PD IEC TS 62998-1:2019



BSI Standards Publication

Safety of machinery — Safety-related sensors used for the protection of persons

bsi.

National foreword

This Published Document is the UK implementation of IEC TS 62998-1:2019.

The UK participation in its preparation was entrusted to Technical Committee MCE/3, Safeguarding of machinery.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

This publication is not to be regarded as a British Standard.

© The British Standards Institution 2023
Published by BSI Standards Limited 2023

ISBN 978 0 580 96576 0

ICS 13.110; 21.020

Compliance with a Published Document cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 May 2023.

Amendments/corrigenda issued since publication

Date	Text affected

IEC TS 62998-1

Edition 1.0 2019-05

TECHNICAL SPECIFICATION

colour inside

Safety of machinery – Safety-related sensors used for the protection of persons

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 13.110; 21.020

ISBN 978-2-8322-6819-3

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 6
INTRODUCTION 8
1 Scope 9
2 Normative references 10
3 Terms and definitions 10
3.1 Characteristics and performance criteria 11
3.2 Dependability 12
3.3 Procedures and architectural deliberations 14
3.4 Terms related to system 16
3.5 Fusion 18
3.6 Safety related information 18
3.7 Test 20
3.8 User groups 22
3.9 Verification and validation 22
4 Lifecycle and interconnection to safety-related electrical control systems (SCS) 24
4.1 General 24
4.2 Hazard and risk analysis 26
4.2.1 General 26
4.2.2 Hazard caused by SRS/SRSS 27
4.2.3 Required SRS/SRSS performance class 28
4.3 Correspondence SRS/SRSS performance class 28
5 Design and development phase 29
5.1 General 29
5.2 SRS/SRSS functions 29
5.3 Design analysis 30
5.4 Simulation 30
5.5 Sensing zone(s) 31
5.6 Safety related zone 31
5.7 Automation related zone 31
5.8 Detection capability and dependability 31
5.8.1 General 31
5.8.2 Object classes and physical properties 32
5.8.3 Environmental influences 33
5.9 User interface 37
5.9.1 General 37
5.9.2 Mounting 37
5.9.3 Safety related information 37
6 Integration and installation phase 40
6.1 General 40
6.2 Fusion of SRS into an SRSS 40
6.2.1 General 40
6.2.2 Limits of use after fusion 41
6.2.3 Detection capability after fusion 41
6.2.4 Sensing zone(s) after fusion 42
6.2.5 Dependability under environmental condition after fusion 42
6.2.6 Safety related information after fusion 42

6.2.7 SRSS performance class after fusion 43
6.2.8 Response time after fusion 44
6.2.9 Verification and validation after fusion 44
6.3 Calibration at user side 44
6.3.1 General 44
6.3.2 Calibration procedure and equipment 45
6.3.3 Verification and validation of calibration 45
7 Operation, maintenance and modification phases 45
8 Verification and validation 46
8.1 General 46
8.2 Verification of an SRS/SRSS 46
8.3 Validation of an SRS/SRSS 47
8.4 Analysis 48
8.5 Test 49
8.5.1 General 49
8.5.2 Test classification 49
8.5.3 Test method and test setup 50
8.5.4 Test piece 51
8.5.5 Test plan and test results 51
9 Information for use 52
Annex A (informative) Examination of systematic capabilities 54
Annex B (informative) User groups 55
B.1 User groups of SRS/SRSS and groups addressed by this document 55
B.2 User groups addressed by fusion 55
Annex C (informative) Functional decomposition and/or integration 58
Annex D (normative) Generation and application of simulation models 59
D.1 General 59
D.2 Recommendations for use 59
D.3 Simulation objectives and measures to achieve them 59
D.4 Verification 62
Annex E (informative) Child properties and behaviour 64
E.1 General 64
E.2 Sizes of parts of body 64
Annex F (informative) Environmental influences 68
F.1 General 68
F.2 Example 1 for application of environmental influences 68
F.3 Example 2 for application of environmental influences 70
Annex G (informative) Faults, failures and influences resulting in a loss of SRS/SRSS safety related function 71
G.1 General 71
G.2 Failure to danger 74
G.3 Normal operation 75
G.4 Signal to initiate the fault reaction function and confidence information as part of safety related information 75
Annex H (informative) Test aspects 77
H.1 General 77
H.2 Mechanical influence test 77
Annex I (informative) Examples of functions, safety related information and fusion 81

