

# INTERNATIONAL STANDARD



**Safety of machinery – Application of protective equipment to detect the presence of persons**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2018 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

#### IEC Catalogue - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [webstore.iec.ch/glossary](http://webstore.iec.ch/glossary)

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

# INTERNATIONAL STANDARD



---

**Safety of machinery – Application of protective equipment to detect the presence of persons**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 13.110

ISBN 978-2-8322-5519-3

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	10
2 Normative references .....	10
3 Terms, definitions and abbreviated terms .....	10
3.1 Terms and definitions.....	10
3.2 Abbreviated terms.....	19
4 Selection of protective measures .....	19
4.1 Procedure (relationship with ISO 12100).....	19
4.2 Machine characteristics .....	21
4.2.1 Suitability of protective equipment .....	21
4.2.2 Suitability of protective equipment as a trip device.....	21
4.3 Environmental characteristics .....	21
4.4 Uses of protective equipment.....	22
4.4.1 General .....	22
4.4.2 Trip function .....	23
4.4.3 Presence sensing function.....	24
4.4.4 Combination trip and presence sensing function.....	25
4.5 Human characteristics.....	25
4.5.1 General .....	25
4.5.2 Approach speed ( $K$ ).....	25
4.5.3 Intrusion/encroachment factor ( $C$ ).....	25
4.5.4 Ability to circumvent protective equipment.....	26
4.6 Protective equipment characteristics.....	26
4.6.1 ESPEs.....	26
4.6.2 Pressure sensitive mats and floors .....	29
4.7 Optional machine control system functions associated with the application of protective equipment.....	29
4.7.1 General .....	29
4.7.2 Stopping performance monitoring (SPM).....	30
4.7.3 Muting .....	30
4.7.4 Reinitiation of machine operation by the protective equipment.....	30
4.7.5 Start interlock .....	30
4.7.6 Restart interlock .....	30
4.7.7 External device monitoring (EDM).....	30
4.7.8 Provision of machine control functions.....	31
5 General application requirements .....	31
5.1 Positioning and configuration of the protective equipment detection zone .....	31
5.2 Integration with the safety-related control system.....	31
5.3 Performance of protective equipment.....	32
5.3.1 General .....	32
5.3.2 Classification of protective equipment.....	32
5.4 Stopping performance monitoring (SPM).....	34
5.5 Start interlock .....	34
5.6 Restart interlock.....	34
5.7 Muting.....	35

5.7.1	General .....	35
5.7.2	Muting to allow access by persons .....	36
5.7.3	Muting to allow access by materials .....	37
5.7.4	Mute dependent override .....	37
5.8	Reinitiation of machine operation by the protective equipment .....	38
6	Particular application requirements for specific protective equipment .....	40
6.1	AOPDs .....	40
6.1.1	General .....	40
6.1.2	Light beam device(s) .....	40
6.1.3	Light curtains .....	42
6.2	AOPDDRs .....	45
6.3	Vision based protective devices VBPD .....	46
6.4	Pressure-sensitive mats and floors .....	47
6.4.1	Pressure sensitive floors .....	47
6.4.2	Pressure sensitive mats .....	47
7	Inspection and test .....	48
7.1	General .....	48
7.2	Functional checks .....	49
7.3	Periodic inspection and test .....	50
7.4	Initial inspection and test .....	50
7.5	Application specific tests .....	51
8	Information for safe use .....	52
Annex A (informative)	Application examples .....	53
A.1	General .....	53
A.2	Protective equipment used as a trip device .....	53
A.3	Use of protective equipment as a combined trip and presence sensing device .....	54
A.3.1	Example 1 .....	54
A.3.2	Example 2 .....	54
A.3.3	Example 3: horizontal AOPD .....	55
A.3.4	Example 4: vertical AOPD .....	56
A.3.5	Example 5 .....	57
A.4	Perimeter guarding .....	58
Annex B (informative)	Additional recommendations for the application of AOPDDRs .....	59
B.1	General .....	59
B.2	Example of the use of an AOPDDR on stationary machinery .....	61
B.3	Example of the use of an AOPDDR on an automatic guided vehicle (AGV) .....	62
B.4	AOPDDR used for the detection of the body or parts of a body with orthogonal approach .....	63
B.4.1	Detection of a whole body .....	63
B.4.2	Detection of parts of the body .....	63
B.5	Examples of the use of an AOPDDR as a whole-body trip device .....	63
B.6	Examples for the use of an AOPDDR as parts of a body trip device .....	65
Annex C (informative)	Application example of a vision based protective system (VBPDS) .....	67
Annex D (informative)	Examples for the configuration of photoelectric muting sensors when used to allow access by materials .....	69
D.1	General .....	69
D.2	Four beams .....	71

