IEC TS 61496-4-2

Edition 2.0 2022-09
REDLINE VERSION

TECHNICAL SPECIFICATION

colour inside

**Safety of machinery – Electro-sensitive protective equipment –
Part 4-2: Particular requirements for equipment using vision based protective devices (VBPD) – Additional requirements when using reference pattern techniques (VBPDPP)**

IEC TS 61496-4-2:2022-09 RLV(en)

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Safety of machinery – Electro-sensitive protective equipment – Part 4-2: Particular requirements for equipment using vision based protective devices (VBPD) – Additional requirements when using reference pattern techniques (VBPDPP)

INTERNATIONAL
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SAFETY OF MACHINERY – ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT –

Part 4-2: Particular requirements for equipment using vision based protective devices (VBPD) – Additional requirements when using reference pattern techniques (VBPDPP)

FOREWORD

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IEC TS 61496-4-2 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 2014. 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 of IEC 61496-1:2020 Light sources or Clause A.9)

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

Draft	Report on voting
44/933/DTS	44/955A/RVDTS

Full information on the voting for the approval of this document 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 http://www.iec.ch/standardsdev/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 reference pattern techniques (VBPDPP) 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 3.4201. Additional annexes are lettered from AA onwards and additional tables are numbered with prefix 42

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.

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- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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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 4-2: Particular requirements for equipment using vision based protective devices (VBPD) – Additional requirements when using reference pattern techniques (VBPDPP)

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 as part of a safety-related system, employing vision-based protective devices (VBPDs) using ~~passive~~ reference pattern~~s~~ techniques (VBPDPP) 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, then 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.

A VBPDPP is defined as consisting of a single image-sensing device viewing on a passive reference pattern as the background and where the detection principle is based on blocking or partially preventing the view of the pattern. Information about the thickness, shape, surface characteristics or location of the object is not required for detection. For multi-image sensing devices, additional techniques, requirements and test procedures can be necessary.

- This document is limited to automatic vision-based ESPEs that do not require human intervention for detection.
- It is limited to automatic vision-based ESPEs that detect objects entering into, or are present in, a detection zone(s).
- It is limited to ESPEs using active illumination technique.
- Excluded from this technical specification are VBPDPPs employing radiation at wavelengths outside 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 is relevant for VBPDPPs having a stated detection capability up to 200 mm.

NOTE The positioning of VBPD in respect of parts of the human body is presented in Annex AA of this document.

This document does not deal with EMC emission requirements.

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2 Normative references

Addition:

IEC 60825-1:~~2007~~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*

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

3 Terms and definitions

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 generally measured by the size of object that can be detected. An increase in detection capability means that a smaller object can be detected.

[SOURCE: IEC 61496-1:~~2012~~2020, 3.3, modified – The text has been changed to make it more relevant to vision based sensors and Note 1 has been added]

Additions:

3.4201
image
snap shot representation of the scene in different planes of the VBPDPP in the form of a two dimensional matrix

3.4202
imaging sensor
optoelectronic device which produces electrical signals representing the characteristics of an image

3.4203
passive reference pattern
static (i.e. fixed location and not changing) regular (periodic) combination of pattern elements on a background that covers at least the detection zone and the tolerance zone – blocking the view of part of the pattern causes detection

Note 1 to entry: Regularity of the pattern refers only to the physical pattern and not to the image of the pattern as seen by the imaging sensor.

3.4204
pattern element
local part of the passive reference pattern

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EXAMPLE Black and white checker board – one black square or one white square.

3.4205
pixel, <of a sensor>
smallest light sensitive element of an imaging sensor array

3.4206
pixel, <of an image>
area of the smallest element that can be distinguished from its neighbouring elements

3.4207
sensing zone
three-dimensional volume defined by the field of view of the image sensor and with the apex at the optical window of the ~~sensor~~ sensing device

Note 1 to entry: The volume could be in the shape of a pyramid or cone.

Note 2 to entry: A zone of limited detection capability, a detection zone and tolerance zone(s) are contained within the sensing zone. The zone of limited detection capability is located between the optical window of the ~~sensor~~ sensing device and the detection zone.

3.4208
tolerance zone
zone outside of and adjacent to the (configured) detection zone within which the specified test piece may not be detected

3.4209
vision-based protective device
VBPD
ESPE using an imaging sensor ~~and active illumination~~, 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.

3.4210
vision-based protective device using passive reference pattern techniques
VBPDPP
VBPD using a single imaging device and active illumination viewing on a passive reference pattern as background

Note 1 to entry: The various parts of a VBPDPP and their relationship to the viewed scene is shown in Figure 1.

Note 2 to entry: This note applies to the French language only.