I.1 Example of functions 81
I.2 Example of safety related information 82
I.3 Example of fusion 83
Bibliography 87

Figure 1 – Measurement accuracy and measurement uncertainty 12
Figure 2 – Example 1 of SRS architecture 24
Figure 3 – Example 2 of SRS architecture 25
Figure 4 –Example of SRSS architecture 25
Figure 5 – Interconnection of an SRS/SRSS into hazard and risk analysis 27
Figure 6 – Safety related information of an SRS/SRSS 38
Figure A.1 – Example for examination of systematic capabilities using safety related sensor standards 54
Figure C.1 – Interconnection of functions and objects 58
Figure C.2 – Example of functions performed in an SRSS 58
Figure D.1 – Verification process 62
Figure E.1 – Body height children 65
Figure E.2 – Chest depth children 66
Figure E.3 – Head width children 66
Figure E.4 – Head length children 67
Figure G.1 – Combination of faults, failures or errors resulting in additional risk throughloss of safety function or bypassing 72
Figure G.2 – Analysis of systematic capabilities during design and development to prevent systematic faults resulting in failure to danger 73
Figure G.3 – Mode of action for systematic fault resulting in fault reaction function 76
Figure G.4 – Mode of action for errors resulting in appropriate confidence information 76
Figure I.1 – Example of SRS applied on driveway intersection 81
Figure I.2 – Example of SRS/SRSS providing decision and confidence information 82
Figure I.3 – Example of SRS/SRSS providing measurement and confidence information 83
Figure I.4 – First dxample of fusion of 2 SRS into an SRSS with combined sensing zones 84
Figure I.5 – Fusion of SRS safety related information 84
Figure I.6 – Approach of verification and validation based on SRS Information for use and SRSS Safety Requirement specification 85
Figure I.7 – Second example of fusion of 2 SRS into an SRSS with combined sensing zones 86

Table 1 – Correspondence between level of safety performance and minimum required SRS/SRSS performance class 29
Table 2 – Functions of an SRS/SRSS as applicable 30
Table 4 – Limits for failure to danger condition (loss of the detection capability) due to environmental interference for high demand mode 35
Table 5 – Minimum required coverage probability/decision probability at high demand rate 39
Table 6 – Maximum applicable SRSS performance class after fusion using two SRS 44

Table 7 – Means to be used for evaluation of verification measures and verification results 47
Table 8 – Overview of information for use to be provided 52
Table B.1 – Roles and task of addressed user groups 55
Table B.2 – Addressed user groups for different integration types using sensing unit, SRS/ SRSS as element or SRS as subsystem 56
Table D.1 – Simulation objectives and measures for SRS/SRSS of low complexity 60
Table D.2 – Simulation objectives and measures for SRS/SRSS of high complexity 61
Table E.1– Body height children 64
Table E.2 – Chest depth children 65
Table E.3 – Head width children 66
Table E.4 – Head length children 67
Table F.1 – Example 1 of environmental influence and classes according to IEC 60721-3-5 69
Table F.2 – Example 2 of environmental influence and classes according to IEC 60721-3-3 70
Table G.1 – Demand rates used for the calculation of Table G.2 values 74
Table G.2 – Limits for failure to danger condition (loss of the detection capability) due to environmental influence for high demand mode 74
Table H.1 – Example of test plan and test result for mechanical influence test 78

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

SAFETY OF MACHINERY –

Safety-related sensors used for the protection of persons

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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a Technical Specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62998-1, which is a Technical Specification, has been prepared by IEC technical committee TC 44: Safety of machinery – Electrotechnical aspects.

The text of this Technical Specification is based on the following documents:

Draft TS	Report on voting
44/826/DTS	44/839A/RVDTS

Full information on the voting for the approval of this Technical Specification can be found in the report on voting indicated in the above table.

