

Dependability management —

Part 3-2: Application guide — Collection of dependability data from the field

The European Standard EN 60300-3-2:2005 has the status of a
British Standard

ICS 03.100.40; 03.120.01

National foreword

This British Standard is the official English language version of EN 60300-3-2:2005. It is identical IEC 60300-3-2:2004. It supersedes BS 5760-11:1994 which is withdrawn.

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**Dependability management
Part 3-2: Application guide –
Collection of dependability data from the field
(IEC 60300-3-2:2004)**

Gestion de la sûreté de fonctionnement
Partie 3-2: Guide d'application –
Recueil de données de sûreté
de fonctionnement dans des conditions
d'exploitation
(CEI 60300-3-2:2004)

Zuverlässigkeitsmanagement
Teil 3-2: Anwendungsleitfaden -
Erfassung von Zuverlässigkeitsdaten
im Betrieb
(IEC 60300-3-2:2004)

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Foreword

The text of document 56/992/FDIS, future edition 2 of IEC 60300-3-2, prepared by IEC TC 56, Dependability, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60300-3-2 on 2005-02-01.

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- | | | |
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| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2005-11-01 |
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Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60300-3-2:2004 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60300-3-1	NOTE	Harmonized as EN 60300-3-1:2004 (not modified).
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INTRODUCTION

The collection and analysis of failure and usage data from the field plays an important role in dependability analysis. It enables:

- a) maintenance planning;
- b) justification of modifications;
- c) calculation of future resource and spares requirements;
- d) confirmation of contractual satisfaction;
- e) assessment of likelihood of achieving a successful mission;
- f) feedback to design and manufacturing;
- g) estimation of cost of warranty period;
- h) improve dependability requirements;
- i) collection of basic data for possible liability cases;
- j) collection of usage data to determine field customer requirements which provide the basis for supplier dependability test specifications and demonstration programs.

Data collection for dependability-related purposes is often a long-term activity. Data covering a lot of item operation and/or many items may be required before appropriate analysis can be completed. Data collection should be undertaken as a planned activity, and executed with appropriate goals in mind.

In the shorter term, data collection objectives for dependability-related purposes include:

- 1) identification of new product design shortfalls;
- 2) adjustment of logistic support;
- 3) identification of customer problems for correction;
- 4) root cause failure analysis to eliminate predominant failure modes in the next design.

Analysis of dependability data requires clear understanding of the item, its operation, its environment and its physical properties. Analysis also needs good understanding of the general subject of dependability and its manifestation in the specific application.

Before starting a data collection process, it is important to realize that data collection cannot usually be performed without co-operation of all the parties involved. This may include item manufacturers, suppliers, repair authorities, users and customers.

DEPENDABILITY MANAGEMENT –

Part 3-2: Application guide – Collection of dependability data from the field

1 Scope

This part of IEC 60300 provides guidelines for the collection of data relating to reliability, maintainability, 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. Emphasis is made on the need to incorporate the return of experience from the field in the dependability process as a main activity.

This standard can be applied during monitoring of a population sample or, more widely, of whole populations. It is applicable, without restriction to diverse items, from components to systems and networks, including hardware, software and man/machine interactions. The items considered may have been designed, manufactured, installed, operated and maintained by one or more organizations. This standard applies to all possible relationships between suppliers and users. It applies to situations where some items may be repaired on site while others may only be replaced on site and repaired at centralized facilities.

No recommendations are made, however, of how to organize maintenance support.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-191 and the following apply.

3.1 environment

continuous or intermittent stress that may cause an event to occur (e.g. failure, a re-replacement, etc.) for an item

3.2 events

things that happen to items

NOTE Events include such things as removals, insertions, and upgrades. Additionally, how many occurrences, actuations, operating states, conditions, etc. are events that relate to product usage that can be evaluated from a damage perspective, where damage equivalence can be obtained with a higher frequency of the damaging event coupled with contributing damage factors from the application such as load, pressure, vibration, etc. Qualification of a product or system relates to understanding the distribution of damaging events per the significant sources of stress.

3.3 life

time between conception of the item and the time at which it is removed from operation.