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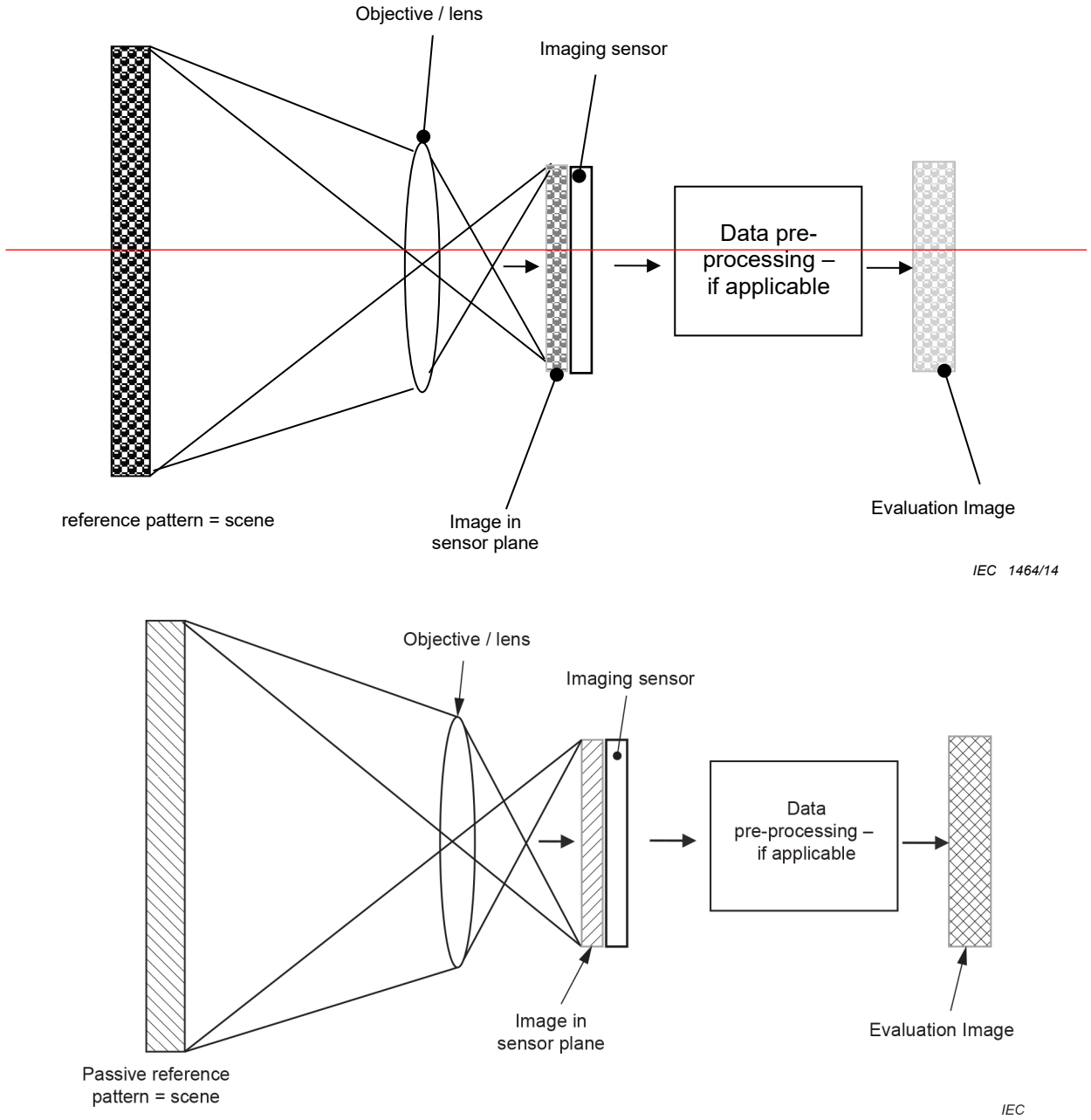

Figure 1 – Image planes in VBPDPP

3.4211
zone with limited detection capability
volume between the detection zone and the optical window(s) of the sensing device which does not achieve the stated detection capability

Note 1 to entry: The dimensions and appropriate information for use of the zone with limited detection capability are provided by the supplier.

4 Functional, design and environmental requirements

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

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4.1 Functional requirements

~~#### 4.1.1 Normal operation~~

~~This subclause of Part 1 is applicable.~~

4.1.2 Sensing function

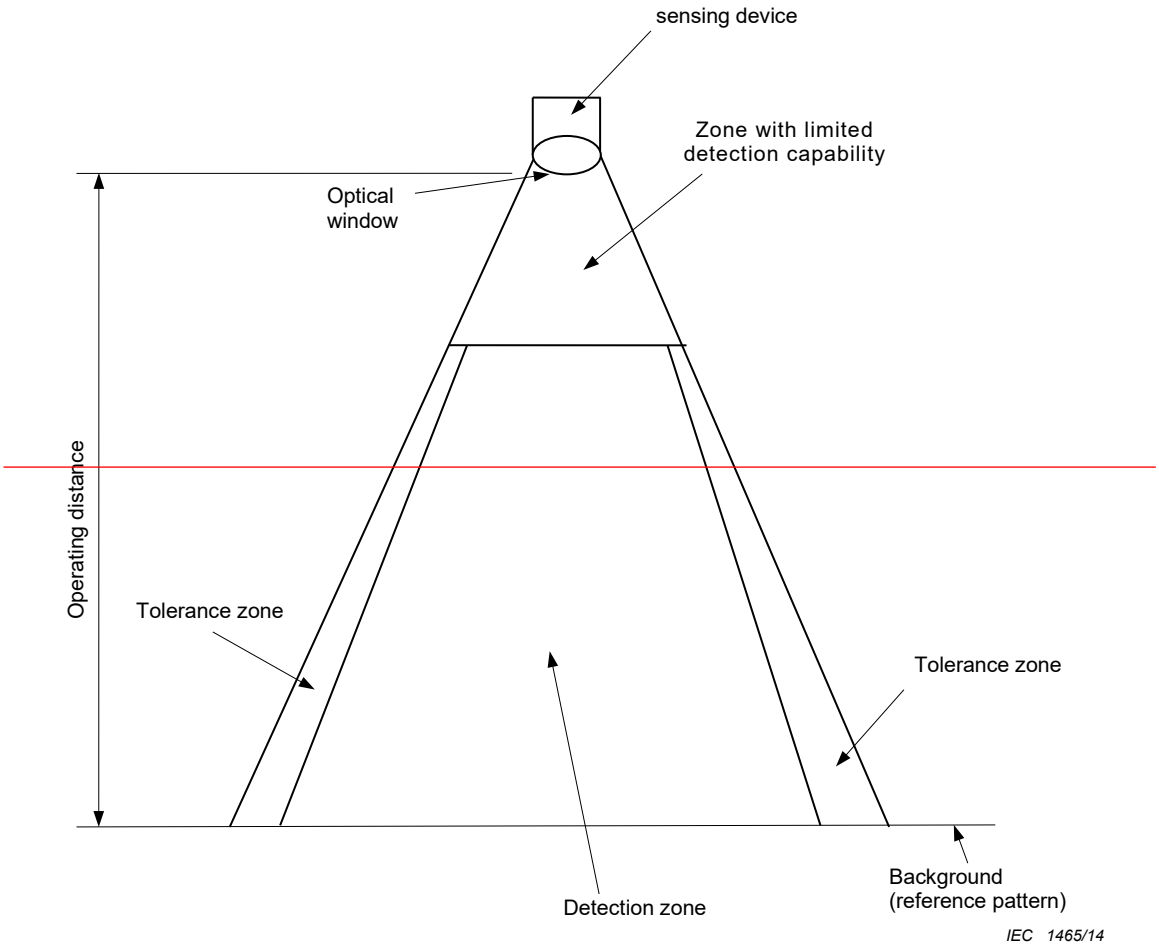
Replacement:

