IEC 60947-5-3

Edition 2.0 2013-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Low-voltage switchgear and controlgear –
Part 5-3: Control circuit devices and switching elements – Requirements for proximity devices with defined behaviour under fault conditions (PDDB)

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Appareillage à basse tension –
Partie 5-3: Appareils et éléments de commutation pour circuits de commande – Exigences pour dispositifs de détection de proximité à comportement défini dans des conditions de défaut (PDDB)

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 5-3: Control circuit devices and switching elements – Requirements for proximity devices with defined behaviour under fault conditions (PDDB)

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International Standard IEC 60947-5-3 has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This second edition replaces the first edition published in 1999 and its amendment published in 2005. It is a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) general principles of IEC 61508 series;
b) classification according to the requirements of IEC 62061;
c) classification according to ISO 13849-1.

This standard is to be read in conjunction with IEC 60947-1, *Low voltage switchgear and controlgear – Part 1: General rules* and IEC 60947-5-2, *Low-voltage switchgear and*

controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches. The provisions of Part 1 and Part 5-2 are only applicable to this standard where specifically called for. The numbering of the subclauses of this standard is sometimes not continuous because it is based on the numbering of the subclauses of IEC 60947-1 or IEC 60947-5-2.

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

FDIS	Report on voting
17B/1821/FDIS	17B/1826/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.

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

A list of all parts in the IEC 60947 series, published under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website.

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

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 5-3: Control circuit devices and switching elements – Requirements for proximity devices with defined behaviour under fault conditions (PDDB)

1 General

1.1 Scope

This part of IEC 60947 series provides additional requirements to those given in IEC 60947-5-2. It addresses the fault performance aspects of proximity devices with a defined behaviour under fault conditions (PDDB). It does not address any other characteristics that can be required for specific applications.

This standard does not cover proximity devices with analogue output.

This Standard does not deal with any specific requirements on acoustic noise as the noise emission of control circuit devices and switching elements is not considered to be a relevant hazard.

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For a PDDB used in applications where additional characteristics, dealt with in other standards, are required, the requirements of all relevant standards apply.

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The use of this standard alone does not demonstrate suitability for the implementation of any specific safety related functionality. In particular, this standard does not provide requirements for the actuation characteristics of a PDDB, or for means to reduce the effects of mutual interference between devices, e.g. coded targets. Therefore these and any other application-specific requirements will need to be considered in addition to the requirements of this standard.

NOTE 1 Due to their behaviour under fault conditions, PDDBs can, for example, be used as interlocking devices (see ISO 14119).

NOTE 2 The requirements for electro-sensitive protective equipment for the detection of persons are given in the IEC 61496 series.

1.2 Normative references

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

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 + 12 h cycle)*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
Amendment 1:1999

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*
Amendment 1:2010

IEC 60947-5-1:2003, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*
Amendment 1:2009

IEC 60947-5-2:2007, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*
Amendment 1:2012

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
Amendment 1:2007
Amendment 2:2010

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

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IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

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IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61131-2:2007, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61508-1:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*

IEC 61508-2:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

IEC 61508-3:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements*

IEC 62061:2005, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
Amendment 1:2012

ISO 13849-1:2006, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

2 Terms, definitions and abbreviations

2.1 General

For the purposes of this document, the terms and definitions given in IEC 60947-1 and IEC 60947-5-2, as well as the following terms, definitions and abbreviations apply.

2.2 Alphabetic index of terms

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2.3 Basic terms and definitions

2.3.1
Performance Level
PL
discrete level (from a to e) used to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions

[SOURCE: ISO 13849-1:2006, 3.1.23, modified – update of the definition]

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2.3.2
Safety Integrity Level
SIL
discrete level (one out of a possible three) for specifying the safety integrity requirements of the safety-related control functions to be allocated to the safety related parts of the control system, where safety integrity level three has the highest level of safety integrity and safety integrity level one has the lowest

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Note 1 to entry: SIL 4 is not considered in this standard. For requirements applicable to SIL 4, see IEC 61508 series.

[SOURCE: IEC 62061:2005, 3.2.23, modified – update of the note]

2.3.3
low complexity component
component in which:

– the failure modes are well-defined; and

– the behaviour under fault conditions can be completely defined

Note 1 to entry: Behaviour of the low complexity component under fault conditions may be determined by analytical and/or test methods.

