

Reliability of systems, equipment and components —

Part 6: Guide to programmes for reliability growth

Committees responsible for this British Standard

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- Association for Consumer Research (ACRE)
- Association of Consulting Engineers
- British Gas plc
- British Railways Board
- British Telecommunications plc
- Cable and Wireless plc
- Civil Aviation Authority
- Cranfield Information Technology Institute
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- EEA (the Association of Electronics, Telecommunications and Business Equipment Industries)
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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 1014:1989, “*Programmes for reliability growth*”, published by the International Electrotechnical Commission (IEC).

Seven Parts of this standard have now 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.

Further Parts are envisaged in order to provide guidance on other techniques of reliability management. At present three further Parts are in the process of being drafted, and these are as follows.

— *Part 7: Guide to fault tree analysis.*

— ¹⁾*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.

— *Part 9: Guide to reliability block diagrams.*

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

Cross-references

International standard	Corresponding British Standard
IEC 50(191):1990	BS 4778 Quality vocabulary Section 3.2:1991 Glossary of international terms (Identical)
IEC 300:1984	BS 5760 Reliability of constructed or manufactured products, systems, equipments and components Part 1:1985 Guide to reliability and maintainability programme management (Technically equivalent)

The Technical Committee has reviewed the provisions of IEC 605-1:1978, IEC 605-2 (draft approved for publication), IEC 605-3 and IEC 605-4:1986, to which reference is made in the text and has decided that they are suitable for use in conjunction with this standard.

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.

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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

Reliability improvement by a growth programme should be part of an overall reliability activity in the development of a product. This is especially true for a design which uses novel or unproven techniques or component parts or a substantial content of software. In such a case the programme may expose, over a period of time, many types of weaknesses having design-related causes. It is essential to reduce the probability of failure due to these weaknesses to the greatest extent possible to prevent their later appearance in formal tests or in the field. At that late stage, design correction is often highly inconvenient, costly and time consuming.

Life cycle costs will be minimised if the necessary design changes are made at the earliest possible stage.

IEC 605-1, Clause 1, refers to a “reliability growth (or improvement) programme” employing equipment reliability testing, with the principal object of upgrading the reliability. The testing and environmental arrangements for such a programme are essentially the same as those covered by IEC 605-1, IEC 605-2 and IEC 605-3.

1 Scope

This international standard specifies requirements and gives guidelines for the exposure and removal of weaknesses in hardware and software items for the purpose of reliability growth. It applies when the specification calls for a reliability growth programme of equipment (electronic, electromechanical and mechanical hardware as well as software) or when it is known that the design is immature and is unlikely to meet the requirements of a compliance test without improvement. A statement of the basic concepts is followed by descriptions of the management, planning, testing (laboratory or field), failure analysis and corrective techniques required. Mathematical modelling, to estimate the level of reliability achieved, is outlined briefly.

2 Object

This standard focuses principally upon reliability improvement through testing but the same general principles may also apply to other activities, even if not required by a formal programme.

Improvement may be based on the results of:

- theoretical studies (e.g. failure modes and effects analysis);
- field trials;
- users’ experience;

— tasks not aimed primarily at reliability improvement.

3 Terms and definitions

General reliability terms used in this standard comply with Chapter 191 of the International Electrotechnical Vocabulary (IEV) [IEC Publication 50(191)] as far as applicable. Terms requiring special definition or clarification are described below in the sense in which they are used in this standard. Unless otherwise stated they apply both to items of pure hardware and to items for which software is included or is predominant.

It is important to distinguish between the terms “failure intensity” (for repaired items) and “failure rate” (for non-repaired or one-shot items) in IEC Chapter 191.

3.1

reliability improvement

a process undertaken with the deliberate intention of improving the reliability performance by eliminating causes of systematic failures and/or by reducing the probability of occurrence of other failures (IEV 191-17-05.)

ADDITIONAL NOTE 1 The method described in this standard is to make corrective, modifications aimed at reducing systematic weaknesses.

ADDITIONAL NOTE 2 For any item there are limits to practicable and economic improvement and to achievable growth.

3.2

reliability growth

a condition characterized by a progressive improvement of a reliability performance measure of an item with time (IEV 191-17-04.)

3.3

weakness failure

a failure due to a weakness in the item itself when subjected to stresses within the stated capabilities of the item

NOTE A weakness may be either inherent or induced. (IEV 191-04-06.)

ADDITIONAL NOTE 1 A weakness is any imperfection (known or unknown) in an item, capable of causing one or more weakness failures.

