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Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

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Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



44/1056/CD

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SECRETARIAT:

United Kingdom

SECRETARY:

Mrs Nyomee Hla-Shwe Tun

OF INTEREST TO THE FOLLOWING COMMITTEES:

HORIZONTAL FUNCTION(S):

ASPECTS CONCERNED:

Safety

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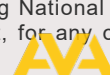
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TITLE:

Safety of machinery - Electro-sensitive protective equipment - Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)

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CONTENTS

FOREWORD

INTRODUCTION

- 1 Scope
- 2 Normative references
- 3 Terms and definitions
- 4 Functional, design and environmental requirements
 - 4.1 Applicable subclauses of IEC 61496-1:20XX
 - 4.2 Functional requirements
 - 4.2.1 Sensing function
 - 4.2.2 Types of ESPE
 - 4.3 Design requirements
 - 4.3.1 Fault detection requirements
 - 4.3.2 Integrity of the AOPD detection capability
 - 4.3.3 Test piece
 - 4.3.4 Wavelength
 - 4.3.5 Radiation intensity
- 5 Testing
 - 5.1 Applicable subclauses of IEC 61496-1:20XX
 - 5.2 General
 - 5.2.1 Correspondences of requirements and tests and AOPD designs
 - 5.2.2 Type tests
 - 5.3 Functional tests
 - 5.3.1 Sensing function
 - 5.3.2 Wavelength
 - 5.3.3 Radiation intensity
 - 5.4 Environmental tests
 - 5.4.1 Light interference
- 6 Marking for identification and safe use
 - 6.1 Applicable subclauses of IEC 61496-1:20XX
 - 6.2 **Information and markings on the enclosure**
 - 6.3 **Information and markings given in the accompanying documents or in digital format**
- 7 Accompanying documents
- Annex A Optional functions of the ESPE(normative)
 - A.1 General
 - A.2 Blanking

A.2.1 General

A.2.2 Functional requirements

A.2.3 Verification

A.3 Reduced resolution

A.3.1 General

A.3.2 Functional requirements

A.3.3 Verification

A.4 Selection of pre-defined blanking or reduced resolution configurations

A.4.1 General

A.4.2 Functional requirements for a type 2 AOPD

A.4.3 Functional requirements for a type 3 or type 4 AOPD

A.4.4 Verification for a type 2 AOPD

A.4.5 Verification for a type 3 or type 4 AOPD

Annex B Type 2 AOPD periodic test configurations(informative)

B.1 Externally initiated and evaluated periodic test

B.2 Internally initiated and evaluated periodic test

Bibliography

Figure 1 - AOPD devices

Figure 2 - Limit area to avoid the risk of beam bypass

Figure 3 - Limit of vertical and horizontal misalignment

Figure 4 - Orientation of the test piece

Figure 5 - Verifying sensing function by moving the test piece through the detection zone

Figure 6 - Limit values for the effective aperture angle

Figure 7 - Determination of the minimum detection capability

Figure 8 - Measuring method for effective aperture angle (direction)

Figure 9 - Prism test to measure effective aperture angle of each beam

Figure 10 - effective aperture angle test using prism

Figure 11 - Example of optical subsystem

Figure 12 - Example of SMD LED Model

Figure 13 - Example of intensity distribution of emitting element

Figure 14 - Example of emitter model with beams internally blocked by aperture stop

Figure 15

- Example of receiving element with off axis beam portion reflected internally on mechanical elements

Figure 16

- Example of test piece inside model of optical subsystem with passing radiation on the receiver

Figure 17 - Example of emitting element adjusted at the limit

Figure 18 - Extraneous reflection test with mirror outside of limit area

Figure 19 - AOPD misalignment test

Figure 20 - Light interference test – Direct method

Figure 21 - Light interference test - Test set-up with incandescent light source

Figure 22 - Light interference test – Test set-up with fluorescent light source

Figure 23 - Light interference test - Test set-up with flashing beacon light source