4.1.2.1 General

The detection zone shall begin at the border of the zone of limited detection capability and end at the passive reference pattern (see Figure 2).

NOTE It is possible that only parts of the passive reference pattern are used to define the detection zone.

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



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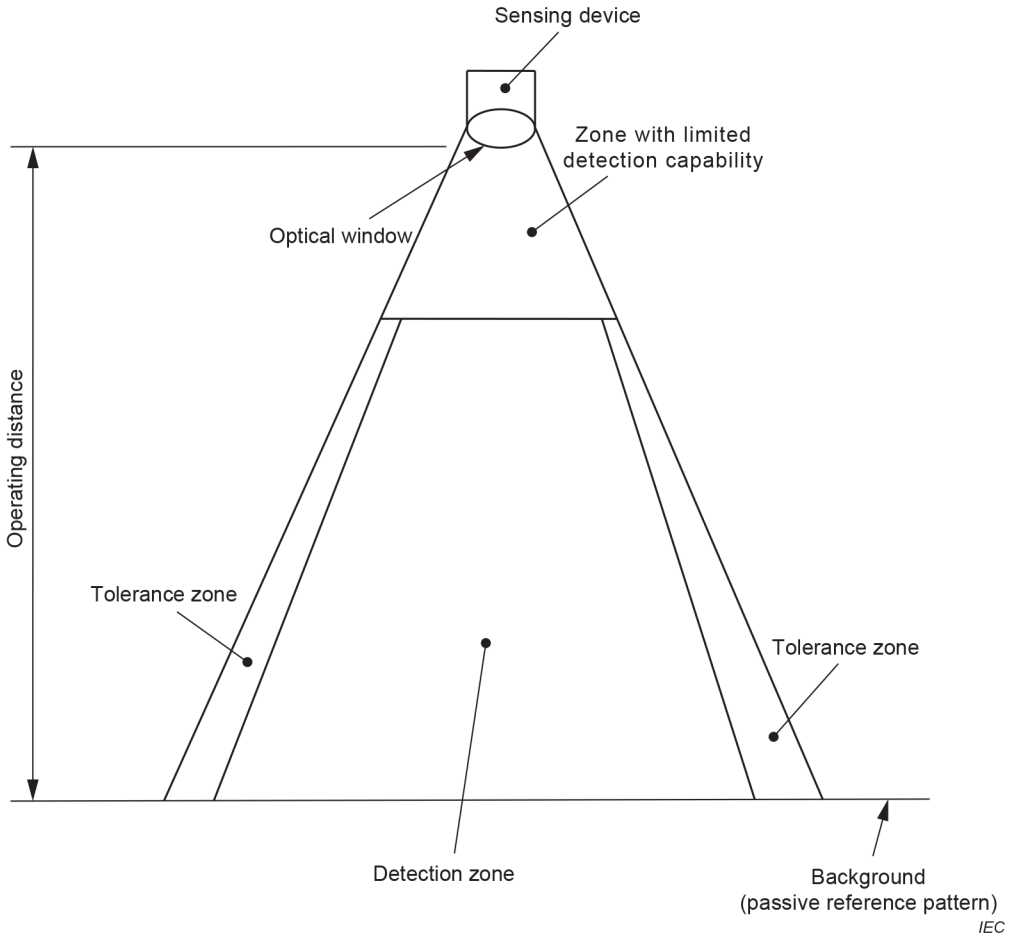

Figure 2 – Side view of VBPDPP using a passive reference pattern

4.1.2.2 Additional functional requirements

The sensing function shall be effective over the specified detection zone. No adjustment of the detection zone or detection capability shall be possible without the use of a security measure (e.g. key, key-word or tool).

The sensing device of a VBPDPP shall respond by giving (an) appropriate output signal(s) when a test piece is placed anywhere within the detection zone either static or moving.

The supplier shall specify the limits of detection capability. The supplier shall take into account worst case scenario including, for example, signal-to-noise ratio, light intensity in the image on the sensor plane, contrast in the image on the sensor plane, position of the image on the sensor, considering all influences listed in this document.

4.1.2.3 Optical performance

The VBPDPP shall be designed and constructed to

- limit the possibility of malfunction during exposure to extraneous radiation in the range of 400 nm to 1 500 nm;
- limit the effects of environmental influences (temperature, vibration and bumps, dust, moisture, ambient light, extraneous reflections, changing illumination, shadows, background reflectivity);
- limit the misalignment at which normal operation is possible.