4 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 on between the customer, the manufacturer and a third party (if any), all contracts should refer to this standard and any other standards which deal with dependability analysis or data collection procedures to be employed.

In addition, the following applies.

Where selection of specific analysis or data collection techniques is concerned, the manner in which analysis or data collection 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 analysis or data collection specification.

Where specific analysis or data collection procedures is concerned, the manner of performance of analysis or data collection, or other tailoring has to be agreed to, the agreements should be stated in an annex in the contract or analysis or data collection specification.

Finally, where any matter requiring agreement has not been resolved, such areas should be specifically identified in the contract or analysis or data collection plan, and suitable provisions including deadlines for agreement and dispute resolution procedures should be stated.

In all instances, the applicable contract or sub-contract should identify the party responsible for performing the analysis or data collection, the party liable for consequence of failure 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 analysis or data collection program by the customer.

5 Objectives of data collection

All customers' needs and expectations focusing on dependability can be categorized as follows:

- a) life time issues;
- b) availability;
- c) service issues;
- d) cost of ownership issues;
- e) operational reliability;
- f) safety.

In addition, the consumers' point of view concentrates on

- g) durability;
- h) value for money;
- i) service.

In addition, professional customers may be interested in

- j) validation of fulfilment of requirements of purchased items;
- k) logistics optimization;
- l) spare stock optimization;
- m) maintenance optimization;
- n) maintainability studies;
- o) availability studies.

Society as a whole is interested in safety, low risk and security. Those aspects can be influenced by dependability properties of items. Also economics is influenced by dependability properties, therefore public interest exists.

From the manufacturer's point of view the following aspects are important:

- comparison with similar products on the market;
- base for improvements for the next generation of the product.

Dependability can have different drivers within different sorts of companies. In general private companies use dependability as a means of increasing or maintaining profits while governmental or charity based companies use it as a means of maintaining a service. This can mean that the different sorts of companies will collect dependability data for different reasons.

The aim of data collection is to improve the relevant products and processes in any organization. Collected data with appropriate analysis close the learning loop back to marketing, design, manufacturing and service. Sub-targets can be risk minimization, cost optimization or the check for conformity with given requirements. Data should be collected for a purpose: to enable analysis, focused on increasing understanding of item operation and failure, and application of this knowledge to a goal or objective. Without a definition of the objective for the future data analysis and the application of its findings, collection of data is likely to be aimless and will omit important data, allow corruption of data, or may waste time and resources by including data that offer little benefit.

While planning data collection, several questions have to be considered such as the following:

- 1) What observed availability is achieved with the applied maintenance regime?
- 2) What values have been achieved with a former, similar product?
- 3) Does the product conform to the requirements?
- 4) What affect has environment and usage on dependability?
- 5) How stable is the dependability of manufactured items with time?

Further, it may be required to do the following:

- 6) Check compliance – to decide whether the product conforms to dependability requirements.
- 7) Check prediction – to compare calculated and observed values.
- 8) Estimate for new item – to use achieved values as a basis for estimation of similar item.

- 9) Check influence of changes in processes – to compare dependability measures before and after changes in manufacturing process.
- 10) Check influence of changes in product versions – to compare dependability measures of different product versions.
- 11) Check stability of dependability measures of manufactured items with time – to compare dependability measures of production lots.
- 12) Improve logistics – to re-plan the spare stock by use of real needs.
- 13) Check maintenance strategy – check the difference between inherent and real availability and different strategies.
- 14) Optimize scheduled maintenance – to use the failure rate distribution of an item to find the best maintenance/replacement.
- 15) Monitor for liability risk and possible product recall.
- 16) Investigate both fault occurrences and causes of no fault found causes – imperfect repair, serial and systematic failures, test of software, patterns of failures and trends.
- 17) Obtain information about operational and environmental influences on the product and output parameters for simulation requirements, customer based dependability requirements, to guide test and simulation reliability specifications.
- 18) Identify troublesome components and their failure mechanisms.
- 19) Evaluate existing dependability models and derive new dependability models.
- 20) Evaluate dependability indicators.
- 21) Undertake logistic and resource planning.
- 22) Justify modifications.
- 23) Ensure contractual satisfaction.
- 24) Evaluate the need for remote condition monitoring to track item health.
- 25) Develop a corporate memory database, incorporating wider data collection, building on individual data collection activities, with wider application of results.
- 26) Collect data to allow physics of failure analysis to be carried out. It is worth noting that a full physics of failure analysis will have a large data requirement for basic physical parameters of an item and the materials it is made from.
- 27) Collect data to support a reliability growth exercise.

