IEC 61496-3

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Safety of machinery – Electro-sensitive protective equipment –
Part 3: Particular requirements for active opto-electronic protective devices responsive to diffuse reflection (AOPDDR)

Sécurité des machines – Équipements de protection électro-sensibles –
Partie 3: Exigences particulières pour les équipements utilisant des dispositifs protecteurs optoélectroniques actifs sensibles aux réflexions diffuses (AOPDDR)

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FOREWORD

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International Standard IEC 61496-3 has been prepared by IEC technical committee 44: Safety of machinery – Electrotechnical aspects.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

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

a) extension of the scope from AOPDDR-2D to AOPDDR-3D;
b) extension of the scope from Type 3 ESPE to Type 2 ESPE;
c) implementation of requirements and test procedures for AOPDDR-3D and Type 2 ESPE;
d) listing of reference boundary monitoring as an optional function of the ESPE;

e) implementation of instructions for positioning of AOPDDR-3D in respect of parts of the human body;

f) revised requirement for combinations of single faults with conditions for no failure to danger, see for example 4.2.2.4, last paragraph.

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

FDIS	Report on voting
44/831/FDIS	44/837/RVD

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

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

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

Where a particular clause or subclause of IEC 61496-1:2012 is not mentioned in this document, that clause or subclause applies as far as is reasonable. Where this document states "addition" or "replacement", the relevant text of IEC 61496-1:2012 is adapted accordingly. Clauses and subclauses which are additional to those of IEC 61496-1:2012 are numbered sequentially, following on the last available number in IEC 61496-1:2012. Where no available number exist, the additional subclauses are numbered starting from 101. Supplementary Annexes are entitled AA and BB.

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 publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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

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 part of IEC 61496 supplements or modifies the corresponding clauses in IEC 61496-1 to specify 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 responsive to diffuse reflection (AOPDDRs) 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 is 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, IEC 62046 and ISO 12100.

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 recommended.

SAFETY OF MACHINERY – ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT –

Part 3: Particular requirements for active opto-electronic protective devices responsive to diffuse reflection (AOPDDR)

1 Scope

This part of IEC 61496 specifies additional requirements for the design, construction and testing of electro-sensitive protective equipment (ESPE) designed specifically to detect persons or parts of persons as part of a safety-related system, employing active opto-electronic protective devices responsive to diffuse reflection (AOPDDRs) for the sensing function. Special attention is directed to requirements which ensure that an appropriate safety-related performance is achieved. An ESPE can include optional safety-related functions, the requirements for which are given both in Annex A of this document and in Annex A of IEC 61496-1:2012.

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.

AOPDDRs are devices that have either

– one or more detection zone(s) specified in two dimensions (AOPDDR-2D), or
– one or more detection zone(s) specified in three dimensions (AOPDDR-3D)

wherein radiation in the near infrared range is emitted by an emitting element(s). When the emitted radiation impinges on an object (for example, a person or part of a person), a portion of the emitted radiation is reflected to a receiving element(s) by diffuse reflection. This reflection is used to determine the position of the object.

Opto-electronic devices that perform only a single one-dimensional spot-like distance measurement, for example, optical proximity switches, are not covered by this document.

This document does not address those aspects required for complex classification or differentiation of the object detected.

This document does not address requirements and tests for outdoor application.

Excluded from this document are AOPDDRs employing radiation with the peak of wavelength outside the range 820 nm to 950 nm, and those employing radiation other than that generated by the AOPDDR itself. For sensing devices that employ radiation of wavelengths outside this range, this document can be used as a guide. This document is relevant for AOPDDRs having a minimum detectable object size in the range from 30 mm to 200 mm.

This document can be relevant to applications other than those for the protection of persons, for example, for the protection of machinery or products from mechanical damage. In those applications, different requirements can be appropriate, for example when the materials that have to be recognized by the sensing function have different properties from those of persons and their clothing.

This document does not deal with electromagnetic compatibility (EMC) emission requirements.

2 Normative references

Clause 2 of IEC 61496-1:2012 applies, except as follows.

