

TECHNICAL SPECIFICATION



**Safety of machinery – Electro-sensitive protective equipment –
Part 4-3: Particular requirements for equipment using vision based protective
devices (VBPD) – Additional requirements when using stereo vision techniques
(VBPDEST)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.110; 29.260.99

ISBN 978-2-8322-5739-5

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

CONTENTS

FOREWORD	4
INTRODUCTION	6
1 Scope	7
2 Normative references	8
3 Terms and definitions	8
4 Functional, design and environmental requirements	12
5 Testing	21
6 Marking for identification and for safe use	34
7 Accompanying documents	34
Annex A (normative) Optional functions of the ESPE	36
Annex B (normative) Catalogue of single faults affecting the electrical equipment of the ESPE, to be applied as specified in 5.3	38
Annex AA (informative) The positioning of VBPDST employing a volume as a detection zone in respect of parts of the human body	39
Annex BB (informative) Relationship between position accuracy and tolerance zones for VBPDST	48
Annex CC (informative) Basic principles of physics for contrast of convex homogeneous bodies	54
Bibliography	61
Figure 1 – Image planes in imaging device of a VBPDST	9
Figure 2 – 3D view of a vision based protective device using stereo vision techniques (VBPDST)	12
Figure 3 – 2D view of a vision based protective device using stereo vision techniques (VBPDST)	13
Figure 4 – Examples for periodic surface structures on the background	25
Figure 5 – Test setup for indirect light interference on the background	30
Figure 6 – Test setup for VBPDST of identical design with PAPT	31
Figure 7 – Test setup for direct light interference on the sensing device	32
Figure AA.1 – Minimum distance S – Example 1	42
Figure AA.2 – Overall minimum distance S_0 without tolerance zone – Example 1	42
Figure AA.3 – Overall minimum distance S_0 including tolerance zone – Example 1	43
Figure AA.4 – Minimum distance S – Example 2	44
Figure AA.5 – Overall minimum distance S_0 without tolerance zone – Example 2	45
Figure AA.6 – Overall minimum distance S_0 including tolerance zone – Example 2	45
Figure AA.7 – Application example for body detection of a VBPDST employing a volume as a detection zone	47
Figure BB.1 – Relationship between test piece position and the probability of detection	49
Figure BB.2 – Example for measurement of the probability of detection	50
Figure BB.3 – Relationship between detection zone and tolerance zone	52
Figure BB.4 – Overall minimum distance S_0 including tolerance zone	53
Figure CC.1 – Illumination model – Sphere illuminated by a point source	55

Figure CC.2 – Illumination model – Sphere illuminated by a half-Ulbricht sphere	55
Figure CC.3 – Brightness of a surface element of a sphere in spherical coordinates	56
Figure CC.4 – Brightness distribution in an image of a sphere	56
Figure CC.5 – Grey value profile over a sphere with low contrast for a typical imaging contrast (Modulation Transfer Function).....	57
Figure CC.6 – Grey value profile over a sphere with the same colour as the background.....	57
Figure CC.7 – Grey value profile over a sphere in front of a background that is half as bright	58
Figure CC.8 – Grey value profile over a sphere in front of a background that is twice as bright	58
Figure CC.9 – Grey value profile over a sphere by low contrast	59
Figure CC.10 – Grey value profile over the sphere from Figure CC.9 but with the direction to the imaging device changed by 10°	59
Figure CC.11 – Grey value profile over a small sphere that results in an image that is 5 pixels in diameter.....	60
Table 431 – Verification of detection capability requirements (see also 4.2.12)	23
Table 432 – Overview of light interference tests	28

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF MACHINERY –
ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT –****Part 4-3: Particular requirements for equipment using
vision based protective devices (VBPD) –
Additional requirements when using stereo
vision techniques (VBPDST)**

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 61496-4-3 has been prepared by IEC technical committee TC 44: Safety of machinery – Electrotechnical aspects. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2015-05. This edition constitutes a technical revision.

This edition includes the following technical changes with respect to the previous edition:

- a) Some requirement clauses and test procedures have been adapted or removed because they have been consolidated in IEC 61496-1:2020 (e.g. 5.4.6.2 Light sources or Clause A.9).

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

Draft	Report on voting
44/934/DTS	44/957A/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this document 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 <https://www.iec.ch/publications>.

This document is to be used in conjunction with IEC 61496-1:2020.

