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TECHNICAL REPORT

Reliability of industrial automation devices and systems – Part 2: System reliability

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RELIABILITY OF INDUSTRIAL AUTOMATION DEVICES AND SYSTEMS –

Part 2: System reliability

FOREWORD

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IEC TR 63164-2 has been prepared by IEC technical committee 65: Industrial-process measurement, control and automation.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
65/771/DTR	65/796/RVDTR

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 63164 series, published under the general title *Reliability of industrial automation devices and systems*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Under the background of Smart Manufacturing, new production modes such as mass customization based on interconnected factories require real-time interconnection, frequent switching and integration across different levels. Therefore, reliability is an important requirement for automation systems in factories. Reliability data of automation systems is the basis for maintenance planning e.g. stock-keeping of spare parts of a production line. An automation system usually consists of several different devices or machines that are used in series, parallel or mixed. This technical report gives guidance for system integrator on how to evaluate the reliability of such entire systems.

This report is the second part of the series. This part concentrates on calculation of failure rates or reliability values for systems based on failure rates or reliability values of single devices depending on the structure of the system. This is necessary for system integrators or designers to be able to calculate the reliability of an entire system from the reliability values of individual devices (see IEC TS 63164-1).

Parts within IEC 63164 series are:

Part 1: Assurance of automation devices reliability data and specification of their source

Part 2: System reliability

Future parts may include following subjects:

- collecting reliability data for automation devices in the field;
- user guide.

RELIABILITY OF INDUSTRIAL AUTOMATION DEVICES AND SYSTEMS –

Part 2: System reliability

1 Scope

This part of IEC 63164 provides guidance on the calculation of reliability data of automation systems which can be simplified as series, parallel or mixed structure based on reliability data of single devices and/or sub-systems, and on the form to present the data.

NOTE This procedure is only targeted to the reliability of automation systems, but not systems that embed automation systems, e.g. process plant.

Reliability is included in dependability, and this document is mainly focused on random hardware failures that affect reliability. Dependability is used as a collective term for the time-related quality characteristics of an item and additionally includes availability, recoverability, maintainability, maintenance support performance, and, in some cases, other characteristics such as durability, safety and security, which are all not in the scope of this Technical Report.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
automation system
DCS- or PLC-based system for the monitoring and controlling of production facilities in the process industry, including control systems based on fieldbus technologies

Note 1 to entry: Whenever “system” is mentioned in this document, it means “automation system”.

[SOURCE: IEC 62381:2012, 3.1.1, modified – Note 1 to entry has been added.]

3.1.2
B_{10} threshold
time until 10 % of the components fail

Note 1 to entry: The applicable time interval is dependent on the nature and application of the asset and can be elapsed time, operating hours, number of cycles, etc.

Note 2 to entry: For this document, an average failure rate is calculated from the B_{10} threshold by dividing 10 % with the B_{10} threshold in hours. The influence of infant mortality is neglected and increasing failure rate is assumed only significant after B_{10}.

Note 3 to entry: Once the B_{10} threshold is reached, the failure rate is assumed unacceptable for pneumatic and electromechanical components.

3.1.3
dependability
ability to perform as and when required

Note 1 to entry: Dependability includes availability (192-01-23), reliability (192-01-24), recoverability (192-01-25), maintainability (192-01-27), and maintenance support performance (192-01-29), and, in some cases, other characteristics such as durability (192-01-21), safety and security.

Note 2 to entry: Dependability is used as a collective term for the time-related quality characteristics of an item.

[SOURCE: IEC 60050-192:2015, 192-01-22]

3.1.4
failure rate
λ
limit, if it exists, of the quotient of the conditional probability that the failure of a non-repairable item occurs within time interval $(t, t + \Delta t)$ by Δt, when Δt tends to zero, given that failure has not occurred within time interval $(0, t)$

Note 1 to entry: See IEC 61703, Mathematical expressions for reliability, availability, maintainability and maintenance support terms, for more detail.

[SOURCE: IEC 60050-192:2015, 192-05-06, modified – The first preferred term "instantaneous failure rate", formula and Note 2 to entry have been deleted]

3.1.5
mean operating time between failures
MTBF
expectation of the duration of the operating time between failures

Note 1 to entry: Mean operating time between failures should only be applied to repairable items. For non-repairable items, see mean operating time to failure (192-05-11).

