

Dependability management —

Part 3-5: Application guide — Reliability test conditions and statistical test principles

ICS 01.040.03

National foreword

This British Standard reproduces verbatim IEC 60300-3-5:2001 and implements it as the UK national standard. IEC 60300-3-5 supersedes IEC 60605-1, and therefore BS IEC 60300-3-5 supersedes BS 5760-10.1:1993. The UK participation in its preparation was entrusted to Technical Committee DS/1, Dependability and terotechnology, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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**Partie 3-5:
Guide d'application – Conditions des essais
de fiabilité et principes des essais statistiques**

Dependability management –

**Part 3-5:
Application guide – Reliability test conditions
and statistical test principles**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

DEPENDABILITY MANAGEMENT –

Part 3-5: Application guide – Reliability test conditions and statistical test principles

FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60300-3-5 has been prepared by IEC technical committee 56: Dependability.

This first edition of IEC 60300-3-5 cancels and replaces the first edition of IEC 60605-1 (1978) as well as its amendment 1 (1982).

The text of this standard is based on the following documents:

FDIS	Report on voting
56/722/FDIS	56/730/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

Annexes A, B and C are for information only.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

INTRODUCTION

This part of IEC 60300 replaces IEC 60605-1 and is considered as an application guide for the series of standards on test conditions as well as on statistical tools used to analyse data from reliability tests of repaired or non-repaired items.

This standard is meant as a guide to the appropriate selection of applicable standards on test conditions and statistical analysis. It is also a general guide to planning, performing and analysing data from reliability tests. By using this standard, the user will be able to select other standards that are appropriate and necessary for planning, carrying out and analysing data generated by a specific reliability test.

This standard therefore refers to statistical tools for analysing constant and non-constant failure intensity and failure rate and other measures such as success/failure ratio.

This standard refers to the environmental and operational conditions and to the statistical methods available as IEC standards, since both should be selected at the same time.

DEPENDABILITY MANAGEMENT –

Part 3-5: Application guide – Reliability test conditions and statistical test principles

1 Scope

This part of IEC 60300 provides guidelines for the planning and performing of reliability tests and the use of statistical methods to analyse test data.

It describes the tests related to repaired and non-repaired items together with tests for constant and non-constant failure intensity and constant and non-constant failure rate.

It is applicable:

- when reliability testing is called for in a contract, either specifically or by inference;
- when planning a reliability test;
- during a reliability test;
- when analysing data from and reporting on the outcome of a reliability test.

This standard also applies when a contract or test plan specifies the use of IEC statistical standards, without specific reference to a particular standard.

Many different tests are performed during the development, design verification and design validation of a new product. The purpose of these tests is to discover weaknesses in the design and to undertake actions to eliminate these weaknesses and thereby improve performance, quality, safety, robustness, reliability and availability and reduce costs. This standard covers only the cases where statistical methods are used to analyse test data although the guidelines on test conditions, test planning and test documentation will be applicable to most tests.

The following topics are important and although discussed in this standard are more fully dealt with in their respective standards: availability testing (see IEC 61070); testing of maintainability measures (see IEC 60706) and measures of reliability growth (see IEC 61014 and IEC 61164).

This standard does not cover software testing (see IEC 61704), however it is applicable to items containing both hardware and software. This standard is therefore applicable to a wide range of products including consumer, industrial, military and aerospace applications. This part of IEC 60300 covers analysis for verification, determination, comparison and success/failure ratio evaluation. A flow chart giving guidance for planning the statistical treatment of reliability test data is shown in clause 9.

Although not described in this standard, the considerations and statistical tools can be used in connection with environmental tests, accelerated step-stress tests and over-stress tests.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60300. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60300 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(191):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 191: Dependability and quality of service*

IEC 60068 (all parts), *Environmental testing*

IEC 60300-2:1995, *Dependability management – Part 2: Dependability programme elements and tasks*

IEC 60300-3-2:1993, *Dependability management – Part 3: Application guide – Section 2: Collection of dependability data from the field*

IEC 60300-3-4:1996, *Dependability management – Part 3: Application guide – Section 4: Guide to the specification of dependability requirements*

IEC 60300-3-7:1999, *Dependability management – Part 3: Application guide – Section 7: Reliability stress screening of electronic hardware*

IEC 60605-2:1994, *Equipment reliability testing – Part 2: Design of test cycles*

IEC 60605-4:1986, *Equipment reliability testing – Part 4: Procedures for determining point estimates and confidence limits from equipment reliability determination tests*

NOTE In revision as 'point estimates and confidence intervals for the exponential distribution'.

