

# INTERNATIONAL STANDARD

# IEC 61511-1

First edition  
2003-01

---

---

## **Functional safety – Safety instrumented systems for the process industry sector –**

### **Part 1: Framework, definitions, system, hardware and software requirements**

*Sécurité fonctionnelle –  
Systèmes instrumentés de sécurité pour le secteur  
des industries de transformation –*

*Partie 1:  
Cadre, définitions et prescriptions concernant  
le système,  
le matériel et le logiciel*

© IEC 2003 — Copyright - all rights reserved

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 the publisher.

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland  
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: [inmail@iec.ch](mailto:inmail@iec.ch) Web: [www.iec.ch](http://www.iec.ch)



Commission Electrotechnique Internationale  
International Electrotechnical Commission  
Международная Электротехническая Комиссия

PRICE CODE

**XC**

*For price, see current catalogue*

## CONTENTS

FOREWORD .....	5
INTRODUCTION .....	7
1 Scope .....	9
2 Normative references.....	14
3 Abbreviations and definitions .....	15
3.1 Abbreviations.....	15
3.2 Definitions .....	16
4 Conformance to this International Standard .....	30
5 Management of functional safety.....	30
5.1 Objective .....	30
5.2 Requirements .....	30
6 Safety life-cycle requirements .....	35
6.1 Objective .....	35
6.2 Requirements .....	35
7 Verification .....	37
7.1 Objective .....	37
8 Process hazard and risk analysis.....	38
8.1 Objectives .....	38
8.2 Requirements .....	38
9 Allocation of safety functions to protection layers.....	39
9.1 Objective .....	39
9.2 Requirements of the allocation process .....	39
9.3 Additional requirements for safety integrity level 4 .....	40
9.4 Requirements on the basic process control system as a protection layer .....	41
9.5 Requirements for preventing common cause, common mode and dependent failures .....	42
10 SIS safety requirements specification .....	43
10.1 Objective .....	43
10.2 General requirements .....	43
10.3 SIS safety requirements.....	43
11 SIS design and engineering .....	44
11.1 Objective .....	44
11.2 General requirements .....	44
11.3 Requirements for system behaviour on detection of a fault .....	46
11.4 Requirements for hardware fault tolerance.....	47
11.5 Requirements for selection of components and subsystems .....	48
11.6 Field devices .....	51
11.7 Interfaces .....	52
11.8 Maintenance or testing design requirements .....	54
11.9 SIF probability of failure.....	54

12	Requirements for application software, including selection criteria for utility software .....	55
12.1	Application software safety life-cycle requirements .....	56
12.2	Application software safety requirements specification.....	62
12.3	Application software safety validation planning .....	64
12.4	Application software design and development.....	64
12.5	Integration of the application software with the SIS subsystem .....	69
12.6	FPL and LVL software modification procedures .....	70
12.7	Application software verification.....	70
13	Factory acceptance testing (FAT) .....	71
13.1	Objectives .....	72
13.2	Recommendations .....	72
14	SIS installation and commissioning .....	73
14.1	Objectives .....	73
14.2	Requirements .....	73
15	SIS safety validation .....	74
15.1	Objective .....	74
15.2	Requirements .....	74
16	SIS operation and maintenance .....	76
16.1	Objectives .....	76
16.2	Requirements .....	77
16.3	Proof testing and inspection.....	78
17	SIS modification.....	79
17.1	Objective .....	79
17.2	Requirements .....	79
18	SIS decommissioning.....	80
18.1	Objectives .....	80
18.2	Requirements .....	80
19	Information and documentation requirements.....	81
19.1	Objectives .....	81
19.2	Requirements .....	81
	Annex A (informative) Differences .....	83
	Figure 1 – Overall framework of this standard .....	8
	Figure 2 – Relationship between IEC 61511 and IEC 61508.....	11
	Figure 3 – Relationship between IEC 61511 and IEC 61508 (see 1.2).....	12
	Figure 4 – Relationship between safety instrumented functions and other functions .....	13
	Figure 5 – Relationship between system, hardware, and software of IEC 61511-1.....	14
	Figure 6 – Programmable electronic system (PES): structure and terminology .....	23
	Figure 7 – Example SIS architecture .....	26
	Figure 8 – SIS safety life-cycle phases and functional safety assessment stages.....	33
	Figure 9 – Typical risk reduction methods found in process plants .....	42
	Figure 10 – Application software safety life cycle and its relationship to the SIS safety life cycle.....	56