Figure B.1 - Single beam sensing device

Figure B.2 - Series connection of single beam sensing devices

Figure B.3 - Assembly of multiple beams tested individually

Figure B.4 - Example of type 2 AOPD with internal test

Table 1 - Limit area to avoid the risk of beam bypass

Table 2 - Limit of vertical misalignment

Table 3 - Correspondences of requirements/testing and AOPD designs

Table 4 - effective aperture angle limit values

Table 5 - Beam deviation angles for different wavelengths and constant prism angle

Table 6

- Maximum permissible angle of misalignment (in degrees) for a type 2 ESPE depending on the dimensions of the light curtain

Table 7

- Maximum permissible angle of misalignment (in degrees) for a type 3 ESPE depending on the dimensions of the light curtain

Table 8

- Maximum permissible angle of misalignment (in degrees) for a type 4 ESPE depending on the dimensions of the light curtain

Table 9 - Light spot radius for different AOPD types

Table 10 - Test parameters for incandescent light source tests

Table 11 - Test parameters for fluorescence light source tests

Table 12 - Test parameters for flashing beacon light source tests

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SAFETY OF MACHINERY - ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT - PART 2: PARTICULAR REQUIREMENTS FOR EQUIPMENT USING ACTIVE OPTO-ELECTRONIC PROTECTIVE DEVICES (AOPDS) –

FOREWORD

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International Standard [1: IEC 61496-2] has been prepared by IEC technical committee 44: Safety of machinery - Electrotechnical aspects, in collaboration with CENELEC technical committee 44X: Safety of machinery - Electrotechnical aspects.

This fifth edition cancels and replaces the fourth edition published in 2020. This edition constitutes a technical revision.

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

- the subclauses are sequentially numbered now, subclauses of [2: IEC 61496-1:2027] which explicitly apply are mentioned in this document in appropriate clauses;



Documents

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The text of this International Standard is based on the following documents:

Draft	Report on voting
XX/XX/FDIS	XX/XX/RVD

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 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 <https://www.iec.ch/standardsdev/publications>.

This standard has the status of a product family standard and can be used as a normative reference in a dedicated product standard for the safety of machinery.

This document is to be used in conjunction with [2: IEC 61496-1:2027].

This document provides additional information for AOPDs to that information provided by [2: IEC 61496-1:2027]. Subclauses of [2: IEC 61496-1:2027] which explicitly apply are mentioned in this document in subclauses called “Applicable subclauses of [2: IEC 61496-1:2027]”. If a subclause of this document applies in addition to a subclause of [2: IEC 61496-1:2027] this subclause is introduced with the remark “Clause x.y of [2: IEC 61496-1:2027] applies in addition to the following”.

References to clauses of [2: IEC 61496-1:2027] are mentioned as “Clause x.y of [2: IEC 61496-1:2027]”.

A list of the parts in the [3: 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.

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.

This document provides particular requirements for the design, construction and testing of electro-sensitive protective equipment (ESPE) for the safeguarding of machinery, employing active opto-electronic protective devices (AOPDs) for the sensing function.

Each type of machine presents its own particular hazards, and it is not the purpose of this document to recommend the manner of application of the ESPE to any particular machine. The application of the ESPE should be a matter for agreement between the equipment supplier, the machine user and the enforcing authority; and in this context, attention is drawn to the relevant guidance established internationally, for example, [ISO 12100](#).

Due to the complexity of the technology of ESPEs, 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.

SAFETY OF MACHINERY - ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT - PART 2: PARTICULAR REQUIREMENTS FOR EQUIPMENT USING ACTIVE OPTO-ELECTRONIC PROTECTIVE DEVICES (AOPDS) –

1 Scope

This document specifies requirements for the design, construction and testing of electro-sensitive protective equipment (ESPE) designed specifically to detect persons as part of a safety-related system, employing active opto-electronic protective devices (AOPDs) 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 61496-1:20XX](#) and of this document.