IEC 60605-6:1997, *Equipment reliability testing – Part 6: Tests for the validity of the constant failure rate or constant failure intensity assumptions*

IEC 60812:1985, *Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)*

IEC 61025:1990, *Fault tree analysis (FTA)*

IEC 61070:1991, *Compliance test procedures for steady-state availability*

IEC 61078:1991, *Analysis techniques for dependability – Reliability block diagram method*

IEC 61123:1991, *Reliability testing – Compliance test plans for success ratio*

IEC 61124:1997, *Reliability testing – Compliance tests for constant failure rate and constant failure intensity*

IEC 61164:1995, *Reliability growth – Statistical test and estimation methods*

IEC 61649:1997, *Goodness of fit tests, confidence intervals and lower confidence limits for Weibull distributed data*

IEC 61650:1997, *Reliability data analysis techniques – Procedures for comparison of two constant failure rates and two constant failure (event) intensities*

IEC 61710:—, *Power law model – Goodness of fit and estimation methods* ¹⁾

ISO 11453:1996, *Statistical interpretation of data – Tests and confidence intervals relating to proportions*

ISO 3534-1:1993, *Statistics – Vocabulary and symbols – Part 1: Probability and general statistical terms*

3 Definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this part of IEC 60300, the terms and definitions given in IEC 60050(191), some of which are reproduced below, or in ISO 3534-1, as well as the following definitions, apply.

3.1.1

acceptance test

test with the purpose of verifying dependability measures before a design or production lot is accepted by the customer

NOTE The customer can be an internal customer or another department of the company or external customer.

3.1.2

censoring

termination of the test after either a certain number of failures or a certain time at which there are still items functioning

3.1.3

comparison test

test to compare two dependability measures

3.1.4

compliance test

test used to show whether or not a characteristic or property of an item complies with the stated reliability requirements

[IEV 191-14-02, modified]

3.1.5

dependability test

test with the purpose of estimating, verifying or comparing dependability measures for items of one or more design and/or production lots

NOTE This standard covers reliability tests within dependability testing.

¹⁾ To be published
© 07-2001

3.1.6

determination test

test used to establish the value of a characteristic or a property of an item

[IEV 191-14-03, modified]

3.1.7

discrimination ratio

ratio, D , ($D > 1$) characterizing a test plan by its ability to distinguish between an acceptable and an unacceptable dependability measure

NOTE The discrimination ratio is a figure of merit for the test plan.

3.1.8

estimation test

test used to establish the value of a characteristic or a property of an item

[IEV 191-14-03, modified]

3.1.9

failure

termination of the ability of an item to perform a required function

[IEV 191-04-01, modified]

3.1.10

failure criteria

set of rules used to decide whether an observed event constitutes a failure

3.1.11

(instantaneous) failure rate

limit, if this exists, of the ratio of the conditional probability that the instant of time, T , of a failure of an item falls within a given time interval, $(t, t + \Delta t)$ and the length of this interval, Δt , when Δt tends to zero, given that the item is in an up state at the beginning of the time interval

[IEV 191-12-02, modified]

3.1.12

(instantaneous) failure intensity

limit, if it exists, of the ratio of the mean number of failures of a repaired item in a time interval $(t, t + \Delta t)$, and the length of this interval, Δt , when the length of the time interval tends to zero

[IEV 191-12-04, modified]

3.1.13

failure ratio

probability that an item will fail or that a trial will be unsuccessful under stated conditions

NOTE An observed failure ratio is the ratio of the number of faulty items or of unsuccessful trials at the completion of testing, to the total number of test items or number of trials.

3.1.14

high degree of simulation

test conditions where the pattern of environmental and operating stresses is as close as possible to that encountered by the product in actual use

3.1.15

hypothesis (null or alternative)

(statistical) statement(s) about one or more reliability measures, or about a distribution, which are to be tested by means of a statistical test

3.1.16

item

any part, component, device, subsystem, functional unit, equipment or system that can be individually described

[IEV 191-01-01, modified]

NOTE An item may, for example, be a system, equipment, functional unit, component or element, consisting of hardware, software or both, and which may, in particular cases, include people.

