IEC TS 62998-3

Edition 1.0 2023-08

TECHNICAL SPECIFICATION

Safety of machinery – Safety-related sensors used for the protection of persons –
Part 3: Sensor technologies and algorithms

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.110; 21.020

ISBN 978-2-8322-7174-2

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

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 7
2 Normative references 7
3 Terms and definitions 8
4 Sensor technologies 11
4.1 General considerations 11
4.2 SRS using visible light 13
4.2.1 General 13
4.2.2 Material considerations 13
4.2.3 Measurement method considerations 13
4.2.4 Sensing unit arrangement considerations 14
4.3 SRS using near infrared radiation 17
4.3.1 General 17
4.3.2 Material considerations 17
4.3.3 Measurement method considerations 18
4.3.4 Sensing unit arrangement considerations 18
4.4 SRS using middle infrared radiation 19
4.4.1 General 19
4.4.2 Material considerations 20
4.4.3 Measurement method considerations 20
4.4.4 Sensing unit arrangement considerations 20
4.5 SRS using millimetre wave radiation 21
4.5.1 General 21
4.5.2 Material considerations 21
4.5.3 Measurement method considerations 21
4.5.4 Sensing unit arrangement considerations 22
4.6 SRS using radio/millimetre wave radiation 23
4.6.1 General 23
4.6.2 Tag considerations 23
4.6.3 Measurement method considerations 23
4.6.4 Sensing unit arrangement considerations 24
4.7 SRS using ultrasound wave radiation 25
4.7.1 General 25
4.7.2 Material considerations 25
4.7.3 Measurement method considerations 25
4.7.4 Sensing unit arrangement considerations 26
5 Algorithm related considerations 27
5.1 General 27
5.2 Design and development phase 30
5.2.1 General 30
5.2.2 Achieve the detection of objects 32
5.2.3 Improve the dependability of the detection capability 33
5.2.4 Provide confidence information at the output unit 33
5.3 Integration and installation phase 33
5.3.1 General 33

5.3.2 Achieve improved detection of objects 35
5.3.3 Improve the dependability of the detection capability 36
5.3.4 Provide confidence information at the output unit 36
5.4 Maintenance phase 36
Annex A (informative) Physical property reflectivity for visible light or near infrared radiation 38
A.1 Process in accordance with IEC TS 62998-1 38
A.2 Persons or parts of a person 39
Annex B (informative) Physical property reflectivity for millimetre wave radiation 42
Annex C (informative) Physical property temperature for middle infrared radiation 44
C.1 Process in accordance with IEC TS 62998-1 44
C.2 Exemplary determination of the temperature 45
Annex D (informative) Physical property reflectivity for ultrasound wave radiation 47
Bibliography 50

Figure 1 – Co-located and stationary sensing unit arrangement 15
Figure 2 – Separated and stationary sensing unit arrangement 15
Figure 3 – Multiple and stationary sensing unit arrangement 16
Figure 4 – Co-located and moving sensing unit arrangement 16
Figure 5 – Separated and moving sensing unit arrangement 16
Figure 6 – Multiple and moving sensing unit arrangement 16
Figure 7 – Exemplary combined stationary and moving sensing unit arrangement 17
Figure 8 – Exemplary multiple combined and moving sensing unit arrangement 17
Figure 9 – Algorithms exemplary applied to an SRS or an SRSS 28
Figure 10 – Flowchart for algorithm based on requirements 29
Figure 11 – Flowchart for algorithm based on training data 30
Figure 12 – Exemplary use of algorithm for peak extraction 31
Figure 13 – Exemplary use of algorithm to combine measurement information 32
Figure 14 – Exemplary combination of two SRS in an SRSS 34
Figure 15 – Exemplary integration of SRS measurement information in an SRSS 35
Figure C.1 – Illustration of temperature measurement 46
Figure D.1 – Object ultrasonic reflectivity quantified by acoustic impedance or reflection coefficient 47
Figure D.2 – Object ultrasonic reflectivity quantified by radar cross section 48

Table 1 – Specific sensor types used as part of SRS 12
Table A.1 – Range of diffuse reflectance values of human skin if detection of skin can be derived from the intended use 39
Table A.2 – Range of diffuse reflectance values of clothes if detection of parts of persons can be derived from the intended use 40
Table A.3 – Diffuse reflectance values if detection of the whole body of persons can be derived from the intended use 41

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

SAFETY OF MACHINERY – SAFETY-RELATED SENSORS USED FOR THE PROTECTION OF PERSONS

Part 3: Sensor technologies and algorithms

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.