Figure 11 – Application software safety life cycle (in realization phase).....	58
Figure 12 – Software development life cycle (the V-model) .....	59
Figure 13 – Relationship between the hardware and software architectures of SIS.....	62
Table 1 – Abbreviations used in IEC 61511 .....	15
Table 2 – SIS safety life-cycle overview .....	36
Table 3 – Safety integrity levels: probability of failure on demand .....	40
Table 4 – Safety integrity levels: frequency of dangerous failures of the SIF .....	40
Table 5 – Minimum hardware fault tolerance of PE logic solvers .....	47
Table 6 – Minimum hardware fault tolerance of sensors and final elements and non-PE logic solvers.....	48
Table 7 – Application software safety life cycle: overview.....	60

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**FUNCTIONAL SAFETY –  
SAFETY INSTRUMENTED SYSTEMS  
FOR THE PROCESS INDUSTRY SECTOR –**
**Part 1: Framework, definitions, system,  
hardware and software requirements**

## 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.

International Standard IEC 61511-1 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/368/FDIS	65A/372/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.

IEC 61511 consists of the following parts, under the general title *Functional safety: Safety instrumented systems for the process industry sector* (see Figure 1):

- Part 1: Framework, definitions, system, hardware and software requirements
- Part 2: Guidelines in the application of IEC 61511-1
- Part 3: Guidance for the determination of the required safety integrity levels

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

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

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

## INTRODUCTION

Safety instrumented systems have been used for many years to perform safety instrumented functions in the process industries. If instrumentation is to be effectively used for safety instrumented functions, it is essential that this instrumentation achieves certain minimum standards and performance levels.

This international standard addresses the application of safety instrumented systems for the Process Industries. It also requires a process hazard and risk assessment to be carried out to enable the specification for safety instrumented systems to be derived. Other safety systems are only considered so that their contribution can be taken into account when considering the performance requirements for the safety instrumented systems. The safety instrumented system includes all components and subsystems necessary to carry out the safety instrumented function from sensor(s) to final element(s).

This international standard has two concepts which are fundamental to its application; safety lifecycle and safety integrity levels.

This standard addresses safety instrumented systems which are based on the use of electrical/electronic/programmable electronic technology. Where other technologies are used for logic solvers, the basic principles of this standard should be applied. This standard also addresses the safety instrumented system sensors and final elements regardless of the technology used. This International Standard is process industry specific within the framework of IEC 61508 (see Annex A).

This International Standard sets out an approach for safety life-cycle activities to achieve these minimum standards. This approach has been adopted in order that a rational and consistent technical policy is used.

In most situations, safety is best achieved by an inherently safe process design. If necessary, this may be combined with a protective system or systems to address any residual identified risk. Protective systems can rely on different technologies (chemical, mechanical, hydraulic, pneumatic, electrical, electronic, programmable electronic). To facilitate this approach, this standard

- requires that a hazard and risk assessment is carried out to identify the overall safety requirements;
- requires that an allocation of the safety requirements to the safety instrumented system(s) is carried out;
- works within a framework which is applicable to all instrumented methods of achieving functional safety;
- details the use of certain activities, such as safety management, which may be applicable to all methods of achieving functional safety.