3.1.17

life test

test with the purpose of estimating, verifying or comparing the lifetime of the class of items being tested

NOTE The end of the useful life will often be defined as the time when a certain percentage of the items have failed for non-repaired items and as the time when the failure intensity has increased to a specified level for repaired items.

3.1.18

low degree of simulation

test conditions where the varying environmental and operating stresses are as close as possible to those encountered in one defined environment and one operating scenario

NOTE The environment and load pattern may be chosen as an average or worst case. Since it is intended to define reproducible and simple operating conditions and not simulate the wide range of actual operating conditions on the field, the testing conditions may be simplified. For example, only the most significant parameters may be represented by the test conditions.

3.1.19

misuse failure

failure due to the application of stresses during use which exceed the stated capabilities of the item

[IEV 191-04-04]

3.1.20

no fault found

reported failure of an item which cannot be replicated or explained based on the conditions of the item

NOTE This may still be a relevant failure.

3.1.21

non-repaired item

item which is not repaired after failure

[IEV 191-01-03]

3.1.22

operating time

time interval during which an item is in an operating state

[IEV 191-09-01]

3.1.23

production test

test with the purpose of estimating, verifying or comparing dependability measures for items of one or more production lots

NOTE The purpose of a production test is often to investigate the influence of the manufacturing and assembly processes on the dependability measures of the items (robustness to variations in raw materials, components and processes).

3.1.24**recurrent failures**

two or more failures that occur in the same location; in the same part in different locations but similar application; in parts of identical type and manufacture; in the same point of the test cycle but not simultaneously

3.1.25**relevant failure**

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]

3.1.26**reliability growth test**

the purpose of a reliability growth test is to improve reliability through a process of test, failure identification, failure analysis, corrective action, implementing corrective action to units under tests, and to continue the test

3.1.27**reliability test**

experiment carried out in order to measure, quantify or classify a reliability measure or property of an item

NOTE 1 Reliability testing is different from environmental testing where the aim is to prove that the items under test can survive extreme conditions of storage, transportation and use.

NOTE 2 Reliability tests may include environmental testing.

3.1.28**repaired item**

reparable item which is in fact repaired after a failure

[IEV 191-01-02]

3.1.29**risk (statistical)**

probability of a false decision based on a statistical test. The false decision may be either to reject the null hypothesis when it is true (type I error, also called producer's risk, significance level, α), or to accept the null hypothesis when it is false (type II error, consumer's risk, significance level β). (See 3.1.12)

3.1.30**secondary failure**

failure of an item, caused either directly or indirectly by a failure or a fault of another item

[IEV 191-04-16]

3.1.31**step-stress test**

test consisting of several increasing stress levels applied sequentially for periods of equal time duration to an item

NOTE The purpose of a step-stress test is often to determine the margin between worst case operating and environmental conditions and the strength of the items under test. The test stress level is therefore increased until the item under test fails and the stress level is then often used instead of time as the measure for the test result.

3.1.32

stochastic

nature of random outcomes

3.1.33

stratification

division of a population into mutually exclusive and exhaustive sub-populations (called strata), which are thought to be more homogeneous with respect to the investigative characteristics than the total population

3.1.34

success ratio

probability that an item will perform a required function or that a trial will be successful under stated conditions

NOTE An observed success ratio is the ratio of the number of non-faulty items or of successful trials at the completion of testing, to the total number of test items or number of trials.

3.1.35

test conditions

any factor(s) or action(s), apart from the inherent properties of the test items themselves, which might affect the occurrence of test item failures. The test conditions include operating conditions, environmental conditions and preventive maintenance

3.1.36

test cycle

periodic repetition of several well-defined and reproducible operating, environmental and maintenance conditions during a test. The operating conditions are varied with time to simulate the time variation of operating and environmental conditions in actual use

3.1.37

test plan

instruction(s) to the person(s) performing the test. It includes the statistical test plan (number of items under test, decision risk, discrimination ratio, etc.). It further specifies test conditions, test equipment and procedures for the performing, surveying, reporting and analysis of the test data

3.1.38

test specification

requirements for the test, for example to estimate or verify reliability measures or compare items of two different designs, together with possible specifications or restriction in time, test equipment or number of items under test. The test specification can further state if the items are repaired or non-repaired or whether the test is a field test or a laboratory test

