

BS 5760-0:2014



BSI Standards Publication

Reliability of systems, equipment and components –

Part 0: Guide to reliability and
maintainability

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Summary of pages

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 March 2014. It was prepared by Technical Committee DS/1, *Dependability*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 5760 supersedes BS 5760-0:1986, which is withdrawn.

Relationship with other publications

The following parts of BS 5760 have been published or are in preparation:

- Part 0: *Guide to reliability and maintainability*;
- Part 2: *Guide to the assessment of reliability*;
- Part 8: *Guide to assessment of reliability of systems containing software*;
- Part 10: *Guide to reliability testing*;
- Part 12: *Guide to the presentation of reliability, maintainability and availability predictions*;
- Part 13: *Guide to reliability test conditions for consumer equipment*;
- Part 18: *Guide to the demonstration of dependability requirements – The dependability case*;
- Part 24: *Guide to the integration of risk techniques in the inspection and testing of complex systems*.

Information about this document

This is a full revision of BS 5760-0 and its changes reflect current practices. While addressing system and equipment level reliability and maintainability, many of the techniques described in the different parts of BS 5760 can also be applied at the component level.

Use of this document

As a guide, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

Reliability and maintainability are vital qualities of any system or product. When assessing how good a system or product is, the end user considers four characteristics: how much did it cost, how well does it perform when it is working, how often does it break down and how easy is it to mend when it has broken down. A successful product or system strikes the correct balance between these considerations. This standard provides guidance on how to assess and control the last two considerations, which are formally named reliability and maintainability, respectively.

When a product fails, it as a minimum inconveniences the user as a result of direct costs involved in undertaking repair and loss of use of the product. In the case of systems with a safety implication, unexpected failure can have far more serious consequences. The outcome of failures can range from loss of reputation through direct and indirect financial penalties to legal action. As reliability and maintainability are inherent design characteristics, it is essential that the required characteristics are identified as early in the design process as possible, when the other performance criteria are also being set. If they are not considered at this stage, it is likely that the product will not be satisfactory.

The activities described within this standard normally form part of an organization's asset management strategy and are therefore aligned to, and consistent with, the organizational objectives.

1 Scope

This part of BS 5760 gives guidance on the basic principles of reliability and maintainability that are applicable to any business model.

It is particularly applicable to reliability and maintainability in the design, manufacturing, management and decommissioning of products, equipment, services, plant or structures, and gives guidance on matters of common interest to any business supplying or purchasing products, services, plant or structures.

This part of BS 5760 provides all managers and engineers involved in the specification, design, development, manufacture, acceptance and use of engineering artefacts with guidance on how to manage reliability and maintainability effectively and develop an auditable record of activities. This standard is also applicable to students and anyone else who needs to understand how to develop, manufacture and support systems and equipment that meet the needs of the user by working when required.

This part of BS 5760 does not give guidance on issues relating to safety. However, much of the guidance could also be applied to the production of safety cases.

NOTE Guidance on component reliability is given in BS CECC 00804.

2 Terms and definitions and abbreviations

For the purposes of this part of BS 5760, the following terms and definitions apply.

2.1 active repair time

part of the active maintenance time during which repairs are performed on an item

NOTE This does not take into account any waiting time for maintenance resources.

2.2 availability

ability to be in a state to perform as required

NOTE Availability depends upon the combined characteristics of the reliability, recoverability, and maintainability of the item, and the maintenance support performance.

2.3 intrinsic availability

availability provided by the design, under ideal conditions of operation and maintenance

NOTE 1 Delays associated with maintenance, such as logistic and administrative delays, are excluded.

NOTE 2 Operational availability is determined considering down time due to failures, outages and associated delays, but excluding external causes.

2.4 corrective maintenance

maintenance carried out after fault detection to effect restoration

NOTE Corrective maintenance of software invariably involves some modification.

