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INTERNATIONAL STANDARD

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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

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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 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 fourth edition cancels and replaces the third edition published in 2013. This edition constitutes a technical revision.

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

a) Requirements and test procedures in Part 2 that were found to be common to all ESPEs have been moved to Part 1. Test procedures that are dependent on the sensing technology remain in Part 2.

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

FDIS	Report on voting
44/875/FDIS	44/878/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

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

This part supplements or modifies the corresponding clauses in IEC 61496-1:2020.

Where a particular clause or subclause of IEC 61496-1:2020 is not mentioned in this Part 2, that clause or subclause applies as far as is reasonable. Where this part 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 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 3.201. Additional annexes are lettered from AA onwards.

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 "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Electro-sensitive protective equipment (ESPE) is applied to machinery that presents 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; 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 clause of Part 1 is replaced by the following:

This part of IEC 61496 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 61496-1:2020 and of this document.

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

This clause of Part 1 is applicable except as follows:

Addition:

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

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

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

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*

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[1] To be published.

3 Terms and definitions

This clause of Part 1 is applicable except as follows:

Addition:

3.201
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 generated, within the device, by an opaque object present in the specified detection zone (or for a light beam device, on the axis of the light beam)

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

3.202
beam centre-line
optical path joining the optical centre of an emitting element to the optical centre of the corresponding receiving element that is intended to respond to light from that emitting element during normal operation

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 AOPD that operates on a retro-reflective technique, the optical path is defined by the retro-reflector target together with the emitting and receiving elements.

3.203
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 AOPD continues in normal operation

3.204
light beam device
AOPD comprising one or more emitting element(s) and corresponding receiving element(s), where a detection zone is not specified by the supplier

3.205
light curtain
AOPD comprising an integrated assembly of one or more emitting element(s) and one or more receiving element(s) forming a detection zone with a detection capability specified by the supplier

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

3.206
test piece
opaque cylindrical element used to verify the detection capability of the AOPD

3.207
geometrically restricted optical design
GROD
AOPD using an optic design where

– the effective aperture angle (EAA) of each emitting and each receiving element does not exceed the values given in Figure 6 and
– the axes of the optical beams are parallel and

– side lobes are minimized and
– the spacing between beam centre-lines is uniform and
– the value of detection capability is based on the complete obscuration of at least one beam for any and all positions of the test piece within the detection zone (see Figure 7).

Replacement:

3.3
detection capability
dimension representing the diameter of the test piece which:

– for a light curtain, will actuate the sensing device when placed in the detection zone;
– for a single light beam device, will actuate the sensing device when placed in the beam centre-line;
– for a multiple light beam device, will actuate the sensing device when placed in any beam centre-line

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.

4 Functional, design and environmental requirements

This clause of Part 1 is applicable except as follows:

4.1 Functional requirements

4.1.2 Sensing function

Replacement:

4.1.2.1 General requirements

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

The sensing device of a light curtain shall be actuated and the OSSD(s) shall go to and remain in the OFF-state when a test piece in accordance with 4.2.13 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 shall be actuated and the OSSD(s) shall go to and remain in the OFF-state when a test piece in accordance with 4.2.13 is present in the beam centre-line, at any point throughout the operating distance, 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).

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

4.1.2.2.1 General

AOPDs using retro-reflective techniques 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.

4.1.2.2.2 Sensing function

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 (see 4.2.13) is placed in the detection zone at any position as specified in 5.2.1.4.

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 5.2.1.4, is placed as close as practicable in front of the sensing surface of the emitting/receiving elements.

4.1.3 Types of ESPE

Replacement:

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. In IEC 61496-1:2020, the effects of electrical and electromechanical faults are considered (such faults are listed in Annex B of IEC 61496-1:2020).

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 removed from the ESPE.

A type 2 ESPE shall fulfil the fault detection requirements of 4.2.2.3.

A type 3 ESPE shall fulfil the fault detection requirements of 4.2.2.4.

A type 4 ESPE shall fulfil the fault detection requirements of 4.2.2.5.

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 removed from the ESPE.

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 4.2.4.4 of IEC 61496-1:2020. In this case, a single safety-related data interface can substitute for two OSSDs in a type 3 ESPE or a type 4 ESPE.

4.2 Design requirements

4.2.2 Fault detection requirements

4.2.2.3 Particular requirements for a type 2 ESPE

Addition:

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

Replacement:

