

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Functional safety of electrical/electronic/programmable electronic
safety-related systems –
Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3**

**Sécurité fonctionnelle des systèmes électriques/électroniques/électroniques
programmables relatifs à la sécurité –
Partie 6: Lignes directrices pour l'application de la CEI 61508-2 et de
la CEI 61508-3**

<https://www.internationalstandards.org/4772280b-f14c-4203-976a-17646297db72/iec-61508-6-2000>

WUJIAOJIAN



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2000 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00



IEC 61508-6

Edition 1.0 2000-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Functional safety of electrical/electronic/programmable electronic
safety-related systems –
Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3**

**Sécurité fonctionnelle des systèmes électriques/électroniques/électroniques
programmables relatifs à la sécurité –
Partie 6: Lignes directrices pour l'application de la CEI 61508-2 et de
la CEI 61508-3**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XB

ICS 25.040.40

ISBN 2-8318-5211-0

CONTENTS

| | Page |
|---|------|
| FOREWORD | 6 |
| INTRODUCTION | 8 |
| Clause | |
| 1 Scope | 10 |
| 2 Normative references | 12 |
| 3 Definitions and abbreviations | 12 |
| | |
| Annex A (informative) Application of IEC 61508-2 and of IEC 61508-3 | 13 |
| A.1 General | 13 |
| A.2 Functional steps in the application of IEC 61508-2 | 15 |
| A.3 Functional steps in the application of IEC 61508-3 | 19 |
| Annex B (informative) Example technique for evaluating probabilities of hardware failure ... | 21 |
| B.1 General | 21 |
| B.2 Average probability of failure on demand (for low demand mode of operation) | 25 |
| B.3 Probability of failure per hour (for high demand or continuous mode of operation) | 38 |
| B.4 References | 46 |
| Annex C (informative) Calculation of diagnostic coverage and safe failure fraction: worked example | 47 |
| Annex D (informative) A methodology for quantifying the effect of hardware-related common cause failures in E/E/PE systems | 51 |
| D.1 General | 51 |
| D.2 Brief overview | 51 |
| D.3 Scope of the methodology | 55 |
| D.4 Points taken into account in the methodology | 55 |
| D.5 Using the β -factor to calculate the probability of failure in an E/E/PE safety-related system due to common cause failures | 56 |
| D.6 Using the tables to estimate β | 57 |
| D.7 Examples of the use of the methodology | 61 |
| D.8 References | 62 |
| Annex E (informative) Example applications of software safety integrity tables of IEC 61508-3 | 63 |
| E.1 General | 63 |
| E.2 Example for safety integrity level 2 | 63 |
| E.3 Example for safety integrity level 3 | 68 |
| | |
| Bibliography | 73 |

| | Page |
|--|------|
| Figure 1 – Overall framework of IEC 61508 | 1 1 |
| Figure A.1 – Application of IEC 61508-2 | 1 7 |
| Figure A.2 – Application of IEC 61508-2 (continued) | 1 8 |
| Figure A.3 – Application of IEC 61508-3 | 2 0 |
| Figure B.1 – Example configuration for two sensor channels | 2 3 |
| Figure B.2 – Subsystem structure | 2 5 |
| Figure B.3 – 1oo1 physical block diagram | 2 6 |
| Figure B.4 – 1oo1 reliability block diagram | 2 6 |
| Figure B.5 – 1oo2 physical block diagram | 2 7 |
| Figure B.6 – 1oo2 reliability block diagram | 2 8 |
| Figure B.7 – 2oo2 physical block diagram | 2 8 |
| Figure B.8 – 2oo2 reliability block diagram | 2 8 |
| Figure B.9 – 1oo2D physical block diagram | 2 9 |
| Figure B.10 – 1oo2D reliability block diagram | 2 9 |
| Figure B.11 – 2oo3 physical block diagram | 3 0 |
| Figure B.12 – 2oo3 reliability block diagram | 3 0 |
| Figure B.13 – Architecture of an example for low demand mode of operation | 3 5 |
| Figure B.14 – Architecture of an example for high demand or continuous mode of operation | 4 4 |
| Figure D.1 – Relationship of common cause failures to the failures of individual channels .. | 5 3 |
| | |
| Table B.1 – Terms and their ranges used in this annex (applies to 1oo1, 1oo2, 2oo2, 1oo2D and 2oo3) | 2 4 |
| Table B.2 – Average probability of failure on demand for a proof test interval of six months and a mean time to restoration of 8 h | 3 1 |
| Table B.3 – Average probability of failure on demand for a proof-test interval of one year and mean time to restoration of 8 h | 3 2 |
| Table B.4 – Average probability of failure on demand for a proof-test interval of two years and a mean time to restoration of 8 h | 3 3 |
| Table B.5 – Average probability of failure on demand for a proof-test interval of 10 years and a mean time to restoration of 8 h | 3 4 |
| Table B.6 – Average probability of failure on demand for the sensor subsystem in the example for low demand mode of operation (one year proof-test interval and 8 h MTTR) | 3 5 |
| Table B.7 – Average probability of failure on demand for the logic subsystem in the example for low demand mode of operation (one year proof-test interval and 8 h MTTR) | 3 6 |
| Table B.8 – Average probability of failure on demand for the final element subsystem in the example for low demand mode of operation (one year proof-test interval and 8 h MTTR) | 3 6 |