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4.1.3 Types of ESPE

Replacement:

In this document, only a type 3 ESPE is considered. It is the responsibility of the machine supplier and/or the user to ~~determine if this type is suitable~~ specify which type is required for a particular application.

The type 3 ESPE shall fulfil the fault detection requirements of 4.2.2.4 of this document. In normal operation, the output circuit of each of at least two output signal switching devices (OSSDs) shall go to the OFF-state when the sensing device is actuated, or when the power is removed from the ~~device~~ ESPE.

When a single safety-related data interface is used to perform the functions of the OSSD(s), then the data interface and associated safety-related communication interface shall meet the requirements of 4.2.4.4 of IEC 61496-1:2020. In this case, a single safety-related data interface can substitute for two OSSDs in a type 3 ESPE.

~~**4.1.4 Types and required safety performance**~~

~~This subclause of Part 1 is applicable.~~

~~**4.1.5 Required PL_r or SIL and corresponding ESPE type**~~

~~This subclause of Part 1 is applicable.~~

~~*New functional requirement*~~ *Addition:*

4.1.6 Zone with limited detection capability

A zone between the optical window and the beginning of the detection zone is referred to as a zone with limited detection capability. In order to ensure no hazard can arise in a particular application due to the presence of this zone between the optical window and the detection zone, its dimensions and appropriate information for use shall be provided by the supplier.

4.2 Design requirements

4.2.2 Fault detection requirements

4.2.2.2 Particular requirements for a type 1 ESPE

This subclause of IEC 61496-1:2020 is not applicable.

4.2.2.3 Particular requirements for a type 2 ESPE

This subclause of IEC 61496-1:2020 is not applicable.

4.2.2.4 Particular requirements for a type 3 ESPE

~~*Replacement:*~~

~~A single fault in the sensing device resulting in a complete loss of the stated VBPDPP detection capability shall cause the ESPE to go to a lock-out condition within the specified response time.~~

~~A single fault resulting in a deterioration of the stated VBPDPP detection capability shall cause the ESPE to go to a lock-out condition within a time period of 5 seconds following the occurrence of that fault.~~

Addition:

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NOTE Examples of deterioration of the VBPDPP detection capability include:

– increase of the minimum detectable object size;

– Increase in the minimum detectable contrast.

~~A single fault resulting in an increase in response time beyond the specified value or preventing at least one OSSD going to the OFF-state shall cause the ESPE to go to a lockout condition immediately, i.e. within the response time, or immediately upon any of the following demand events where fault detection requires a change in state:~~

~~– on actuation of the sensing function;~~

~~– on switch off/on;~~

~~– on reset of the start interlock or the restart interlock, if available (see Clauses A.5 and A.6 of IEC 61496-1:2012).~~

~~It shall not be possible for the ESPE to achieve a reset from a lock-out condition, for example, by interruption and restoration of the mains power supply or by any other means, when the fault which initiated the lock-out condition is still present.~~

~~In cases where a single fault which does not cause a failure to danger of the ESPE is not detected, the occurrence of one additional fault shall not cause a failure to danger.~~

~~For verification of this requirement, see 5.3.4.~~

4.2.2.5 Particular requirements for a type 4 ESPE

This subclause of IEC 61496-1:2020 is not applicable.

NOTE Type 4 is not considered in this document. Additional definitions, requirements and test procedures would be necessary.

~~*Additional design requirements:*~~

4.2.12 Integrity of the ~~VBPDPP~~ ESPE detection capability

Replacement:

4.2.12.1 General

The design of the VBPDPP shall ensure that the detection capability is not ~~degraded~~ decreased below the limits specified by the supplier and in this document by any of, but not limited to, the following:

a) at the minimum contrast between an object and reference pattern on the evaluation images;

NOTE Minimum contrast on the evaluation image can be achieved by low or high contrast in the scene.

b) the position of the object within the detection zone

c) the number of objects;

d) the size of objects;

e) auto-adjustment, for example the following:

1) auto-focus
2) gain control
3) orientation
4) sample rate
5) shutter time
6) aperture stops
7) focal length

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f) properties/limitations of imaging sensor, for example the following:
   1) signal noise (e.g. fixed pattern noise; dark noise)
   2) dynamic range
   3) sensitivity
   4) micro lenses
   5) gain settings
   6) cold and hot pixels
   7) dark current
   8) change of characteristics, e.g. wavelength dependent sensitivity, filter
   9) photo response non-uniformity
g) accuracy of object position in images, accuracy and stability of calibration;
h) at the limits of alignment and/or adjustment;
i) ageing of components;
j) performance and limitations of the optical components;
k) component tolerances;
l) changing of internal and external references to guarantee the detection capability;
m) environmental conditions specified in 4.3.

If a single fault (as specified in Annex B of IEC 61496-1:2012 2020), which under normal operating conditions (see 5.1.2.1 of IEC 61496-1:2012 2020) would not result in a loss of VBPDPP detection capability but, when occurring with a combination of the conditions specified above, would result in such a loss, that fault, together with that combination of conditions (as determined to be relevant during the analysis of the design) shall be considered as a single fault and the VBPDPP shall respond to such a single fault as required in 4.2.2.4.

The VBPDPP shall not fail to danger if a reflective object (for example, reflective clothes) is placed at any position in the detection zone.

The relationship of the minimum detectable object size and the size of the elements of the ~~background~~ passive reference pattern shall be sufficient to ensure the integrity of the detection capability (e.g. object size is three or more times the size of the pattern element).

4.2.12.2 Detection zone

The supplier shall specify the size, shape and other relevant parameters of the detection zone(s). The supplier shall define values in the range up to 200 mm as the minimum detectable object size of the VBPDPP. The minimum detectable object size may be distance dependent. All points on a path projected from any point on the border of the detection zone to the imaging sensor of the VBPDPP shall be within the detection zone or the zone with limited detection capability (see 4.1.~~4~~6).