This International Standard on safety instrumented systems for the process industry

- addresses all safety life-cycle phases from initial concept, design, implementation, operation and maintenance through to decommissioning;
- enables existing or new country specific process industry standards to be harmonized with this standard.

This International Standard is intended to lead to a high level of consistency (for example, of underlying principles, terminology, information) within the process industries. This should have both safety and economic benefits.

In jurisdictions where the governing authorities (for example, national, federal, state, province, county, city) have established process safety design, process safety management, or other requirements, these take precedence over the requirements defined in this standard.

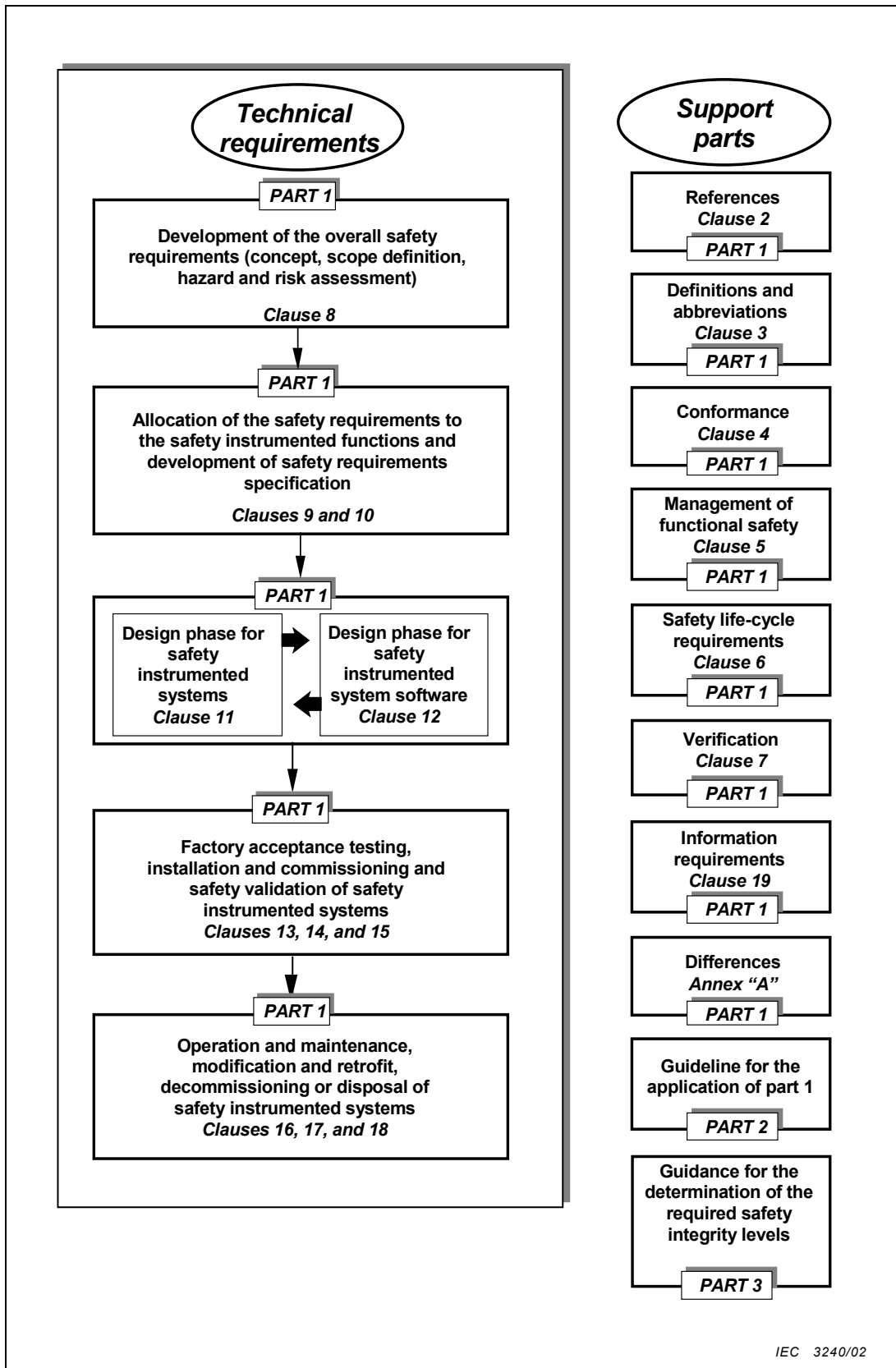


Figure 1 – Overall framework of this standard

# FUNCTIONAL SAFETY – SAFETY INSTRUMENTED SYSTEMS FOR THE PROCESS INDUSTRY SECTOR –

## Part 1: Framework, definitions, system, hardware and software requirements

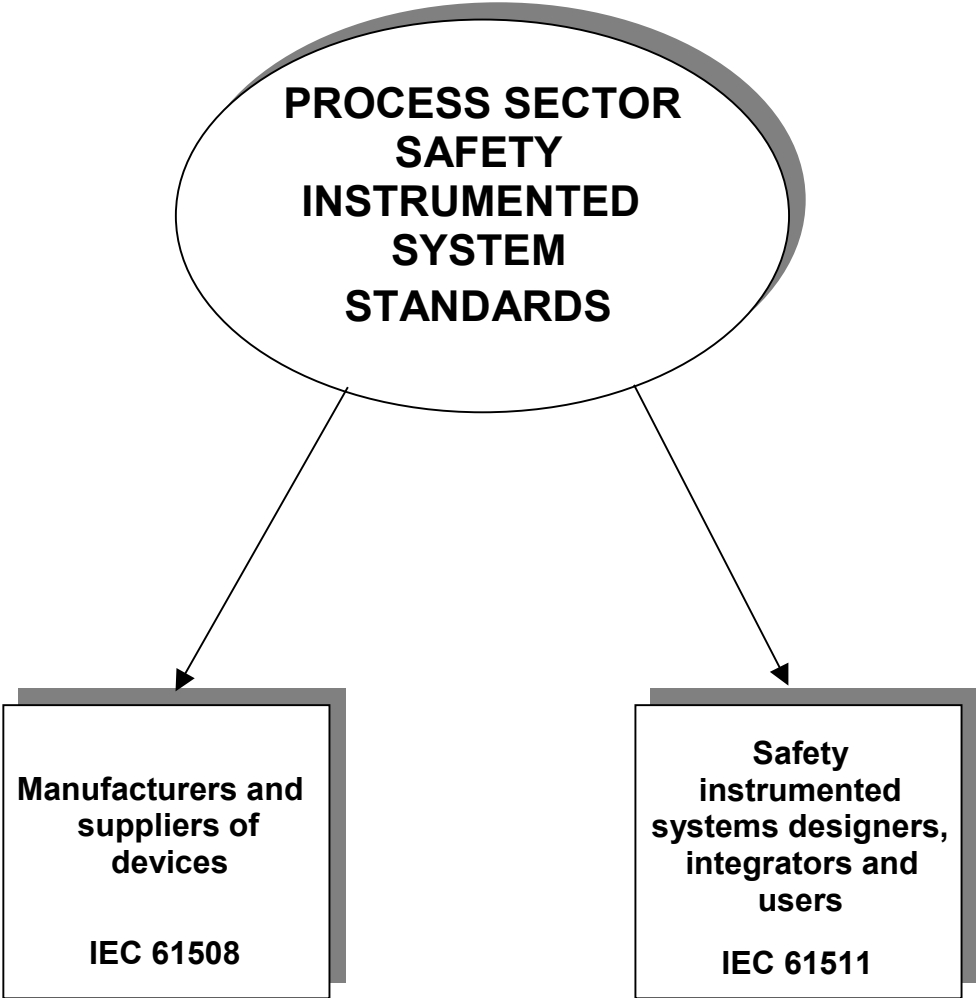
### 1 Scope

This International Standard gives requirements for the specification, design, installation, operation and maintenance of a safety instrumented system, so that it can be confidently entrusted to place and/or maintain the process in a safe state. This standard has been developed as a process sector implementation of IEC 61508.

