#### AMERICAN NATIONAL STANDARD

### ANSI/ISA-61511-1-2018 IEC 61511-1:2016+AMD1:2017 CSV

Functional Safety – Safety Instrumented Systems for the Process Industry Sector – Part 1: Framework, definitions, system, hardware and application programming requirements (IEC 61511-1:2016+AMD1:2017 CSV, IDT)

Approved 11 July 2018

ANSI/ISA-61511-1-2018 / IEC 61511-1:2016+AMD1:2017 CSV, Functional Safety – Safety Instrumented Systems for the Process Industry Sector – Part 1: Framework, definitions, system, hardware and application programming requirements (IEC 61511-1:2016+AMD1:2017 CSV, IDT)

ISBN: 978-1-945541-95-7

Copyright © 2016, 2017 IEC. Copyright © 2018 ISA. These materials are subject to copyright claims of IEC and ISA. No part of this publication may be reproduced in any form, including an electronic retrieval system, without the prior written permission of ISA. All requests pertaining to the ANSI/ISA-61511-1-2018 / IEC 61511-1:2016+AMD1:2017 CSV Standard should be submitted to ISA.

ISA 67 T.W. Alexander Drive P.O. Box 12277 Research Triangle Park, North Carolina 27709 E-mail: <u>standards@isa.org</u>

#### Preface

This preface is included for information purposes only and is not part of ANSI/ISA-61511-1-2018 / IEC 61511-1:2016+AMD1:2017 CSV.

This standard has been prepared as part of the service of ISA, the International Society of Automation, toward a goal of uniformity in the field of automation. To be of real value, this document should not be static but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Secretary, Standards and Practices Board; ISA, 67 T.W. Alexander Drive; P.O. Box 12277; Research Triangle Park, NC 277099; Telephone (919) 549-8411; Fax (919) 549-8288; E-mail: <u>standards@isa.org</u>.

The ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards, recommended practices, and technical reports. The Department is further aware of the benefits of USA users of ISA standards of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, the Department will endeavor to introduce SI and acceptable metric units in all new and revised standards to the greatest extent possible. The Metric Practice Guide, which has been published by the Institute of Electrical and Electronics Engineers (IEEE) as ANSI/IEEE Std. 268-1992, and future revisions, will be the reference guide for definitions, symbols, abbreviations, and conversion factors.

It is the policy of ISA to encourage and welcome the participation of all interested individuals in the development of ISA standards. Participation in the ISA standards-making process by an individual in no way constitutes endorsement by the employer of that individual, of ISA, or of any of the standards, recommended practices, and technical reports that ISA develops.

CAUTION — ISA ADHERES TO THE POLICY OF THE AMERICAN NATIONAL STANDARDS INSTITUTE WITH REGARD TO PATENTS. IF ISA IS INFORMED OF AN EXISTING PATENT THAT IS REQUIRED FOR USE OF THE DOCUMENT, IT WILL REQUIRE THE OWNER OF THE PATENT TO EITHER GRANT A ROYALTY-FREE LICENSE FOR USE OF THE PATENT BY USERS COMPLYING WITH THE DOCUMENT OR A LICENSE ON REASONABLE TERMS AND CONDITIONS THAT ARE FREE FROM UNFAIR DISCRIMINATION.

EVEN IF ISA IS UNAWARE OF ANY PATENT COVERING THIS DOCUMENT, THE USER IS CAUTIONED THAT IMPLEMENTATION OF THE DOCUMENT MAY REQUIRE USE OF TECHNIQUES, PROCESSES, OR MATERIALS COVERED BY PATENT RIGHTS. ISA TAKES NO POSITION ON THE EXISTENCE OR VALIDITY OF ANY PATENT RIGHTS THAT MAY BE INVOLVED IN IMPLEMENTING THE DOCUMENT. ISA IS NOT RESPONSIBLE FOR IDENTIFYING ALL PATENTS THAT MAY REQUIRE A LICENSE BEFORE IMPLEMENTATION OF THE DOCUMENT OR FOR INVESTIGATING THE VALIDITY OR SCOPE OF ANY PATENTS BROUGHT TO ITS ATTENTION. THE USER SHOULD CAREFULLY INVESTIGATE RELEVANT PATENTS BEFORE USING THE DOCUMENT FOR THE USER'S INTENDED APPLICATION.

HOWEVER, ISA ASKS THAT ANYONE REVIEWING THIS DOCUMENT WHO IS AWARE OF ANY PATENTS THAT MAY IMPACT IMPLEMENTATION OF THE DOCUMENT NOTIFY THE ISA STANDARDS AND PRACTICES DEPARTMENT OF THE PATENT AND ITS OWNER. ADDITIONALLY, THE USE OF THIS DOCUMENT MAY INVOLVE HAZARDOUS MATERIALS, OPERATIONS OR EQUIPMENT. THE DOCUMENT CANNOT ANTICIPATE ALL POSSIBLE APPLICATIONS OR ADDRESS ALL POSSIBLE SAFETY ISSUES ASSOCIATED WITH USE IN HAZARDOUS CONDITIONS. THE USER OF THIS DOCUMENT MUST EXERCISE SOUND PROFESSIONAL JUDGMENT CONCERNING ITS USE AND APPLICABILITY UNDER THE USER'S PARTICULAR CIRCUMSTANCES. THE USER MUST ALSO CONSIDER THE

## APPLICABILITY OF ANY GOVERNMENTAL REGULATORY LIMITATIONS AND ESTABLISHED SAFETY AND HEALTH PRACTICES BEFORE IMPLEMENTING THIS DOCUMENT.