4.2.12.3 Response time

Objects of the minimum detectable size that are either stationary or moving within the detection zone at any speed up to 1,6 m/s shall be detected by the ESPE within the specified response time. The supplier shall specify the maximum response time. The supplier shall take into account worst case conditions including, for example, frame rate, evaluation time, minimum diameter of the test piece, maximum speed of the test piece and number of objects in the detection zone as well as environmental influences. Where the supplier states that a VBPDPP can be used to detect objects moving at speeds greater than 1,6 m/s, the requirements shall be met at any speed up to and including the stated maximum speed(s).

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4.2.12.4 Tolerance zone(s)

Where a tolerance zone is necessary, the supplier shall specify the tolerance zone(s).

The supplier shall take into account worst-case conditions including for example, signal-to-noise ratio S/N.

NOTE The tolerance zone depends on optical performance, systematic interferences, pixel size, resolution, geometry of the pattern elements, etc.

4.2.12.5 Passive reference pattern(s) and object discrimination

The passive reference pattern is part of the VBPDPP. The design of the passive reference pattern shall be made in a way that discrimination of the object from the pattern can be achieved. The detection capability shall not be decreased below the limits specified by the supplier by any of, but not limited to the following influences:

a) contrast between pattern elements;
b) contrast changes within pattern elements;
c) size of pattern elements and number of pattern elements used for object detection;
d) size of pixels and numbers of pixels used for object detection;
e) algorithm/routines used for object discrimination in front of passive reference pattern;
f) automatic~~al~~ adaption of algorithm/routines;
g) size, shape, colour, reflectivity, position and texture of object compared to passive reference pattern;
h) resulting contrast between object and pattern elements on the imaging sensor.

4.2.13 Test piece~~s for type testing~~

Replacement:

4.2.13.1 General

The test pieces shall be provided by the supplier for use in the type tests of Clause 5. They shall be marked with a type reference and identification of the VBPDPP with which they are intended to be used.

The test pieces shall be opaque.

The test pieces shall have a diameter equal to the maximum specified detection capability (minimum diameter).

Different test pieces can be required for different phases of the test procedures.

Characteristics of the test piece which shall be considered are:

– size;
– shape;
– colour;
– reflectivity;
– contrast with background;
– texture.

When defining the characteristics of the test piece, protection against camouflage (i.e. mimic the background appearance), with the passive reference pattern shall be taken into account. The reflectivity of the test piece shall be selected to create a worst-case condition for the

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passive reference pattern discriminators. As a minimum, the following surfaces shall be considered:

– a black surface with a coefficient of diffuse ~~reflectance value below~~ reflection of less than 5 % at the operating wavelength of the VBPDPP;
– a white surface with a coefficient of diffuse ~~reflectance value in the range~~ reflection of 80 % to 90 % at the operating wavelength of the VBPDPP;
– a retroreflective surface that complies with the requirements for separate performance retro-reflective material of ISO 20471 or equivalent.

Where other surface characteristics are shown to be critical as result of the analysis of the design, these characteristics shall be applied to the test piece. Test pieces of different reflectivity may be necessary.

~~**4.2.13.2 Spherical test piece**~~

~~If the VBPDPP is intended to be used for whole body detection, then the test piece shall be a sphere with a maximum diameter of 200 mm attached to a cylinder with a maximum diameter of 50 mm and a length selected for ease of use.~~

~~NOTE A spherical test piece with a diameter of 200 mm is intended to represent the thickness of a body.~~

4.2.13.~~3~~2 Cylindrical test piece

The test piece shall be cylindrical for detection capabilities up to 40 mm. The test piece shall have a diameter equal to the maximum specified detection capability (minimum diameter) and a length selected for ease of use.

NOTE Depending on the diameter of the cylindrical test piece, it can represent fingers, hands or wrists.

4.2.13.~~4~~3 Conical test piece

The test piece shall be a truncated cone in combination with a cylinder if the VBPDPP is intended to be used for arm detection. The test piece starts with a diameter of 40 mm increasing up to 55 mm as a cone over a length of 180 mm and continues as a cylinder with a diameter of 55 mm to an overall length of 440 mm.

The test piece shall be a truncated cone if the VBPDPP is intended to be used for leg detection. The test piece starts with a diameter of 50 mm increasing up to 117 mm over a length of 1 000 mm.

If the VBPDPP is intended to be used for detection of different parts of a body, the selection of the most appropriate test pieces shall be dependent on the analysis of the design and intended application. In some cases, all test pieces can be required.

4.2.13.4 Spherical test piece

If the VBPDPP is intended to be used for whole body detection, then the test piece shall be a sphere with a maximum diameter of 200 mm attached to a cylinder with a maximum diameter of 50 mm and a length selected for ease of use.

NOTE A spherical test piece with a diameter of 200 mm is intended to represent the thickness of a body.

Addition:

4.2.14 Wavelength

VBPDPPs shall operate at a wavelength within the range of 400 nm to 1 500 nm.

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4.2.15 Radiation intensity

Where the VBPDPP is of the type that emits light and if the emitting ~~device~~ element uses LED technology, the radiation intensity generated and emitted by the VBPDPP shall meet the requirements of exempt group in accordance to IEC 62471~~:2006~~.

NOTE Exempt group is equal to risk group zero (IEC 62471~~:2006~~).

