BS EN 62059-41:2006

Electricity metering equipment — Dependability —

Part 41: Reliability prediction

The European Standard EN 62059-41:2006 has the status of a British Standard

ICS 91.140.50

British Standards

National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/13, Electricity meters, which has the responsibility to:

- aid enquirers to understand the text;
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Foreword

The text of document 13/1348/FDIS, future edition 1 of IEC 62059-41, prepared by IEC TC 13, Equipment for electrical energy measurement and load control, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62059-41 on 2006-02-01.

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Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62059-41:2006 was approved by CENELEC as a European Standard without any modification.

CONTENTS

INTRODUCTION

The main objective is to provide a tool for predicting the failure rate of electricity metering equipment using the parts stress method. It also provides an overview of reliability analysis and prediction methods.

The result of the prediction can be used in the design phase to support design decisions, in relation with type approval to support decisions concerning the certification period and in the operation phase to determine the necessary maintenance performance to obtain the required availability.

ELECTRICITY METERING EQUIPMENT – DEPENDABILITY –

Part 41: Reliability prediction

1 Scope

This part of IEC 62059-41 is applicable to all types of static metering equipment for energy measurement and load control.

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 60050-191:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 191: Dependability and quality of service*
Amendment 1(1999)
Amendment 2 (2002)

IEC 61709:1996, *Electronic components – Reliability – Reference conditions for failure rates and stress models for conversion*

IEC 62059-11:2002, *Electricity metering equipment – Dependability – Part 11: General concepts*

IEC 62059-21:2002*, Electricity metering equipment – Dependability – Part 21: Collection of meter dependability data from the field*

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms and definitions apply.

NOTE Only those terms relevant to the subject, which have not already been included in IEC 62059-11, are given here.

3.1
accelerated test
test in which the applied stress level is chosen to exceed that stated in the reference conditions in order to shorten the time duration required to observe the stress response of the item, or to magnify the response in a given time duration

NOTE To be valid, an accelerated test shall not alter the basic fault modes and failure mechanisms, or their relative prevalence.

[IEV 191-14-07]

3.2
administrative delay (for corrective maintenance)
accumulated time during which an action of corrective maintenance on a faulty item is not performed due to administrative reasons

[IEV 191-08-09]

3.3
ageing failure, wearout failure
failure whose probability of occurrence increases with the passage of time, as a result of processes inherent in the item

[IEV 191-04-09]

3.4
constant failure intensity period
that period, if any, in the life of a repaired item during which the failure intensity is approximately constant

[IEV 191-10-08]

3.5
constant failure rate period
that period, if any, in the life of a non-repaired item during which the failure rate is approximately constant

[IEV 191-01-09]

3.6
equipment under prediction
EUP
static electricity metering equipment for which a reliability prediction is being made

3.7
failure cause
circumstances during design, manufacture or use which have led to a failure

[IEV 191-04-17]

3.8
failure intensity acceleration factor
in a time interval of given duration, whose beginning is specified by a fixed age of a repaired item, ratio of the number of failures obtained under two different sets of stress conditions

[IEV 191-14-12]

3.9
(instantaneous) failure rate
$\lambda(t)$
limit, if it exists, of the quotient of the conditional probability that the instant of a failure of a non-repaired item falls within a given time interval $(t, t + \Delta t)$ and the duration of this time interval, Δt, when Δt tends to zero, given that the item has not failed up to the beginning of the time interval

NOTE 1 The instantaneous failure rate is expressed by the formula:

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{1}{\Delta t} \frac{F(t+\Delta t) - F(t)}{R(t)} = \frac{f(t)}{R(t)}$$

where $F(t)$ and $f(t)$ are respectively the distribution function and the probability density of the failure instant, and where $R(t)$ is the reliability function, related to the reliability $R(t_1,t_2)$ by $R(t) = R(0,t)$.

NOTE 2 An estimated value of the instantaneous failure rate can be obtained by dividing the ratio of the number of items which have failed during a given time interval to the number of non-failed items at the beginning of the time interval, by the duration of the time interval.