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.

Excluded from this document are AOPDs employing radiation at wavelengths outside the range 400 nm to 1 500 nm.

This document can be relevant to applications other than those for the protection of persons, 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 electromagnetic compatibility (EMC) emission requirements.

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

IEC 61496-1:20XX, *Safety of machinery - Electro-sensitive protective equipment - Part 1: General requirements and tests*

IEC 62046, *Safety of machinery - Application of protective equipment to detect the presence of persons*

IEC 62061, *Safety of machinery - Functional safety of safety-related control systems*

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

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

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13855, *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*

IEC 60050-428:2024, *International Electrotechnical Vocabulary (IEV) - Part 428: Safety of machinery*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61496-1:20xx and the following apply.

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

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

Abbreviations list

AOPD active opto-electronic protective device

EAA effective aperture angle

E emitting device

GROD geometrically restricted optical design

MP measuring point

OSSD output signal switching device

R receiving device

TP test piece

3.1

active opto-electronic protective device

AOPD

device whose sensing function is performed by opto-electronic emitting and receiving elements detecting the interruption of optical radiations by an opaque object

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

3.2

beam centre-line

optical path joining the optical centre of an emitting element to the optical centre of the corresponding receiving element

Note 1 to entry: The optical axis of a light beam is not always on the beam centre-line.

Note 2 to entry: Physical displacement of the [beam centre-line](#) may occur as a consequence of normal operation (for example, by the use of a motor-driven mirror).

Note 3 to entry: For an [active opto-electronic protective device](#) that operates on a retro-reflective technique, the optical path is defined by the [retro-reflector target](#) together with the emitting and receiving elements.

3.3

detection capability

<of an active opto-electronic protective device> dimension representing the diameter of the [test piece](#)

Note 1 to entry: The term "[detection capability](#)" can also be used to mean the ability to detect a [test piece](#) of the specified diameter.

[SOURCE: IEC 60050-428:2024, 428-05-01, 3.37, modified – term adapted to the active opto-electronic protective device technology, Note 1 added]

3.4

effective aperture angle

EAA

maximum angle of deviation from the optical alignment of the [emitting element\(s\)](#) and the [receiving element\(s\)](#) within which the [active opto-electronic protective device](#) continues in normal operation

3.5

emitting device

E

emitter assembly

emitter

<of an active opto-electronic protective device> contains the [active opto-electronic protective device emitting element\(s\)](#)

3.6

emitting element

<of an active opto-electronic protective device> light source, lens and necessary circuitry which provide the light beam

3.7

emitting/receiving device

emitter/receiver assembly

emitter/receiver in the same assembly

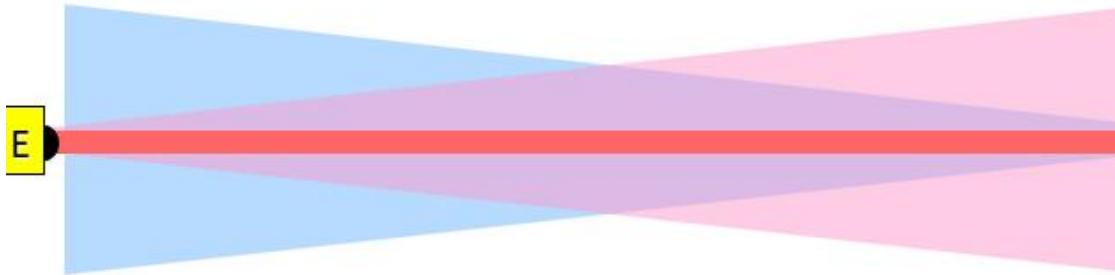
<of an active opto-electronic protective device> contains the [active opto-electronic protective device](#) emitting and [receiving element\(s\)](#)

3.8

geometrically restricted optical design

GROD

optical design based on mechanical restrictions providing a defined beam



shaping

3.9

light beam device

active opto-electronic protective device consisting of emitting element(s) and corresponding receiving element(s) forming a single light beam(s)

3.10

light curtain

active opto-electronic protective device consisting of an integrated assembly of emitting element(s) and receiving element(s) forming a detection zone

Note 1 to entry: A light curtain with a large detection capability is sometimes referred to as a light grid.