Table B.9 – Example for a non-perfect proof test..... 3 8

Table B.10 – Probability of failure per hour (in high demand or continuous mode of operation) for a proof-test interval of one month and a mean time to restoration of 8 h..... 4 0

Table B.11 – Probability of failure per hour (in high demand or continuous mode of operation) for a proof test interval of three months and a mean time to restoration of 8 h..... 4 1

Table B.12 – Probability of failure per hour (in high demand or continuous mode of operation) for a proof test interval of six months and a mean time to restoration of 8 h..... 4 2

Table B.13 – Probability of failure per hour (in high demand or continuous mode of operation) for a proof-test interval of one year and a mean time to restoration of 8 h..... 4 3

Table B.14 – Probability of failure per hour for the sensor subsystem in the example for high demand or continuous mode of operation (six month proof-test interval and 8 h MTTR)..... 4 4

Table B.15 – Probability of failure per hour for the logic subsystem in the example for high demand or continuous mode of operation (six month proof-test interval and 8 h MTTR)..... 4 5

Table B.16 – Probability of failure per hour for the final element subsystem in the example for high demand or continuous mode of operation (six month proof-test interval and 8 h MTTR)..... 4 5

Table C.1 – Example calculations for diagnostic coverage and safe failure fraction..... 4 9

Table C.2 – Diagnostic coverage and effectiveness for different subsystems 5 0

Table D.1 – Scoring programmable electronics or sensors/final elements..... 5 8

Table D.2 – Value of Z: programmable electronics 6 0

Table D.3 – Value of Z: sensors or final elements..... 6 0

Table D.4 – Calculation of β or β_b 6 1

Table D.5 – Example values for programmable electronics..... 6 2

Table E.1 – Software safety requirements specification (see 7.2 of IEC 61508-3)..... 6 4

Table E.2 – Software design and development: software architecture design (see 7.4.3 of IEC 61508-3)..... 6 5

Table E.3 – Software design and development: support tools and programming language (see 7.4.4 of IEC 61508-3)..... 6 5

Table E.4 – Software design and development: detailed design (see 7.4.5 and 7.4.6 of IEC 61508-3) (this includes software system design, software module design and coding)..... 6 6

Table E.5 – Software design and development: software module testing and integration (see 7.4.7 and 7.4.8 of IEC 61508-3)..... 6 6

Table E.6 – Programmable electronics integration (hardware and software) (see 7.5 of IEC 61508-3)..... 6 6

