AMERICAN NATIONAL STANDARD

ANSI/ISA-61511-3-2018 / IEC 61511-3:2016

Functional Safety – Safety Instrumented Systems for the Process Industry Sector – Part 3: Guidelines for the determination of the required safety integrity levels (IEC 61511-3:2016, IDT)

Approved 11 July 2018

ANSI/ISA-61511-3-2018 / IEC 61511-3:2016, Functional Safety – Safety Instrumented Systems for the Process Industry Sector – Part 3: Guidance for the determination of the required safety integrity levels (IEC 61511-3:2016, IDT)

ISBN: 978-1-945541-97-1

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

Preface

This preface is included for information purposes only and is not part of ANSI/ISA-61511-3-2018 / IEC 61511-3:2016.

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: standards@isa.org.

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 (www.isa.org) 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 Automation.com, a leading online publisher of automation-related content, and is the founding sponsor of The Automation Federation (www.automationfederation.org), 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 (www.isasecure.org) and the ISA Wireless Compliance Institute (www.isa100wci.org).

CONTENTS

This page intentionally left blank.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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

Part 3: Guidance for the determination of the required safety integrity levels

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.
9) 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.

International Standard IEC 61511-3: 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:

Additional H&RA example(s) and quantitative analysis consideration annexes are provided.

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

FDIS	Report on voting
65A/779/FDIS	65A786/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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

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

The IEC 61511 series addresses the application of SIS for the process industries. A process hazard and risk assessment is carried out to enable the specification for SIS 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 SIS. The SIS includes all devices and subsystems necessary to carry out the 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 (SIL).

The IEC 61511 series addresses SIS which are based on the use of Electrical (E)/Electronic (E)/Programmable Electronic (PE) technology. Where other technologies are used for logic solvers, the basic principles of the IEC 61511 series should be applied. 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 IEC 61508:2010.

The IEC 61511 series sets out an approach for SIS 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, and programmable electronic). Any safety strategy should consider each individual SIS in the context of the other protective systems. To facilitate this approach, the IEC 61511 series covers:

– a hazard and risk assessment is carried out to identify the overall safety requirements;
– 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;
– addressing all SIS safety life-cycle phases from initial concept, design, implementation, operation and maintenance through to decommissioning;
– enabling 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 (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 regulations, these take precedence over the requirements defined in the IEC 61511-1.

The IEC 61511-3 deals with guidance in the area of determining the required SIL in hazards and risk assessment. The information herein is intended to provide a broad overview of the wide range of global methods used to implement hazards and risk assessment. The information provided is not of sufficient detail to implement any of these approaches.

Before proceeding, the concept and determination of SIL provided in IEC 61511-1:2016 should be reviewed. The informative annexes in the IEC 61511-3 address the following:

Annex A provides information that is common to each of the hazard and risk assessment methods shown herein.

Annex B provides an overview of a semi-quantitative method used to determine the required SIL.

Annex C provides an overview of a safety matrix method to determine the required SIL.

Annex D provides an overview of a method using a semi-qualitative risk graph approach to determine the required SIL.

Annex E provides an overview of a method using a qualitative risk graph approach to determine the required SIL.

Annex F provides an overview of a method using a layer of protection analysis (LOPA) approach to select the required SIL.

Annex G provides a layer of protection analysis using a risk matrix.

Annex H provides an overview of a qualitative approach for risk estimation & SIL assignment.

Annex I provides an overview of the basic steps involved in designing and calibrating a risk graph.

Annex J provides an overview of the impact of multiple safety systems on determining the required SIL

Annex K provides an overview of the concepts of tolerable risk and ALARP.

Figure 1 shows the overall framework for IEC 61511-1, IEC 61511-2 and IEC 61511-3 and indicates the role that the IEC 61511 series plays in the achievement of functional safety for SIS.