#### THE USER OF THIS DOCUMENT SHOULD BE AWARE THAT THIS DOCUMENT MAY BE IMPACTED BY ELECTRONIC SECURITY ISSUES. THE COMMITTEE HAS NOT YET ADDRESSED THE POTENTIAL ISSUES IN THIS VERSION.

ISA (<u>www.isa.org</u>) is a nonprofit professional association that sets the standard for those who apply engineering and technology to improve the management, safety, and cybersecurity of modern automation and control systems used across industry and critical infrastructure. Founded in 1945, ISA develops widely used global standards; certifies industry professionals; provides education and training; publishes books and technical articles; hosts conferences and exhibits; and provides networking and career development programs for its 40,000 members and 400,000 customers around the world.

ISA owns <u>Automation.com</u>, a leading online publisher of automation-related content, and is the founding sponsor of The Automation Federation (<u>www.automationfederation.org</u>), an association of non-profit organizations serving as "The Voice of Automation." Through a wholly owned subsidiary, ISA bridges the gap between standards and their implementation with the ISA Security Compliance Institute (<u>www.isasecure.org</u>) and the ISA Wireless Compliance Institute (<u>www.isa100wci.org</u>).

## CONTENTS

F	FOREWORD			
IN	TRODU	ICTION	7	
1	Scop	e	9	
2	Norm	native references	. 12	
3	Term	s, definitions and abbreviations	.13	
Ū	3.1	Terms	13	
	3.2	Terms and definitions	13	
	3.3	Abbreviations	.31	
4	Conf	ormance to the IEC 61511-1:2016	.32	
5	Mana	agement of functional safety	.32	
-	5 1	Objective	32	
	5.2	Requirements	.33	
	5.2.1	General	.33	
	5.2.2	Organization and resources	.33	
	5.2.3	Risk evaluation and risk management	.33	
	5.2.4	Safety planning	.33	
	5.2.5	Implementing and monitoring	.34	
	5.2.6	Assessment, auditing and revisions	.34	
	5.2.7	SIS configuration management	. 37	
6	Safe	ty life-cycle requirements	. 37	
	6.1	Objectives	. 37	
	6.2	Requirements	. 38	
	6.3	Application program SIS safety life-cycle requirements	.40	
7	Verif	ication	.43	
	7.1	Objective	.43	
	7.2	Requirements	.43	
8	Proc	ess H&RA	.45	
	8.1	Objectives	.45	
	8.2	Requirements	.45	
9	Alloc	ation of safety functions to protection layers	.46	
	91	Objectives	46	
	9.2	Requirements of the allocation process	.46	
	9.3	Requirements on the basic process control system as a protection layer	.49	
	9.4	Requirements for preventing common cause, common mode and dependent		
		failures	. 50	
10	) SIS s	safety requirements specification (SRS)	.50	
	10.1	Objective	. 50	
	10.2	General requirements	.50	
	10.3	SIS safety requirements	.51	
11	SIS	design and engineering	. 53	
	11.1	Objective	. 53	
	11.2	General requirements	.53	
	11.3	Requirements for system behaviour on detection of a fault	.54	
	11.4	Hardware fault tolerance	.55	
	11.5	Requirements for selection of devices	.56	

IEC 61511-1:2016+AMD1:2017 CSV - 3 - © IEC 2017

012020		
11.5	5.1 Objectives	56
11.5	5.2 General requirements	56
11.5	5.3 Requirements for the selection of devices based on prior use	56
11.5	5.4 Requirements for selection of FPL programmable devices (e.g., field devices) based on prior use	57
11.5	5.5 Requirements for selection of LVL programmable devices based on prior use	
11.5	5.6 Requirements for selection of FVL programmable devices	59
11.6	Field devices	59
11.7	Interfaces	59
11.7	7.1 General	59
11.7	7.2 Operator interface requirements	59
11.7	7.3 Maintenance/engineering interface requirements	60
11.7	7.4 Communication interface requirements	60
11.8	Maintenance or testing design requirements	61
11.9	Quantification of random failure	61
12 SIS	application program development	63
12.1	Objective	63
12.2	General requirements	63
12.3	Application program design	64
12.4	Application program implementation	
12.5	Requirements for application program verification (review and testing)	
12.6	Requirements for application program methodology and tools	67
13 Eact	tory acceptance test (FAT)	68
10 1 400		
12.1		00
	instellation and commissioning	00
14 515	Installation and commissioning	69
14.1	Objectives	69
14.2	Requirements	69
15 SIS	safety validation	70
15.1	Objective	70
15.2	Requirements	70
16 SIS	operation and maintenance	73
16.1	Objectives	73
16.2	Requirements	73
16.3	Proof testing and inspection	75
16.3	8.1 Proof testing	75
16.3	3.2 Inspection	76
16.3	B.3 Documentation of proof tests and inspection	76
17 SIS	modification	76
17 1	Objectives	76
17.2	Requirements	70
18 SIS	decommissioning	77
10 010		·····
10.1		11
18.2	Requirements	/ ð
IS INTOR	mation and documentation requirements	
19.1	Objectives	78
19.2	Requirements	78

