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**Selection of opto-electronic protective devices –
Functional safety and optical performance features**

Dear Sir or Madam,

With the new safety standard EN ISO 13849-1, which replaces EN 954-1, the following question is frequently asked:

Is it sufficient to only take the performance level into account for the selection of opto-electronic protective devices?

Today, we are informing you about the practical and normative background of this topic.

With a decision-making aid, we would like to support you in your design and selection process.

If you have any further questions or require support, our experts will be happy to help you. Contacts are available on the back page.

Yours sincerely,

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Selection of opto-electronic protective devices – Examination of the optical performance features

Up to the end of 2009, for a risk analysis and risk assessment, the required safety level of a control function was primarily specified by the machine designers using categories B, 1, 2, 3 and 4 of EN 954-1. Opto-electronic protective devices (ESPE) are among the equipment used as techni-

cal protective measures. They are classified by Types 2, 3 and 4 in accordance with the series of standards, IEC 61496. With the Type, a direct reference has been established to categories 2, 3 and 4 of EN 954-1 (see fig. 1).

Category acc. to EN ISO 13849-1 or EN 954-1	Type acc. to IEC 61496	Examples from SICK
2	2	 <p>Single-beam photoelectric safety switches, L2000 Multiple light beam safety device, M2000 Safety light curtain, C2000 Safety light curtain, miniTwin2 Safety laser scanner, S200 Safety camera system, V200</p>
3	3	 <p>Safety laser scanner, S300 Safety camera system, V300</p> <p>(Type 3 light curtains are not defined in IEC 61496)</p>
4	4	 <p>Single-beam photoelectric safety switches, L4000 Multiple light beam safety device, M4000 Safety light curtain, C4000 Safety light curtain, miniTwin4</p>

↑ Low risk reduction
↓ High risk reduction

Fig. 1: The higher the risk reduction required, the higher the category and the higher the ESPE Type to be used.

EN 954-1 was further developed, resulting in EN ISO 13849-1 where the reliability of safe control functions is defined with performance levels (PL) a, b, c, d and e. PL e represents the highest level. In addition to the structural requirements described by the categories, the probability of a dangerous failure, measures for

avoiding and containing faults, the avoidance or containment of systematic faults and the quality of the design process are additionally or more intensively taken into account.

EN 62061 with safety integrity levels (SIL) 1, 2 and 3 has the same claim.

Is it sufficient to only take the PL into account for the selection of opto-electronic protective devices?

Unlike simple control systems, such as electronic safety switches, additional criteria need to be taken into account for opto-electronic protective devices.

These include the required detection capability that results from the optical active principles and that is specified in the series of standards, IEC 61496 (see fig. 2).

Functional safety	Resistance to environmental influences	Electromagnetic compatibility	Detection capability
EN ISO 13849-1 mainly describes requirements for the functional safety of safety-related parts of control systems: <ul style="list-style-type: none"> ▪ Structure (categories) ▪ Probability of a dangerous failure ▪ Measures for avoiding and detecting faults ▪ Avoidance or containment of systematic faults ▪ Quality of the design process ▪ Documentation 		IEC 61496 describes the requirements for opto-electronic protective devices: <ul style="list-style-type: none"> ▪ Design of the ESPE ▪ Optical performance features ▪ Detection capability ▪ Reliability of detection capability ▪ EMC ▪ Structure (categories) 	
PL EN ISO 13849-1		+	Type IEC 61496

Fig. 2: Addition to the requirements of EN ISO 13849-1 and IEC 61496

The high flexibility of EN ISO 13849-1 in the assessment of the functional safety of safety circuits or sub-systems permits the classification e.g. of a Type 2 light curtain (structure according to category 2) in a

wide range of the PL. According to the simplified method for the assessment of a PL in EN ISO 13849-1, performance levels a to d are possible (see fig. 3).