Table E.7 – Software safety validation (see 7.7 of IEC 61508-3) 6 7

Table E.8 – Software modification (see 7.8 of IEC 61508-3) 6 7

Table E.9 – Software verification (see 7.9 of part 3) 6 7

Table E.10 – Functional safety assessment (see clause 8 of IEC 61508-3) 6 8

| | Page |
|--|------|
| Table E.11 – Software safety requirements specification (see 7.2 of IEC 61508-3)..... | 6 9 |
| Table E.12 – Software design and development: software architecture design (see 7.4.3 of IEC 61508-3)..... | 6 9 |
| Table E.13 – Software design and development: support tools and programming language (see 7.4.4 of IEC 61508-3) | 7 0 |
| Table E.14 – Software design and development: detailed design (see 7.4.5 and 7.4.6 of IEC 61508-3) (this includes software system design, software module design and coding) | 7 0 |
| Table E.15 – Software design and development: software module testing and integration (see 7.4.7 and 7.4.8 of IEC 61508-3)..... | 7 1 |
| Table E.16 – Programmable electronics integration (hardware and software) (see 7.5 of IEC 61508-3)..... | 7 1 |
| Table E.17 – Software safety validation (see 7.7 of IEC 61508-3)..... | 7 1 |
| Table E.18 – Modification (see 7.8 of IEC 61508-3)..... | 7 2 |
| Table E.19 – Software verification (see 7.9 of IEC 61508-3)..... | 7 2 |
| Table E.20 – Functional safety assessment (see clause 8 of IEC 61508-3) | 7 2 |

iTeh Standards
(<https://standards.itih.ai>)
Document Preview

IEC 61508-6:2000

<https://standards.itih.ai/standards/iec/4/72280b-f14c-4203-976a-17646297db72/iec-61508-6-2000>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FUNCTIONAL SAFETY OF ELECTRICAL/ELECTRONIC/PROGRAMMABLE ELECTRONIC SAFETY-RELATED SYSTEMS –

Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3

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.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

IEC 61508-6 has been prepared by subcommittee 65A: System aspects, of IEC technical committee 65: Industrial-process measurement and control.

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

| | |
|--------------|------------------|
| FDIS | Report on voting |
| 65A/295/FDIS | 65A/304/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 3.

Annexes A to E are for information only.

IEC 61508 consists of the following parts, under the general title *Functional safety of electrical/electronic/programmable electronic safety-related systems*:

- Part 1: General requirements
- Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems

- Part 3: Software requirements
- Part 4: Definitions and abbreviations
- Part 5: Examples of methods for the determination of safety integrity levels
- Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3
- Part 7: Overview of techniques and measures

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

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

Withdrawing

iTech Standards
(<https://standards.itih.ai>)
Document Preview

<https://standards.itih.ai/standards/iec/472280b-f14c-4203-976a-17646297db72/iec-61508-6-2000>

INTRODUCTION

Systems comprised of electrical and/or electronic components have been used for many years to perform safety functions in most application sectors. Computer-based systems (generically referred to as programmable electronic systems (PESs)) are being used in all application sectors to perform non-safety functions and, increasingly, to perform safety functions. If computer system technology is to be effectively and safely exploited, it is essential that those responsible for making decisions have sufficient guidance on the safety aspects on which to make those decisions.

This International Standard sets out a generic approach for all safety lifecycle activities for systems comprised of electrical and/or electronic and/or programmable electronic components (electrical/ electronic/programmable electronic systems (E/E/PESs)) that are used to perform safety functions. This unified approach has been adopted in order that a rational and consistent technical policy be developed for all electrically based safety-related systems. A major objective is to facilitate the development of application sector standards.

In most situations, safety is achieved by a number of protective systems which rely on many technologies (for example mechanical, hydraulic, pneumatic, electrical, electronic, programmable electronic). Any safety strategy must therefore consider not only all the elements within an individual system (for example sensors, controlling devices and actuators) but also all the safety-related systems making up the total combination of safety-related systems. Therefore, while this International Standard is concerned with electrical/ electronic/programmable electronic (E/E/PE) safety-related systems, it may also provide a framework within which safety-related systems based on other technologies may be considered.

It is recognized that there is a great variety of E/E/PES applications in a variety of application sectors and covering a wide range of complexity, hazard and risk potentials. In any particular application, the exact prescription of safety measures is dependent on many factors specific to the application. This International Standard, by being generic, will enable such a prescription to be formulated in future application sector international standards.