NOTE 3 In English, the instantaneous failure rate is sometimes called "hazard function".

[IEV 191-12-02]

3.10
failure rate acceleration factor

ratio of the failure rate under accelerated testing conditions to the failure rate under stated reference test conditions

NOTE Both failure rates refer to the same time period in the life of the tested items.

[IEV 191-14-11]

3.11
fault

state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources

NOTE 1 A fault is often the result of a failure of the item itself, but may exist without prior failure.

NOTE 2 In English, the term “fault” is also used in the field of electric power systems with the meaning as given in 604-02-01: then the corresponding term in French is “défaut”.

[IEV 191-05-01]

3.12
maintenance

combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform a required function

[IEV 191-07-01]

3.13
maintenance policy

description of the interrelationship between the maintenance echelons, the indenture levels and the levels of maintenance to be applied for the maintenance of an item

[IEV 191-07-03]

3.14
maintenance time

time interval during which a maintenance action is performed on an item either manually or automatically, including technical delays and logistic delays

NOTE Maintenance may be carried out while the item is performing a required function.

[IEV 191-08-01]

3.15
mean repair time
MRT
expectation of the repair time

[IEV 191-13-05]

3.16
mean operating time between failures
MTBF
expectation of the operating time between failures

[IEV 191-12-09]

3.17
mean time to failure
MTTF
expectation of the time to failure

[IEV 191-12-07]

3.18
operating time
time interval during which an item is in an operating state

[IEV 191-09-01]

3.19
prediction
process of computation used to obtain the predicted value(s) of a quantity

NOTE The term “prediction” may also be used to denote the predicted value(s) of a quantity.

[IEV 191-16-01]

3.20
redundancy
in an item, existence of more than one means for performing a required function

[IEV 191-15-01]

3.21
reference data
data which, by general agreement, may be used as a standard or as a basis for prediction and/or comparison with observed data

[IEV 191-14-18]

3.22
reliability model
mathematical model used for prediction or estimation of reliability performance measures of an item

[IEV 191-16-02]

3.23
(instantaneous) repair rate

***μ*(*t*)**

limit, if this exists, of the ratio, of the conditional probability that the corrective maintenance action terminates in a time interval, $(t, t + \Delta t)$ and the duration of this time interval, Δt, when Δt tends to zero, given that the action had not terminated at the beginning of the time interval

[IEV 191-13-02]

3.24
repair time

that part of active corrective maintenance time during which repair actions are performed on an item

[IEV 191-08-16]

3.25
required function

function or a combination of functions of an item, which is considered necessary to provide a given service

[IEV 191-01-05]

3.26
(steady-state) availability

the mean of the instantaneous availability under steady-state conditions over a given time interval

NOTE Under certain conditions, for instance constant failure rate and constant repair rate, the steady-state availability may be expressed by the ratio of the mean up time to the sum of the mean up time and mean down time. Under these conditions, asymptotic and steady state availability are identical and are often referred to as "availability".

[IEV 191-11-06]

3.27
stress model

mathematical model used to describe the influence of relevant applied stresses on a reliability performance measure or any other property of an item

[IEV 191-16-10]

4 General information

Reliability prediction methods are used to determine the probability that in a certain time interval, an EUP will be in the operating state, will be out of service or will be in the maintenance process. Results of such prediction methods can also indicate the percentage of equipment in a given population operating correctly, failed or being repaired, and the mean length of these intervals.

Reliability prediction is a statistical process reaching into the future, and it is based on information known from the past. The result therefore is always a probability of certain variables. To perform reliability predictions, detailed system knowledge and component reliability data are necessary.

It is important to distinguish between repairable and non-repairable items because the variables characterizing them are quite different, although there is a relationship between these variables.

In a non-repairable system, the Time To Failure (TTF) of the system components determines the useful life, during which the equipment performs its required functions with an estimated probability.