Note 2 to entry: A subsystem or subsystem element comprising one or more limit switches, operating, possibly via interposing electro-mechanical relays, one or more contactors to de-energise an electric motor is an example of a low complexity component.

[SOURCE: IEC 62061:2005, 3.2.7]

2.3.4
complex component
component in which:

– the failure modes are not well-defined; or

– the behaviour under fault conditions cannot be completely defined

[SOURCE: IEC 62061:2005, 3.2.8]

2.3.5
failure
the termination of the ability of an item to perform a required function

Note 1 to entry: After failure the system has a fault.

Note 2 to entry: “Failure” is an event, as distinguished from “fault”, which is a state.

Note 3 to entry: The concept of failure as defined does not apply to items consisting of software only.

[SOURCE: IEC 60050-191:1990, 191-04-01]

2.3.6
dangerous failure
failure of a PDDB that has the potential to cause a hazard or non-functional state

[SOURCE: IEC 62061:2005, 3.2.40, modified – deletion of the notes]

2.3.7
safe failure
failure of a PDDB that does not have the potential to cause a hazard

[SOURCE: IEC 62061:2005, 3.2.41 modified – update of the definition]

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2.3.8
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

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Note 1 to entry: A fault is often the result of the item itself but can exist without prior failure.

Note 2 to entry: In English the term “fault” and its definition are identical to those given in IEC 60050-191:1990, 191-05-01. In the field of machinery, the French term “défaut” and the German term “Fehler” are used rather than the term “panne” and “Fehlzustand” that appear with this definition.

[SOURCE: IEC 62061:2005, 3.2.30, modified – new definition and new notes]

2.3.9
Safety-Related Control Function
SRCF
control function with a specified integrity level, partly or completely implemented by a PDDB, that is intended to maintain the safe condition of the equipment under control or prevent an immediate increase of the risk(s)

Note 1 to entry: ISO 13849-1 uses the term SRF (safety related function), IEC 61508 series uses SF (safety function), Terms and definitions concerning the integrity.

[SOURCE: IEC 62061:2005, 3.2.16 modified – new definition and new note]

2.3.10
safety integrity
probability of a safety related control system or its PDDB satisfactorily performing the required safety-related control functions under all stated conditions

[SOURCE: IEC 62061:2005, 3.2.19, modified – update of the definition and deletion of the notes]

2.3.11
hardware safety integrity
part of the safety integrity of a safety related control system or its PDDB comprising requirements for both the probability of dangerous random hardware failures and architectural constraints

[SOURCE: IEC 62061:2005, 3.2.20, modified – update of the definition]

2.3.12
software safety integrity
part of the safety integrity of a PDDB relating to systematic failures in a dangerous mode of failure that are attributable to software

Note 1 to entry: Software safety integrity cannot usually be quantified precisely.

[SOURCE: IEC 61508-4:2010, 3.5.5, modified – update of the definition and addition of a note]

2.3.13
systematic safety integrity
part of the safety integrity of a PDDB relating to systematic failures in a dangerous mode of failure

Note 1 to entry: Systematic safety integrity cannot usually be quantified (as distinct from hardware safety integrity which usually can).

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Note 2 to entry: Requirements for systematic safety integrity apply to both hardware and software aspects of a PDDB.

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[SOURCE: IEC 61508-4:2010, 3.5.6 modified – update of the definition and addition of a note]

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2.3.14
mode of operation
way in which a safety function operates, which may be either:

– **low demand mode**: where the safety function is only performed on demand, in order to transfer the EUC into a specified safe state, and where the frequency of demands is no greater than one per year; or

Note 1 to entry: The E/E/PE safety-related system that performs the safety function normally has no influence on the EUC or EUC control system until a demand arises. However, if the E/E/PE safety-related system fails in such a way that it is unable to carry out the safety function then it may cause the EUC to move to a safe state.

– **high demand mode:** where the safety function is only performed on demand, in order to transfer the EUC into a specified safe state, and where the frequency of demands is greater than one per year; or

– **continuous mode:** where the safety function retains the EUC in a safe state as part of normal operation

[SOURCE: IEC 61508-4:2010, 3.5.16, modified – update of the note]

2.3.15
target failure measure
intended probability of dangerous mode failures to be achieved in respect of the safety integrity requirements, specified in terms of either:

– the average probability of dangerous failure to perform the design function on demand PFD_{avg} (for a low demand mode of operation);

– the average frequency of a dangerous failure over a given period of time PFH_D (for a high demand or continuous mode of operation)

Note 1 to entry: The term “probability of dangerous failure per hour” is not used in the standard but the abbreviation PFH has been retained but when it is used it means “average frequency of dangerous failure”.