2.5 dependability

ability to perform as and when required

NOTE 1 Dependability includes availability, reliability, recoverability, maintainability and maintenance support performance, and, in some cases, other characteristics such as durability, safety and security.

NOTE 2 Dependability is used as a collective term for the time-related quality characteristics of an item.

2.6 failure

loss of ability to perform as required, or event that results in a fault state of that item

NOTE 1 Qualifiers such as catastrophic, critical, major, minor, marginal and insignificant may be used to categorize failures according to the severity of consequences; the choice and definitions of severity criteria depend upon the field of application.

NOTE 2 Qualifiers such as misuse, mishandling and weakness may be used to categorize failures according to the cause of failure.

2.7 function

activity or feature that an item is required to be capable of doing in order to meet an operational (user) requirement

2.8 integrated logistic support

management process to determine and co-ordinate the provision of all materials and resources required to meet the needs for operation and maintenance

2.9 item

subject being considered

NOTE 1 The item might be an individual part, component, device, functional unit, equipment or system and consist of hardware, software, people or any combination thereof.

NOTE 3 The item is often comprised of elements that may each be individually considered.

2.10 maintainability

ability to be retained in, or restored to a state to perform as required, under given conditions of use and maintenance

NOTE Given conditions include aspects that affect maintainability, such as location of maintenance, accessibility, maintenance procedures and maintenance resources.

2.11 level of maintenance

set of maintenance actions to be carried out at a specified indenture level

[SOURCE: BS 4778-3.2:1991, IEC 60050-191:1991, 191-07-06]

2.12 preventive maintenance

maintenance carried out to mitigate degradation and reduce the probability of failure

2.13 reliability

ability to perform as required, without failure, for a given time interval, under given conditions

NOTE 1 The time interval duration might be expressed in units appropriate to the item concerned, e.g. calendar time, operating cycles, distance run.

NOTE 2 Given conditions include aspects that affect reliability, such as mode of operation, stress levels, environmental conditions and maintenance.

NOTE 3 Reliability may be quantified using appropriate measures.

2.14 reliability centred maintenance (RCM)

systematic method for determining the respective maintenance actions and associated frequencies, based on the probability and consequences of failure

NOTE 1 RCM uses analysis of modes of failure to select the best defence strategy for each possible failure mode.

NOTE 2 RCM studies may be conducted at any indenture level of a system, and provide feedback to initiate modifications of design or procedures to effect improvements.

2.15 reliability growth

iterative process for reliability improvement by addressing design and manufacturing weaknesses

2.16 reliability model

mathematical model used for prediction or estimation of reliability measures

NOTE Modelling techniques may be applied to other characteristics, such as maintainability and availability.

2.17 system

set of inter-related items that collectively fulfil a requirement

NOTE 1 A system is considered to have a defined real or abstract boundary.

NOTE 2 External resources (from outside the system boundary) might be required for the system to operate.

NOTE 3 A system structure might be hierarchical, e.g. system, subsystem, component.

2.18 Abbreviations

For the purposes of this part of BS 5760, the following abbreviations apply.

BIT	Built in test
BITE	Built in test equipment
DRACAS	Data reporting and corrective action system
ESS	Environmental stress screening
FMECA	Failure mode, effects and criticality analysis
ILS	Integrated logistic support
LCC	Life cycle costing
MART	Mean active repair time
MTBF	Mean time between failures of the system
R&M Case	Reliability and maintainability case
RCM	Reliability centred maintenance
MTTR	Mean time to repair
WLC	Whole life cost

3 Basic principles of reliability

3.1 General

Reliability is used to measure how likely items are to function to fulfil their designed specification, when required. The observable result of reliability can be viewed from two perspectives. The first is the ability to deliver its design performance and functionality on demand during a defined operational period. This is normally expressed as a probability. As a probability, reliability is strictly a number between 0 and 1, often quoted as a percentage.

