution of Chartered Surveyors
- Royal Statistical Society
- Safety and Reliability Society
- Society of Environmental Engineers
- Society of Motor Manufacturers and Traders Limited
- University of Bradford
- University of Technology, Loughborough
- West Midlands Enterprise Board

This British Standard, having been prepared under the direction of the Management Systems Sector Board (S/-), was published under the authority of the Standards Board and comes into effect on 15 February 1995

© BSI 03-1999

The following BSI references relate to the work on this standard:
Committee reference QMS/23
Draft for comment 84/26500 DC

ISBN 0 580 23866 0

Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Introduction	1
1 Scope	1
2 Normative references	1
3 Definitions	1
4 Relations between test conditions and conditions of use	2
5 Description of the conditions of use	2
6 Procedure for the design of test cycles	3
7 Summary of documentation of a reliability test cycle	7
Annex A (informative) Worked example	10
Figure 1 — Evaluation of severities	5
Figure 2 — Simple test cycle	9
Figure A.1 — Final test cycle	16
Table 1 — Climatic parameters	3
Table 2 — Mechanical parameters	3
Table 3 — Interrelationships between parameters or severities	4
Table 4 — Examples of relative durations	6
Table A.1 — <i>Untitled</i>	10
Table A.2 — <i>Untitled</i>	10
Table A.3 — Master table	13
Table A.4 — <i>Untitled</i>	14
Table A.5 — <i>Untitled</i>	14
Table A.6 — <i>Untitled</i>	15
List of references	Inside back cover

National foreword

This Part of BS 5760 has been prepared by Technical Committee QMS/23. It is identical with IEC 605-2:1994 *Equipment reliability testing — Part 2: Design of test cycles*, published by the International Electrotechnical Commission (IEC).

This Part provides a general procedure for design of test cycles, where no applicable test cycles can be found in BS 5760-13.1. It applies to the design of operating and environmental test cycles referred to in BS 5760-10.1. The resulting test cycle should be included in the detailed reliability test specification. Tests that include cycles designed according to this standard are not intended to replace ordinary tests such as qualification tests, functional performance tests and environmental tests.

BS 5760 provides comprehensive guidance on many aspects of reliability management. Fourteen 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 senior management and non-specialists on the importance of reliability and explains how measures to achieve reliability should be integrated with other aspects of project management.
- *Part 1: Guide to reliability and maintainability programme management.* This Part discusses the essential features of a comprehensive reliability and maintainability programme to produce reliable and maintainable products.
- *Part 2: Guide to the assessment of reliability.* This Part contains guidance on quantitative and statistical aspects of reliability including reliability modelling and 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 detailed guidance on the specification of reliability.
- *Part 5: Guide to failure modes, effects and criticality analysis (FMEA) and (FMECA).* This Part gives guidance on the application of these techniques.
- *Part 6: Guide to programmes for reliability growth.* This Part describes procedures to expose and remove weakness 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 gives guidance on the application of fault tree analysis 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 testing the availability performance of frequently maintained items under defined conditions.
 - *Section 10.5: Compliance test plans for success ratio.* This Section gives procedures for preparing and applying compliance test plans for success ratio or failure ratio. Plans are provided for three main types of test.

NOTE Further Sections of Part 10 based on other Parts of IEC 605 and related IEC standards are also planned.

— *Part 11: Collection of reliability, availability, maintainability and maintenance support data from the field.* This Part provides guidelines for the collection of data relating to reliability, availability and maintenance support performance of items operating in the field. It deals in general terms with the practical aspects of data collection and presentation and briefly explores the related topics of data analysis and presentation of results.

— *Part 12: Guide to the presentation of reliability, maintainability and availability predictions.* This Part gives guidance on the presentation of quantitative predictions of reliability, maintainability and availability. The items to be included when presenting prediction information are listed and explained with the object facilitating comparisons between projects and reports.

— *Part 13: Guide to reliability test conditions for consumer equipment.*

— *Section 13.1: Conditions providing a low degree of simulation for indoor portable equipment.*

— *Section 13.2: Conditions providing a high degree of simulation for equipment for stationary use in weatherprotected locations.*

— *Section 13.3: Conditions providing a low degree of simulation for equipment for stationary use in partially weatherprotected locations.*

— *Section 13.4: Conditions providing a low degree of simulation for equipment for portable and non-stationary use.*

— *Part 14: Guide to formal design review.* This Part provides guidelines for planning and conducting design reviews. Much of the guidance given is widely applicable and is relevant to the general conduct of design reviews but it also includes details of the specific contributions to be made by various specialists. Further Parts of BS 5706 are envisaged in order to provide guidance on other techniques of reliability management. A further Part is in the process of being drafted, and this is as follows.

— *Part 8¹⁾: Guide to the assessment of reliability of systems containing software.* This Part will provide guidance on the assessment of reliability of systems containing software.

¹⁾ Currently published as a Draft for Development, DD 198:1991.

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> Section 3.2:1991 <i>Glossary of international terms</i> (Identical)
IEC 68	BS 2011 <i>Environmental testing</i> (most Parts identical)
IEC 605-1:1978	BS 5760 <i>Reliability of systems, equipment and components</i> Section 10.1:1993 <i>General requirements</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)
IEC 721-2	BS 7527 <i>Classification of environmental conditions</i> Part 2: <i>Environmental conditions appearing in nature</i> (all Parts identical)
IEC 721-3	BS EN 60721-3 <i>Classification of environmental conditions</i> Part 3: <i>Classification of groups of environmental parameters and their severities</i> (all Parts identical)

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 16, 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

A test cycle is a sequence of different operating and environmental test conditions which are based upon actual conditions of use, as defined, for example, by the relevant product specification. The equipment undergoing reliability testing is normally subjected to repeated test cycles. The number of cycles will depend on the accumulated relevant test time, as required by the selected compliance test plan of IEC 605-7, or as suitable for determination testing according to IEC 605-4.

