

# 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  
(VBPDS)**

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# TECHNICAL SPECIFICATION



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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)**

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

IEC TS 61496-4-3, which is a technical specification, has been prepared by IEC technical committee 44: Safety of machinery – Electrotechnical aspects.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
44/711/DTS	44/722/RVC

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

This part is to be used in conjunction with IEC 61496-1:2012.

This part supplements or modifies the corresponding clauses in IEC 61496-1:2012 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 Part 1 is not mentioned in this Part 4-3, that clause or subclause applies as far as is reasonable. Where this part states "*addition*", "*modification*" or "*replacement*", the relevant text of Part 1 shall be adapted accordingly.

Clauses and subclauses which are additional to those of Part 1 are numbered sequentially, following on the last available number in Part 1. Terminological entries (in Clause 3) which are additional to those in Part 1 are numbered starting from 3.4301. Additional annexes are lettered from AA onwards.

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- 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 technical specification 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. 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 (VBPDEST)

#### 1 Scope

##### *Replacement:*

This part of IEC 61496 specifies requirements for the design, construction and testing of 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 may include optional safety-related functions, the requirements for which are given in Annex A of IEC 61496-1:2012 and this Technical Specification.

This part of IEC 61496 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 of an object(s).

- This part of IEC 61496 is limited to vision based ESPEs with distances (stereo base) and directions between the different imaging devices fixed during manufacture.
- 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 VBPDESTs employing radiation at wavelengths within the range 400 nm to 1 500 nm.
- This part of IEC 61496 does not address those aspects required for complex classification or differentiation of the object detected.
- This part of IEC 61496 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 Figures of 4.1.2 (e.g. changing backgrounds, horizontal orientation of the optical axis with respect to the floor);
- Intended for outdoor applications.

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

This technical specification may 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 technical specification 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, *Safety of machinery – Electro-sensitive protective equipment – Part 1: General requirements and tests*

IEC 62471, *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, *High visibility clothing – Test methods and requirements*

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## 3 Terms and definitions

*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 – text changed to make more relevant to vision based sensors.]

### 3.4

#### **detection zone, <of a VBPDST>**

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

### 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.

*Additional definitions:*

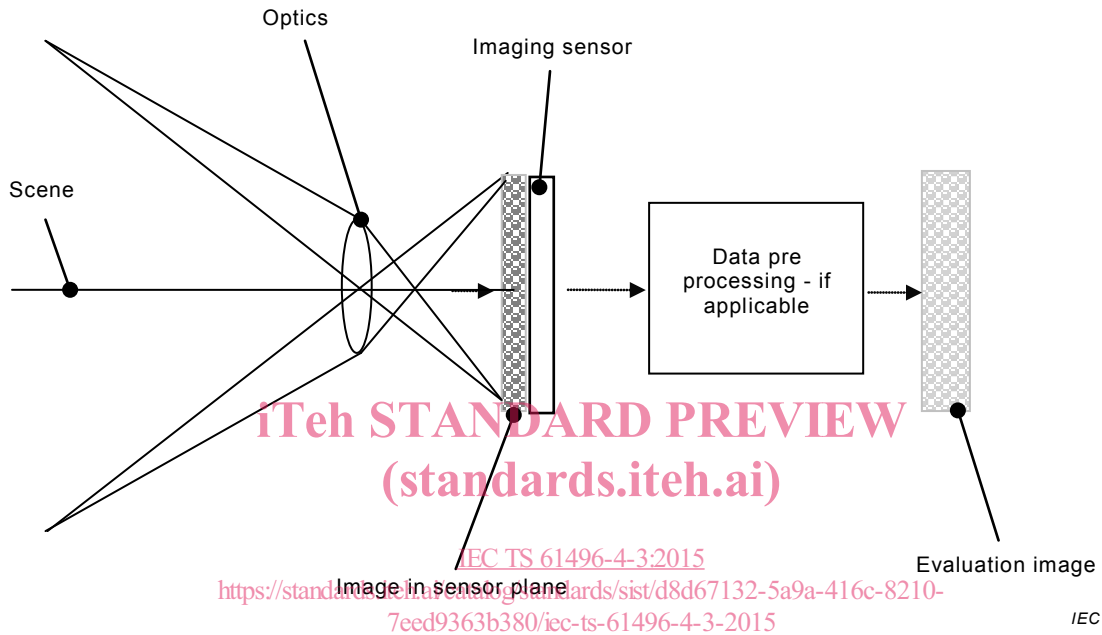
**3.4301**  
**minimum detection zone**

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 VBPDST**

**3.4303**  
**image, <of a VBPDST>**

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

**3.4304**  
**vision based protective device using stereo vision techniques**  
**VBPDST**

VBPD with two or more imaging devices using stereo vision techniques

**3.4305**  
**imaging sensor**

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

SEE: Figure 1.