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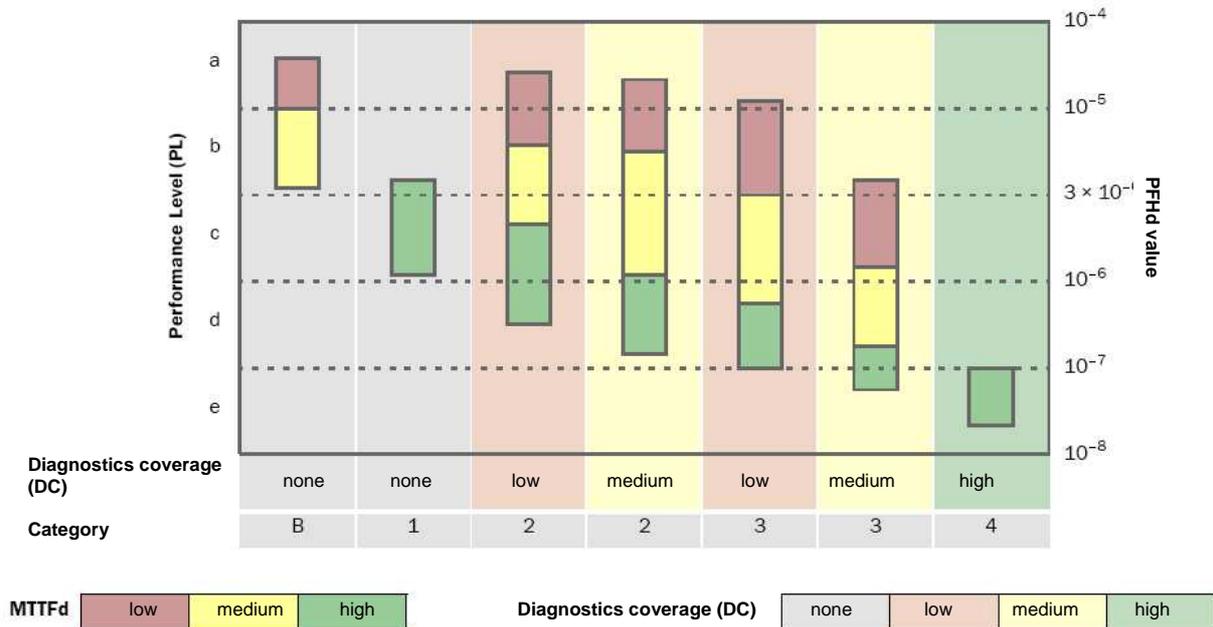


Fig. 3: Determining the PL of a sub-system according to the simplified method of EN ISO 13849-1

However, the required systematic capabilities of the light curtain are not covered by the PL alone.

To achieve the necessary risk reduction, the detection capability already mentioned and the reliability of this detection capability must be taken into account.

The detection capability describes the ability to reliably detect objects of a certain size (e.g., 14, 30, 40 mm for safety light curtains) thus resulting in the deactivation of the outputs (OSSDs) of the opto-electronic protective device.

It is one of the main parameters for defining the use, e.g., for detecting fingers, hands or bodies and the minimum distance to the hazardous point.

The reliability of the detection capability is determined by the Type classification. Requirements for optical sources of interference (sunlight, different lamp types, devices of the same design, etc.), reflective surfaces, misalignment during normal operation and the diffuse reflection of safety laser scanners play an important role (see fig. 4).

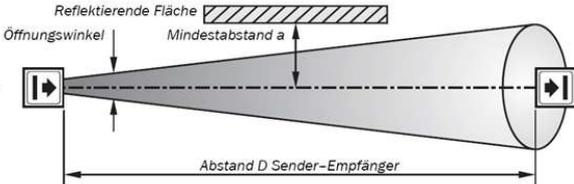
	Type 2	Type 4	Advantage of Type 4
Functional safety	Between the test intervals, the protective function may be lost during the occurrence of a failure.	The protective function is retained even during several failures..	Higher risk reduction
EMC (electromagnetic compatibility)	Basic requirements	Increased requirements	Higher reliability of the detection capability.
Maximum field of view of the optics ¹⁾	10°	5°	
Minimum distance <i>a</i> to reflective surfaces over a distance of <i>D</i> < 3 m	262 mm	131 mm	Higher system availability in difficult ambient conditions. Mounting nearer to the machine → saves space.
Minimum distance <i>a</i> to reflective surfaces over a distance of <i>D</i> > 3 m	 = distance x tan (10° / 2)	 = distance x tan (5° / 2)	
Several senders of the same design in a system	No special requirements (Beam coding is recommended)	No effect; however if affected, OSSDs switch off.	

Fig. 4: Main differences between Type 2 and Type 4 ESPE according to IEC 61496. The requirements for Type 4 devices are higher than for Type 2.

Important!

For opto-electronic protective devices, the related classification type must be taken into account in addition to the required performance level. It must be considered the necessary risk reduction.

PL + Type



The information above applies to a required safety integrity level (SIL) in a similar manner.

¹⁾ The limitation on a maximum field of view of the optics for Type 4 devices to 5° reduces the probability of the failure to detect objects due to reflective affects, and reduces therefore the probability of a dangerous failure.