In particular, this standard

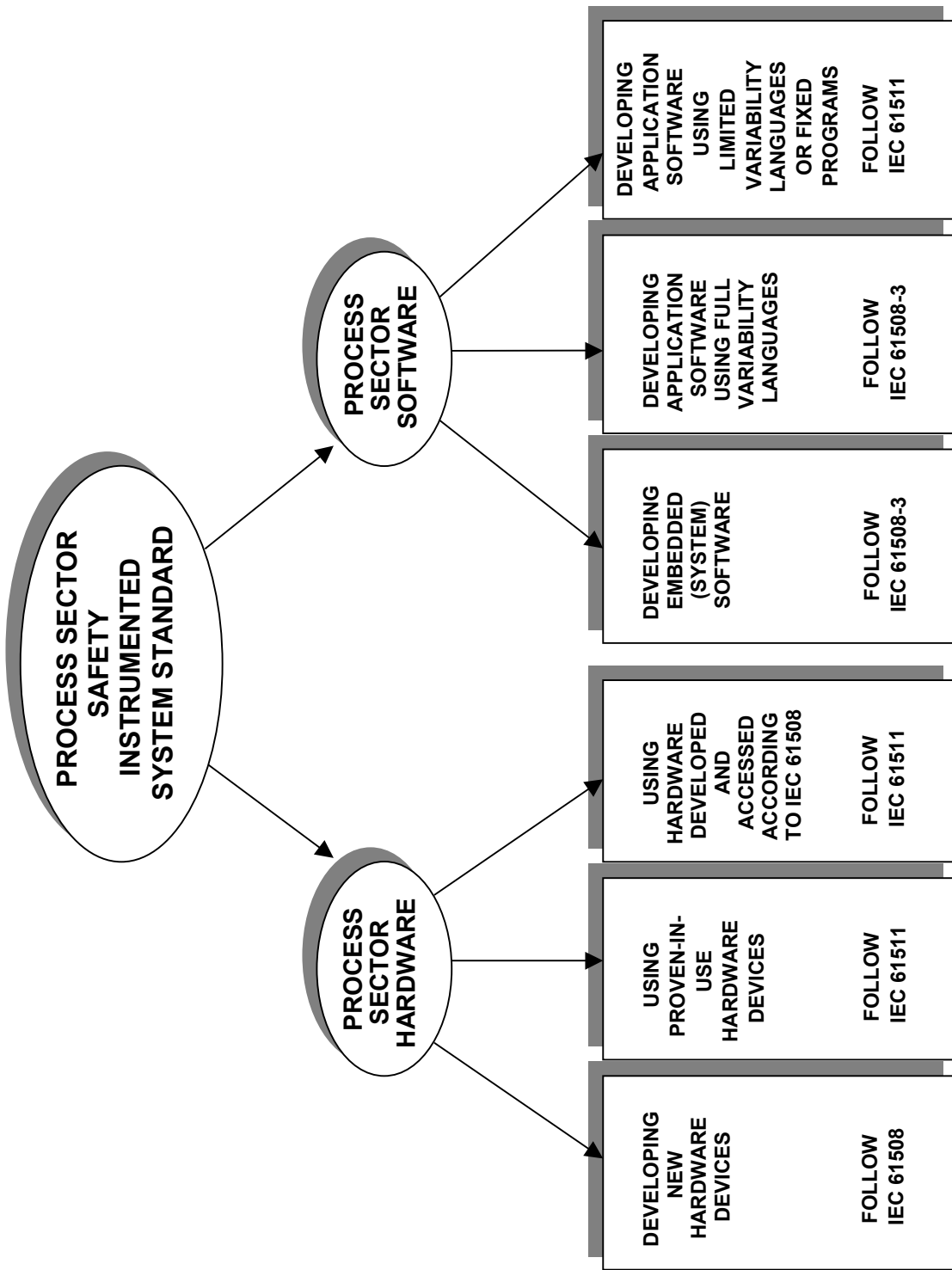
- a) specifies the requirements for achieving functional safety but does not specify who is responsible for implementing the requirements (for example, designers, suppliers, owner/operating company, contractor); this responsibility will be assigned to different parties according to safety planning and national regulations;
- b) applies when equipment that meets the requirements of IEC 61508, or of 11.5 of IEC 61511-1, is integrated into an overall system that is to be used for a process sector application but does not apply to manufacturers wishing to claim that devices are suitable for use in safety instrumented systems for the process sector (see IEC 61508-2 and IEC 61508-3);
- c) defines the relationship between IEC 61511 and IEC 61508 (Figures 2 and 3);
- d) applies when application software is developed for systems having limited variability or fixed programmes but does not apply to manufacturers, safety instrumented systems designers, integrators and users that develop embedded software (system software) or use full variability languages (see IEC 61508-3);
- e) applies to a wide variety of industries within the process sector including chemicals, oil refining, oil and gas production, pulp and paper, non-nuclear power generation;  
NOTE Within the process sector some applications, (for example, off-shore), may have additional requirements that have to be satisfied.
- f) outlines the relationship between safety instrumented functions and other functions (Figure 4);
- g) results in the identification of the functional requirements and safety integrity requirements for the safety instrumented function(s) taking into account the risk reduction achieved by other means;
- h) specifies requirements for system architecture and hardware configuration, application software, and system integration;
- i) specifies requirements for application software for users and integrators of safety instrumented systems (clause 12). In particular, requirements for the following are specified:
  - safety life-cycle phases and activities that are to be applied during the design and development of the application software (the software safety life-cycle model). These requirements include the application of measures and techniques, which are intended to avoid faults in the software and to control failures which may occur;
  - information relating to the software safety validation to be passed to the organization carrying out the SIS integration;