D.2.1	Four beams – Positioning of the sensors .....	71
D.2.2	Four beams – timing control .....	72
D.2.3	Four beams – sequence control .....	73
D.2.4	Four beams with additional swinging doors .....	74
D.2.5	Methods to avoid manipulation of the muting function .....	75
D.2.6	Connection of the sensors to a two input muting control .....	77
D.2.7	Two sensors – positioning of the sensors .....	78
D.2.8	Two sensors – timing control .....	81
D.2.9	Two muting sensor beams in combination with swinging doors .....	82
D.2.10	Height of the crossing point of the muting sensor beams .....	84
D.3	Two parallel muting sensor beams – exit only .....	85
D.4	Protection of conveyor systems working in a coordinated manner .....	88
Bibliography .....		90
Figure 1	– Relationship of this International Standard to other standards .....	9
Figure 2	– Risk reduction process .....	20
Figure 3	– Detection principle of through-beam AOPD .....	27
Figure 4	– Through-beam AOPD using mirrors .....	27
Figure 5	– Retro-reflective AOPD .....	27
Figure 6	– Detection principle of AOPDDR .....	28
Figure 7	– Detection principle of VBPDST .....	29
Figure 8	– Example of the effect of reflective surfaces .....	40
Figure 9	– Detection capability of single light beam device .....	42
Figure 10	– Detection capability of a multiple light beam device .....	42
Figure 11	– Example of use of blanking .....	44
Figure 12	– Example of reduced resolution .....	45
Figure A.1	– Protective equipment used as a trip device .....	53
Figure A.2	– Protective equipment used as combined trip and presence sensing device – Example 1 .....	54
Figure A.3	– Protective equipment used as a combined trip and presence sensing device – Example 2 .....	54
Figure A.4	– Horizontal AOPD .....	55
Figure A.5	– Vertical AOPD .....	56
Figure A.6	– Increased minimum distance .....	57
Figure A.7	– Additional mechanical protection .....	58
Figure A.8	– Use of a trip device .....	58
Figure B.1	– Example of the use of an AOPDDR on machinery .....	60
Figure B.2	– Example of the use of an AOPDDR on stationary machinery .....	61
Figure B.3	– Example of the use of an AOPDDR on an AGV .....	62
Figure B.4	– Use of an AOPDDR as a whole-body trip device – Example 1 .....	63
Figure B.5	– Use of an AOPDDR as a whole-body trip device – Example 2 .....	64
Figure B.6	– Use of an AOPDDR as parts of a body trip device – Example 1 .....	65
Figure B.7	– Use of an AOPDDR as parts of a body trip device – Example 2 .....	65
Figure C.1	– Application example of a VBPDST .....	68
Figure D.1	– T configuration with timing control .....	69

Figure D.2 – L configuration with timing control.....	70
Figure D.3 – Parallel beams with timing or sequence control .....	70
Figure D.4 – Four parallel beams with timing control.....	71
Figure D.5 – Positioning of the muting sensors to avoid muting by a person's body (plan view).....	72
Figure D.6 – Positioning of the muting sensors (side view) .....	72
Figure D.7 – Timing diagram: four parallel beams with timing control.....	73
Figure D.8 – Four beams: timing control and crossed beams (not recommended) .....	73
Figure D.9 – Timing diagram: four beams and sequence control .....	74
Figure D.10 – Four beams with additional swinging doors.....	75
Figure D.11 – Timing diagram for mute enable signal (mute enable activated) .....	75
Figure D.12 – Timing diagram for mute enable signal (mute enable not activated) .....	76
Figure D.13 – Presence of the mute enable signal during more than one mute cycle .....	76
Figure D.14 – Avoidance of manipulation of the muting function (plan view) .....	77
Figure D.15 – Avoidance of manipulation of the muting function (front view) .....	77
Figure D.16 – Connection of the muting sensors.....	78
Figure D.17 – Two sensors – Crossed beams .....	78
Figure D.18 – Two sensors – Crossed beams (risk of entering the hazardous zone without detection when $x > 200$ mm) .....	79
Figure D.19 – Positioning of the muting sensors .....	80
Figure D.20 – Detection of the test object .....	80
Figure D.21 – Timing diagram for two crossed beams (normal operation) .....	81
Figure D.22 – Timing diagram for two crossed beams (timeout) .....	81
Figure D.23 – Single swinging doors in combination with a two-beam muting system (correct position).....	82
Figure D.24 – Reaching hazardous zone behind the pallet (incorrect position of swinging doors) .....	83
Figure D.25 – Reaching hazardous zone in front of pallet (incorrect position of swinging doors) .....	84
Figure D.26 – Height of crossing point .....	85
Figure D.27 – Interruption of the beam by foot .....	85
Figure D.28 – Two muting sensor beams – exit only .....	86
Figure D.29 – Timing diagram; two muting sensor beams – exit only, muting terminated by the LSPE.....	86
Figure D.30 – Timing diagram; two muting sensor beams – exit only, muting terminated by the 4 s timer .....	87
Figure D.31 – Timing diagram, muting terminated by the muting timeout.....	87
Figure D.32 – Production line incorporating two conveyors (2 hazardous zones) (incorrect application) .....	88
Figure D.33 – Production line incorporating two conveyors(2 hazardous zones).....	89
Table 1 – ESPE Types and achievable PL or SIL.....	33
Table 2 – Beam heights for light beam devices .....	41
Table D.1 – Truth table, four beams – sequence control .....	74