3.11

operating distance

<of an active opto-electronic protective device> distance between emitting device and receiving device or the emitting/receiving device and the retro-reflector target

3.12

receiving device

R

receiver assembly

receiver

<of an active opto-electronic protective device> contains the active opto-electronic protective device receiving element(s)

3.13

receiving element

detector, lens and necessary circuitry to monitor the presence of the light beam from the emitting element(s)

3.14

retro-reflector target

device used to reflect the light beam(s) back to the emitting/receiving device

3.15

test piece

TP

<of an active opto-electronic protective device> opaque cylindrical element used to verify the detection capability of the active opto-electronic protective device

[SOURCE: IEC 61496-1:20XX, 3.30, modified - term adapted to the active opto-electronic protective device technology]

4 Functional, design and environmental requirements

4.1 Applicable subclauses of IEC 61496-1:20XX

In the context of this document, 4.2.1, 4.2.4, 4.2.5, 4.3.1 - 4.3.11 and 4.4 of IEC 61496-1:20XX apply.

4.2 Functional requirements

4.2.1 Sensing function

4.2.1.1 General requirements

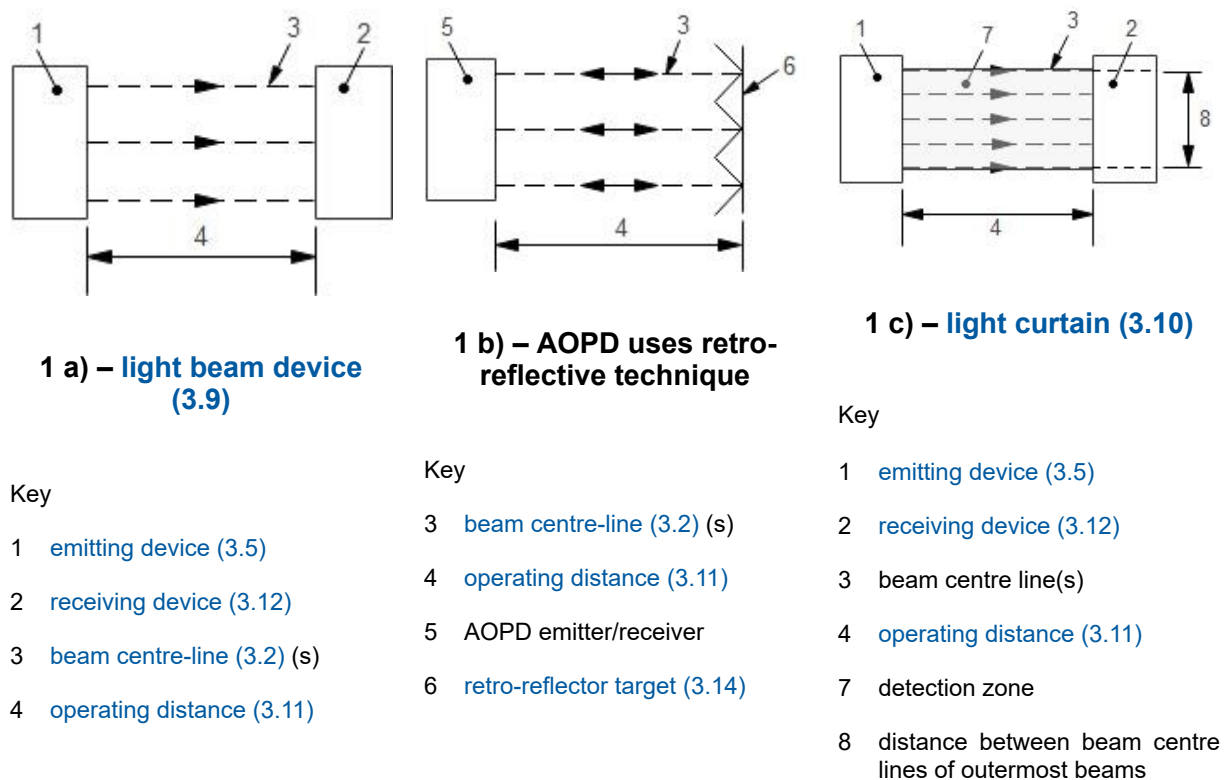


Figure 1 – AOPD devices

The **detection capability (3.3)** shall be effective over the detection zone specified by the supplier. No adjustment of the detection zone, **detection capability (3.3)** or blanking function shall be possible without the use of a key, keyword or dedicated tool.

The sensing device of a **light curtain (3.10) (1 c))** shall be actuated and the OSSD(s) shall go to and remain in the OFF-state when a **test piece (3.15)** in accordance with 4.3.3 is present anywhere within the detection zone either static (at any angle) or moving (with the axis of the cylinder normal to the plane of the detection zone), at any speed between 0 m/s and 1,6 m/s.

The sensing device of a [light beam device \(3.9\)](#) (1 a)) shall be actuated and the OSSD(s) shall go to and remain in the OFF-state when a [test piece \(3.15\)](#) in accordance with [4.3.3](#) is present in the [beam centre-line \(3.2\)](#) , at any point throughout the [operating distance \(3.11\)](#) , with the axis of the cylinder normal to the axis of the beam.

