

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
(VBPDST)**

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.110; 29.260.99

ISBN 978-2-8322-5815-6

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

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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

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TS 61496-4-3:2015. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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 (VBPDST) 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.

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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 ~~required~~ 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.

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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)

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 (VBPDST) for the sensing function. Special attention is directed to features which ensure that an appropriate safety-related performance is achieved. An ESPE ~~may~~ **can** include optional safety-related functions, the requirements for which are given in Annex A of IEC 61496-1:2012/2020 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 ~~location~~ **position** of an object(s).

- This document is limited to vision based ESPEs with **fixed** distances (stereo base) and **fixed** directions ~~between the different imaging devices fixed during manufacture~~ of the optical axes using a fixed focal length.
- ~~— It is limited to vision based ESPEs, with a minimum distance from the sensing device to the detection zone of 4 times of the stereo base.~~
- ~~— It is limited to vision based ESPEs that can detect objects with at least 5 pixel diameter in the image plane.~~
- 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 VBPDSTs 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 ~~may~~ **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 61496-1:2012/2020, *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*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

This clause of IEC 61496-1:2020 is applicable except as follows:

Replacement:

3.3

detection capability

ability to detect the specified test pieces (see 4.2.13) in the specified detection zone

Note 1 to entry: Detection capability is measured by the size of an object that can be detected. An increase in detection capability means that a smaller object can be detected.

[SOURCE: IEC 61496-1:2012, 3.3, modified – The text has been changed to make it more relevant to vision based sensors and Note 1 has been added.]

3.4

detection zone, <of a VBPDS>

three-dimensional volume ~~(for example, in the shape of a pyramid or cone)~~ within which a specified test piece will be detected by the VBPDS

Note 1 to entry: Example for three-dimensional volume are a pyramid or a cone

3.5

electro-sensitive protective equipment ESPE

Addition:

Note 3 to entry: Illumination unit(s), if applicable, is/are part(s) of the sensing device.

Addition:

3.4301

minimum detection zone

lowest dimension of the detection zone for a test piece moving with maximum speed

Note 1 to entry: This is the lowest dimension that ensures the integrity of the detection capability.

3.4302

evaluation images, pl

set of images which are used by the detection algorithms

SEE: Figure 1.

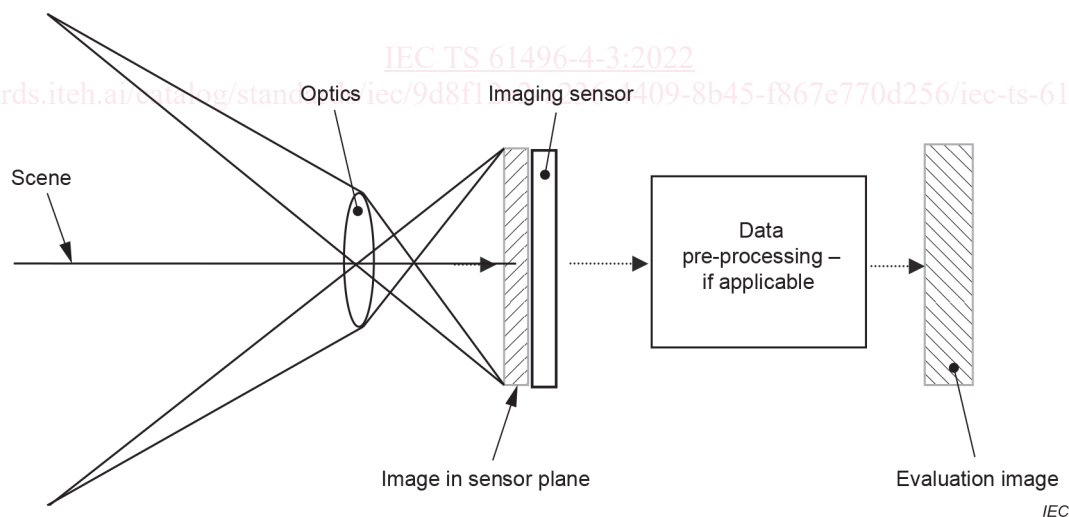


Figure 1 – Image planes in imaging device of a VBPDS

3.4303

Image

<of a VBPDS>

snapshot representation of the scene in different planes of the VBPDS in form of a two dimensional pixel matrix

3.4304

vision-based protective device

VBPD

ESPE using an imaging sensor, operating in the visible and near infrared light spectrum to detect an object in a defined field of view

Note 1 to entry: This note applies to the French language only.

3.4305

vision based protective device using stereo vision techniques

VBPDST

VBPD with two or more imaging devices using stereo vision techniques and with or without active illumination

3.4306

imaging sensor

opto-electronic device which produces electrical signals representing the characteristics of an image

SEE: Figure 1.

3.4307

imaging device

combination of an imaging sensor, optics and the processing unit (if applicable)

SEE: Figure 1.

Note 1 to entry: The imaging devices are part of the sensing device.

3.4308

operating distance

distance measured along the z-axis of the sensing device coordinate system

3.4309

Pixel

<of a sensor>

smallest light sensitive element of an imaging sensor

3.4310

Pixel

<of an image>

area of the smallest element that can be distinguished from its neighbouring elements

3.4311

ambient illumination technique

AIT

technique that relies on scene lighting for illumination and contrast to obtain range measurements

3.4312

pattern projection technique

PAPT

technique that uses a special projection to enhance the contrast of a scene

3.4313

sensing device coordinate system

coordinate system oriented to the sensing device

Note 1 to entry: Typically, the z-axis is parallel to the optical axis of one imaging device.

3.4314

tolerance zone

zone outside of and adjacent to the detection zone within which the specified test piece is detected with a probability of detection lower than the required probability within the detection zone

Note 1 to entry: The tolerance zone is necessary to achieve the required probability of detection of the specified test piece within the detection zone. For explanation of the concept of probability of detection and the tolerance zone, see Annex BB.

3.4315

user coordinate system

coordinate system that may be configured by the user

3.4316

zone with limited detection capability

volume between the detection zone and the front of the sensing device in which the stated detection capability is not achieved

3.4317

stereo base

distance between the centres of the entrance pupils of two imaging devices

Note 1 to entry: The expression baseline is often used as synonym for stereo base.

3.4318

position accuracy

accuracy in three dimensions of the position of an object as measured by VBPDST

Addition:

Abbreviated terms

AIT	Ambient illumination technique
BTP	Black test piece
GB	Grey background
GTP	Grey test piece
lx	Lux
LC	Low contrast
OD	Operating distance
P1	Position 1 of the light source
P2	Position 2 of the light source
PAPT	Pattern projection techniques
PTZ	Tolerance zone related to probability
RRTP	Retro-reflective test piece
STZ	Tolerance zone related to systematic influences
TTC	Typical test condition (test condition for normal operation tests)
TI	Typical illumination (illumination used for normal operation tests)
VBPDST	Vision based protective devices using stereo vision techniques
WTP	White test piece