4.2.12 Integrity of the AOPD detection capability

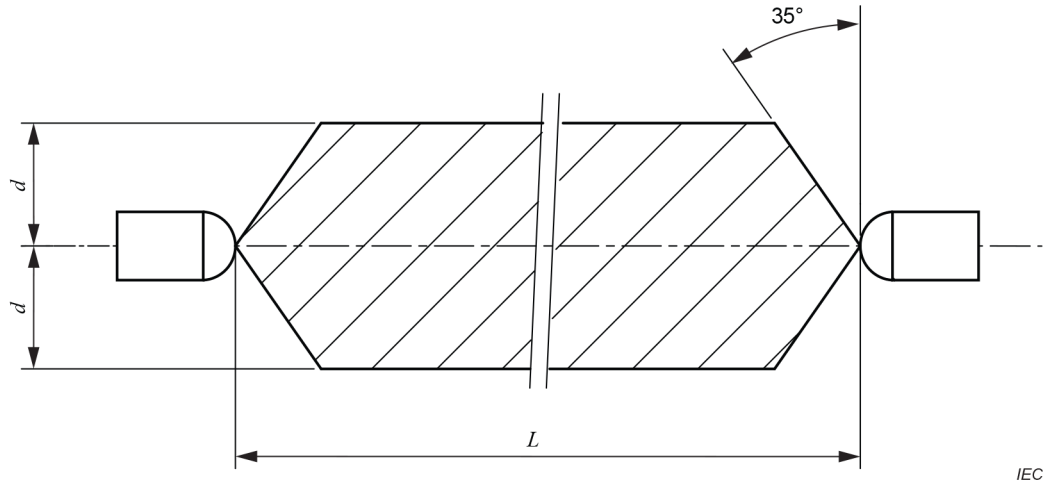
The design of the AOPD shall be such that the AOPD detection capability does not change from the value stated by the supplier when the AOPD is operated under any and all combinations of the following:

– any condition within the specification of the supplier;
– the environmental conditions specified in 4.3;
– at the limits of alignment and/or adjustment;
– over the entire detection zone.

If a single fault (as specified in Annex B of IEC 61496-1:2020), which under normal operating conditions (see 5.1.2.1) would not result in a loss of AOPD 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 shall be considered as a single fault, and the AOPD shall respond to such a single fault as required in 4.2.2.

The AOPD shall be designed and constructed to:

a) limit the possibility of failure to danger resulting from extraneous reflections (for operating range up to 3 m, see Figure 1);
b) limit the misalignment at which normal operation is possible.
For an operating range of 3 m the limits of Figure 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.



For type 4: d = 131 mm, L = 250 mm to 3 000 mm

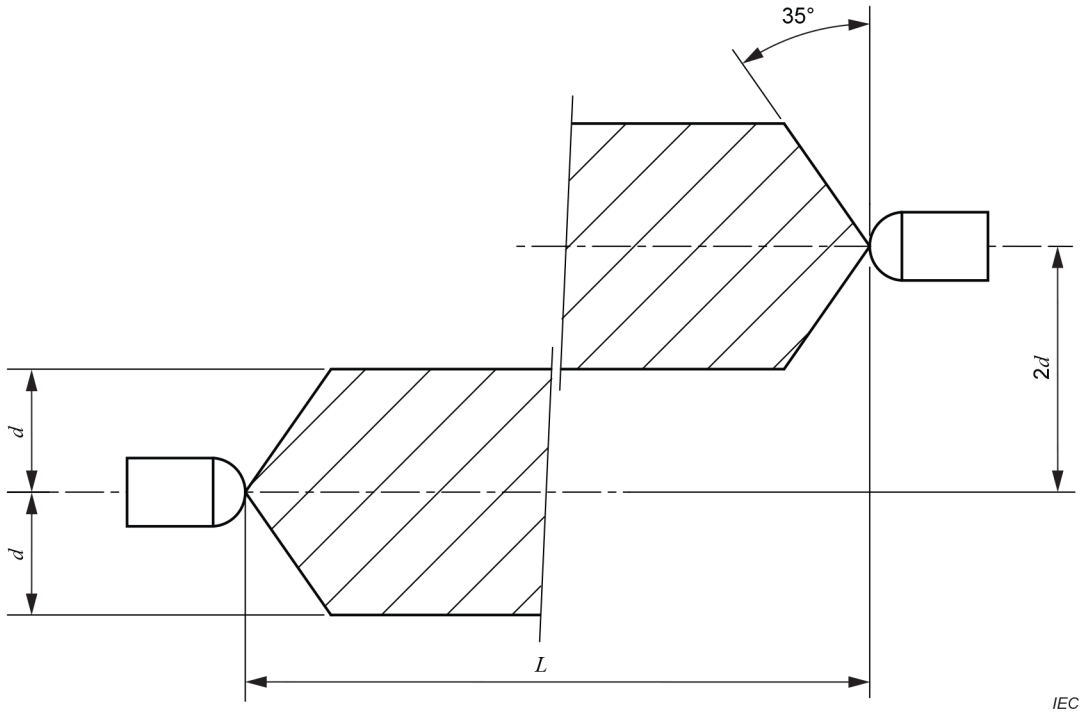
For type 3: d = 184 mm, L = 375 mm to 3 000 mm

For type 2: d = 262 mm, L = 500 mm to 3 000 mm

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 1 – Limit area for the protection against the risk of beam bypass

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



For type 4: $2d$ = 262 mm, L = 3 000 mm

For type 3: $2d$ = 368 mm, L = 3 000 mm

For type 2: $2d$ = 524 mm, L = 3 000 mm

Figure 2 – Limit of vertical and horizontal misalignment

4.2.13 Test piece

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

For AOPDs using retro-reflective techniques and for AOPDs using mixed emitter/receivers in the same assembly (see 4.1.2.2), the surface of the opaque test piece shall be:

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

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

– a mirror-type reflective surface having a reflection factor greater than or equal to 90 % at the operating wavelength, 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 of not more than 40 mm, the test piece for a light curtain 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 is intended to be used.

When more than one detection capability can be configured on the AOPD, the supplier shall provide a test piece for each detection capability.