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Part 4: Particular requirements for equipment using vision based protective devices (VBPD)

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National foreword

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TECHNICAL REPORT

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Safety of machinery – Electro-sensitive protective equipment –

Part 4: Particular requirements for equipment using vision based protective devices (VBPD)

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INTRODUCTION

This technical report provides information related to the design, construction and testing of electro-sensitive protective equipment (ESPE) that employs vision-based protective devices (VBPDs) for the sensing function for the safeguarding of machinery.

At the time of writing this technical report, there were no commercial examples of VBPDs on the market. Therefore, to provide an example of a VBPD for the writing of this technical report, the working group used the results of a Japanese research project. The working group understands that the possibilities for VBPDs are much greater than the limited technologies demonstrated by this example. When real systems do arrive, it is believed that some of the basic concepts put forth in this technical report can be used as a guide for the evaluation and testing of those first systems.

It is anticipated that the characteristics and requirements for VBPDs will vary significantly depending on the underlying technologies and methodologies employed. Therefore, it is planned that this technical report will be divided into subparts which address the unique requirements of the different types of vision-based devices (for example IEC 61496-4-1 would cover general requirements and IEC 61496-4-2 would cover requirements unique to devices using a passive reference pattern).

SAFETY OF MACHINERY – ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT –

Part 4: Particular requirements for equipment using vision based protective devices (VBPD)

1 Scope

NOTE As an example for the development of this technical report, a VBPD is defined as consisting of a single image-sensing device viewing one two-dimensional image against a passive pattern as the background and where the detection principle is blocking the view of the pattern. Information about the thickness, shape and surface characteristics of the object is not required for detection. A passive pattern is not created by a light source.

Replacement:

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 vision-based protective devices (VBPDs) for the sensing function. Special attention is directed to features which ensure that an appropriate safety-related performance is achieved. An ESPE may include optional safety-related functions, the requirements for which are given in Annex A of IEC 61496-1 and this technical report.

This technical report 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.

- It is limited to automatic vision-based ESPEs that do not require human intervention for detection.
- It is limited to automatic vision-based ESPEs that detect objects entering into, or present in, a detection zone(s).
- Excluded from this part are VBPD employing radiation at wavelengths outside the range 400 nm to 1 500 nm.
- This technical report does not address those aspects required for complex classification or differentiation of the object detected.

This technical report may 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 may be necessary, for example when the materials that are to be recognized by the sensing function have different properties from those of persons.

This technical report does not deal with EMC emission requirements.

2 Normative references

Additions:

IEC 60825-1:2007, *Safety of laser products – Part 1: Equipment classification and requirements*

ISO 13855:2002, *Safety of machinery – Positioning of protective equipment with respect to the approach speeds of parts of the human body*

3 Terms and definitions

Replacement:

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

NOTE Detection capability is generally measured by the size of object that can be detected. An increase in detection capability means that a smaller object can be detected.

Additions:

3.401
image
array of pixels

3.402
imaging sensor
optoelectronic device which produces electrical signals representing the characteristics of an image

3.403
passive pattern
static (i.e. fixed location and not changing) regular pattern on a flat background that covers at least the detection zone and the tolerance zone – obscuration of part of the pattern causes detection

NOTE Regularity of the pattern refers only to the physical pattern and not to the image of the pattern as seen by the imaging sensor.

3.404
pattern element
unique part of the passive pattern which is defined on the basis of the actual pattern (example used in this technical report: black and white checker board – one black square or one white square)

3.405
physical pixel
for a sensor, smallest element of an imaging sensor array

3.406
pixel
area of the smallest element of a picture that can be distinguished from its neighbouring elements

3.407
sensing zone
three-dimensional volume (for example in the shape of a pyramid or cone) defined by the field of view of the image sensor and with the apex at the optical window of the sensor device. A zone of limited detection capability and a detection zone are contained within the sensing zone. The zone of limited detection capability is located between the optical window of the sensor device and the detection zone

3.408
test piece
object used to verify the detection capability of the vision based protective device (VBPD)

3.409
tolerance zone
zone outside the detection zone which is necessary to achieve the required probability of detection of the specified test piece within the detection zone

3.410
vision-based protective device (VBPD)
ESPE using an imaging sensor operating in the visible and near infrared light spectrum to detect an object in a defined field of view

NOTE For this technical report, the VBPD consists of an image-sensing device viewing a two-dimensional image against a passive pattern as the background.