For a repairable system, its steady-state availability is the most important, and the mean repair-time or maintainability also become important variables since the cost of maintenance and the frequency of functional interruptions depend on each other.

This distinction shall also be made because requirements must be set for the correct set of variables. For example, it is not possible to set or meet requirements for availability by observing or predicting only the reliability function, without considering maintainability, including the maintenance policy of the utility.

Before any prediction can be made, the EUP shall be modelled. An EUP usually consists of several subsystems or components. Components are the smallest units, which form the system. Components are defined to be non-repairable otherwise they are regarded as subsystems. Prediction methods for non-repairable systems are therefore also applicable to components. System reliability prediction depends on the reliability of the components, and system reliability calculations use component reliability data. To obtain good prediction results, the reliability of components must be known as exactly as possible.

It is also important to know the operating conditions of the components, as these have influence on the reliability of the components. Some prediction methods also require the structural knowledge of the system.

Predictions are only valid if:

- no unforeseen events in or outside the EUP occur (for example the EUP is damaged);
- the EUP does not change its characteristics except from ageing;
- environmental conditions are constant or predictable;
- functional conditions (e.g. mains voltage) are constant or predictable;
- detailed performance requirements or failure criteria of the EUP exist;
- no design failures are present.

The above criteria are the only scale by which the correct functioning of the EUP can be judged.

Therefore, reliability prediction results shall always be presented together with the assumptions and conditions for which the prediction was made. See also 6.6.

5 Reliability analysis methods

For any reliability model, it is essential to perform an analysis of the EUP to confirm that the model chosen is suitable to achieve the desired result. Techniques to make this analysis are outlined in Annex B.

Reliability analysis methods usually provide information on system reliability at a particular instant of time at present or for a time interval in the past. For reliability analysis and prediction the relevant variables, characteristics, and parameters are mostly the same. Additionally, reliability analysis can and should provide information on the failure causes.

If the EUP is considered repairable, then information on the reintroduction into the field after repair (end of down time interval) will also be known precisely.

6 Reliability prediction using the parts stress method

6.1 Overview

The parts stress method is used for predicting the failure rate of a system based on the failure rate of its components under the operating conditions experienced during the use of the system.

The basic assumption is that equal importance is placed on all components concerning system reliability, i.e. failure of any component is assumed to lead to a system failure (simple series model). In many practical cases, this assumption is of course not true. In such cases, this method may lead to pessimistic results.

Additionally, all failure rates are assumed to be constant for the time period considered, i.e. an exponential failure distribution is assumed. During the operating life of an EUP this is an acceptable approximation.

The following data are needed:

- the number of components in each component category;
- failure rate of each component under reference conditions;
- stress factors and conversion models for each component;
- structural information for the circuits, which are not intrinsically series connected.

The failure rate of the system is calculated by totalling the failure rate of each component in each category under their respective operating conditions.

The inverse function of this failure rate is the MTBF, which is the average time between two failures. The end of the useful life on the other hand is determined by the wear out of the components and cannot be estimated based on the exponential model.

If redundancy were built in, then due to the higher number of components, the parts stress method would indicate lower reliability for better systems. In such cases, it is necessary to combine the parts stress method with other reliability prediction and analysis methods. Redundant subsystems shall be treated as single elements in order that the resulting failure rate can be included in the series connected parts model. This failure rate can be calculated by other methods, for example combinatorial probability computation (multi-level approach).

6.2 Component failure rate data

Component failure rate data may be obtained from appropriate handbooks (see Bibliography). The advantage of using handbook data is that system designs from different manufacturers can be readily compared. However, data provided by component suppliers and data on items and components obtained from field feedback may provide results that are more accurate hence use of such data is preferred. For components not included in the database chosen, data may only be obtained from the item supplier or field feedback from previous designs.

IEC 61709 provides guidance on the use of failure rate data for predicting the reliability of components in electronic equipment. It presents reference conditions and generic and component category specific stress models for converting failure rates under reference conditions to failure rates under operating conditions.