Note 2 to entry: The numerical values for the target failure measures are given in Table 2 and Table 3 of IEC 61508-1:2010. These limit values are valid for the whole safety related function.

[Adapted from IEC 61508-4:2010, 3.5.17]

2.3.16
SIL Claim Limit
SILCL
maximum SIL that can be claimed for a PDDB in relation to architectural constraints and systematic safety integrity

[SOURCE: IEC 62061:2005, 3.2.24 modified – update of the definition]

2.3.17
mean time to dangerous failure
$MTTF_d$
expectation of the mean time to dangerous failure

Note 1 to entry: Adapted from IEC 62061:2005, definition 3.2.34.

[SOURCE: ISO 13849-1:2006, 3.1.25]

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2.3.18
failure in time
FIT
the number of failures in 10^9 device-hours of operation

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2.4 Terms and definitions concerning the architectural constraints

2.4.1
safe failure fraction
SFF
ratio of the average failure rates of safe failures plus dangerous detected failures of the PDDB to the total average failure rate (sum of safe failure rate and all dangerous failure rate) of the PDDB

[Adapted from IEC 61508-4:2010, 3.6.15]

2.4.2
diagnostic coverage
DC
measure of the effectiveness of diagnostics, which may be determined as the ratio between the failure rate of detected dangerous failures and the failure rate of total dangerous failures

[SOURCE: ISO 13849-1:2006, 3.1.26, modified – deletion of the notes]

fraction of dangerous failures detected by automatic on-line diagnostic tests

Note 1 to entry: The fraction of detected dangerous failures is computed to be the rate of dangerous failures that are detected by automatic on-line diagnostic tests divided by the rate of total dangerous failures.

Note 2 to entry: There is a different approach between the IEC 62061/IEC 61508 and ISO 13849-1 failure concepts. Prescriptions for architectural constraints on subsystems according to IEC 62061:2005 (Table 5) are given as a function of the hardware fault tolerance and the safe failure fraction. ISO 13849-1 does not consider any safe failure/safe failure fraction. Performance levels are based on well-defined architectures. The achieved PL is then a function of the architecture, the $MTTF_d$, the diagnostic coverage and the common cause failures.

[SOURCE: IEC 62061:2005, 3.2.38, modified – update of the notes]

2.4.3
hardware fault tolerance
HFT
ability of a system to perform its safety function in the presence of faults

Note 1 to entry: Hardware fault tolerance of N means that N+1 faults could cause a loss of the safety function. In determining the hardware fault tolerance no consideration is given to other faults, for example in diagnostics.

[Adapted from IEC 61508-2:2010, 7.4.4.1.1]

2.4.4
diagnostic test interval
interval between on-line tests to detect faults in a safety-related system that has a specified diagnostic coverage

[SOURCE: IEC 61508-4:2010, 3.8.7]

2.4.5
proof test
periodic test performed to detect failures in a safety-related system so that, if necessary, the system can be restored to an “as new” condition or as close as practical to this condition

[SOURCE: IEC 61508-4:2010, 3.8.5, modified – update of the definition and deletion of the notes]

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2.4.6
safety-related system
designated system that both

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– implements the required safety functions necessary to achieve or maintain a safe state for the Equipment Under Control; and
– is intended to achieve, on its own or with other E/E/PE safety-related systems, other technology safety-related systems or external risk reduction facilities, the necessary safety integrity for the required safety functions

[SOURCE: IEC 61508-4:2010, 3.4.1, modified – deletion of the notes]

2.4.7
equipment under control
EUC
equipment, machinery, apparatus or plant used for manufacturing, process, transportation, medical or other activities

Note 1 to entry: The EUC control system is separate and distinct from the EUC.

[SOURCE: IEC 61508-4:2010, 3.2.1]

2.5 Terms and definitions concerning the parts of a PDDB

2.5.1
sensing means
part of the PDDB which detects the presence or absence of a defined target

2.5.2
output signal switching device
OSSD
component of the PDDB which goes to the OFF-state according to the defined behaviour