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Type 2 or Type 4?

The required PL or SIL can be determined quickly. However, since the current IEC 61496 does not include any relationship of the Type classes for PL or SIL, the design engineer relies on extensive experience or support.

The following decision-making aids for the selection of Type 2 or 4 for AOPDs (single-beam, multiple light beam safety devices, safety light curtains) are recommended by SICK (as of January 2010):

1. Observance of the specifications in the existing C standards (product standards for special machine types). See list of standards in the official journal of the European Union under www.ec.europa.eu/enterprise.

2. If the specifications in the C standards have not yet been adapted to the new safety standards or if a corresponding C standard does not exist, you can proceed as follows:

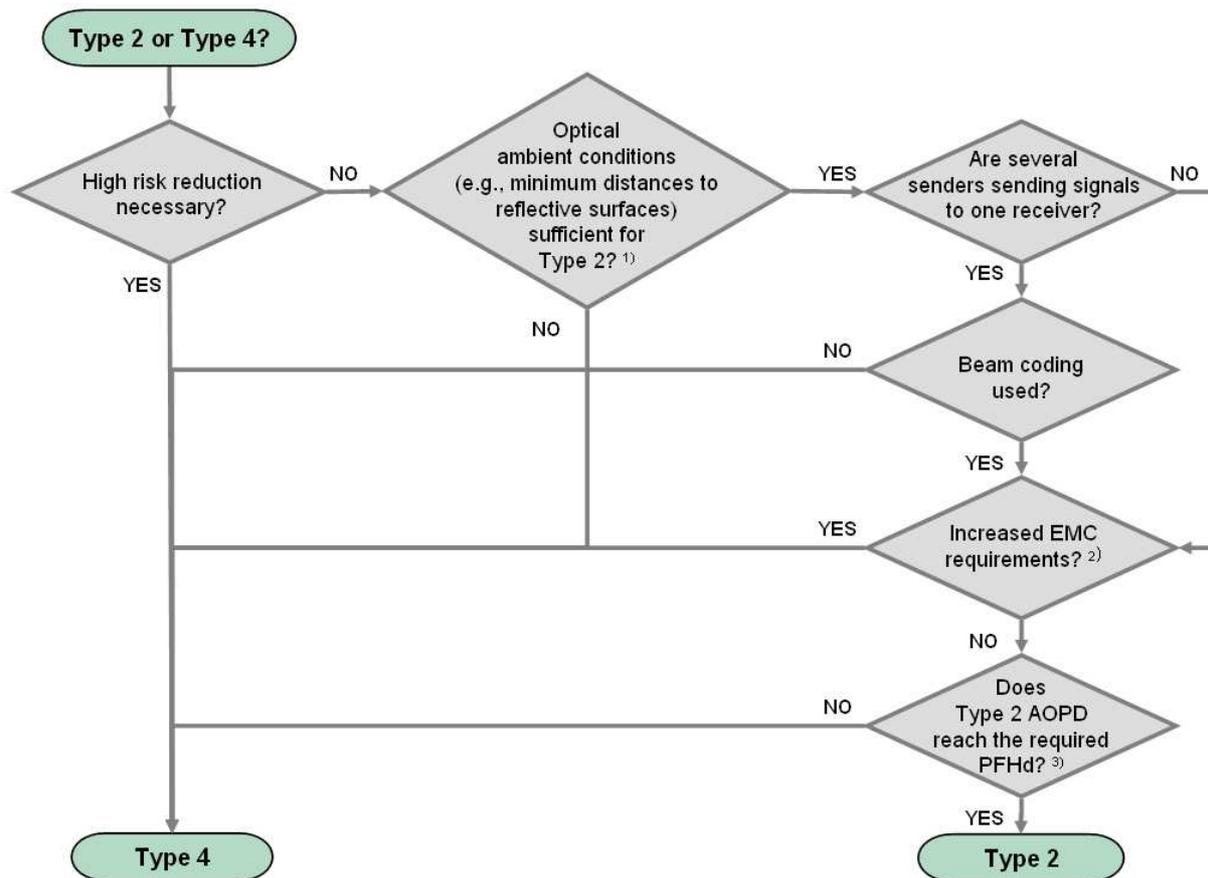


Fig. 5: Procedure for the selection of the required AOPD Type

¹⁾ Optical ambient conditions, → Fig 4.

²⁾ The following can occur: - High frequency radio signals on the cables (e.g., transmitters in the vicinity)
- High voltage electrostatic discharges (ESD)
- Powerful electromagnetic fields (e.g., due to welding processes)
- Powerful burst/surge interference (e.g., due to electrical switching in the vicinity or systems in the vicinity that are poorly protected against lightning).