This International Standard

- considers all relevant overall, E/E/PES and software safety lifecycle phases (for example, from initial concept, through design, implementation, operation and maintenance to decommissioning) when E/E/PESs are used to perform safety functions;
- has been conceived with a rapidly developing technology in mind; the framework is sufficiently robust and comprehensive to cater for future developments;
- enables application sector international standards, dealing with safety-related E/E/PESs, to be developed; the development of application sector international standards, within the framework of this International Standard, should lead to a high level of consistency (for example, of underlying principles, terminology, etc.) both within application sectors and across application sectors; this will have both safety and economic benefits;
- provides a method for the development of the safety requirements specification necessary to achieve the required functional safety for E/E/PE safety-related systems;
- uses safety integrity levels for specifying the target level of safety integrity for the safety functions to be implemented by the E/E/PE safety-related systems;

- adopts a risk-based approach for the determination of the safety integrity level requirements;
- sets numerical target failure measures for E/E/PE safety-related systems which are linked to the safety integrity levels;
- sets a lower limit on the target failure measures, in a dangerous mode of failure, that can be claimed for a single E/E/PE safety-related system; for E/E/PE safety-related systems operating in
 - a low demand mode of operation, the lower limit is set at an average probability of failure of 10^{-5} to perform its design function on demand,
 - a high demand or continuous mode of operation, the lower limit is set at a probability of a dangerous failure of 10^{-9} per hour;

NOTE A single E/E/PE safety-related system does not necessarily mean a single-channel architecture.

- adopts a broad range of principles, techniques and measures to achieve functional safety for E/E/PE safety-related systems, but does not rely on the concept of fail-safe, which may be of value when the failure modes are well-defined and the level of complexity is relatively low – the concept of fail-safe was considered inappropriate because of the full range of complexity of E/E/PE safety-related systems that are within the scope of the standard.

Withhold

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

<https://standards.iteh.ai> IEC 61508-6:2000

<https://standards.iteh.ai/standards/iec/472280b-f14c-4203-976a-17646297db72/iec-61508-6-2000>