**3.4306**  
**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.

**3.4307****operating distance**

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

**3.4308****pixel, <of a sensor>**

smallest light sensitive element of an imaging sensor

**3.4309****pixel, <of an image>**

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

**3.4310****ambient illumination technique****AIT**

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

**3.4311****pattern projection technique****PAPT**

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

**3.4312****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.

**3.4313****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.

**3.4314****user coordinate system**

coordinate system that may be configured by the user

**3.4315****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

**3.4316****stereo base**

distance between the entrance pupils of two imaging devices

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

**3.4317****position accuracy**

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

*Addition:*

**Abbreviated terms**

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

**4 Functional, design and environmental requirements**

This clause of Part 1 is applicable except as follows:

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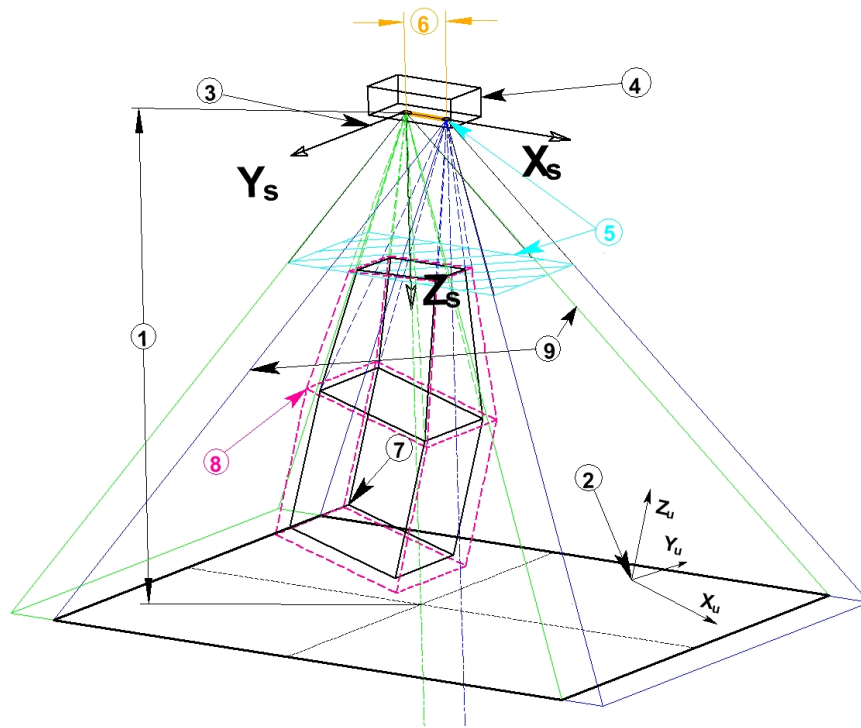
**4.1 Functional requirements**

*Replacement:*

**4.1.2 Sensing function**

The detection zone shall begin at the border of the zone with limited detection capability and end at the maximum operating distance (see Figure 2 and Figure 3).

Object(s) in the zone with limited detection capability shall not reduce the detection capability within the detection zone. Any reduction of the detection capability shall be detected and the VBPDS shall go to lock-out condition (see 4.2.2.4).



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**Key**

- |                                      |  |                          |
|--------------------------------------|--|--------------------------|
| 1 - Maximum operating distance       | 4 - Sensing device                         | 7 - Detection zone       |
| 2 - User coordinate system           | 5 - Zone with limited detection capability | 8 - Tolerance zone       |
| 3 - Sensing device coordinate system | 6 - Stereo base                            | 9 - Stereo field of view |

NOTE The figure shows a system with parallel axes and a maximum operating distance on a plane perpendicular to the axes.

**Figure 2 – 3D view of a vision based protective device using stereo vision techniques (VBPDS)**