3.411
zone with limited detection capability
zone within the sensing zone in which the detection capability is lower than that stated by the supplier. Its dimensions and appropriate information for use are provided by the supplier.

NOTE Limitations can be size, colour, etc.

4 Functional, design and environmental requirements

This clause of Part 1 is applicable except as follows:

4.1 Functional requirements

Replacement:

4.1.2 Sensing function

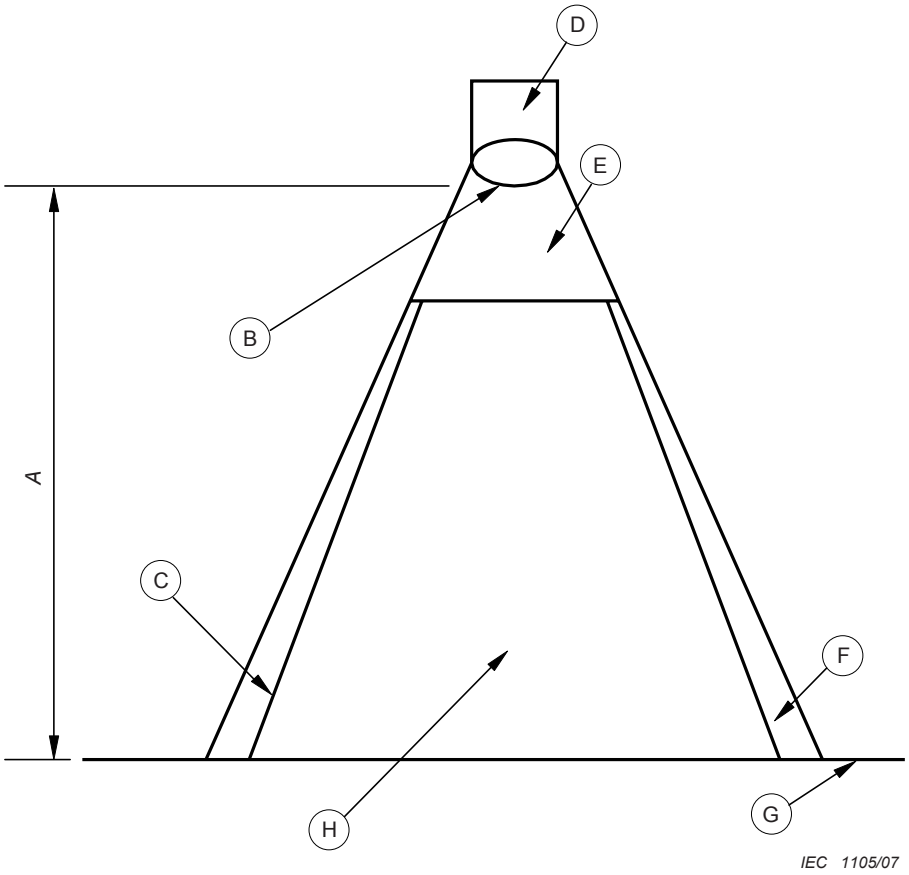
The detection zone should begin at the border of the zone of limited detection capability and end at the passive pattern (see Figure 1).

NOTE It is possible that only parts of the passive pattern are used to define the detection zone.

An object(s) in the zone of limited detection capability should not lead to a failure to danger.

To assure the integrity of the detection capability, the relationship of the minimum detectable object size and the size of the elements of the background pattern should be greater than, or equal to, three (i.e. object size is three or more times the size of the pattern element).

NOTE The restriction for the relationship of the object size to the pattern element size is a result of difficulties in defining a test procedure which adequately verifies integrity of detection capability (see Figure 2).