Where the supplier states that an AOPD can be used to detect objects moving at speeds greater than those specified above, the above requirements shall be met at any speed up to and including the stated maximum speed(s)

4.2.1.2 Additional requirements for AOPDs using retro-reflective techniques and for AOPDs using mixed emitters and receivers in the same assembly

AOPDs using retro-reflective techniques ([1 b\)](#)) where the light beam traverses the detection zone more than once (over the same path) and AOPDs using mixed emitters and receivers in the same assembly shall not fail to danger if a reflective object (for example, reflective clothes) is placed at any position in the detection zone.

NOTE: The use of mirrors to return the light beam is not considered to be a retro-reflective technique.

The OSSD(s) shall go to the OFF-state when a reflective object of a size equal to, or greater than, the diameter and length of the [test piece \(3.15\)](#) (see [4.3.3](#)) is placed in the detection zone at any position as specified in [5.3.1.4](#).

For a type 3 AOPD or a type 4 AOPD, under normal operating conditions, the OSSD(s) shall go to the OFF-state when a reflective object, as specified in [5.3.1.4](#), is placed as close as practicable in front of the sensing surface of the emitting/receiving elements.

4.2.2 Types of ESPE

In this document, only type 2, type 3 and type 4 ESPEs are considered. The types differ in their performance in the presence of faults and under influences from environmental conditions. The effects of electrical and electromechanical faults are considered in [IEC 61496-1:20XX](#) (such faults are listed in Annex B of [IEC 61496-1:20XX](#)).

NOTE: The machine supplier and/or the user will determine which type is required for a particular application.

For a type 2 ESPE, in normal operation the output circuit of at least one output signal switching device shall go to the OFF-state when the sensing function is actuated, or when power is switched off.

A type 2 ESPE shall fulfil the fault detection requirements of [4.3.1.1](#).

A type 3 ESPE shall fulfil the fault detection requirements of [4.3.2.4](#) of [IEC 61496-1:20XX](#).

A type 4 ESPE shall fulfil the fault detection requirements of [4.3.2.5](#) of [IEC 61496-1:20XX](#).