3.1.39

time to failure

total time duration of operating time of an item, from the instant it is first put in an up state, until failure or, from the instant of restoration until the next failure

[IEV 191-10-02]

3.1.40**time compression**

test method where the non-operational periods of the item in the field as well as its low environmental load periods are not reproduced during the test. The operating periods and the periods of high environmental load are reproduced in the test cycle. A test with test cycles of a given duration will therefore correspond to a longer calendar time in the field

3.1.41**time between failures**

time duration between two consecutive failures of a repaired item

[IEV 191-10-03]

3.1.42**trend**

upward or downward tendency, after exclusion of the random error and cyclical effects, when observed values are plotted in the order of observations

3.2 Abbreviations

MTBF Mean operating time between failures

MTTFF Mean time to first failure

ANOVA Analysis of variance

HPP Homogeneous Poisson process

NHPP Non-homogeneous Poisson process

PWA Printed wiring assembly

PWB Printed wiring board

PCB Printed circuit board

PCA Printed circuit assembly

3.3 Legends for figures

For the purposes of this standard, the following legends are used:

	Observed operation time
	Assumed/estimated operation time
	Start of operation
	Start of observation period
	End of operation by failure
	Can be used to depict different failure modes except  and 
	End of operation without failure

4 General considerations

4.1 Introductory remarks and legal considerations

By using this standard, the user will be able to select other standards that are appropriate and necessary for planning, carrying out and analysing data generated by a specific reliability test.

This standard refers to the environmental and operational conditions and to the statistical methods available as IEC standards, since both should be selected at the same time.

The methods are applicable to all types of equipment and systems containing, for example, electronic, electrical, electromechanical, mechanical, pneumatic and hydraulic devices. The equipment may be repaired or not repaired in use and during the testing.

The methods are applicable to one or more of the product life cycle phases: for example design and development (laboratory model, subassembly or prototype), pre-production, normal production and field use.

The methods can be used for laboratory tests as well as for field tests and are also applicable to items where wear-out occurs during the operating period.

Wherever 'failure' is referred to in this standard, the event may be replaced by repair or other events as may be appropriate.

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

Wherever failure rate/intensity is mentioned then this means instantaneous rate/intensity unless otherwise stated.

This part of IEC 60300 covers analysis for verification, determination, comparison and success/failure ratio evaluation. A flow chart giving guidance for planning the statistical treatment of reliability test data is shown in clause 9.

Although not described in this standard, the considerations and statistical tools can be used in connection with environmental tests, accelerated step-stress tests and over-stress tests.

Legal considerations

If a conflict should arise between this standard and the relevant contract or specification(s), the latter should apply.

Since this standard requires several issues to be agreed upon between the customer, the manufacturer, and an independent test agency (if any), all contracts or test plans should refer to this standard and any other standards which deal with specific test procedures to be employed.

In addition:

- where selection of specific test procedures, the manner in which tests are to be performed, or any other tailoring of the standard for purposes of the project is intended, the party given the discretion, and the areas in which discretion is to be exercised should specifically be mentioned in the contract or test specification;
- where specific test procedures, the manner of performance of testing, or other tailoring has to be agreed to, the agreements should be stated in an annex to the contract or test specification; and
- where any matter requiring agreement has not been resolved, such areas should be specifically identified in the contract or test plan, and suitable provisions including deadlines for agreement and dispute resolution procedures should be stated.

In all instances, the applicable contract or subcontract should identify the party responsible for performing the testing, the party liable for consequences of failure to perform the testing appropriately or the consequences of the system failing to comply with the specifications, the scope of or limitations of such liability, and the nature of or limitations on remedies available to the damaged party, witnessing of or participation in the testing program by the customer.

4.2 Objectives of reliability testing

An engineering design process decision should be based on measurable and reproducible information. This will in most cases involve some sort of testing.

The aim of reliability testing is to give objective and reproducible data on the reliability performance of an item. This requires that the test conditions described in a test plan be as reproducible as possible, and that the items tested be representative (see 4.5).

The detailed purposes of reliability tests can be as follows:

- evaluating reliability measures;
- discovering the "weak" points of the item and undertaking the tasks directed to improving the product;
- checking calculations and predictions made during the item design phase (for example to verify that design margins are adequate);
- revealing factors causing failures of the item to establish some activities aiming at the elimination of these factors;
- estimation of influence of technological processes on the reliability;
- elaboration of optimized system maintenance;
- making the product more robust, failure tolerant and safer;
- improving the performance and quality of the product;
- reducing the initial cost and life-cycle cost of the product;
- analysis of conditions of use (operational conditions) and their influence on the reliability;
- justification of reliability measures for technical documentation;
- evaluation of the cost of some phases of the life cycle.