As with most dependability tools and analysis, the underlying reason for performing data collection as a dependability task is to improve product quality, monitor performance, modify logistic support, determine if required reliability is achieved, identify deficiencies for root cause analysis leading to product improvement by modification, to improve performance and, in the longer term, to improve company profits or quality of service. This aim leads to the need to understand all the costs associated with a particular project. These costs are known as the life cycle costs and include all costs involved in the design, manufacture, use and disposal of an item. Data collection plays a part in the identification of these costs since it allows management to make assessments of such things as value-for-money, cost-effectiveness, cost-of-warranty and the risks associated with liability and product recall.

As far as data of supplied items are affected, the benefits of the information gathered can be maximized when the loop to the supplier is closed. This supports supplier development as well as long-term partnership. Generally, the equipment/system supplier's responsibility is to design data collection.

An equipment life cycle can be thought of as a three-stage process. These stages are design, manufacture and operation. Data collection can be performed at each level and the information collected can be fed back to any of the previous stages as shown in Figure 1.

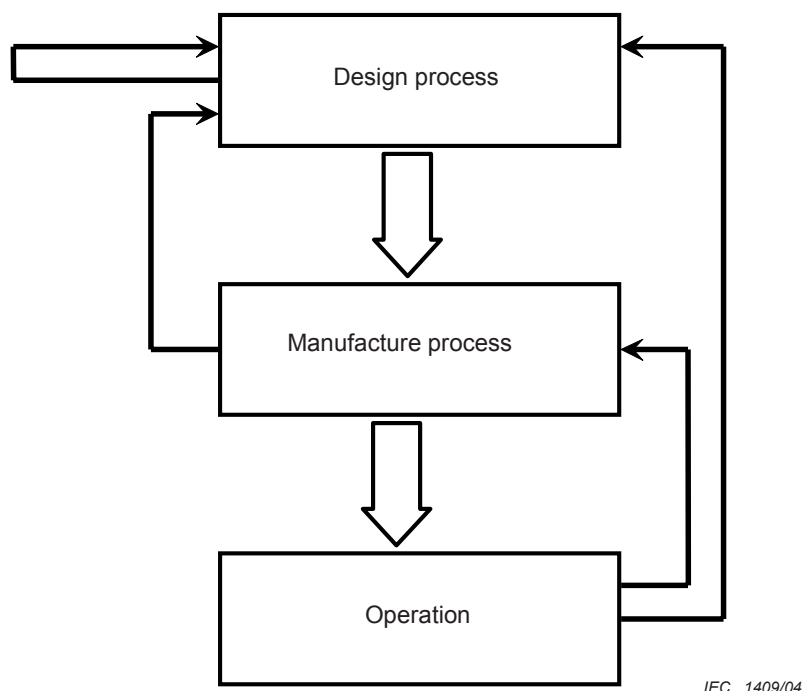


Figure 1 – Feedback into design process

Collection of dependability data can help improve processes for the following:

- i) Marketing – by use of knowledge concerning customer needs and expectations for defining and refining requirements for new products.
- ii) Design – by use of findings about dependability performance of delivered products and information on failure mechanisms obtained by failure analysis and determination of customer usage requirements with assessment of variation in customer usage observed in application.
- iii) Manufacturing – by use of analyses of failures, to learn what design and manufacturing aspects are essential for manufacture of dependable products.
- iv) Operation – by use of analyses of data on maintainability, to improve maintenance support performance as well as future design for maintainability.

6 Considerations on level of reporting

Data can be collected for different levels of an item, such as

- a) system,
- b) equipment,
- c) module or unit,
- d) part or component,
- e) software module.