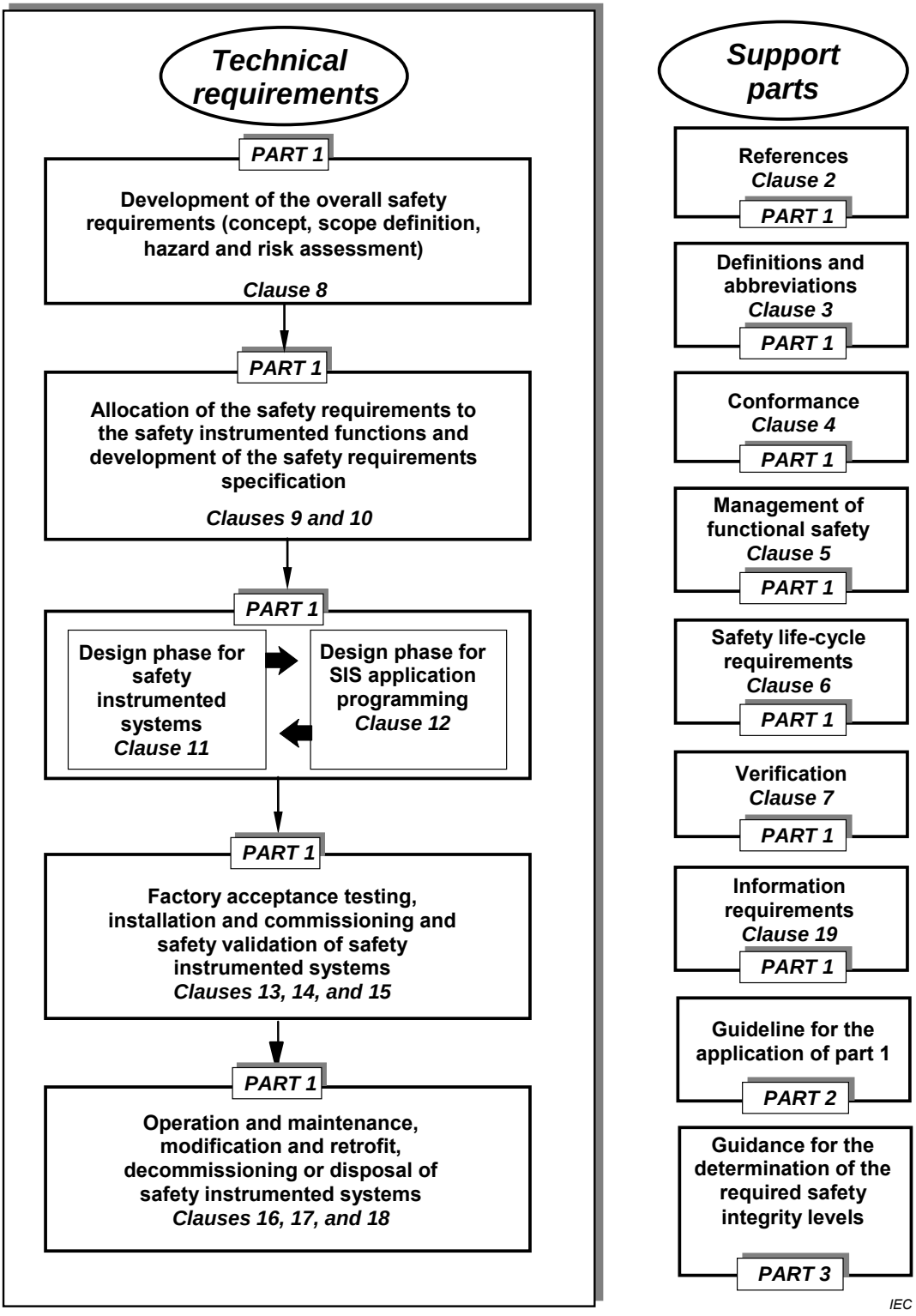

Figure 1 – Overall framework of the IEC 61511 series

This page intentionally left blank.

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

Part 3: Guidance for the determination of the required safety integrity levels

1 Scope

This part of IEC 61511 provides information on:

– the underlying concepts of risk and the relationship of risk to safety integrity (see Clause A.4);

– the determination of tolerable risk (see Annex K);

– a number of different methods that enable the safety integrity level (SIL) for the safety instrumented functions (SIF) to be determined (see Annexes B through K);

– the impact of multiple safety systems on calculations determining the ability to achieve the desired risk reduction (see Annex J).

In particular, this part of IEC 61511:

a) applies when functional safety is achieved using one or more SIF for the protection of either personnel, the general public, or the environment;

b) may be applied in non-safety applications such as asset protection;

c) illustrates typical hazard and risk assessment methods that may be carried out to define the safety functional requirements and SIL of each SIF;

d) illustrates techniques/measures available for determining the required SIL;

e) provides a framework for establishing SIL but does not specify the SIL required for specific applications;

f) does not give examples of determining the requirements for other methods of risk reduction.

NOTE Examples given in the Annexes of this Standard are intended only as case specific examples of implementing IEC 61511 requirements in a specific instance, and the user should satisfy themselves that the chosen methods and techniques are appropriate to their situation.

Annexes B through K illustrate quantitative and qualitative approaches and have been simplified in order to illustrate the underlying principles. These annexes have been included to illustrate the general principles of a number of methods but do not provide a definitive account.

NOTE 1 Those intending to apply the methods indicated in these annexes can consult the source material referenced in each annex.

NOTE 2 The methods of SIL determination included in Part 3 may not be suitable for all applications. In particular, specific techniques or additional factors that are not illustrated may be required for high demand or continuous mode of operation.

NOTE 3 The methods as illustrated herein may result in non-conservative results when they are used beyond their underlying limits and when factors such as common cause, fault tolerance, holistic considerations of the application, lack of experience with the method being used, independence of the protection layers, etc., are not properly considered. See Annex J.

Figure 2 gives an overview of typical protection layers and risk reduction means.