A reliability test specification should embrace:

- real life conditions;
- goal/objectives of tests;
- formulation of the test purpose;
- planned selection of test items and type of test;
- specification of requirements regarding the test item characteristics and parameters (see IEC 60300-3-4);
- test arrangements;
- collection and processing of test data;
- evaluation of test results and their utilization;
- verification of the test methodology.

It should be noted that reliability testing is only one of several possible elements of a reliability program (see IEC 60300-2). The objective of the latter is to improve the effectiveness of reliability related activities in the design, development and production of new equipment.

4.3 Classification of reliability tests

4.3.1 Classification according to general purpose

From a statistical point of view, reliability tests can be classified according to their general purpose:

- estimation of reliability measures of the item (this is sometimes called determination);
- compliance of reliability measures stated, for example in a contract or specification;
- comparison of two designs or two products from a reliability point of view.

4.3.2 Classification according to the test place

Reliability tests can be classified according to the place where the tests are performed:

- laboratory testing;
- field testing.

The advantage of a laboratory test is that measurements and assessments can be made under controlled conditions, therefore they can be reproduced. In the planning of laboratory tests, it is recommended that the qualifications of the test operator compared to those of the operator in the field be considered. In a laboratory test, the number of items under test is often much lower than in a field test, therefore the sampling is relatively more important.

In a field test, the items under test are basically the items operated by the customer(s). This has the advantage that the operating conditions are identical to the conditions in (part of) the field. Since the conditions often differ from customer to customer it is preferable to analyse reliability for each condition of use. However, when data from different conditions are pooled, the observed reliability performance measures are an average for the population. The variation may be reduced by selecting them from only a part of the field, but in that case the results only apply to that particular part. An example would be to limit the test population to one country or one batch of items.

Laboratory test conditions in many cases can be designed to ensure with greater certainty that test limits are not exceeded. Earlier test decisions and problem identification is possible, permitting more timely corrective action.

Field tests, on the other hand, provide more realistic test results and require fewer test facilities. The direct cost of a field test may often be lower than that of a corresponding laboratory test. The test items may be operated normally. The inability to perform field tests under closely controlled conditions may, however, represent a significant disadvantage. The reproducibility of a field test is generally lower than that of a laboratory test.

Laboratory and field test methods are very similar with respect to the requirements and performance of the reliability test.

If there are several sites available for the field reliability testing, the choice of test site(s) depends on the basic reasons for the testing.

- If a high assurance is required that the achieved reliability level is not below a specified value, sites with the most severe conditions contained in the applicable specifications should be chosen.
- For estimation of the reliability performance parameters applicable to normal use conditions or for optimization of the maintenance planning, sites with the most typical conditions should be chosen.
- If comparative reliability information is requested, the sites should have the same or nominally identical condition, unless reliability under different conditions is being compared.
- Availability, competence and knowledge of personnel on test sites.

The operating and environmental test conditions should preferably be monitored continuously during the test period. If this is not possible during the normal field use of a repairable item, monitoring should be done on a time sampling basis and/or the reported observations of the operators should be used.

4.3.3 Classification according to time of receiving the results

Reliability tests can be classified still further according to the time required for obtaining the desired information in conjunction with applied test conditions:

- normal test – test under nominal stress conditions;
- accelerated tests – test with applied stresses higher than the nominal values, or compressed in time or cycles, for example, time compressed tests, step-stress test.

4.4 Statistical test plans

Reliability test plans should describe the number of test items, the way of dealing with failed (repaired, replaced, removed) items and the criteria for ending the test. There are two basic test plans that can be performed with or without replacement/repair of tested items:

- truncated sequential tests;
- time/failure terminated tests.

Note that all statistical test plans covered in this standard should specify the following as appropriate:

- a) number of items under test at the beginning of the test;
- b) whether items are replaced during the test;
- c) the number of items surviving at the end of the test;
- d) conditions under which the test was terminated (time truncated or failure terminated).

The test plans are necessarily based on statistical considerations, because reliability measures are statistical in nature.