6.3 Stress models

Components may not always operate under the reference conditions. In such cases, operational conditions will result in failure rates different from those given for reference conditions. Therefore, models for stress factors by which failure rates under reference conditions can be converted to values applying for operating conditions (actual ambient temperature and actual electrical stress on the components) may be required.

Clause 7 of IEC 61709 includes specific stress models and values for component categories and should be used for converting reference failure rates to field operational failure rates. However, if models that are more specific are applicable for particular component types then these models should be used and their usage noted.

The conversion of failure rates is only possible within specified functional limits of the components.

The general equation for calculating the failure rate under operating conditions is:

$$\lambda = \lambda_{\mathrm{ref}} \times \pi_{\mathrm{U}} \times \pi_{\mathrm{I}} \times \pi_{\mathrm{T}}$$

where

λ_{ref} is the failure rate under reference conditions;

π_{U} is the voltage dependence factor;

π_{I} is the current dependence factor;

π_{T} is the temperature dependence factor.

For certain component categories, not all the π factors listed above are used or different π factors apply. Some examples are:

π_{D} is the drift sensitivity factor, used with certain semiconductor components in drift sensitive circuits;

π_{ES} is the electrical stress dependence factor, for example with relays and switches (also known as load dependence factor, π_{L});

π_E is the environment dependence factor, relevant, for example for relays and switches;

π_W is the stress profile factor, relevant for components not continually stressed, for example with relays.

For each component category, IEC 61709 contains the appropriate equations for the calculation of the failure rate under operating conditions and for the calculation of the relevant π -factors.

The databases contain the failure rates at reference conditions and the equations and constants for calculating the failure under operating conditions.

NOTE IEC 61709 does not include π factors for taking into account the effect of humidity, pressure and mechanical stress. The effect of such conditions may be evaluated using accelerated test methods and appropriate damage models. For more information, see IEC 62308, Annex B.

The “typical” values of the reference failure rates and the constants used in the equations to calculate the π factors are the average of typical component values specified by various manufacturers specifications and test results. These data can be quite reliable, but in some cases, the data are not specified or not obtained directly from field data. Consequently, failure rate predictions often differ from field data and it is always advisable to use field data wherever possible. By introducing an extra π_{FD} factor, it is possible to calibrate the prediction using data collected from the field. See also B.2.5.

Furthermore, certain components, like batteries and LCDs are difficult to model and it may be necessary for the manufacturer to provide separate information about reliability and expected lifetime when such components are used in certain operating conditions.

6.4 Failure rate prediction using the parts stress method

As outlined in 6.1, assuming a simple series system model and constant failure rates, the system failure rate is the sum of the failure rates of its components i.e.

$$\lambda = \lambda_1 + \lambda_2 + \lambda_3 + ... + \lambda_n$$

The reliability of the EUP can therefore be predicted from the failure rate of its components.

6.5 Phases of the failure rate prediction process

The failure rate prediction process consists of the following phases:

- identify EUP and functions to be covered by prediction;
- define failures;
- specify the operating conditions of the EUP, based on which the operating conditions of each component can be determined. These shall include the voltage across the voltage circuits, supply voltage if different, load current in the current circuits, ambient temperature and any other relevant conditions;
- analyse equipment structure for redundancy;
- determine stress profile for each component;

- select reference failure rate for each component from the database or other relevant source;
- calculate failure rate for each component using the relevant stress factors;
- sum up the component failure rates.

NOTE The calculation can be performed by commercially available software.

6.6 Presentation of results

When reporting reliability predictions according to this standard, at least the following information shall be provided:

- purpose of the prediction, like business decisions, system architecture decisions, equipment design decisions;
- object of prediction (EUP);
- EUP functions covered and any functions that are excluded from the prediction shall be listed together with the reasons for their exclusion.
- a statement that the prediction is based on the reliability model and method presented in IEC 61709 and IEC 62059-41 (this standard);
- a statement that the prediction applies for the constant failure rate interval;
- failure definitions: relevant failures according to IEC 62059-21;
- environmental and operating conditions for which the prediction is made;
- ratings and π factors assumed;
- component failure rate data source, (see Bibliography, Siemens Norm 29500). If data sources other than handbooks are used, the sources and the justification of using them shall be presented;
- prediction result: failure rate in %/year.