³⁾ PFHd: Probability of dangerous failure per hour.

3. When in doubt, following allocation is recommended:

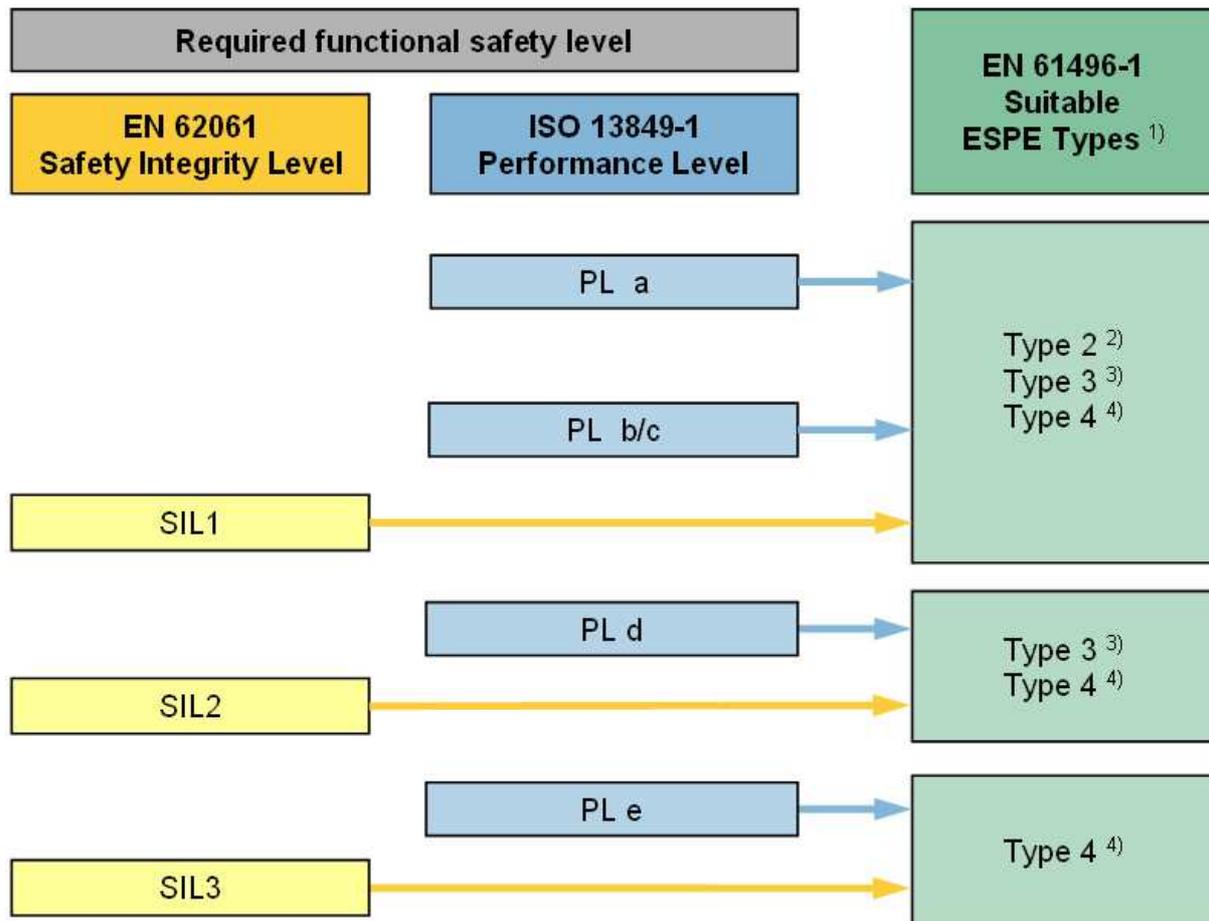


Fig. 6: Recommended assignment of SIL/PL to Type

The operating instructions for the opto-electronic protective devices contain further application information and instructions that must be taken into account.

¹⁾ ESPE: Electro-sensitive protective equipment

²⁾ Type 2: E.g., Single-beam Photoelectric Safety Switches, Safety Light Curtains. For the necessary external tests and their demand rates see technical specifications.

³⁾ Type 3: E.g., Safety Laser Scanner, Safety Camera Systems.

⁴⁾ Type 4: E.g., Single-beam Photoelectric Safety Switches, Safety Light Curtains.

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