A – Operating distance
B – Optical window
C – Tolerance Zone
D – Imaging sensor device
E – Zone with limited detection capability
F – Tolerance Zone
G – Background (passive pattern)
H – Detection zone

Figure 1 – Side view of VBPD using a passive pattern

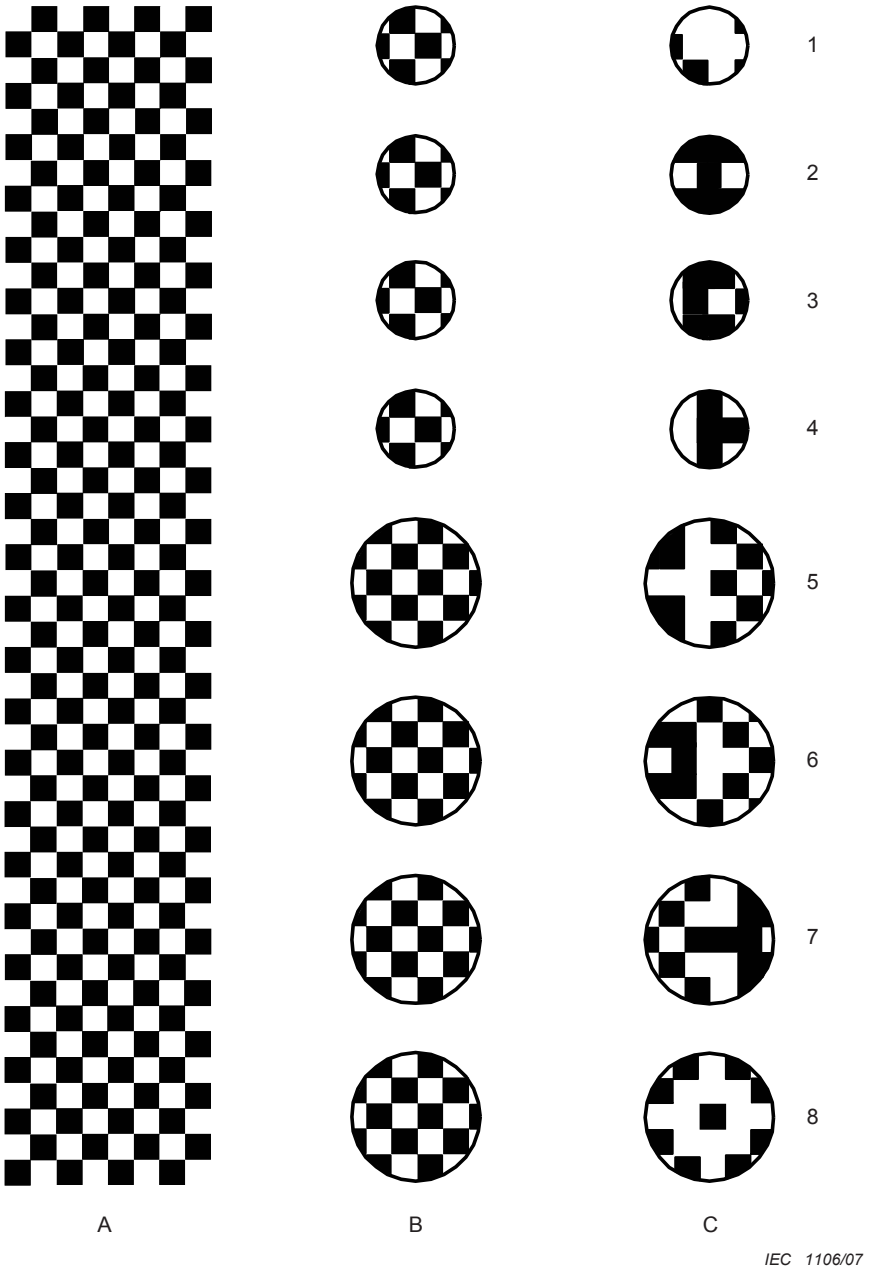


Figure 2 – Examples of circular disc test pieces according to 4.2.13.3

NOTE Figure 2 shows the following:

A example of a passive pattern with 8 x 46 pattern elements;

B sections of the passive pattern with the dimension of a circular test piece. B1 to B4 correspond to the requirement of 4.1.2 that the relationship of the minimum detectable object size and the size of the elements of the background pattern should be greater than, or equal to, three.

C examples of circular disc test pieces with non-regular patterns. The examples follow the recommendation of 4.2.13.3 that such a non-regular pattern should have a difference of approximately 25 % of the pattern elements. In C1 to C4 the area of change is approximately two pattern elements and in C5 to C8 approximately five pattern elements.