7 Other dependability considerations

The predicted failure rate can also be used for the calculation of other reliability functions. The system reliability R can be mathematically expressed as:

$$R(t) = e^{-\lambda t}$$

where

e = 2,71828;

t is the time period;

λ is the failure rate.

Reliability can be expressed also in terms of cumulative number of failures $F(t)$ during a specified time period t:

$$F(t) = 1 - R(t)$$

As shown in IEC 62059-11, Annex A, there is a relationship between the reliability and availability figures through the maximum time between the occurrence and the discovery of the failure.

To ensure an appropriate level of service, the main requirement is set for the Availability (A) of the metering equipment operating at the customer's premises.

From the required availability figure (A), the necessary reliability of the metering equipment (λ or MTBF) can be calculated taking into account the maintenance policy of the operator of the meter park, for example discovering a fault at yearly, monthly meter reading, etc. On the other hand, if the reliability figure for a given metering equipment type is known, then the maintenance policy can be tailored to the availability requirements.

If the field performance of the metering equipment is different from the failure rate predicted, then the required availability can be maintained by adapting the maintenance process.

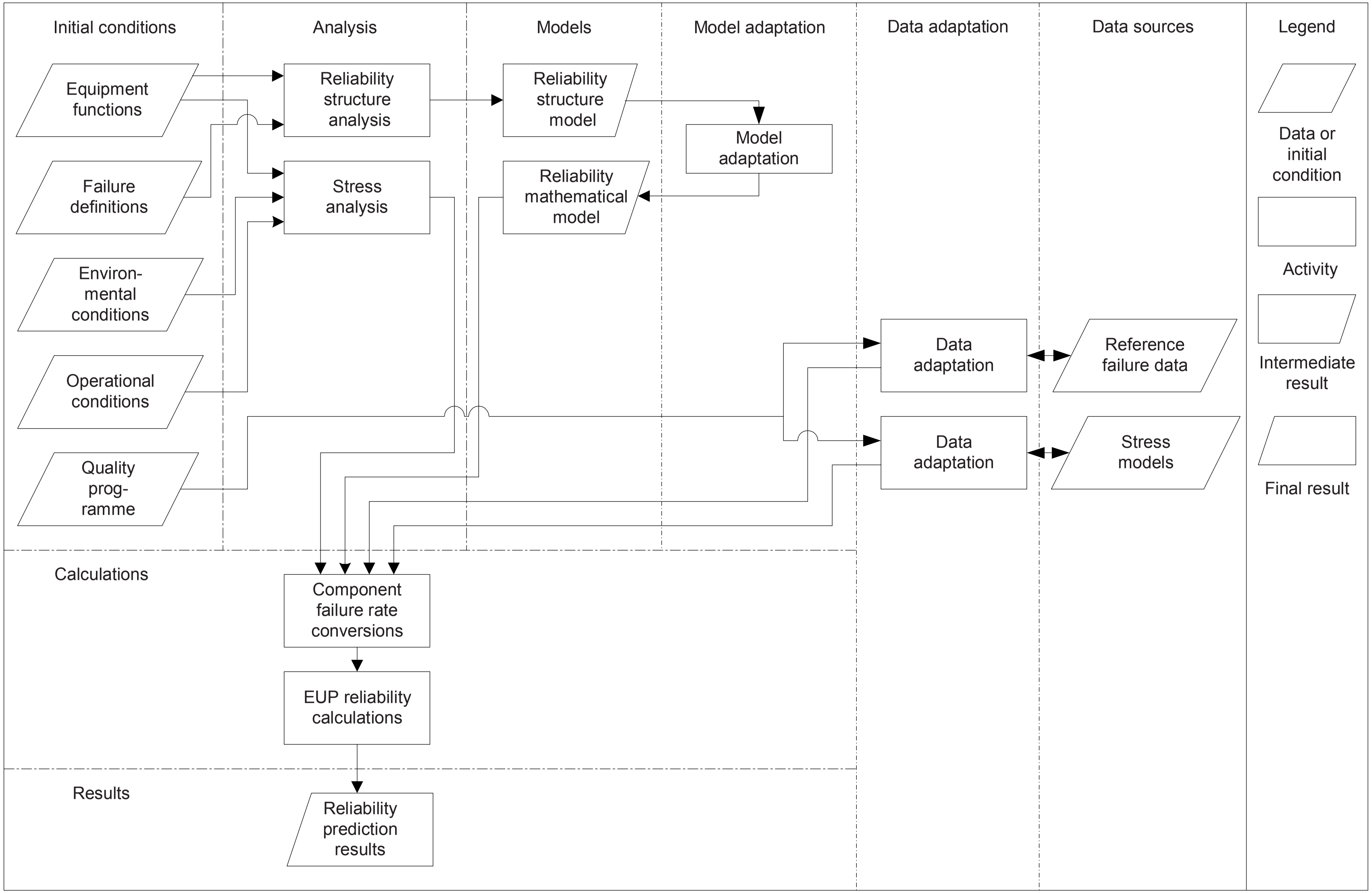
8 Life time of life limited components

In order to validate the end of the constant failure rate period, the life expectancy for life limited components shall be estimated. Components that have limited life (wear out) are typically (see IEC 62380):

- solderings (vibration and thermal cycles);
- power transistors (cycles at junction temperature);
- optocouplers, LED's, laser diodes;
- non-solid electrolytic capacitors;
- relays, reed relays, thermal relays;
- switches, connectors;
- varistors, and
- batteries.

Data from component suppliers or from field feed back should be used. IEC 62380 also contains equations to predict life expectancy for life limited components.

Annex A
(normative)