- preparation of information and procedures concerning software needed by the user for the operation and maintenance of the SIS;
  - procedures and specifications to be met by the organization carrying out modifications to safety software;
- j) applies when functional safety is achieved using one or more safety instrumented functions for the protection of personnel, protection of the general public or protection of the environment;
  - k) may be applied in non-safety applications such as asset protection;
  - l) defines requirements for implementing safety instrumented functions as a part of the overall arrangements for achieving functional safety;
  - m) uses a safety life cycle (Figure 8) and defines a list of activities which are necessary to determine the functional requirements and the safety integrity requirements for the safety instrumented systems;
  - n) requires that a hazard and risk assessment is to be carried out to define the safety functional requirements and safety integrity levels of each safety instrumented function;
- NOTE See Figure 9 for an overview of risk reduction methods.
- o) establishes numerical targets for average probability of failure on demand and frequency of dangerous failures per hour for the safety integrity levels;
  - p) specifies minimum requirements for hardware fault tolerance;
  - q) specifies techniques/measures required for achieving the specified integrity levels;
  - r) defines a maximum level of performance (SIL 4) which can be achieved for a safety instrumented function implemented according to this standard;
  - s) defines a minimum level of performance (SIL 1) below which this standard does not apply;
  - t) provides a framework for establishing safety integrity levels but does not specify the safety integrity levels required for specific applications (which should be established based on knowledge of the particular application);
  - u) specifies requirements for all parts of the safety instrumented system from sensor to final element(s);
  - v) defines the information that is needed during the safety life cycle;
  - w) requires that the design of a safety instrumented function takes into account human factors;
  - x) does not place any direct requirements on the individual operator or maintenance person.