4.1.2.1 General

The sensing function should be effective over the specified detection zone. No adjustment of the detection zone or detection capability should be possible without the use of a security measure (for example key, key-word or tool).

The sensing device of a VBPD should respond by giving (an) appropriate output signal(s) when a test piece is placed anywhere within the detection zone either static or moving, at any speed between 0 m/s and 1,6 m/s.

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

Objects which mimic the passive pattern or are similar in appearance to the passive pattern that are present in the detection zone should be detected and the VBPD should respond by giving an appropriate output signal(s).

4.1.2.2 Optical performance

The VBPD should be designed and constructed to

a) limit the possibility of malfunction during exposure to extraneous radiation in the range of 400 nm to 1 500 nm;
b) limit the effects of environmental influences (temperature, vibration and bumps, dust, moisture, ambient light, extraneous reflections, changing illumination, shadows, background reflectivity);
c) limit the misalignment at which normal operation is possible.

Addition:

4.1.4 Zone with limited detection capability

A zone between the optical window and the beginning of the detection zone is referred to as a zone with limited detection capability. In order to ensure no hazard can arise in a particular application due to the presence of this zone between the optical window and the detection zone, its dimensions and appropriate information for use should be provided by the supplier.

4.2 Design requirements

Additional design requirement:

4.2.12 Integrity of the VBPD detection capability

The design of the VBPD should ensure that the detection capability is not degraded below the limits specified by the supplier and in this technical report when the VBPD is operated under any and all combinations of the following:

– any condition within the specification of the supplier;
– environmental conditions specified in 4.3 (IEC 61496-1 and IEC 61496-4);
– at the limits of alignment and/or adjustment.

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

4.2.13 Test pieces for type testing

4.2.13.1 General

The test pieces are part of the VBPD and should therefore be provided by the supplier for use in the type tests of Clause 5. They should be marked with a type reference and identification of the VBPD with which they are intended to be used.

The diameters of the test pieces should not exceed 200 mm to assure suitability for whole body detection. The test pieces should be opaque.

Different test pieces can be required for different phases of the test procedures.

Characteristics of the test piece which should be considered are:

– size;
– shape;
– colour;
– reflectivity;
– contrast with background;
– texture.

When defining the characteristics of the test piece, protection against camouflage with the background should be taken into account.

4.2.13.2 Spherical test piece

The test piece should be a sphere with a diameter equal to the specified detection capability. The colour of the test piece should be selected to create a worst-case condition for the background pattern discriminators. Where other surface characteristics are shown to be critical as result of the analysis of the design, these characteristics should be applied to the spherical test piece. Test pieces of different colours may be necessary.

4.2.13.3 Circular disc test piece

The test piece should be a circular disc with a diameter equal to the specified detection capability and a thickness of approximately 5 % of the diameter (thickness is not critical). The test piece should have a non-regular pattern with the same pattern elements, colours and reflectivity as the background pattern. The details of the non-regular pattern selected depends on an analysis of the design of the VBPD (for example the algorithms for detecting objects and compensating for contamination or ageing of the background pattern, relationship between size of pattern elements, detection capability and pixel resolution).

NOTE A non-regular pattern should have a difference of approximately 25 % of the elements (examples of test piece patterns are given in Figure 2).

4.2.13.4 Cylindrical test piece

If the VBPD is intended for use only as a trip device, the test piece should be a cylindrical object with a diameter equal to the detection capability and a length of 150 mm. The cylindrical test piece should have the same surface characteristics as the spherical test piece.

4.2.14 Wavelength

VBPDs should operate at a wavelength within the range 400 nm to 1 500 nm.

4.2.15 Radiation intensity

Where the VBPD is of the type that generates laser light the radiation intensity emitted by the VBPD should at no time exceed the maximum power or energy levels for a class 1M device in accordance with 8.2 of IEC 60825-1.

NOTE The use of class 2M devices is under consideration.

4.3 Environmental requirements

4.3.1 Ambient air temperature range and humidity

Addition:

The ESPE should not fail to danger when subjected to a rapid change of temperature and humidity leading to condensation on the optical window.