Addition:

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC TR 60721-4-5, *Classification of environmental conditions – Part 4-5: Guidance for the correlation and transformation of environmental condition classes of IEC 60721-3 to the environmental tests of IEC 60068 – Ground vehicle installations*

IEC 60825-1:2014, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 61496-1:2012, *Safety of machinery – Electro-sensitive protective equipment – Part 1: General requirements and tests*

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

ISO 13855:2010, *Safety of machinery – Positioning of safeguards with respect to the approach speeds of parts of the human body*

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

3 Terms and definitions

Clause 3 of IEC 61496-1:2012 applies, except as follows.

Replacement of 3.3 and 3.4:

3.3
detection capability
ability to detect the specified test pieces (see 4.2.13) in the specified detection zone

Note 1 to entry: A list of influences which can affect the AOPDDR detection capability is given in 4.2.12.1.

Note 2 to entry: Detection capability is often described by the minimum detectable object size and the object reflectivity. The supplier can state more than one value as the minimum detectable object size, for example depending on distances or mounting conditions. For an AOPPDR-2D the minimum detectable object size is the diameter of the cylindrical test piece.

3.4
detection zone
zone within which the specified test piece(s) (see 4.2.13) is detected by the AOPDDR with a minimum required probability of detection (see 4.2.12.2)

Note 1 to entry: A tolerance zone is necessary to achieve the required probability of detection of the specified test piece(s) within the detection zone.

Addition:

3.301
active opto-electronic protective device responsive to diffuse reflection
AOPDDR
device, whose sensing function is performed by opto-electronic emitting and receiving elements, that detects the diffuse reflection of optical radiations generated within the device by an object present in a detection zone specified in two or three dimensions

Note 1 to entry: A receiving element can be composed by optics/optic-arrays and a single sensor element(s) or a sensor array(s).

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

3.302
AOPDDR-2D
AOPDDR that has one or more detection zone(s) specified in two dimensions

Note 1 to entry: For example, a third dimension is not greater than the minimum detectable object size, then the AOPDDR is regarded as 2D (see Figures 1 and 2).

Note 2 to entry: A typical example of an AOPDDR-2D is a laser scanner that performs distance measurement by measuring the time a pulse needs for travelling from the sensing device to an object and back to the sensing device. An AOPDDR-2D that has more than one detection zone may carry out distance measurements in different planes.

Note 3 to entry: This note applies to the French language only.

3.303
AOPDDR-3D
AOPDDR that has one or more detection zone(s) specified in three dimensions

Note 1 to entry: For example, a third dimension as specified by the supplier is greater than the minimum detectable object size, the AOPDDR is regarded as 3D (see Figures 1 and 2). The detection zone(s) can be set-up for example as a volume in the shape of a pyramid or a cone.

Note 2 to entry: Typical examples of AOPDDR-3D are laser scanners with two perpendicular positioned moving mirrors or time-of-flight-cameras (TOF) that perform distance measurement on several pixels. An AOPDDR-3D that has more than one detection zone may carry out distance measurements in different volumes.

Note 3 to entry: This note applies to the French language only.

3.304
basic test distance
BTD
Radius, respectively width and length (or equivalent values), of the detection zone used for test set-up

Note 1 to entry: For dimension of BTD, see 5.1.1.2.

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

3.305
centre axis
line through the origin of distance measurement and the centre of the maximum detection zone stated by the supplier

Note 1 to entry: See Figure 1 and Figure 2.

3.306
corner axis
line through the origin of distance measurement and defined by the bounding line of the detection zone

Note 1 to entry: See Figure 1 and Figure 2.

3.307
minimum detection zone
lowest dimension of the detection zone which is necessary to ensure the integrity of the detection capability

3.308
position accuracy
accuracy in two or three dimensions of the position of an object as measured by the AOPDDR

3.309
tolerance zone
TZ
zone outside of and adjacent to the detection zone within which the specified test piece(s) (see 4.2.13) is detected with a probability of detection lower than the required probability within the detection zone

Note 1 to entry: The tolerance zone is necessary to achieve the required probability of detection of the specified test piece(s) within the detection zone

Note 2 to entry: For explanation of the concept of probability of detection and the tolerance zone, see Annex BB.

Note 3 to entry: This note applies to the French language only.