Where the VBPDPP is of the type that emits light and if the emitting ~~device~~ element uses laser technology, the radiation intensity generated and emitted by the VBPDPP shall at no time exceed the maximum power or energy levels for a class 1M device in accordance with 8.2 of IEC 60825-1:~~2007~~2014. The marking as class 1 or class 1M laser shall be carried out as required in 5.2 of IEC 60825-1:2014.

4.2.16 Mechanical construction

When the detection capability can be decreased below the limit stated by the supplier as a result of a change of position of its components, the fixing of those components shall not rely solely on friction.

NOTE The use of oblong mounting holes without additional means could lead for example to a change of the position of the detection zone under mechanical interference such as bump.

4.3 Environmental requirements

~~**4.3.1 Ambient air temperature range and humidity**~~

Addition:

~~The ESPE shall not fail to danger when subjected to a rapid change of temperature and humidity leading to condensation on the optical window.~~

~~This requirement is verified by the condensing test of 5.4.2.~~

~~*Additional environmental requirements:*~~

4.3.~~5~~6 Ambient light intensity

The VBPDPP shall continue in normal operation within a range of illumination on the passive reference pattern, from 100 lx to 1 500 lx. If the supplier specifies background characteristics with lower limits those shall be used. The tests shall be performed at those limits. Outside this range or these limits the VBPDPP shall not fail to danger.

~~**4.3.6 Light interference**~~

~~The VBPDPP shall continue in normal operation when subjected to the following:~~

- ~~incandescent light;~~
- ~~flashing beacons;~~
- ~~fluorescent lights operated with high-frequency electronic and line power supply.~~

~~The VBPDPP shall not fail to danger when subjected to~~

- ~~incandescent light;~~
- ~~stroboscopic light;~~
- ~~high-intensity fluorescent lights operated with high-frequency electronic and line power supply;~~
- ~~laser beam;~~
- ~~VBPDPP of identical design.~~

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~~These requirements are verified by the tests of 5.4.6.~~

~~The supplier shall inform the user of potential problems not covered by the requirements of this technical specification.~~

~~Based on the technologies and algorithms used as well as the analysis of 5.2.9, additional tests may be necessary.~~

4.3.7 Pollution interference

4.3.7.1 Effects on optical window

Pollution on the optical window shall not lead to a failure to danger.

Pollution resulting in a complete loss of the stated VBPDPP detection capability shall cause the ~~ESPE to go to a lock-out condition~~ OSSDs to go to the OFF-state within the specified response time.

Pollution resulting in a deterioration of the stated VBPDPP detection capability shall cause the ~~ESPE to go to a lock-out condition~~ OSSDs to go to the OFF-state within a time period of 5 s following the occurrence of the pollution interference.

4.3.7.2 Effects in the detection zone

Pollution within the detection zone or the zone with limited detection capability shall not lead to a failure to danger.

Pollution resulting in a complete loss of the stated VBPDPP detection capability shall cause the ~~ESPE to go to a lock-out condition~~ OSSDs to go to the OFF-state within the specified response time.

Pollution resulting in a deterioration of the stated VBPDPP detection capability shall cause the ~~ESPE to go to a lock-out condition~~ OSSDs to go to the OFF-state within a time period of 5 s following the occurrence of the pollution interference.

4.3.8 Changes of passive reference pattern

Changes of the passive reference pattern caused by, for example, fading, ageing, mechanical effects or contamination shall not lead to a failure to danger.

4.3.9 Manual interference

The following conditions shall not lead to a failure to danger:

– covering the optical window of the housing of the VBPDPP or other parts (if applicable);
– placing objects within the zone of limited detection capability;
– moving the passive reference pattern (except if the pattern is required to be permanently fixed) in any direction.

~~In such cases,~~ If the manual interference would result in a failure to danger condition then the VBPDPP shall respond by giving (an) appropriate output signal(s) within 5 s. The appropriate output signal(s) shall remain until the manual interference is removed.

4.3.10 Optical occlusion (eclipsed by small object)

The VBPDPP detection capability shall be maintained if moving or static objects or parts of a machine which are smaller than the detection capability are in the detection zone or the zone with limited detection capability, which can block the view of the object which shall be detected.

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If the detection capability can not be maintained the OSSDs shall go to the OFF-state and shall remain in the OFF-state if the object is removed. This shall be verified by analysis and by a test according to 5.4.9.

NOTE Software filtering algorithms are sometimes provided to disregard small objects, for example, to increase the reliability of operation.

4.3.11 Drift or ageing of components

Drift or ageing of components that would reduce the detection capability below the stated value shall not cause a failure to danger of the ESPE, shall be detected within 5 s and shall lead to a lock-out condition.

If a reference object is used for monitoring ageing and drift of components, variations in the properties of the reference object (for example, reflectance) shall not cause a failure to danger of the ESPE. If a reference object is used to monitor ageing and drift of components, it shall be considered to be part of the VBPDPP and shall be provided by the supplier of the VBPDPP.

5 Testing

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

5.1 General

5.1.1 Type tests

5.1.1.1 Test samples

Addition:

As a result of the analysis of the design and optical performance of the VBPDPP the test plan shall be established considering the test conditions and parameters outlined in this document.

The minimum test conditions shall be as specified in this document or by the supplier, whichever is more stringent. Unless otherwise stated, the tests shall be done with the minimum detection zone positioned as specified in ~~Table 1~~ Table 421.

In the following tests, it shall be verified that when the OSSDs go to the OFF-state, they remain in the OFF-state while the test piece is present in the detection zone.