Generically, these can all be termed items.

Data can also be collected for different phases of the life cycle of a product such as

- 1) production to delivery (malfunctioning on arrival),
- 2) installation (run-in, early failures, installation problems),
- 3) operation,
- 4) first phase of operation (especially information about early failures),
- 5) time of warranty (information supporting determination of warranty costs),
- 6) long term behaviour, useful life, service effort,
- 7) item isolation for maintenance purposes (e.g. to replace parts),
- 8) withdrawal from operation (disposal).

During each phase of the life cycle, issues such as fault diagnosis and repair should also be considered as these have major implication on fault coverage and in the instance of no fault founds.

7 Which analysis can be performed ?

Analysis is the identification and quantification of calculated values, distributions and trends. The analysis can be targeted on the whole item, individual modules, specific failure modes, specific users, specific events, specific environments, etc. The target will be achieved by selecting only events that fulfil the necessary selection criteria. Data analysis is not a single calculation; rather it is a series of examinations of the data, exploring the breadth and depth of the data in a series of structured examinations. Data collection and analysis should be progressive and should increase as experience increases. It is often useful first to examine the data in a broad view, and to use this broad view to guide more in-depth examinations.

- a) Exploratory data analysis – The aim of exploratory data analysis is to gain understanding of the general nature of the data.
- b) Number of events – The most basic level of analysis is the calculation of the number of events during a particular period or within several sub-periods. The number of events can be broken down into appropriate sub-divisions, such as events relating to critical shutdowns, customer complaints, safety involvement, and then further broken down into modules causing such problems. Examination of numbers of events will enable identification of specific areas that warrant further investigation.
- c) General rates – A rate is the number of events that occur per unit time, per operation, or per cycle. Calculating rates can give some indication of how the number of events will change with time. Rates can be modelled as being approximately constant or as non-constant.

- d) Distributional analysis – The next level of analysis would be to carry out distributional analysis (e.g. Weibull). However, there are criteria regarding the data needed for input, reflecting its power in identifying distributions. These criteria will be described in the relevant standards.
- e) Non-parametric analysis – If distributional analysis is unsuitable, then non-parametric analysis can be performed. This often has less stringent criteria than distributional analysis but will deliver less information.

8 Which data can be collected ?

8.1 General

Inventory – This includes information proving that a particular item exists in the field, how that item is configured, and what other items that item contains.

Usage – This includes information about when an item was placed into the field, how that item is operated in the field, and when that item was removed from the field.

Environment – This includes information about the operating conditions of the item, often in terms of factors that are considered important to the dependability of the item.

Events – This include information about any thing that has happened to the item during its life, these will include failures, repairs, upgrades, etc.

Often it is not possible to obtain all the data that would be required for a particular dependability task, perhaps because of operational issues or because it is too expensive to collect such data. In these cases, it is often necessary to assess why the data are required and perform trade-off analysis between the reason the data are required and the difficulty of collecting such data. Sometimes collecting the data could mean making changes to the operational processes that already exist within an organization and the difficulty and cost of this has to be offset by the benefit obtained by performing the dependability analysis that the data collection will enable.

A statistical model will always model the data with some approximation. Engineering judgement and goodness of fit (GOF) tests should be used to evaluate if the approximations give useful results. Sensitivity to the preconditions can be evaluated by simulated data, e.g. using the Monte Carlo method.

8.2 Inventory

Inventory records are often retained that identify original build state, manufacturer, batch number, modification state, repair history and other information. These data are particularly important when assessing the factors that govern susceptibility to various events. Without such information, dependability analysis will never be able to identify trends that apply only to specific sub-groups of otherwise identical items.

Many event types (failures for instance) are inherent to the individual item concerned, introduced by either a manufacturing flaw or design weakness. Such events are precipitated by life consumption (including zero life: initial switch-on). Life consumption will accumulate uniquely on individual items and, accordingly, full life analysis can be carried out if the item concerned is specifically identified in each record, by some unique serial number. Some forms of life analysis do not have this requirement, for example $M(t)$ analysis in IEC 60605-6.