FUNCTIONAL SAFETY OF ELECTRICAL/ELECTRONIC/PROGRAMMABLE ELECTRONIC SAFETY-RELATED SYSTEMS –

Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3

1 Scope

1.1 This part of IEC 61508 contains information and guidelines on IEC 61508-2 and IEC 61508-3.

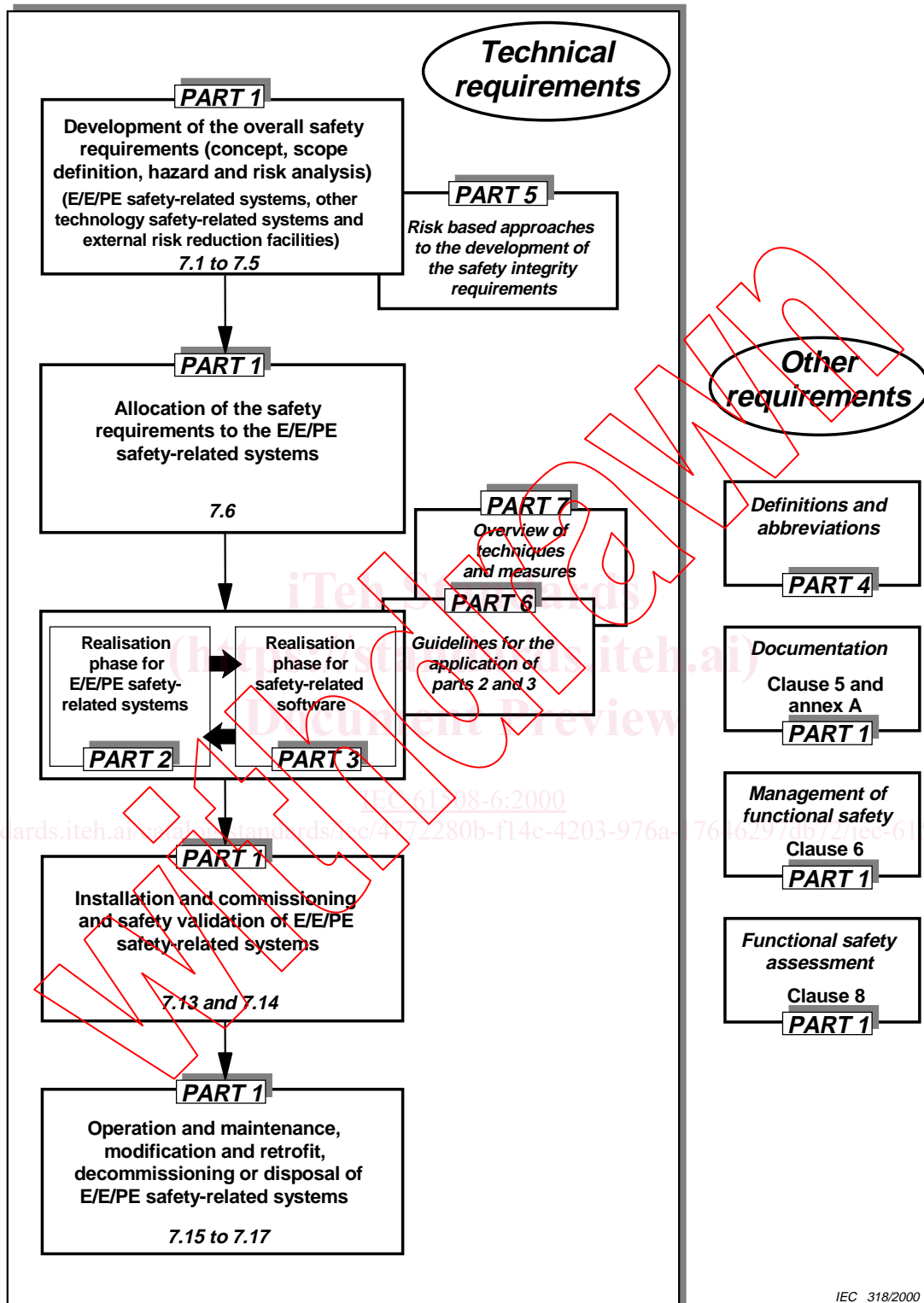
- Annex A gives a brief overview of the requirements of IEC 61508-2 and IEC 61508-3 and sets out the functional steps in their application.
- Annex B gives an example technique for calculating the probabilities of hardware failure and should be read in conjunction with 7.4.3 and annex C of IEC 61508-2 and annex D.
- Annex C gives a worked example of calculating diagnostic coverage and should be read in conjunction with annex C of IEC 61508-2.
- Annex D gives a methodology for quantifying the effect of hardware-related common cause failures on the probability of failure.
- Annex E gives worked examples of the application of the software safety integrity tables specified in annex A of IEC 61508-3 for safety integrity levels 2 and 3.

1.2 IEC 61508-1, IEC 61508-2, IEC 61508-3 and IEC 61508-4 are basic safety publications, although this status does not apply in the context of low complexity E/E/PE safety-related systems (see 3.4.4 of IEC 61508-4). As basic safety publications, they are intended for use by technical committees in the preparation of standards in accordance with the principles contained in IEC Guide 104 and IEC/ISO Guide 51. IEC 61508 is also intended for use as a stand-alone standard.

1.3 One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications. In this context, the requirements, test methods or test conditions of this basic safety publication do not apply unless specifically referred to or included in the publications prepared by those technical committees.

NOTE In the USA and Canada, until the proposed process sector implementation of IEC 61508 (i.e. IEC 61511) is published as an international standard, existing national process safety standards based on IEC 61508 (i.e. ANSI/ISA 884.01-1996) can be applied to the process sector instead of IEC 61508.

1.4 Figure 1 shows the overall framework for parts 1 to 7 of this standard and indicates the role that IEC 61508-6 plays in the achievement of functional safety for E/E/PE safety-related systems.



IEC 318/2000

Figure 1 – Overall framework of IEC 61508

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61508. 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 61508 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 ISO and IEC maintain registers of currently valid International Standards.