Reliability prediction – Procedural flow



IEC 2262/05

Annex B
(informative)

Overview of other reliability analysis and prediction methods

B.1 Reliability analysis methods

B.1.1 Network techniques

The underlying model is a Boole’s condition of only two states (operating/failed) for all components as well as for the system. This is in many cases a coarse simplification, but it needs only very simple mathematical skills to analyse large systems. Results are worst-case, i.e. no hidden risks remain. Many software packages exist for these methods.

In order to calculate system reliability, the following techniques can be used:

- combinatorial rules for components states;
- simple logical series/parallel systems: basic reliability calculation as above;
- reliability block diagrams: decompose the system into separate reliability blocks (not functions) that are statistically independent from one another, and calculate the system reliability. For large, complex or meshed systems this method becomes too laborious, hence an interval estimate of system reliability may be obtained using cut and tie sets:
  - min-tie (path) sets: find all the minimum subsets that tie together the inputs and outputs to make the system function. Then the upper bound on system reliability is given by: $R_{\text{s-upper}} = \sum_{j=1}^{T} \prod_{k=1}^{n_j} R_k$

    where T is the number of tie sets, n_j is the number of blocks in the j^th^ tie set and R_k is the reliability of the k^th^ block.
  - min-cut sets: find all the minimum subsets that cut all ties (paths) between the inputs and the outputs to make the system fail. Then the lower bound on system reliability is given by

    $$R_{\text{s-lower}} = 1 - \sum_{j=1}^{C} \prod_{k=1}^{n_j} (1 - R_k)$$

    where C is the number of cut sets, n_j is the number of blocks in the j^{th} cut set and R_k is the reliability of the k^{th} block.

NOTE For high block reliabilities, $R_s \to R_{\text{s-lower}}$ whilst “calculated” $R_{\text{s-upper}} > 1$, i.e. $R_{\text{s-upper}} = 1$. For low block reliabilities, $R_s \to R_{\text{s-upper}}$ whilst “calculated” $R_{\text{s-lower}} < 0$, i.e. $R_{\text{s-lower}} = 0$.