~~**5.1.2 Test Conditions**~~

~~**5.1.2.1 Test environment**~~

~~*Addition:*~~

~~Unless otherwise stated in this part of IEC 61496, the VBPDPP shall be set up for the test with ambient light intensity of between 50 lx and 300 lx measured on the background.~~

~~The ambient light source should provide evenly distributed illumination as far as practical.~~

~~**5.1.2.2 Measurement accuracy**~~

~~*Addition to the first paragraph:*~~

~~– for light intensity measurement: ±10 %~~

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5.2 Functional tests

5.2.1 Sensing function

Addition:

5.2.1.1 General

The sensing function and the integrity of the detection capability shall be tested as specified, taking into account the following:

– Tests shall be performed with the test piece close to the passive reference pattern, close to the zone of limited detection and close to the tolerance zone(s). Tests at other locations may be required depending on analysis of the design and worst-case considerations.

– All tests shall be performed with the test piece axis parallel to the passive reference pattern. Tests at other angles of inclinations may be required depending on analysis of the design and worst-case considerations.

– During the tests, the fixture holding the test piece should not be visible to the sensor (as much as practical).

– The tests shall verify that the specified test pieces are detected when the test piece is placed entirely inside the stated detection zone(s) as far as the stated detection capability.

– The tests shall verify that the specified test pieces are continuously detected when the test piece is moving into or within the detection zone at any speed from 0 m/s to 1,6 m/s. Where the supplier states that objects can be detected moving at higher speeds, the requirements shall be met at all speeds up to the stated maximum speeds.

– The number, selection and conditions of the individual tests shall be such as to verify the requirements of 4.2.12.

It shall be verified that the sensing device is continuously actuated and, where appropriate, that the OSSDs go to the OFF-state as described below, taking into account the operating principle of the VBPDPP and, in particular, the techniques used to provide tolerance to environmental interference.

An overview of the minimum tests required for verification of the detection capability is shown in ~~Table 1~~ Table 421.

Table ~~1~~ 421 – Verification of detection capability requirements (see also 4.2.12)

Sub-clause	Test related to	Conditions [a]	Maximum operating distance from sensing device to passive reference pattern		Minimum operating distance from sensing device to passive reference pattern [b]	
			Test piece at minimum detection distance [c]	Test piece on passive reference pattern [c]	Test piece at minimum detection distance [c]	Test piece on passive reference pattern [c]
5.2.1.1	Sensing function	Applicable test piece (see 4.2.13) Speed between 0 m/s and 1,6 m/s	X	X	X	X
5.2.1.3	~~Ageing of components~~ Endurance Test	[d]	See 5.2.1.3	See 5.2.1.3		
5.4.2 of IEC 61496-1:2020	Ambient temperature variation	50 °C or maximum[e] 5.4.2 of IEC 61496-1:~~2012~~2020 applies.				X

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5.4.2 of IEC 61496-1:2020	Ambient temperature variation	0° or minimum, non-condensing [f] 5.4.2 of IEC 61496-1:2020 applies.				X
5.4.2 of IEC 61496-1:2020	Humidity	5.4.2 applies.				X
5.4.3 of IEC 61496-1:2020	Electrical disturbances	4.3.2, 5.2.3.1 and 5.4.3 of IEC 61496-1:~~2012~~2020 apply.				X
5.4.4.1	Vibration	5.4.4.1 applies				X
5.4.4.2	~~Bump~~ Shock	5.4.4.2 applies				X
5.4.6	Light interference	~~See Table 2~~ See Table 422				
5.4.7	Pollution on the surface of the optical window (4.3.7.1)		See 5.4.7	See 5.4.7	See 5.4.7	See 5.4.7
5.4.7	Pollution in the detection zone (4.3.7.2)		See 5.4.7	See 5.4.7	See 5.4.7	See 5.4.7
5.4.8	Changes of passive reference pattern	Homogenous change for ageing Local effects for damage	See 5.4.8	See 5.4.8	See 5.4.8	See 5.4.8
5.4.9	Manual interference	Based on VBPDPP specific analysis	See 5.4.9	See 5.4.9	See 5.4.9	See 5.4.9
5.4.10	Optical occlusion	See 5.4.10	X (test piece position 5.4.10)	X (test piece position 5.4.10)		

[a] Specific tests may be required depending on an analysis of the design.

[b] For ease of use, testing at 0,5m may be performed if the minimum operating distance stated by the supplier is below this distance. Tests at other and/or additional operating distance(s) may be required based on analysis.

[c] Determining the location of the test piece within the detection zone may require analysis of the system to ensure that a worst case test is performed (e.g. when the sensor axis is not perpendicular to the passive reference pattern).

[d] Effects of ageing of components, undetected faults of components and pollution on the surface of the optical window of the housing should be addressed within the endurance test, otherwise additional tests may be necessary.

[e] VBPDPP in test chamber – open test chamber – start test within 1 min.

[f] VBPDPP in test chamber – open test chamber – test without condensation

5.2.1.2 Integrity of the VBPDPP detection capability

It shall be verified that the VBPDPP detection capability is continuously maintained or the ESPE does not fail to danger by systematic analysis of the design of the VBPDPP, using testing where appropriate and/or required, taking into account 4.2.12.1 and 4.2.12.5.

5.2.1.3 Endurance test of the detection capability

It shall be verified that the detection capability is maintained by carrying out an endurance test as follows. The results of the analysis and testing according to 5.2.1.2 shall be used to determine the conditions and the appropriate test piece (see 4.2.13) to use for this test.

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A limited functional test B (B test) in accordance with 5.2.3.3 of IEC 61496-1:2020 shall be carried out with the ESPE in continuous operation under the conditions determined. The test piece shall be placed in a position with minimum contrast of the evaluation image between passive reference pattern and test piece and left in this position for a time period of 96 h.