For a type 3 or a type 4 ESPE, in normal operation the output circuit of at least two output signal switching devices shall go to the OFF-state when the sensing function is actuated, or when power is switched off.

When a single safety-related data interface is used to perform the functions of the OSSD(s), the data interface and associated safety-related communication interface shall meet the requirements of [4.3.4.4](#) of [IEC 61496-1:20XX](#). In this case, a single safety-related data interface can substitute for two OSSDs in a type 3 ESPE or a type 4 ESPE.

4.3 Design requirements

4.3.1 Fault detection requirements

4.3.1.1 Particular requirements for a type 2 ESPE

Clause 4.3.2.3 of [IEC 61496-1:20XX](#) applies in addition to the following:

The periodic test shall verify that each light beam operates in the manner specified by the supplier.

Different configurations are considered that differ in the way the testing of the safety related performance is carried out.

[Annex B](#), [Figure B.1](#), [Figure B.2](#) and [Figure B.3](#) are examples of type 2 AOPDs where the periodic test is externally initiated and the results are externally evaluated. [Annex B](#), [Figure B.4](#) is an example of a type 2 AOPD where the periodic test is automatically initiated and evaluated internally.

4.3.2 Integrity of the AOPD [detection capability \(3.3\)](#)

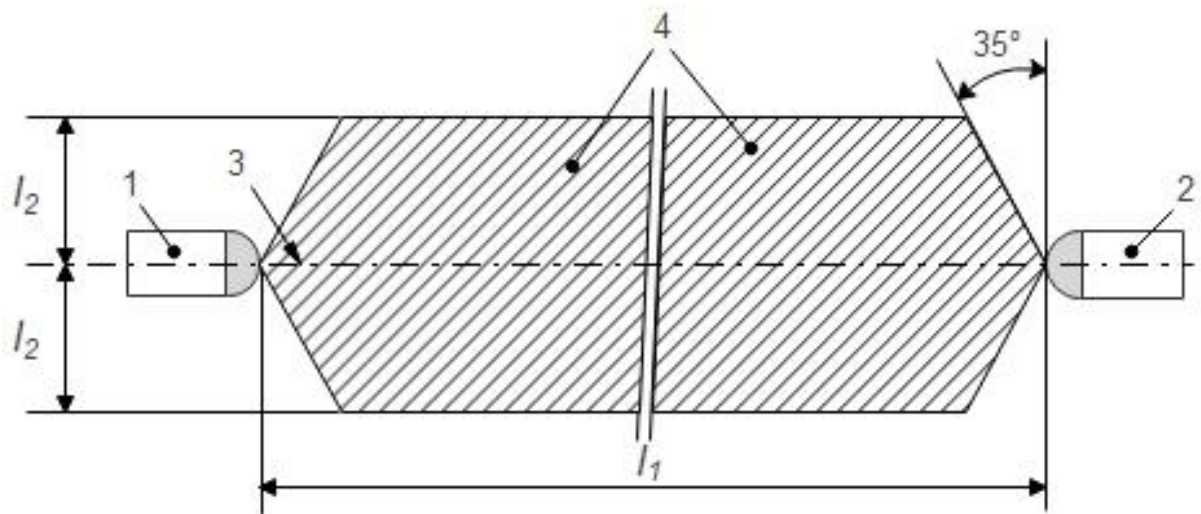
The design of the AOPD shall be such that the AOPD [detection capability \(3.3\)](#) does not change from the value stated by the supplier when the AOPD is operated under any and all combinations of the following:

- any condition within the specification of the supplier;
- the environmental conditions specified in 4.4 of [IEC 61496-1:20XX](#);
- at the limits of alignment and/or adjustment;
- over the entire detection zone.