The step-by-step procedure described here is intended for any specific equipment to be tested, when it is considered necessary to simulate closely the real conditions of use of the equipment. It applies fully to laboratory testing, but may be applied to field testing, in so far as conditions can be controlled, with respect to operating conditions only (including load, supply, etc.).

1 Scope

This part of IEC 605 provides a general procedure for design of test cycles, where no applicable preferred test cycles can be found in IEC 605-3. It applies to the design of operating and environmental test cycles referred to in 8.1 and 8.2 of IEC 605-1. The resulting test cycle should be included in the detailed reliability test specification.

Tests which include cycles designed according to this standard are not intended to replace ordinary tests such as qualification tests, functional performance tests and environmental tests.

Pre-exposure tests may in some cases be necessary before commencing the test cycles designed by the methods of this standard. The basis of the decision as to whether to include pre-exposure tests is outside the scope of this standard.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 605. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 605 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, *Environmental testing*.

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

Amendment No. 1 (1982)

IEC 721-1:1990, *Classification of environmental conditions — Part 1: Environmental parameters and their severities*.

IEC 721-2, *Classification of environmental conditions — Part 2: Environmental conditions appearing in nature*.

IEC 721-3, *Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities*.

3 Definitions

For the purpose of this part of IEC 605, the terms and definitions of IEC 50(191) apply, in addition to the following terms and definitions given below:

3.1

phase

state of usage and exposure to environment

3.2

environmental conditions

physical and chemical conditions external to the equipment to which it is subjected at a certain time, comprising a combination of environmental parameters with stated severities

NOTE This is in line with IEC 721-1, clause 3.

3.3

operating conditions

equipment functional conditions comprising a combination of operating parameters with stated severities

3.4

parameter (operating or environmental)

chemical or physical quantity or combination of quantities defining the type of operational or environmental stress

NOTE Examples of operating parameters are load and power supply (see 5.1). Examples of environmental parameters are ambient temperature and vibration (see 5.2).

3.5

severity (of operating or environmental parameter)

one or more quantities describing the operating or environmental parameter

NOTE 1 This is in line with IEC 721-1, clause 3.

NOTE 2 The severity defines the stress level. Examples of severities are: power load 35 W, voltage drop – 10 % and frequency deviation of power supply + 2 %, ambient temperature + 70 °C, sinusoidal vibration 50 m/s² at 20 Hz to 500 Hz.

3.6**severity class**

interval of severity between two stated limits within the relevant severity range (see Figure 1)

NOTE An example of a severity class is ambient temperature + 15 °C to + 35 °C.

3.7**test severity**

severity of operating or environmental parameter applied to the item(s) during testing

3.8**representative severity**

test severity judged to give a failure rate approximating to the average for a severity class

4 Relations between test conditions and conditions of use

Generally, a good correlation between test and use reliability is desired. It is thus necessary that the test conditions are properly correlated to those to which the equipment is subjected in real use. These conditions may, however, be very complex and not possible to reproduce in detail with the testing facilities. A proper correlation can therefore be achieved only if the influences of operating conditions, individual and combined environments and sequences of environments are carefully examined to choose the most important parameters for simulation by the reliability test conditions.

Calendar time compression by shortening periods of operating under low stress conditions, such as no load or idling, may be used in testing. However, accelerated testing by overstress conditions should normally be avoided; see 8.2 of IEC 605-1.

In most cases, testing under constant and unchanging conditions is not adequate for the purpose. A test cycle should be designed giving an appropriate sequence of different operating and environmental test conditions, some of them combined. For practical reasons, the resulting test cycle will generally be only an approximation of the real conditions of use.

The test cycle may be deliberately designed to provide a closer or rougher approximation, corresponding to a higher or lower degree of simulation of the conditions of use. A cycle with a high degree of simulation is more complex and is closer to the actual conditions of use, but is also more costly to realize and to perform by practical testing. A high degree of simulation is recommended when the outcome of the test is crucial, for example, when failure consequences are critical in terms of safety and economic loss, or in conflict with regulations, as with environmental pollution. Where failure consequences are less serious, for example, in TV and radio for entertainment, a low degree of simulation of conditions of use may be adopted.

The procedure described here is intended mainly for a high degree of simulation. A test cycle with a low degree of simulation may be derived from one with a high degree of simulation, but not vice versa. The same procedure may be used with lower precision to arrive directly at a low degree of simulation.

The principle followed in the procedure should result in a test cycle so designed that all important combinations of operating and environmental conditions appear during the test cycle with a relative duration or frequency similar to that appearing during the relevant part of equipment life. However, the technical feasibility and cost of generating the test conditions should be actively considered at every step.

5 Description of the conditions of use

The conditions of use normally consist of a number of operating and environmental parameters appearing simultaneously or sequentially. Each of these parameters may have stress levels (severities) that could cause equipment failures.

5.1 Operating conditions

Operating parameters to be considered are as follows (see also 8.2 of IEC 605-1):

- functional modes (non-operation is considered as one possible functional mode);
- input signals, data, or material to be processed;
- load conditions, output power level, static load, etc.;
- actual manipulation by operator and personnel;
- supporting supplies, for example, power, cooling, lubrication.

The severities of the operating parameters describe the stresses imposed by operation.