Addition after 5.2.8.4:

5.2.9 Verification of optical performance

A systematic analysis of the electro-optical subsystem shall be carried out to determine

a) confirmation of any filtering techniques (especially software filtering algorithms) employed, and their characteristics;
b) the decision criteria used to determine whether or not the defined test piece(s) is (are) detected as being inside the detection zone;
c) the discrimination of object in front of passive reference pattern in accordance with 4.2.12.5;
d) the effect of undetected faults, in accordance with 4.2.2.4, on the electro-optical characteristics;
e) worst-case response time;
f) the effect of environmental influence.

The results of this analysis shall be used to determine if the requirements of 4.1.2 can be met.

5.2.10 Wavelength

The wavelength used in the VBPDPP shall be verified either by inspection of the device data sheets or by measurement.

5.2.11 Radiation intensity

If the emitting ~~device~~ element uses LED technology, the radiation intensity shall be verified by measurement in accordance with IEC 62471 and inspection of the technical documentation provided by the supplier.

If the emitting ~~device~~ element uses Laser technology, the radiation intensity shall be verified by measurement in accordance with IEC 60825-1 and inspection of the technical documentation provided by the supplier. The marking as a class 1 or class 1M laser shall be verified for correctness.

5.3 Performance testing under fault conditions

5.3.2 Type 1 ESPE

This subclause of IEC 61496-1:2020 is not applicable.

5.3.3 Type 2 ESPE

This subclause of IEC 61496-1:2020 is not applicable.

5.3.4 Type 3 ESPE

Addition:

It shall be verified that the drift or ageing of components that influence the detection capability will be detected within a time period of 5 s according to 4.3.11 and shall lead to a lock-out condition.

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~~In practice, it will be impossible to combine single faults with all operating conditions and/or influences listed in 4.2.12.1 by practical test.~~ A combination of one or more of the following is sufficient to verify the requirement to combine single faults with operating conditions/influences as required by 4.2.2.~~4~~1 of IEC 61496-1:2020.

– analysis;

– simulation; and

– tests carried out in the presence of a single fault, where relevant.

5.3.5 Type 4 ESPE

This subclause of IEC 61496-1:2020 is not applicable.

5.4 Environmental tests

~~**5.4.2 Ambient temperature variation and humidity**~~

~~*Addition:*~~

~~The ESPE shall be subjected to the following condensing test:~~

~~– the ESPE shall be supplied with its rated voltage and stored in a test chamber at an ambient temperature of 5 °C for 1 h;~~

~~– the ambient temperature and the humidity shall be changed within a time period of up to 2 min to a temperature of (25 ± 5) °C and a relative humidity of (70 ± 5) %;~~

~~– a C-test shall be performed with a duration of 10 min using the test piece (see 4.2.13);~~

~~– if a restart interlock is available it shall not be operational during the C-test.~~

5.4.4 Mechanical influences

5.4.4.1 Vibration

Addition:

~~If the sensing device of the VBPDPP is not intended to be mounted on a machine (i.e. not intended to be subjected to high vibration), the levels of amplitude and frequency may be reduced for the A-test depending on the intended application. In this case, a C-test may be carried out instead of the B-test.~~

At the end of the tests, the VBPDPP shall be inspected for the absence of damage including displacement of optical components and mounting brackets. It shall be verified by test that the detection zone has not changed in orientation, size or position.

5.4.4.2 ~~Bump~~ Shock

Addition:

~~If the sensing device is not intended to be mounted on a machine (i.e., not intended to be subjected to severe bumps), the test conditions may be reduced for the A-test depending on the intended application. In this case, a C-test may be carried out instead of the B-test.~~

At the end of the tests, the VBPDPP shall be inspected for the absence of damage including displacement of optical components and mounting brackets. It shall be verified by test that the detection zone has not changed in orientation, size or position.

~~*Additional environmental tests:*~~

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5.4.6 Light interference

5.4.6.1 General

Replacement:

Each test shall be carried out at the operating distance as specified in ~~Table 2~~ Table 422, and under the stated conditions as a minimum requirement. Additional tests shall be carried out under different combinations of operating distances and environmental conditions when

– the supplier states higher immunity levels, which shall be verified by testing at those levels with appropriate light sources, and/or

– an analysis shows such tests to be necessary.

~~Ambient light shall be delivered by using the incandescent light source or using natural illumination. Unless otherwise stated, the ambient light intensity during interfering light tests shall be within a range of 50 lx and 300 lx.~~

In the following test procedures, unless otherwise stated, the light intensity limits are contributed by the interfering light source. The ambient light values should be added during light intensity measurements.

~~Table 2~~ Table 422 gives an overview of the light interference tests.

Table ~~2~~ 422 – Overview of light interference tests

Test Num.	Sub clause	Test related to [a]	Light source /Test sequence [a]	Light intensity	Maximum operating distance from sensing device to passive reference pattern		Minimum operating distance from sensing device to passive reference pattern [b]	
					Test piece at minimum detection distance [c]	Test piece on passive reference pattern [c]	Test piece at minimum detection distance [c]	Test piece on passive reference pattern [c]
1	5.4.6.4	Normal operation- Interference on pattern	Incandescent / Test sequence 1	1 500 lx	X	X	X	X
2	5.4.6.4	Normal operation- Interference on pattern	Incandescent / Test sequence 1	100 lx	X	X	X	X
~~3~~	~~5.4.6.4~~	~~Normal operation- Interference on pattern~~	~~Flashing beacon / Test sequence 1~~	~~Resulting from mounting distance 3 m to optical axis and 2 m over floor~~	~~X~~	~~X~~		
3	5.4.6.4	Normal operation- Interference on pattern	Incandescent with shadow / Test sequence 1	1 500 lx bright area – ≤750 lx shadow area	X	X		
4	5.4.6.5	Failure to danger- Interference on pattern	Incandescent / Test sequence 2	3 000 lx	X	X	X	X

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