B.1.2 State space techniques

The underlying model is the Markov process. The basic assumption is a two-state (binary) model for all components, but as system characterisation, the state space vector composed of all component states as elements is introduced. Since this results in 2^n possible system states from n components, this system characterisation is in many practical cases much too detailed.

For a Markov-model based reliability analysis approach, knowledge of the following is necessary:

- number and states of all components;
- degree of independence of all components from each other;
- degree of independence from earlier states than the last one (is it a Markov process?);
- (crucial) transition rate between states, usually constant, time-independent (at least piecewise);
- classification of every state and its influence on the system.

This approach results in the complete description of the system behaviour in the future. It is the most common method for calculating reliability variables for repairable systems. Matrix elements have to stay constant during a time step interval.

Without detailed information on transition rates between all states, the system matrix – the key element of the system differential equation – cannot be quantified; i.e. no calculations are possible and no results can be obtained. It is essential that every matrix element be estimated.

B.1.3 Testing

As in probabilistic calculations, it is also possible to evaluate reliability variables by the testing of specimens. The basic standards for testing are IEC 60300-3-5 and IEC 60605-2.

It can take a long time to confirm certain parameters if the equipment is designed for high reliability (low failure rate), because failures may occur only after a lengthy testing time. Therefore, accelerated testing must be used.

To identify weak points and failure modes in the design, step stress test (HALT test) can be used.

B.2 Reliability modelling and prediction methods

B.2.1 Overview

Reliability modelling and prediction is a process of quantitatively assessing the reliability of a system both during the design phase and during field operation. During design and development, the prediction serves as a guide by which design alternatives can be evaluated. In field operation, the prediction serves as a useful guide to identify items likely to fail in a given time span thus allowing an estimation of field servicing requirements.

Methods to analyse system reliability often serve as prediction tools, assuming that all relevant system and environmental parameters stay the same over the appropriate time interval. It is basically a probabilistic extrapolation of the past into the future.

There are four basic prediction categories:

- system simulation;
- mathematical modelling and analysis;
- testing;
- collecting and processing field data.

Limitations of reliability models and predictions are as follows:

- reliance is placed on the accuracy and validity of failure rate data;
- for new technology devices, failure rate data may not be available;
- whilst the models may indicate that a low failure rate can be achieved through temperature reductions, in practice other stresses may predominate and render temperature reductions alone ineffective in achieving high reliability;
- the methods provide only a broad estimation of reliability;
- the assumption of constant failure rate during useful life may not always be valid;
- repairable systems cannot be modelled by this approach.

B.2.2 System simulation

The system or its functions are simulated either by hardware or software models. Hardware modelling (e.g. by a prototype) is quite common before launching the production. This is usually the best way to find out whether the design performs as required. Simulation usually takes a much longer time for reliability prediction purposes. Using software simulation, an analysis of complex stochastic processes of systems can be done.

B.2.3 Mathematical modelling and analysis

These methods model and analyse the system today to predict its future reliability behaviour. The following categories of mathematical prediction exist.

B.2.3.1 Basic probability calculations

These are restricted to very simple systems having simple structures. For these, formulae exist that can be used to determine system reliability from components reliability data.

On the other hand, expenditure rises exponentially with the number of components and system complexity, and the results are valid only for one instant of time. Such analysis should therefore be limited to complicated active components (key components).

B.2.3.2 Theory of stochastic processes

It describes the performance and failures of a system versus time. Basic variables used are system states, mean time intervals for the states and probabilities for state transitions. Usually, deterministic and stochastic processes occur at the same time, for example change of tariff (deterministic) and unpredictable operational/failed states (stochastic).

B.2.4 Testing

Accelerated life testing is another useful technique, but it is important that the right failure mechanisms are exercised, for example to make sure that excessive temperature stresses do not change the main failure mechanism and, in case of the presence of different failure mechanisms, the basic relationship between them stays the same.