If a single fault (as specified in Annex B of [IEC 61496-1:20XX](#)), which under normal operating conditions (see 5.1.2.1 of [IEC 61496-1:20XX](#)) would not result in a loss of AOPD [detection capability \(3.3\)](#) 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 shall be considered as a single fault, and the AOPD shall respond to such a single fault as required in [4.3.1](#).

The AOPD shall be designed and constructed to:

- a) limit the possibility of failure to danger resulting from extraneous reflections (for operating distances up to 3 m, see [Figure 2](#) and [Table 1](#));
- b) limit the misalignment at which normal operation is possible. For an [operating distance \(3.11\)](#) of 3 m the limits of [Figure 3](#) and [Table 2](#) shall be met;
- c) limit the possibility of malfunction during exposure to extraneous light in the range of 400 nm to 1 500 nm.



Key

- 1 emitting device (3.5)
 - 2 receiving device (3.12)
 - 3 beam centre-line (3.2)
 - 4 limit area to avoid the risk of beam-bypass
- l_1 operating distance (3.11) (see Table 1)
- l_2 half width of limit area (see Table 1)

NOTE: In this figure, extraneous reflections from surfaces outside the shaded area will not cause a failure to danger. For short ranges (250 mm for type 4, 375 mm for type 3 and 500 mm for type 2), the angle of 35° is a limit selected by the working group based on known designs of AOPDs.

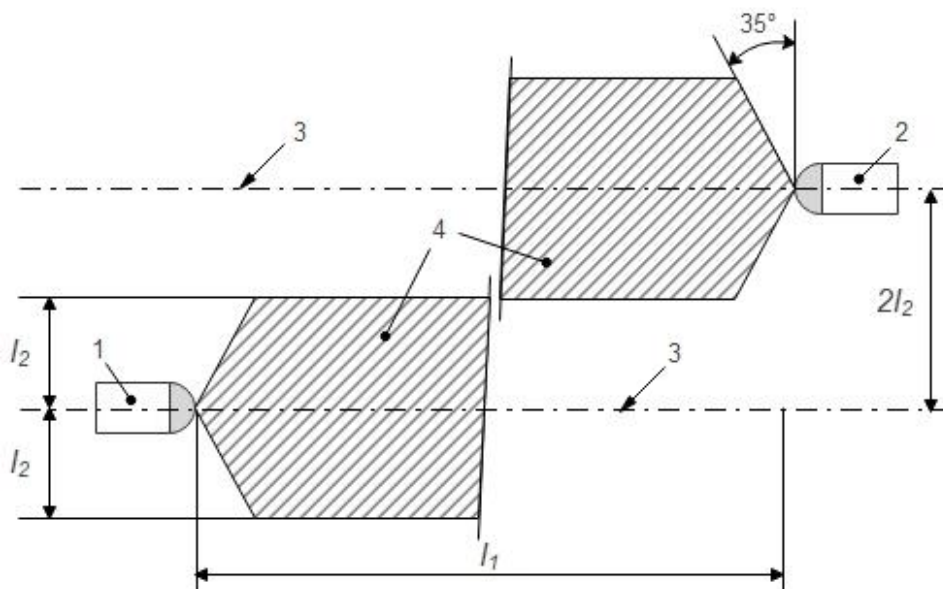
Figure 2 – Limit area to avoid the risk of beam bypass

Table 1 – Limit area to avoid the risk of beam bypass

Dimensions in mm

AOPD Type	operating distance (3.11) l_1		Half width of limit area l_2
	from	to	
Type 2	500	3 000	262
Type 3	375	3 000	184
Type 4	250	3 000	131
Dimensions in mm			

If the AOPD is intended to provide protection when mounted very close to a reflective surface (i.e. inside the shaded area of Figure 2), the AOPD shall be designed in such a manner that no optical bypassing can occur on the reflective surfaces. For such a device, an **effective aperture angle (3.4)** much less than $2,5^\circ$ (for example, less than $0,1^\circ$) can be necessary. In this case, Figure 2 does not apply and the limits of protection against optical bypassing shall be as specified by the manufacturer.