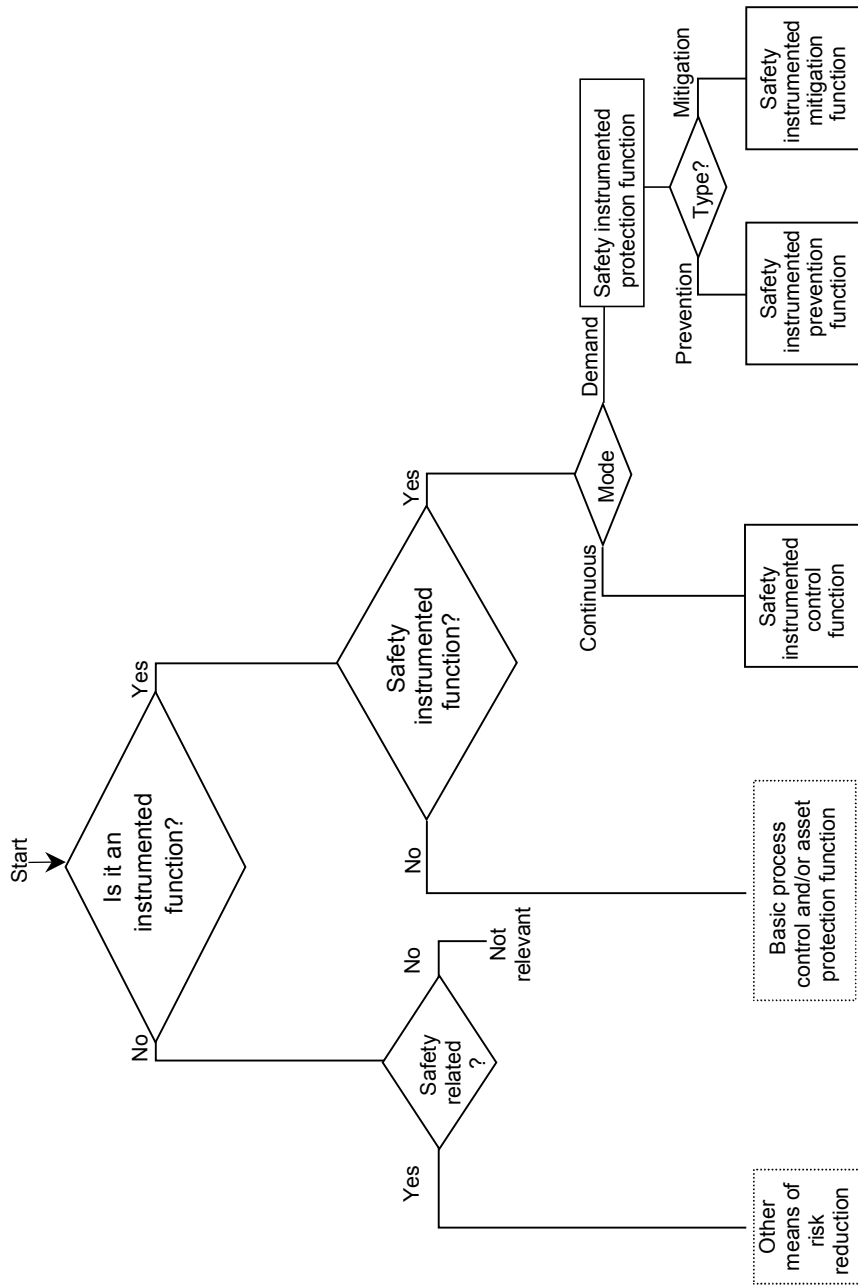
IEC 3241/02

Figure 2 – Relationship between IEC 61511 and IEC 61508



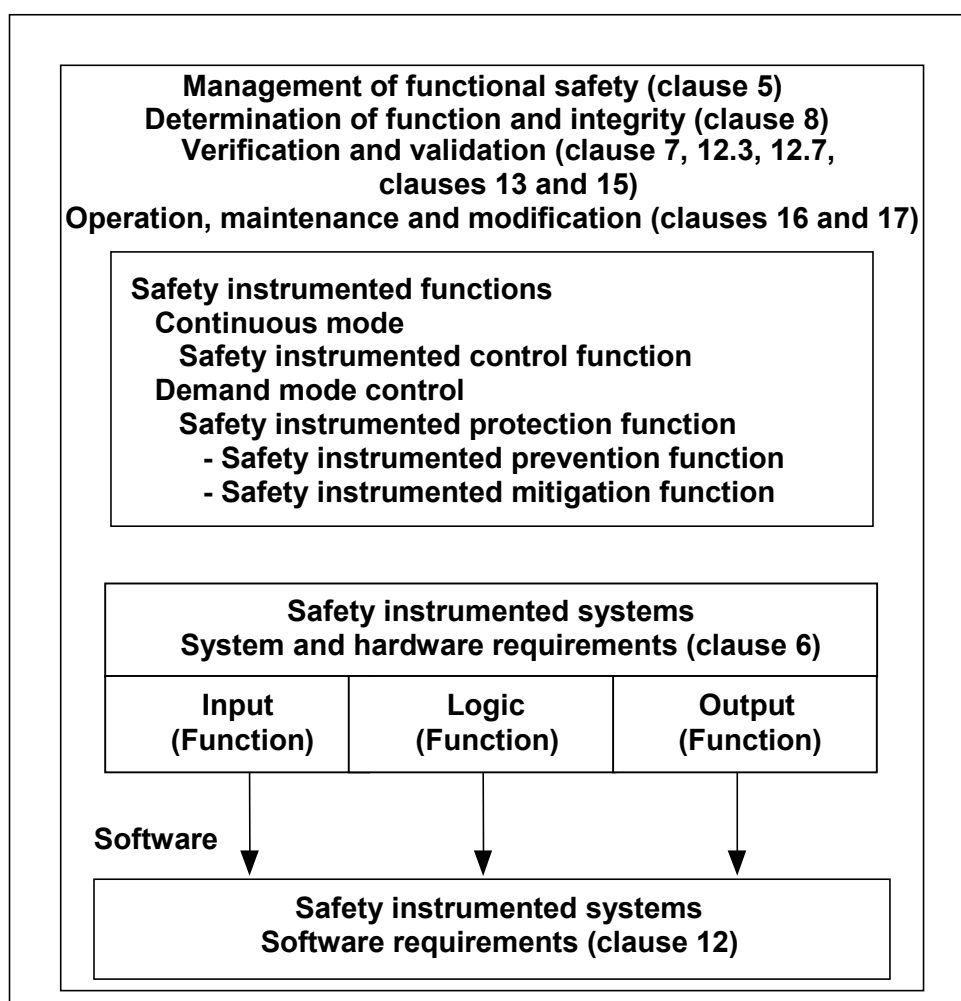
IEC 3242/02

Figure 3 – Relationship between IEC 61511 and IEC 61508 (see clause 1)



Standard specifies activities which are to be carried out but requirements are not detailed.

Figure 4 – Relationship between safety instrumented functions and other functions



IEC 3244/02

**Figure 5 – Relationship between system, hardware, and software of IEC 61511-1**

## 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 60654-1:1993, *Industrial-process measurement and control equipment – Operating conditions – Part 1: Climatic conditions*

IEC 60654-3:1998, *Industrial-process measurement and control equipment – Operating conditions – Part 3: Mechanical influences*

IEC 61326-1: *Electrical equipment for measurement, control and laboratory use – EMC requirements*

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

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

IEC 61511-2: *Functional safety – Safety instrumented systems for the process industry sector*  
– Part 2: *Guidelines in the application of IEC 61511-1*<sup>1</sup>

---

<sup>1</sup> To be published.