3.310
zone with limited detection capability
zone, between the optical window and the beginning of the detection zone, where the detection capability is not achieved

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

Addition:

3.101 Abbreviated terms

AGV automated guided vehicle

BTD basic test distance

POD probability of detection

TZ tolerance zone

4 Functional, design and environmental requirements

4.1 Functional requirements

4.1.3 Types of ESPE

Replacement:

In this document, only type 2 and type 3 ESPE are considered. The types differ in their performance in the presence of faults and under influences from environmental conditions. It is the responsibility of the machine supplier and/or the user to prescribe which type is suitable for a particular application.

The type 2 ESPE shall fulfil the fault detection requirements of 4.2.2.3 of this document. In normal operation, the output circuit of each of at least two output signal switching devices (OSSDs) or of one output signal switching device (OSSD) and one secondary switching device (SSD) of the type 2 ESPE shall go to the OFF-state when the sensing device is actuated, or when the power is removed from the device.

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) of the type 3 ESPE shall go to the OFF-state when the sensing device is actuated, or when the power is removed from the device.

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. In this case, a single safety-related data interface can substitute for two OSSDs in a type 3 ESPE.

Addition:

4.1.6 Zone(s) with limited detection capability

In order to ensure no hazard can arise in a particular application due to the presence of one or more zone(s) with limited detection capability between the optical window and the detection zone, its dimensions and appropriate information for use shall be provided by the supplier.

If the zone with limited detection capability extends more than 50 mm from the optical window in direction to the detection zone(s), then additional and effective technical measures shall be applied to prevent undetected presence of objects or persons or parts of persons in the zone with limited detection capability.

4.2 Design requirements

4.2.2 Fault detection requirements

4.2.2.2 Particular requirements for a type 1 ESPE

4.2.2.2 of IEC 61496-1:2012 does not apply.

4.2.2.3 Particular requirements for a type 2 ESPE

Replacement:

A type 2 ESPE shall have a means of periodic test to reveal a failure to danger (for example loss of detection capability, response time exceeding that specified).

The test shall be performed also at power-on of the ESPE before going to the ON-state and at each reset.

Depending on the application, the periodic test may need to be performed more often to achieve a desired safety performance. Generic functional safety standards give requirements how often periodic test have to be applied to fulfil the requirements for a certain safety performance.

NOTE 1 The periodic test can be initiated by external or internal means.

When it is not possible to reveal a failure to danger by periodic tests other equivalent measures shall be applied.

A single fault resulting in the loss of the stated AOPDDR detection capability or the increase in response time beyond the specified time or preventing one or more of the OSSDs going to the OFF-state shall result in a lock-out condition as a result of the next periodic test.

A single fault resulting in the deterioration of the stated AOPDDR detection capability shall result in a lock-out condition at least as a result of the next periodic test. If periodic test cycle is less than 5 s then deterioration of the stated AOPDDR detection capability shall be detected within 5 s.

NOTE 2 Examples of deterioration of the AOPDDR detection capability include

– the increase of the minimum detectable object size,
– the increase in the minimum detectable reflectivity, and;
– the decrease of position accuracy.

The occurrence of single faults shall be considered by analysis and/or test with each of the following conditions and throughout the entire detection zone:

– environmental conditions specified in 4.3;
– at the limits of alignment and/or adjustment.

Where the periodic test is intended to be initiated by an external (for example machine) safety-related control system, the ESPE shall be provided with suitable input facilities (for example terminals).

The duration of the periodic test shall be such that the intended safety function is not impaired, especially if the ESPE is intended for use as a trip device.

If the periodic test is automatically initiated, the correct functioning of the periodic test shall be monitored. In the event of a fault, the OSSD(s) shall be signalled to go to the OFF-state. If one or more OSSDs do(es) not go to the OFF-state, a lock-out condition shall be initiated.

An ESPE with only one OSSD shall have a minimum of one SSD (see Clause A.4 of IEC 61496-1:2012).

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 AOPDDR detection capability shall cause the ESPE to go to a lock-out condition within the specified response time.

NOTE 1 For AOPDDR using rotating mirrors for scanning the detection zone, this requirement can be fulfilled by scanning on a defined reference object located outside the detection zone and the tolerance zone.

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

NOTE 2 Examples of deterioration of the AOPDDR detection capability include

– the increase of the minimum detectable object size,
– the increase in the minimum detectable reflectivity, and
– the decrease of position accuracy.

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 lock-out condition 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);
– on the application of an external test signal, if available.