Key

- 1 emitting device (3.5)
- 2 receiving device (3.12)
- 3 beam centre-line (3.2)

4 limit area to avoid the risk of beam-bypass

l_1 operating distance (3.11) (see Table 2)

l_2 half width of limit area (see Table 2)

Figure 3 – Limit of vertical and horizontal misalignment

Table 2 – Limit of vertical misalignment

Dimensions in mm

AOPD Type	operating distance (3.11) l_1	Half width of limit area l_2	Limit of vertical alignment $2l_2$
Type 2	3 000	262	524
Type 3	3 000	184	368
Type 4	3 000	131	262
Dimensions in mm			

4.3.3 Test piece

The test piece (3.15) shall be cylindrical and opaque, with a minimum effective length of 150 mm. The diameter of the test piece (3.15) shall not exceed the AOPD detection capability (3.3) stated by the supplier.

For AOPDs using retro-reflective techniques and for AOPDs using mixed emitter/receivers in the same assembly (see 4.2.1.2), the surface of the opaque test piece (3.15) shall be:

- a retro-reflecting material complying with the requirements for separate performance retro-reflective material of ISO 20471;

NOTE: Table 4 of [4: ISO 20471:2013] defines the minimum coefficient of retro-reflection for separate performance retro-reflective material as $330 \text{ cd lx}^{-1} \text{ m}^{-2}$ with an entrance angle of 5° and an observation angle of $0,2^\circ$ ($12'$).

- a mirror-type reflective surface having a reflection factor greater than or equal to 90 % at the wavelength of the emitter, for example, polished chrome plating or polished aluminium;
- a diffuse reflective surface, white with a coefficient of diffuse reflectance in the range of 80 % to 90 % at the wavelength of the emitter. Example of suitable material is white paper.

For an AOPD detection capability (3.3) of not more than 40 mm, the test piece (3.15) for a light curtain (3.10) shall be provided by the supplier and shall be marked with the following.

- diameter in millimetres;
- type reference and an indication of the AOPD with which the [test piece \(3.15\)](#) is intended to be used.

When more than one [detection capability \(3.3\)](#) can be configured on the AOPD, the supplier shall provide a [test piece \(3.15\)](#) for each [detection capability \(3.3\)](#).

Verification shall be by inspection.

4.3.4 Wavelength

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

4.3.5 Radiation intensity

If the [emitting device \(3.5\)](#) uses LED technology, the radiation intensity generated and emitted by the AOPD shall meet the requirements of exempt group in accordance with [IEC 62471](#).

NOTE 1: Exempt group is equal to risk group zero ([\[5: IEC 62471\]](#)).

If the [emitting device \(3.5\)](#) uses laser technology, the radiation intensity generated and emitted by the AOPD shall at no time exceed the maximum power or energy levels for a class 1M laser in accordance with [IEC 60825-1](#).

NOTE 2: Class 2 devices can be used for alignment or adjustment.

5 Testing

5.1 Applicable subclauses of [IEC 61496-1:20XX](#)

In the context of this document, [5.1](#), [5.2.2 - 5.2.8](#), [5.3](#), [5.4.1 - 5.4.5](#), [5.4.6.2](#), [5.4.6.3](#) and [5.5 IEC 61496-1:20XX](#), apply.

5.2 General

5.2.1 Correspondences of requirements and tests and AOPD designs

Clause 5.1 of [IEC 61496-1:20XX](#) applies in addition to the following:

In the following tests, it shall be verified that when the OSSD(s) go to the OFF-state, they remain in the OFF-state while the [test piece \(3.15\)](#) is present in the detection zone (or light beam). If the AOPD incorporates a restart interlock, the restart interlock shall be disabled during the tests of [Clause 5](#).

AOPD may be designed in different ways. [Table 3](#) shows the different designs and corresponding requirements and tests as described within this document.