B.2.5 Collecting and processing field data

This can only be the last part of a prediction methodology, because it always lags behind. Field data form the one and only true basis for any reliability performance measurement. While this is a retrospective methodology, it can be used to calibrate prediction models for future use.

Using field data for reliability prediction requires the knowledge of the instant of time when the failure occurred, i.e. at what instant of time did the system transit from an operational to a faulty state. In order to accomplish this, failure criteria must be defined beforehand. In the case of metering equipment, it may be, for example the acceptable percentage error limits on the field.

In order to accomplish this, the failure criteria (e.g. acceptable percentage error in accuracy in the field, see IEC 62059-21) and the method for establishing the time of the failure shall be given.

Due to the operational process of electricity metering equipment, a delay may occur between the occurrence of the failure and logging of the failure, for example at the next regular meter reading time. Depending on the operational practice, this may be half a month or half a year on the average if monthly or yearly reading is used. Errors introduced due to this potential delay between the “true instant of failure” and the “logged instant of failure” are not significant in the long-term steady-state reliability prediction results. Thus, reliable data can be obtained by applying the IEC 62059-21.

Bibliography

Dependability standards

IEC 60300-3-1:2003, *Dependability management – Part 3-1: Application guide – Analysis techniques for dependability – Guide on methodology*

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

IEC 60300-3-5:2001, *Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles*

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

IEC 60605-3-2:1986, *Equipment reliability testing –* Part 3: *Preferred test conditions. Equipment for stationary use in weatherprotected locations – High degree of simulation*

IEC 60605-3-3:1992, *Equipment reliability testing – Part 3: Preferred test conditions – Section 3: Test Cycle 3: Equipment for stationary use in partially weatherprotected locations – Low degree of simulation*

IEC 60605-4:2001, *Equipment reliability testing –* Part 4: *Statistical procedures for exponential distribution – Point estimates, confidence intervals, prediction intervals and tolerance intervals*

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

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

NOTE Harmonized as EN 61078:1993 (not modified).

IEC 61165:1995, *Application of Markov techniques*

IEC 62308, *Reliability assessment methods*[1]

Reliability data handbooks

IEC 62380:2004, *Reliability handbook – Universal model for reliability prediction of electronic components, PCBs and equipment*

Siemens Norm 29500, *Failure rates of components*

SN29500 Part	Failure rates of components *Expected values for…*	Date of issue
1	Expected values, General	2004-01
1 H1		2005-01
2	Integrated circuits	2004-12
3	Discrete semiconductors	2004-12
4	Passive components	2004-03
5	Electrical connections	2004-06

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[1] To be published

6	Electrical and optical connectors and sockets	1996-06
7	Relays	1997-07
9	Switches and push buttons	1992-04
10	Signals and pilot lamps	1982-05
11	Contactors	1990-08
12	Optical semiconductor signal receivers	1994-03
13	Light-emitting diodes (LED), infrared-emitting diodes and semiconductor lasers	1994-03
14	Optocouplers and light barriers	1994-03

NOTE The latest issue of the Siemens Norm (with automatic update service) can be obtained from:

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Literature

CARUSO and DASGUPTA: *A fundamental overview of Accelerated-Testing Analytic Models*, RAMS 1998

LOLL, V.: *From Reliability-Prediction to a Reliability-budget* RAMS 1998

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-191	1990	International Electrotechnical Vocabulary (IEV) Chapter 191: Dependability and quality of service	-	-
+ A1	1999		-	-
+ A2	2002		-	-
IEC 61709	1996	Electronic components - Reliability - Reference conditions for failure rates and stress models for conversion	EN 61709	1998
IEC/TR 62059-11	2002	Electricity metering equipment - Dependability Part 11: General concepts	-	-
IEC/TR 62059-21	2002	Electricity metering equipment - Dependability Part 21: Collection of meter dependability data from the field	-	-

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