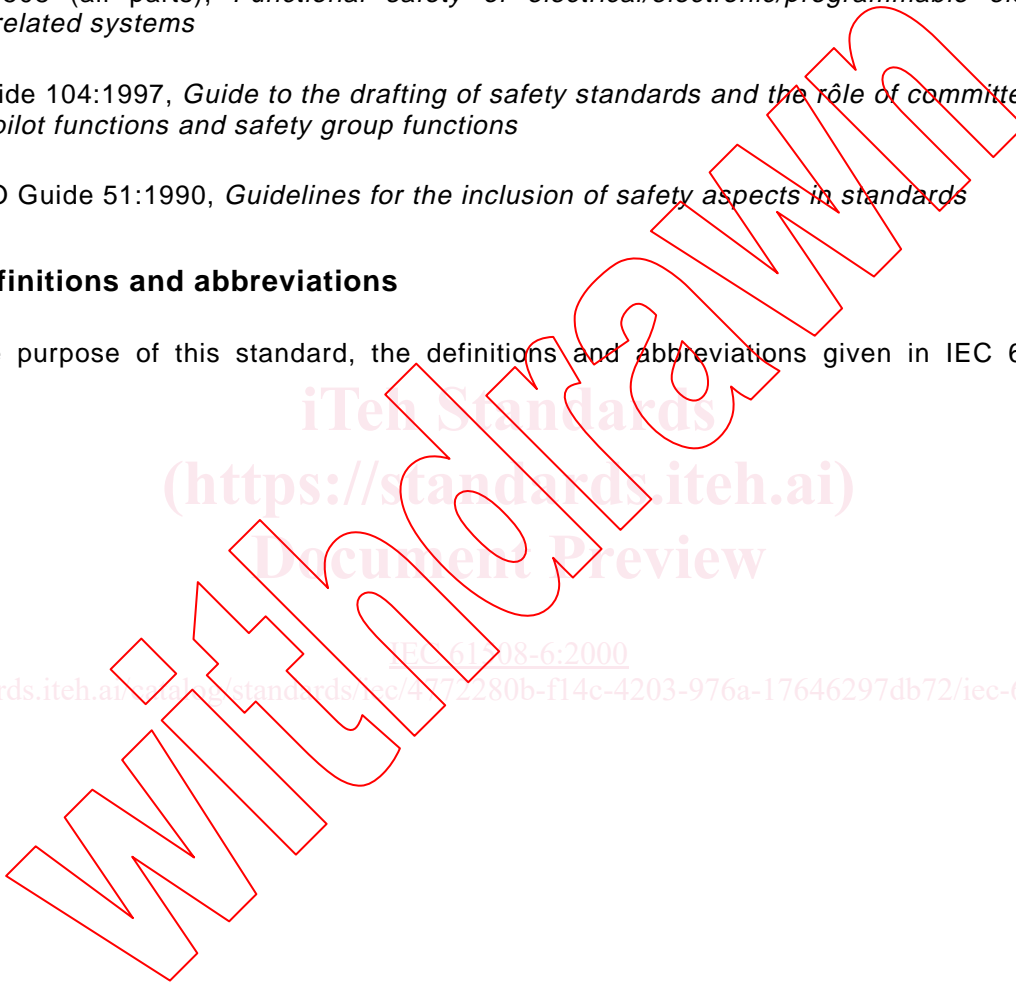
IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC Guide 104:1997, *Guide to the drafting of safety standards and the rôle of committees with safety pilot functions and safety group functions*

IEC/ISO Guide 51:1990, *Guidelines for the inclusion of safety aspects in standards*

3 Definitions and abbreviations

For the purpose of this standard, the definitions and abbreviations given in IEC 61508-4 apply.



iTeh Standards
(<https://standards.itih.ai>)
Document Preview

[IEC 61508-6:2000](https://standards.itih.ai/standards/iec/472280b-f14c-4203-976a-17646297db72/iec-61508-6-2000)

<https://standards.itih.ai/standards/iec/472280b-f14c-4203-976a-17646297db72/iec-61508-6-2000>