4.5 Test specification

At the time of test preparation, all methodological, technical and financial questions as well as those related to the testing personnel should be considered in detail. Since reliability consists of a performance aspect as well as a time aspect, the following information concerning the test items should be stated during test planning:

- failure criteria;
- time period covered by the test;
- constant or non-constant failure intensity / constant or non-constant failure rate (assumed or verified);
- age in calendar time, storage conditions and pre-test conditioning;
- environmental conditions during the test;
- operating conditions and operating cycle;
- required and allowed preventive maintenance.

The choice of the population from which the items are sampled is usually made on the basis of schedules, technical conditions and economy. It will only be possible to estimate how representative the test items are from a qualitative point of view.

In practice, reliability compliance tests are often performed based on development or pre-production models in order to reach a decision early in the production cycle. Often development and pre-production items are not representative of the production lots, and this may result in an incorrect decision.

The sample of test items should be selected to be representative of the population in order to provide information or judgement about the population. This may be ensured by the procedure of selecting the test items at random. If the sample is not representative of the population, then the results obtained can be misleading.

No action is allowed on the test items from the time of sampling until the test starts, unless otherwise specified in the detailed reliability test plan. The original sub-assemblies, components, etc. in the test items should be left alone during the test period, except for allowed maintenance and modifications as noted in 6.4.

If an interruption is made in the test procedure in order to carry out preventive or corrective maintenance or for administrative or any other (unforeseen) reason, the test should be resumed with a minimum of delay and for cycled test conditions, at a point in the cycle corresponding to the point of interruption, unless otherwise specified.

If applicable, the detailed reliability test plan should state the permitted interruptions allowed in the test, the maximum duration of such interruptions and for cycled test conditions, the time phases of allowed resumption. During interruptions of a laboratory test, the items should be stored under standard laboratory conditions, unless otherwise stated in the test plan.

In a number of tests, accumulated test time is used. If the failure intensity/failure rate is not constant, this may influence the test result significantly. If the number of items on the test is small and the operating time during the test relatively long, the failures occurring after a long operating time (wear-out failures) may be observed in the test. But if the same accumulated operating time is achieved with a larger number of test items, the probability of wear out failures will be relatively smaller. For early failures, the opposite will be the case.

Repair activities and suspended items (removing items from the test) should be described and recorded in the test procedure or test file, since they are of vital importance to the statistical analysis.

If it is suspected that repaired items selected for the test may have a high level of early failures, any non-constant failure intensity should be taken into account in the statistical analysis. If early failures are not relevant for the test, then reliability stress screening could be performed before the reliability test is started.

For non-repaired items selected for the test, allowance should be made for a possible high level of early failures. Any non-constant failure rate should be taken into account in the statistical analysis. If early failures are not relevant for the test, then reliability stress screening (see IEC 60300-3-7) could be performed on the lot before the reliability test is started.

For failure intensity, failure rate, mean operating time between failures (MTBF) or mean time to first failure (MTTFF), the testing is performed as a time test during which the relevant times to failure are observed. Any a priori assumptions should be stated if made.

Reliability tests for very reliable items may require either a large number of test items (for example, field tests) or accelerated test conditions (for example, laboratory tests). For items with redundancies, the testing may apply to items that are sub-assemblies of the item. Finally, in some cases, methods other than testing may have to be used (see IEC 60300-2).

4.6 Utilisation of the test result

It should be emphasised that the test results are based only on the tested items. The test report should justify to what extent the sample is representative of the population.

Further justification is needed if reliability compliance or determination test results are extrapolated to:

- other population of items (for example lots);
- stress levels and environmental conditions differing from the test conditions;
- longer time of operation than applied during the testing.

In order to evaluate the extent to which such extrapolation is valid, a sound engineering knowledge is necessary of:

- the difference between the items in the populations;
- effect of stress levels and environmental conditions on the relevant failure modes;
- expected variation of the failure intensity/failure rate with time.

Due to the complexity and variability of environment of use for most items, close agreement between reliability measures obtained from laboratory tests and those experienced in actual use should not be expected in each individual case.

These variations, from laboratory to field conditions, are not covered by the statistical confidence limits.

The final conclusion drawn from a reliability test should not be limited to the formal decisions reached. The causes and consequences of each failure observed during a reliability test should be analysed in detail, and any possibility of making effective corrective action should be investigated.