IEC TS 62998-3 has been prepared by IEC technical committee TC 44: Safety of machinery – Electrotechnical aspects. It is a Technical Specification.

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

Draft	Report on voting
44/981/DTS	44/1002/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.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

This document is intended to be used in conjunction with IEC TS 62998-1.

A list of all parts in the IEC 62998 series, published under the general title *Safety of machinery – safety-related sensors used for the protection of persons*, can be found on the IEC website.

Future documents in this series will carry the new general title as cited above. Titles of existing documents in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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.

IMPORTANT – The "colour inside" logo on the cover page of this document 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

Applications of automated guided vehicles, service robotics used in public areas or human machine interaction in industries show an increasing demand and use of new sensor technologies and new kinds of sensor functions with respect to hazard exposure of persons. A rapidly increasing number of sensors, with different sensor technologies, are used in these applications to achieve a high degree of automation up to autonomy. The systematic capabilities of such sensors are relevant to reduce the risk of personal injury. Other aspects of functional safety related to sensors as part of control systems are covered by e.g. IEC 61508 (all parts), IEC 62061 or ISO 13849 (all parts).

Existing design specific sensor standards set requirements on systematic capabilities for a selected sensor technology and how these can be assessed by analysis and test. The specific requirements are derived from products with limited classes of safety performance and already well-known sensor technology.

IEC TS 62998-1 sets general requirements for the development, integration and maintenance of safety related sensors (SRS) and safety related sensor systems (SRSS) applicable to all sensor technologies with special attention to systematic capabilities. IEC TS 62998-1 is appropriate for the risk reduction in accordance with all classes of safety performance in an identified application.

First assessments of SRS/SRSS in accordance with IEC TS 62998-1 identified the need for additional guidance for the required analysis of sensor technologies and use of algorithms.

Sensor technology is defined by the wavelength range, the measurement method and the arrangement of the sensing unit in an SRS, respectively arrangement of SRS in an SRSS. This document gives guidance for sensor technologies without setting requirements for a specific design or limiting the class of safety performance. If applicable to the sensor technology, additional information is given for physical properties of the objects to be detected or relevant objects that interfere with the detection of such objects.

Algorithms are a core element to achieve safety related functions in an SRS/SRSS, such as signal processing to extract peaks in analogue signals, localization or classification of objects that are important to guide an autonomous or highly automated system in a more or less known surrounding. Platforms such as cloud services provide e.g. algorithms or measures for their automated generation that can be implemented by different integrators of SRS into an SRSS or by the manufacturer of such sensors. This document gives guidance on the correct implementation of algorithms to prevent intolerable risk for persons.

SAFETY OF MACHINERY – SAFETY-RELATED SENSORS USED FOR THE PROTECTION OF PERSONS

Part 3: Sensor technologies and algorithms

1 Scope

This part of IEC 62998, which is a technical specification, gives guidance on:

– analysis of sensor technologies of different wavelength ranges, measurement methods, and the sensing unit arrangement in an SRS, respectively the arrangement of SRSs in an SRSS;
– representative physical properties of safety-related objects with due consideration of their material characteristics and the sensor technology/technologies used in an SRS/SRSS to achieve the detection capability and comparable results during verification and validation;
– analysis of the interference of objects present in the surrounding on the safety related objects and thereby the influence on the dependability of the detection capability;
– use of algorithms during design, development and maintenance to achieve appropriate detection capability and dependability of detection;
– appropriate use of algorithms during the integration of SRS or SRSS by the integrator to improve execution of measurement information or provide decision information derived from measurement information.

If an SRS/SRSS uses sensor technologies not stated in this document, then the generic approach in accordance with IEC TS 62998-1 applies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60079-29 (all parts), *Explosive atmospheres - Part 29 - Gas detectors*

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

IEC TS 62998-1:2019, *Safety of machinery - Safety-related sensors used for the protection of persons*

EN 50402, *Electrical apparatus for the detection and measurement of combustible or toxic gases or vapours or of oxygen – Requirements on the functional safety of fixed gas detection systems*