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

A list of all parts in the IEC 62998 series, published under the general title *Safety of machinery*, can be found on the IEC website.

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

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

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

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 related sensors are applied to machinery presenting a risk of personal injury. They provide protection by causing the machine to revert to a safe condition before a person can be placed in a hazardous situation.

IEC 61496 (all parts) provides design and performance requirements of electro-sensitive protective equipment (ESPE). It gives a clear but limited guideline for

– specific sensor technologies (like optical sensors) or sensing functions (like capability to detect a specified object);

– typical conditions representing indoor use in industrial environment;

– detection of objects representing parts of body of adults using the properties geometry and reflectivity;

– design, functional requirements and tests in accordance with ESPE specific safety performance classification in types (2,3 and 4).

Autonomous systems like automated guided vehicles (AGV), service robotics or human machine interaction in industries show an increasing demand, for example in

– new sensor technologies (e.g. radar, ultrasonic sensors),

– new kind of sensor functions (e.g. classification of objects, position of an object), and

– combination of different sensor technologies in a sensor system.

Sensor manufacturers or integrators use in such cases generic functional safety standards as guideline for the safety related product design. Generic functional safety standards like IEC 61508 (all parts) or sector specific machinery standards like IEC 62061 or ISO 13849 (all parts) are general and product design can be carried out without inappropriate limitations. Applying these standards would require a dedicated analysis of systematic capabilities of a sensor or sensor system (e.g. dependability of the sensing function under tolerance conditions and environmental influences). There is not enough guidance given in these standards to prevent design failures or insufficient capability to detect the specified object in certain environmental conditions. This can result in an intolerable risk for persons.

This document fills the gap for the examination of systematic capabilities between design specific sensor standards and generic functional safety standards of electrical, electronic or programmable electronic control systems.

NOTE 1 Examples for the examination of systematic capabilities by using different safety related sensor standards are given in Annex A.

This document is addressed to safety related sensor manufacturers and integrators of safety related sensors into a safety related sensor system.

NOTE 2 Examples for addressed user groups are given in Annex B.

SAFETY OF MACHINERY –

Safety-related sensors used for the protection of persons

1 Scope

This Technical Specification gives requirements for the development and integration of safety related sensors (SRS) and safety related sensor systems (SRSS) used for protection of persons with special attention to systematic capabilities.

This generic standard only applies if

– protection of persons is to be performed by using sensors, and
– standards for functional safety of electrical control systems address sensor(s) as subsystem or subsystem element, and
– product specific sensor standards (e.g. IEC 61496 (all parts), IEC 60947-5-2) do not contain all necessary provisions, or product specific sensor standards are not developed.

The approach of examination of systematic capabilities by using different safety related sensor standards is described in Annex A.

The requirements and methods within this document are limited to the purpose of protection of persons

– by detection of potentially hazardous objects,
– by detection of a body, parts of a body and objects associated to parts of a body entering a hazardous area, or
– by classification respective discrimination of these against other objects.

NOTE 1 Application of SRS/SRSS in public can require detecting not only of persons, but also their associated equipment, for example wheelchairs, walking sticks or infusion stands.

Performance classes of sensors and sensor systems are defined in accordance with existing functional safety standards (e.g. IEC 62061, IEC 61508 (all parts), and ISO 13849 (all parts)).

NOTE 2 There will be no definitions of or interconnections to the types as defined in IEC 61496-1 within this document to simplify and prevent misuse. Simplification for end users is achieved by correlation to existing PL, SIL or SIL_{cl}.

Special attention is given to the sensing function and dependability of the detection capability. Environmental influences and tests for indoor and outdoor use are defined which influence the sensing function and dependability of the detection capability.

NOTE 3 Environmental influences, their classification and test procedures are primarily specified in accordance with generic environmental standards. More specific requirements and tests are only described in absence of respective standards.

This document can be relevant to applications other than those for the protection of persons in industries, for example, for the protection of persons in public like agriculture or metro stations.

This document does not consider and address proven in use (e.g. processes or elements) as done in IEC 61508-2.