This requirement is verified by the condensing test of 5.4.2.

4.3.3 Mechanical requirements

Addition:

NOTE VBPD may have limitations of vibration and bump which are lower than those of IEC 61496-1. In particular, relative movement between the sensor and passive pattern can cause unreliable operation.

4.3.5 Light interference

The VBPD should continue in normal operation when the passive pattern is illuminated by

– incandescent light;
– flashing beacons;
– fluorescent lights operated with high-frequency electronic and line power supply.

The VBPD should continue in normal operation when shadows of objects (in accordance with 5.4.6.4) outside of the detection zone appear on the passive pattern.

The VBPD should not fail to danger when subjected to

– high-intensity incandescent light (simulated daylight using a quartz lamp);
– stroboscopic light;
– high-intensity fluorescent lights operated with high-frequency electronic and line power supply;
– manufacturer's required illumination fading to zero lux.

The VBPD should not fail to danger when shadows of objects (in accordance with 5.4.6.5) appear on the passive pattern.

No requirements are given for immunity to other extraneous light sources which may cause abnormal operation or failure to danger.

Based on the technologies and algorithms used as well as the analysis of 5.2.9.1, additional tests may be necessary.

4.3.6 Pollution interference

4.3.6.1 Effects on optical window

Pollution on the window should not lead to a failure to danger.

4.3.6.2 Effects on passive pattern

Changes in the passive pattern (for example ageing or damage caused by environmental effects) should not lead to a failure to danger.

4.3.6.3 Effects in the detection zone

Pollution within the detection zone should not lead to a failure to danger.

4.3.7 Changes of passive pattern

Changes of the passive pattern caused by, for example fading, ageing, mechanical effects or contamination should not lead to a failure to danger.

4.3.8 Manual interference

The following conditions should not lead to a failure to danger:

– covering the optical window of the housing of the VBPD or other parts (if applicable);
– placing objects within the zone of limited detection capability;
– moving the passive pattern (except if the pattern is required to be permanently fixed) in any direction.

In such cases, the VBPD should respond by giving (an) appropriate output signal(s) until the manual interference is removed.

NOTE Depending on the interlock conditions an automatic restart may be acceptable.

4.3.9 Optical occlusion (eclipsed by small object) in the detection zone

The VBPD detection capability should be maintained or the VBPD should not fail to danger when objects or parts of the machine which are smaller than the detection capability are present in the detection zone which can block the view of the object which should be detected. This is a particular concern when the system is able to detect the presence of small objects which should be disregarded.

Information should be given in accordance with Clause 7 that the installer should verify that the view of the passive pattern is not blocked by parts of the machine or other objects.

NOTE Software filtering algorithms may be provided to disregard small objects, for example to increase the reliability of operation.

5 Testing

This clause of Part 1 is applicable except as follows:

5.1 General

Addition:

In the following tests, it should be verified that when the OSSD(s) go to the OFF-state, they remain in the OFF-state while the test piece is present in the detection zone or for at least 80 ms, whichever is greater.

5.1.2.1 Test environment

Addition:

– ambient lighting condition: 200 lux to 750 lux.

5.1.2.2 Measurement accuracy

Addition to first paragraph:

– for light intensity measurement: ±10 %

5.2 Functional tests

5.2.1 Sensing function

Addition:

5.2.1.1 General

The sensing function and the integrity of the detection capability should be tested as specified, taking into account the following:

– all tests should be performed with the test piece close to the background and close to the zone of limited detection. Tests at other locations may be required depending on analysis of the design and worst-case considerations;

– the tests should verify that the specified test pieces are detected when the test piece is placed entirely inside the stated detection zone(s);

– the tests should verify that the specified test pieces are continuously detected when the test piece is moving into or within the detection zone at any speed from 0 m/s to 1,6 m/s or up to 2 m/s if the stated detection capability is less than 30 mm. Where the supplier states that objects can be detected moving at higher speeds, the requirements should be met at all speeds up to the stated maximum speeds;

– the number, selection and conditions of the individual tests should be such as to verify the requirements of 4.2.12.