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF MACHINERY – APPLICATION OF PROTECTIVE  
EQUIPMENT TO DETECT THE PRESENCE OF PERSONS**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62046 has been prepared by IEC technical committee 44: Safety of machinery – Electrotechnical aspects.

This first edition cancels and replaces IEC TS 62046, published in 2008. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC TS 62046:2008:

- a) additional annexes relating to muting and vision systems,
- b) muting requirements have been updated,
- c) blanking requirements have been updated,
- d) addition of IEC 61496 series Types and capping the Safety Integrity level according to IEC 62061 and performance levels according to ISO 13849-1,
- e) alignment to changes in IEC 61496 series.

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

FDIS	Report on voting
44/803/FDIS	44/812/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.

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.

A bilingual version of this publication may be issued at a later date.

**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

This International Standard provides requirements and information on the application of protective equipment, which employs (a) sensing device(s) to detect person(s), in order to reduce or minimize a risk from hazardous parts of machinery, without providing a physical barrier.

The objective of this document is to assist standards writing committees responsible for developing machine standards ("C" Standards), machine designers, manufacturers and refurbishers, machine safety certification organizations, workplace authorities and others on the proper application of protective equipment to machinery.

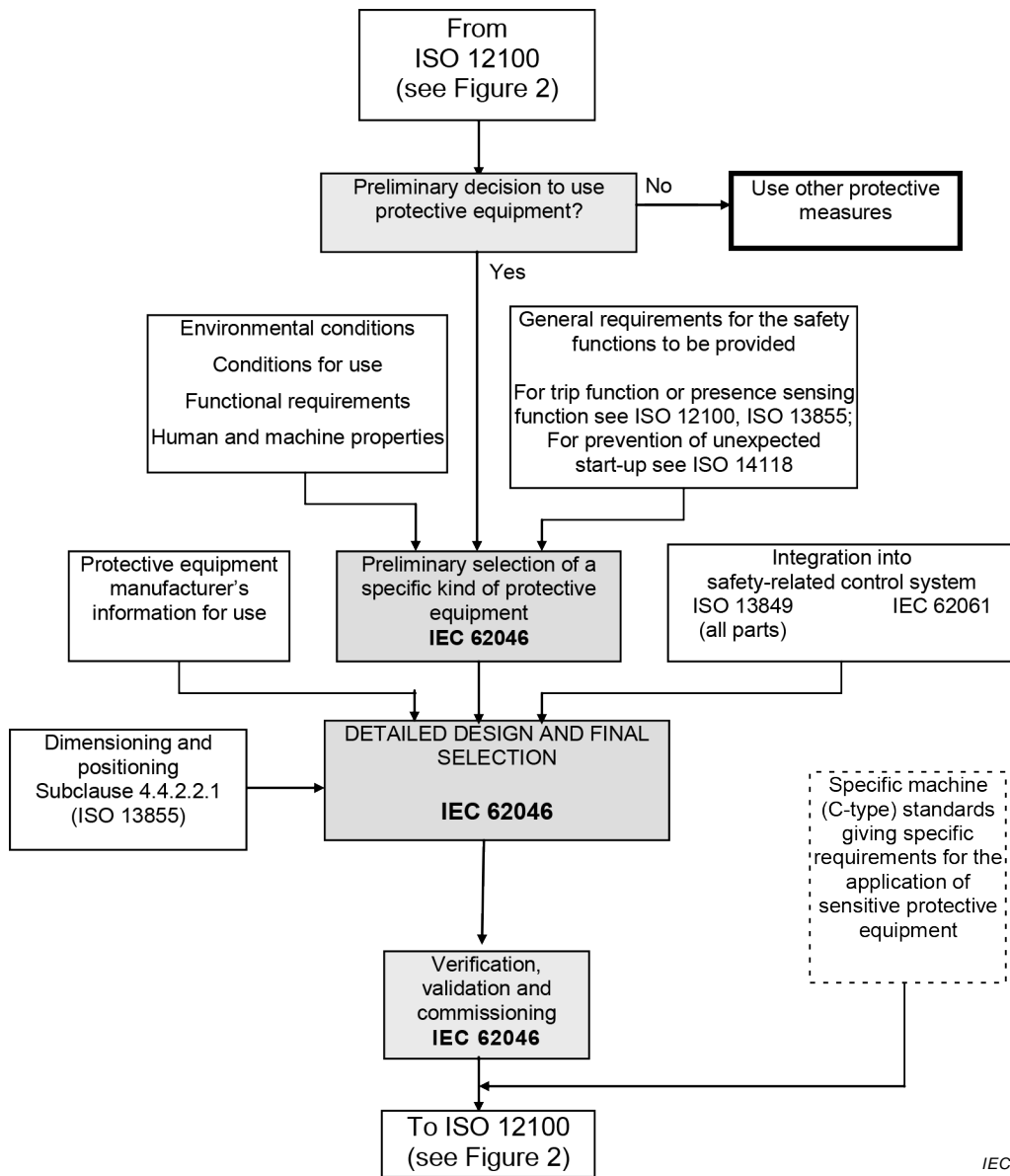
Figure 1 and Figure 2 show the general context and the intended use of this standard.