ADDITIONAL NOTE 2 Each type of weakness is assumed to be statistically independent of all other such types.

3.4

systematic weakness

a weakness which can only be eliminated, or its effects reduced, by a modification of the design or manufacturing process, operational procedures, documentation or other relevant factors, or elimination of substandard batches of component parts

NOTE 1 Repair or replacement (or re-run in case of software) without modification is likely to lead to recurrent failures of a similar kind.

NOTE 2 Software weaknesses are always systematic.

3.5 residual weakness

a weakness which is not systematic

NOTE 1 In this case, risk of recurrent failure of a similar kind is negligible, within the expected test time scale.

NOTE 2 Software weaknesses cannot be residual.

3.6 relevant failure

a failure that should be included in interpreting test or operational results or in calculating the value of a reliability performance measure

NOTE The criteria for inclusion should be stated. (IEV 191-04-13.)

ADDITIONAL NOTE The criteria for inclusion are stated in 7.2 below.

3.7 non-relevant failure

a failure that should be excluded in interpreting test or operational results or in calculating the value of a reliability performance measure

NOTE The criteria for exclusion should be stated. (IEV 191-04-14.)

ADDITIONAL NOTE The criteria for exclusion are stated in 7.1 below.

3.8 systematic failure

a failure related in a deterministic way to a certain cause, which can only be eliminated by a modification of the design or of the manufacturing process, operational procedures, documentation or other relevant factors

NOTE 1 Corrective maintenance without modification will usually not eliminate the failure cause.

NOTE 2 A systematic failure can be induced at will by simulating the failure cause. (IEV 191-04-19.)

ADDITIONAL NOTE In this standard, a systematic failure is interpreted as a failure resulting from a systematic weakness.

3.9 residual failure

a failure resulting from a residual weakness

3.10 failure category A

a systematic failure for which management decides not to attempt corrective modification, due to cost, time, technological constraints or other reasons

3.11 failure category B

a systematic failure for which management decides to attempt corrective modification

3.12 instantaneous reliability measure

a reliability measure for an item at a given point (past or present) in a reliability growth programme

NOTE 1 The reliability measures commonly used are the (instantaneous) failure intensity (IEV 191-12-04) or the mean operating time between failures (MTBF) (IEV 191-12-09); as well as the (instantaneous) failure rate (IEV 191-12-02) or the mean time to failure (MTTF) (IEV 191-12-07).

NOTE 2 The values of these measures are estimated by a reliability growth model.

3.13 extrapolated reliability measure

the reliability measure for an item, predicted for a given future point in a reliability growth programme, where the corrective modifications are promptly introduced throughout the programme

NOTE 1 The definition of the modifier “extrapolated ...” in IEV Chapter 191, 191-18-03 applies here, but is restricted to time.

NOTE 2 The previous test conditions and corrective modification procedures are assumed to continue unchanged.

NOTE 3 The value of the reliability measure is estimated by a reliability growth model applied to the previous data and the same trend is assumed to apply also to the future period of the programme.

NOTE 4 The reliability measures commonly used are the (instantaneous) failure intensity (IEV 191-12-04) or the mean operating time between failures (MTBF) (IEV 191-12-09); as well as the (instantaneous) failure rate (IEV 191-12-02) or the mean time to failure (MTTF) (IEV 191-12-07).

3.14 projected reliability measure

the reliability measure predicted for an item as a consequence of the simultaneous introduction of a number-of corrective modifications

NOTE 1 The modifications are often introduced between two successive phases in the programme.

NOTE 2 The reliability measures commonly used are the (instantaneous) failure intensity (IEV 191-12-04) or the mean operating time between failures (MTBF) (IEV 191-12-09); as well as the (instantaneous) failure rate (IEV 191-12-02) or the mean time to failure (MTTF) (IEV 191-12-07).

NOTE 3 The values of these measures are estimated by a reliability growth model.

4 Basic concepts

In a programme of reliability growth, laboratory or field testing is used to stimulate the exposure of weaknesses and improve the reliability of a system, equipment, component part or similar item. When a failure occurs it shall be diagnosed, repair and/or replacement carried out and testing continued. Concurrently with testing, past failures shall be analysed to find their basic causes and, where appropriate, corrective modifications introduced into design or other procedures, resulting in progressive reliability growth. This procedure applies equally to pure hardware and to embedded software.

A reliability growth programme on non-repaired, or one-shot, items or component parts only, shall provide for successively modified samples, each of a more reliable design standard than before.