It should be verified that the sensing device is continuously actuated and, where appropriate, that the OSSD(s) go to the OFF-state as described below, taking into account the operating principle of the VBPD and, in particular, the techniques used to provide tolerance to environmental interference.

Table 1 – Verification of detection capability requirements (see also 4.2.12)

Test		Conditions	Distance between the VBPD image sensor window and the passive pattern and the location of the test piece in the detection zone[a)]			
			Maximum operating distance from sensor to passive pattern as stated by the supplier (see Figure 2)		Minimum operating distance from sensor to passive pattern as stated by the supplier (see Figure 2)	
			Test piece as close to the sensor as possible but inside the detection zone	Test piece on passive pattern	Test piece as close to the sensor as possible but inside the detection zone	Test piece on passive pattern
A	Spherical test piece	Test piece stationary (see 4.2.13.2) (orientation is not critical)	X	X	X	
B[1]	Spherical test piece	Test piece moving at 1,6 m/s (see 4.2.13.2) (orientation is not critical)	X	X	X	
C	Circular test piece	Test piece (see 4.2.13.3) (to confuse with passive pattern (see Figure 2))		X		X
D	Cylindrical test piece (for trip device only)	Test piece is moving into the detection zone with the axis parallel to the background plane (see 4.2.13.4)	X	X	X	X
E	Ageing of components	b)	X	X	X	X
F	Undetected faults of components	b)				X
G	Electrical disturbances	Subclauses 4.3.2, 5.2.3.1 and 5.4.3 of IEC 61496-1 apply. Use the circular disc test piece				X Or 1 m if the minimum operating distance is less than 1 m
H	Pollution on the surface of the optical window (4.3.6.1)	Use the circular disc test piece. The tests should include the entire surface area of the passive pattern.				X Or 1 m if the minimum operating distance is less than 1 m

Table 1 *(continued)*

Test		Conditions	Distance between the VBPD image sensor window and the passive pattern and the location of the test piece in the detection zone[a)]			
			Maximum operating distance from sensor to passive pattern as stated by the supplier (see Figure 2)		Minimum operating distance from sensor to passive pattern as stated by the supplier (see Figure 2)	
			Test piece as close to the sensor as possible but inside the detection zone	Test piece on passive pattern	Test piece as close to the sensor as possible but inside the detection zone	Test piece on passive pattern
L	Pollution within the detection zone (4.3.6.2)	Use the circular disc test piece. The tests should include the entire surface area of the passive pattern				X Or 1 m if the minimum operating distance is less than 1 m
M	Pollution on the passive pattern (4.3.6.3)	Use the circular disc test piece. The tests should include the entire surface area of the passive pattern (the pollution should be between the pattern and the test piece)				X Or 1 m if the minimum operating distance is less than 1 m
N	Ambient temperature variation	50 °C or maximum[c)]				X Or 1 m if the minimum operating distance is less than 1 m
O	Ambient temperature variation	0° or minimum, non-condensing[d)]				
P	Humidity	Subclause 5.4.2 applies. The circular disc should be used				X Or 1 m if the minimum operating distance is less than 1 m
Q	Normal operation (see 5.4.6.4)	Interference from incandescent light source, flashing beacon, fluorescent light sources, single incandescent light source with shadow	x	x	x	x

Table 1 *(continued)*

Test		Conditions	Distance between the VBPD image sensor window and the passive pattern and the location of the test piece in the detection zone[a)]			
			Maximum operating distance from sensor to passive pattern as stated by the supplier (see Figure 2)		Minimum operating distance from sensor to passive pattern as stated by the supplier (see Figure 2)	
			Test piece as close to the sensor as possible but inside the detection zone	Test piece on passive pattern	Test piece as close to the sensor as possible but inside the detection zone	Test piece on passive pattern
R	Failure to danger (5.4.6.5)	Interference from incandescent light source, stroboscopic light source, fluorescent light sources, single incandescent light source with shadow	x	x	x	x
S	Failure to danger (5.4.6.6)	Interference from incandescent light source, stroboscopic light source, fluorescent light sources	x	x	x	x
T	Failure to danger (5.4.6.7)	Fading ambient light	x	x	x	x
U	Vibration and bump	Subclause 5.4.4 applies				X

[a)] Determining the location of the test piece within the detection zone may require analysis of the system to ensure that a worst case test is performed (e.g. when the sensor axis is not perpendicular to the background pattern).