This document supplements or modifies the corresponding clauses in IEC 61496-1:2020 to specify particular requirements for the design, construction and testing of electro-sensitive protective equipment (ESPE) for the safeguarding of machinery, employing vision based protective devices (VBPD) using stereo vision techniques (VBPDEST) for the sensing function.

Where a particular clause or subclause of IEC 61496-1:2020 is not mentioned in this document, that clause or subclause applies as far as is reasonable. Where this document states "*addition*", "*modification*" or "*replacement*", the relevant text of IEC 61496-1:2020 is adapted accordingly.

Clauses and subclauses which are additional to those of IEC 61496-1:2020 are numbered sequentially, following on the last available number in IEC 61496-1:2020. Terminological entries (in Clause 3) which are additional to those in IEC 61496-1:2020 are numbered starting from 3.4301. Additional annexes are lettered from AA onwards and additional tables are numbered with prefix 43.

A list of all parts in the IEC 61496 series, published under the general title *Safety of machinery – Electro-sensitive protective equipment*, 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 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

An electro-sensitive protective equipment (ESPE) is applied to machinery presenting a risk of personal injury. It provides protection by causing the machine to revert to a safe condition before a person can be placed in a hazardous situation.

The working group responsible for drafting this document was concerned that, due to the complexity of the technology, there are many issues that are highly dependent on analysis and expertise in specific test and measurement techniques. In order to provide a high level of confidence, independent review by relevant expertise is recommended. They considered that if this high level of confidence could not be established these devices would not be suitable for use in safety related applications.

SAFETY OF MACHINERY – ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT –

Part 4-3: Particular requirements for equipment using vision based protective devices (VBPD) – Additional requirements when using stereo vision techniques (VBPDEST)

1 Scope

Replacement:

This document specifies requirements for the design, construction and testing of non-contact electro-sensitive protective equipment (ESPE) designed specifically to detect persons or parts of persons as part of a safety-related system, employing vision-based protective devices (VBPDs) using stereo vision techniques (VBPDEST) for the sensing function. Special attention is directed to features which ensure that an appropriate safety-related performance is achieved. An ESPE can include optional safety-related functions, the requirements for which are given in Annex A of IEC 61496-1:2020 and this document.

NOTE "Non-contact" means that physical contact is not required for sensing.

Where this document does not contain all necessary provisions, IEC TS 62998-1 applies.

It is also possible, for those aspects not considered in this document, to use provisions from IEC TS 62998-1 additionally.

This document does not specify the dimensions or configurations of the detection zone and its disposition in relation to hazardous parts for any particular application, nor what constitutes a hazardous state of any machine. It is restricted to the functioning of the ESPE and how it interfaces with the machine.

The detection principle is based on the evaluation of images from different viewing points (stereoscopic view) for the determination of distance information. This distance information is used to determine the position of an object(s).

- This document is limited to vision based ESPEs with fixed distances (stereo base) and fixed directions of the optical axes using a fixed focal length.
- It is limited to vision based ESPEs that do not require human intervention for detection.
- It is limited to vision based ESPEs that detect objects entering into or being present in a detection zone(s).
- It is limited to VBPDESTs employing radiation at wavelengths within the range 400 nm to 1 500 nm.
- This document does not address those aspects required for complex classification or differentiation of the object detected.
- This document does not consider the aspects of a moving ESPE installation.

Additional requirements and tests can apply in the following cases:

- Use of multi-spectral (colour) techniques;
- Setups other than as shown in Figure 2 and Figure 3 (e.g. changing backgrounds, horizontal orientation of the optical axis with respect to the floor);

- Intended for outdoor applications.

This document is relevant for VBPDSTs having a stated detection capability up to 200 mm.

This document can be relevant to applications other than those for the protection of persons or parts of persons like arm or fingers (in the range 14 mm to 200 mm), for example the protection of machinery or products from mechanical damage. In those applications, additional requirements can be necessary, for example when the materials that are to be recognized by the sensing function have different properties from those of persons.

This document does not deal with EMC emission requirements.

2 Normative references

Addition:

IEC 60825-1:2014, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 61496-1:2020, *Safety of machinery – Electro-sensitive protective equipment – Part 1: General requirements and tests*

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

ISO 13855:2010, *Safety of machinery – Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 20471:2013, *High visibility clothing – Test methods and requirements*