	- 4 -	IEC 61511-1:2016+AMD1:2017 CSV
		© IEC 2017
Bibliography		

Figure 1 – Overall framework of the IEC 61511 series	8
Figure 2 – Relationship between IEC 61511 and IEC 61508	10
Figure 3 – Detailed relationship between IEC 61511 and IEC 61508	11
Figure 4 – Relationship between safety instrumented functions and other functions	12
Figure 5 – Programmable electronic system (PES): structure and terminology	24
Figure 6 – Example of SIS architectures comprising three SIS subsystems	26
Figure 7 – SIS safety life-cycle phases and FSA stages	38
Figure 8 – Application program safety life-cycle and its relationship to the SIS safety life-cycle	41
Figure 9 – Typical protection layers and risk reduction means	49
Table 1 – Abbreviations used in IEC 61511	31

Table 2 – SIS safety life-cycle overview (1 of 2)	39
Table 3 – Application program safety life-cycle: overview (1 of 2)	42
Table 4 – Safety integrity requirements: PFD <sub>avg</sub>	47
Table 5 – Safety integrity requirements: average frequency of dangerous failures of the SIF	47
Table 6 – Minimum HFT requirements according to SIL	55

IEC 61511-1:2016+AMD1:2017 CSV © IEC 2017

#### INTERNATIONAL ELECTROTECHNICAL COMMISSION

- 5 -

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

# Part 1: Framework, definitions, system, hardware and application programming requirements

### FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

#### DISCLAIMER

This Consolidated version is not an official IEC Standard and has been prepared for user convenience. Only the current versions of the standard and its amendment(s) are to be considered the official documents.

This Consolidated version of IEC 61511-1 bears the edition number 2.1. It consists of the second edition (2016-02) [documents 65A/777/FDIS and 65A/784/RVD], its corrigendum 1 (2016-09) and its amendment 1 (2017-08) [documents 65A/844/FDIS and 65A/848/RVD]. The technical content is identical to the base edition and its amendment.

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 61511-1 has been prepared by subcommittee 65A: System aspects, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2003. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

- references and requirements to software replaced with references and requirements to application programming;
- functional safety assessment requirements provided with more detail to improve management of functional safety.
- management of change requirement added;
- security risk assessment requirements added;.
- requirements expanded on the basic process control system as a protection layer;
- requirements for hardware fault tolerance modified and should be reviewed carefully to understand user/integrator options.

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

FDIS	Report on voting
65A/777/FDIS	65A/784/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 61511 series, published under the general title *Functional safety* – *safety instrumented systems for the process industry sector*, 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 website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

# IEC 61511-1:2016+AMD1:2017 CSV - © IEC 2017

#### - 7 -

#### INTRODUCTION

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

The IEC 61511 series addresses the application of SISs for the process industries. The IEC 61511 series also addresses a process Hazard and Risk Assessment (H&RA) to be carried out to enable the specification for SISs to be derived. Other safety systems' contributions are only considered with respect to the performance requirements for the SIS. The SIS includes all devices necessary to carry out each SIF from sensor(s) to final element(s).

The IEC 61511 series has two concepts which are fundamental to its application: SIS safety life-cycle and safety integrity levels (SILs).

IEC 61511 The series addresses SISs which are based on the use of electrical/electronic/programmable electronic technology. Where other technologies are used for logic solvers, the basic principles of the IEC 61511 series should be applied to ensure the functional safety requirements are met. The IEC 61511 series also addresses the SIS sensors and final elements regardless of the technology used. The IEC 61511 series is process industry specific within the framework of the IEC 61508 series.

The IEC 61511 series sets out an approach for SIS safety life-cycle activities to achieve these minimum principles. 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. However in some instances this is not possible or not practical. 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, and programmable electronic). To facilitate this approach, the IEC 61511 series:

- addresses that a H&RA is carried out to identify the overall safety requirements;
- addresses that an allocation of the safety requirements to the SIS is carried out;
- works within a framework which is applicable to all instrumented means 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.

The IEC 61511 series on SIS for the process industry:

- addresses all SIS 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 the IEC 61511 series.

The IEC 61511 series is intended to lead to a high level of consistency (e.g., of underlying principles, terminology, and information) within the process industries. This should have both safety and economic benefits. Figure 1 below shows an overall framework of the IEC 61511 series.

In jurisdictions where the governing authorities (e.g., national, federal, state, province, county, city) have established process safety design, process safety management, or other regulations, these take precedence over the requirements defined in the IEC 61511 series.