Clauses 1 to 5, 7 and 8 of this document apply to all protective equipment included in the scope, Clause 6 contains guidance for the application of specific kinds of protective equipment.

The principles of this document can be useful in the application of devices using other detection technologies but this document does not give specific requirements for devices other than those listed above.

This document considers devices standardised in the IEC 61506 series and the ISO 13856 series. Unless a product-specific safety-related standard for devices using other sensing technologies is published, their suitability as the sole means of protection from machine hazards is unknown. Great care should be taken in the selection and use of devices for which there is no product-specific safety-related standard because their behaviour, particularly under fault conditions, is not known to be sufficiently predictable.

An SILCL (SIL claim limit, see IEC 62061) or PL (Performance Level, see ISO 13849-1) or SIL (Safety Integrity Level, see IEC 61508) is not sufficient as an indication of a device's suitability for use as a safeguard. Suitability depends on appropriate sensing means, environmental conditions especially noise that can affect the detection capability, behaviour under fault conditions, etc



IEC

**Figure 1 – Relationship of this International Standard to other standards**

(see also Figure 2)

# SAFETY OF MACHINERY – APPLICATION OF PROTECTIVE EQUIPMENT TO DETECT THE PRESENCE OF PERSONS

## 1 Scope

This International Standard specifies requirements for the selection, positioning, configuration and commissioning of protective equipment to detect the momentary or continued presence of persons in order to protect those persons from dangerous part(s) of machinery in industrial applications. This standard covers the application of electro-sensitive protective equipment (ESPE) specified in IEC 61496 (all parts) and pressure sensitive mats and floors specified in ISO 13856-1.

It takes into account the characteristics of the machinery, the protective equipment, the environment and human interaction by persons of 14 years and older.

This document includes informative annexes to provide guidance on the application of protective equipment to detect the presence of persons. These annexes contain examples to illustrate the principles of this standard. These examples are not intended to be the only solutions to a given application and are not intended to restrict innovation or advancement of technology. The examples are provided only as representative solutions to illustrate some of the concepts of integration of protective equipment, and have been simplified for clarity, so they may be incomplete.

## 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 62061, *Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems*

ISO 12100:2010<sup>1</sup>, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

ISO 13849 (all parts), *Safety of machinery – Safety-related parts of control systems*

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

## 3 Terms, definitions and abbreviated terms

### 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

---

<sup>1</sup> ISO 12100:2010 constitutes a consolidation without technical changes of ISO 12100-1:2003, ISO 12100-2:2003, ISO 14121-1:2007 and related amendments. This consolidation does not require updates or revisions to type B- and type C- standards or other documents (e.g. for risk assessment) based on the previous standards.