[SOURCE: IEC 60050-192:2015, 192-05-13, modified – The last preferred term "MOTBF" has been deleted]

3.1.6
mean operating time to failure
MTTF
expectation of the operating time to failure

Note 1 to entry: In the case of non-repairable items with an exponential distribution of operating times to failure (i.e. a constant failure rate) the MTTF is numerically equal to the reciprocal of the failure rate. This is also true for repairable items if after restoration they can be considered to be "as-good-as-new".

[SOURCE: IEC 60050-192:2015, 192-05-11, modified – Note 2 has been deleted]

3.1.7
mean time to restoration
MTTR
expectation of the time to restoration

Note 1 to entry: IEC 60050-191:1990 (now withdrawn; replaced by IEC 60050-192:2015) defined the term ”mean time to recovery” as a synonym, but restoration and recovery are not synonyms.

[SOURCE: IEC 60050-192:2015, 192-07-23]

3.1.8
mission time
T_M
period of time covering the intended use

Note 1 to entry: For complex system with maintenance of components, the mission time of system can be longer than the mission time of individual components of the system.

[SOURCE: ISO 13849-1:2015, 3.1.28, modified – "of an SRP/CS" has been deleted and the note to entry has been added]

3.1.9
random hardware failure
failure, occurring at a random time, which results from one or more of the possible degradation mechanisms in the hardware

[SOURCE: IEC 61508-4:2010, 3.6.5, modified – The notes have been deleted]

3.1.10
reliability

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

Note 1 to entry: The time interval duration may be expressed in units appropriate to the item concerned, e.g. calendar time, operating cycles, distance run, etc., and the units should always be clearly stated.

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

[SOURCE: IEC 60050-192:2015, 192-01-24, modified – Note 3 to entry has been deleted]

3.1.11
systematic failure
failure, related in a deterministic way to a certain cause, which can only be eliminated by a modification of the design or of the manufacturing process, operational procedures, documentation or other relevant factors

Note 1 to entry: Corrective maintenance without modification will usually not eliminate the failure cause.

Note 2 to entry: A systematic failure can be induced by simulating the failure cause.

Note 3 to entry: Examples of causes of systematic failures include human error in

– the safety requirements specification;

– the design, manufacture, installation, operation of the hardware;

– the design, implementation, etc. of the software.

Note 4 to entry: In this document, failures in a safety-related system are categorized as random hardware failures (see 3.1.9) or systematic failures.

[SOURCE: IEC 61508-4:2010, 3.6.6]

3.1.12
useful life
time interval, from first use until user requirements are no longer met, due to economics of operation and maintenance, or obsolescence

Note 1 to entry: In this context, “first use” excludes testing activities prior to hand-over of the item to the end-user.

[SOURCE: IEC 60050-192:2015, 192-02-27]

3.2 Abbreviated terms

FIT	Failures in time
METBF	Mean (elapsed) time between failures
MTBF	Mean operating time between failures
MTTF	Mean operating time to failure
MTTR	Mean time to restoration
T_M	Mission time
FMEA	Fault modes and effects analysis
FTA	Fault tree analysis
RBD	Reliability block diagram
PoF	Physics of failure

4 System reliability

Typically, an automation system consists of several different types of sub-systems, automation devices and accessories, and requires consistency in the reliability data of the automation system as well as automation devices.

The reliability of the system needs to consider the reliability of hardware, including interface, communication, etc. In addition to hardware reliability, other factors such as software, human factor, security, may also be considered (see Annex A).

NOTE Communication in this document means the hardware used for communication, such as cable, router.

5 Calculation of system reliability

5.1 General

This document provides guidance for calculation of system reliability for simple system structures with constant failure rates for its elements, based on reliability block diagrams. For these and other type of system structures, e.g. k-out-of-n structures, see e.g. IEC 61078. For more information about other calculation methods for systems, see e.g. IEC 60300-3-1.

Reliability data from observation of devices in the field and laboratory test are not addressed in this document, but it is referred to IEC TS 63164-1.

Every single element of the system needs to have reliability data, like MTTF, MTBF, λ or B_{10}. To calculate the whole system all single elements need the same kind of data.

Some values for reliability data can be derived as following under certain conditions, see IEC 61703.

Example:

MTTF = $1/\lambda$ (for constant failure rate)

$\lambda = 0{,}1 \times C/B_{10}$ (assuming constant failure rate), where C is equal to the number of operations per hour and B_{10} is given in cycles, see IEC 62061.