The second is the necessity of undertaking repairs when the system fails or becomes defective in some way. This is typically expressed in the form of the failure rate, or mean time between failures. In both cases, the reliability is exactly the same, but the first perspective is of primary interest to the user of the item and the second to those who maintain it. The elements which affect reliability are given in 3.2 to 3.6.

3.2 Required function

During concept studies of new items (6.3.1), the functions that are required to enable it to complete its task successfully should be identified and an analysis should be performed to define the capabilities and performance requirements of the item.

In items that are capable of many functions, some of which might not be continuously required, the importance of each function should also be identified.

NOTE It is often the case that some functions are regarded as critical to task success, whereas others might simply be desirable.

3.3 Failure

Reliability cannot be measured directly for a single item in the same way as weight, speed or most other performance measures. This is because reliability is a stochastic ¹⁾ parameter that is dependent on unpredictably occurring events, i.e. failures.

Reliability should only be measured to a level of statistical confidence for a number of items, or the operation of one item over many instances. The level of confidence in the item should increase with the amount of data that is available but it is never likely to reach 100%.

The meaning of failure should be defined because its meaning is dependent upon the item requirements. Initial definitions of failure should be taken into account during the analysis of performance requirements when they would be categorized as critical or non-critical. The latter should be termed a fault or defect.

NOTE 1 A defect is an incident that might or might not degrade equipment performance but does require corrective maintenance (6.4.5.2).

Failure definitions should be established early and be included in the reliability and maintainability requirement specifications. They should be clear, concentrate on objective criteria and be based on effects rather than on causes.

NOTE 2 Further information on failure patterns is given in Annex A.

3.4 Performance

The performance represents the limiting boundaries of the functionality of an item. For example:

- a) maximum forward or reverse speed;
- b) maximum rate of turn; or
- c) minimum number of communication channels available.

The type of parameter to be considered depends upon the specific item and its intended use.

¹⁾ Having an element of chance (as opposed to deterministic parameters, which can be measured repeatedly).

3.5 Conditions

The environmental conditions (temperature, pressure, chemical, dust, etc.) in which an item is used, stored and transported, and the way in which it is operated and maintained, can have a major influence on its reliability. These conditions should be defined to the design team during the design and development of an item.

NOTE For example, a standard car could not be expected to achieve the same reliability when driven on desert tracks as it would in UK road use; cars intended for such use are especially designed for the conditions.

3.6 Usage times

The period of usage in which an item is expected to function should be determined as part of the development of requirements (5.2).

NOTE For example, the typical flight pattern for an aircraft, a typical day for a transport vehicle, the period between major shut downs for an industrial plant, or a 12 month period for an eCommerce system.

Reliability of items might vary with their age (covering calendar time, usage time, distance travelled, number of cycles or whatever metric is appropriate). Separate requirements for reliability under different conditions or for different periods of time (for instance summer or winter use, or periods of continuous use versus intermittent usage) should be identified and related to the relevant functions.

4 Basic principles of maintainability

4.1 General

Maintainability is the quantitative assessment of how easily and quickly preventive maintenance might be performed or a system restored to functionality through corrective maintenance (6.4.5.2). This is dependent upon both the environment in which maintenance is performed and the resources available to do so.

The considerations associated with maintainability are given in 4.2 and 4.3.

4.2 Maintenance context

These are the conditions under which preventive maintenance or repair is conducted. Factors such as ease of access, maximum allowable downtime, temperature, field or workshop conditions, and lighting and restrictive clothing should all be defined to the design team if they are externally imposed, or should be taken into account by the designers in response to the overall reliability and maintainability requirements if not.

4.3 Stated procedures and resources

The customer or user might put constraints on the resources allowed for preventive maintenance and repair.

NOTE For instance, where items need to fit into an existing maintenance environment, e.g. an aircraft.

These could include skill levels and number of maintainers, storage capacity for spares, tools or handbooks, special-to-type tools or test equipment and availability of utilities. Although influenced by these factors, the designers should be responsible for defining procedures for preventive maintenance and repair as they evolve from the design.