[b)] Specific tests may be required depending on an analysis of the design.

[c)] VBPD in test chamber – open test chamber – start test within 1 min.

[d)] VBPD in test chamber – open test chamber – test without condensation

5.2.1.2 Integrity of the VBPD detection capability

It should be verified that the VBPD detection capability is continuously maintained or the ESPE does not fail to danger by systematic analysis of the design of the VBPD, using testing where appropriate, taking into account all combinations of the conditions specified in Table 1 and the faults specified in 5.3.

Additional functional tests:

5.2.9 Verification of optical performance

A systematic analysis of the electro-optical subsystem should be carried out to determine

a) confirmation of any filtering techniques (especially software filtering algorithms) employed, and their characteristics;

b) the decision criteria used to determine whether or not the defined test piece(s) is detected as being inside the detection zone;

c) the effect of undetected faults, in accordance with 4.2.2, on the electro-optical characteristics;

d) worst-case response time;

e) the effect of environmental influence.

The results of this analysis should be used to determine if the requirements of 4.1.2 can be met.

5.2.10 Wavelength

The wavelength used in the VBPD should be verified either by inspection of the device data sheets or by measurement.

5.2.11 Radiation intensity

Where the VBPD is of the type that generates laser light the radiation intensity should be verified by measurement in accordance with IEC 60825-1 and inspection of the technical documentation provided by the supplier.

5.4 Environmental tests

Additions:

5.4.2 Ambient temperature variation and humidity

The ESPE should be subjected to the following condensing test:

– the ESPE should be supplied with its rated voltage and stored in a test chamber at an ambient temperature of 5 ºC for 1 h;

– the ambient temperature and the humidity should be changed within a time period of up to 2 min to a temperature of (25 ± 5) ºC and a relative humidity of (70 ± 5) %;

– a C-test should be performed with a duration of 10 min using the circular disc test piece (see 4.2.13.3);

– if a restart interlock is available it should not be operational during the C-test.

5.4.4 Mechanical influences

5.4.4.1 Vibration

Addition:

NOTE If the imaging sensor of the VBPD is not intended to be mounted on a machine (i.e. not intended to be subjected to high vibration), the levels of amplitude and frequency may be reduced for the A test depending on the intended application. In this case, a C test may be carried out instead of the B test.

At the end of the tests, the VBPD should be inspected for the absence of damage including displacement of optical components and mounting brackets. It should be verified by test that the detection zone has not changed in orientation, size or position.

5.4.4.2 Bump

Addition:

NOTE If the video sensor is not intended to be mounted on a machine (i.e. not intended to be subjected to severe bumps), the test conditions may be reduced for the A test depending on the intended application. In this case, a C test may be carried out instead of the B test.

At the end of the tests, the VBPD should be inspected for the absence of damage including displacement of optical components and mounting brackets. It should be verified by test that the detection zone has not changed in orientation, size or position.

Additional environmental tests:

5.4.6 Light interference

5.4.6.1 General

Each test should be carried out at the minimum and maximum operating distance as specified by the supplier, and under the stated conditions as a minimum requirement. Additional tests shall be carried out under different combinations of operating distances and environmental conditions when

– the supplier states higher immunity levels, which should be verified by testing at those levels with appropriate light sources, and/or

– an analysis shows such tests to be necessary.

Where ambient light is required in the test setup, this ambient light should be delivered by using the incandescent light source or using natural illumination.

NOTE In the following test procedures, unless otherwise stated, the light intensity limits include the combination of ambient light and light contributed by the indicated light source.

5.4.6.2 Light sources

The light sources (for background pattern effects) should be as follows.

a) Incandescent light source: a tungsten halogen (quartz) lamp having characteristics within the following limits:
   - colour temperature: 3 000 K to 3 200 K;
   - input power: 500 W to 1 kW rated power;
   - rated voltage: any value within the range 100 V... 250 V;
   - supply voltage: rated voltage ± 5 %, sinusoidal a.c. (50/60Hz);
   - length: 150 mm to 250 mm nominal.

b) Line-frequency fluorescent light source: a linear fluorescent tube having characteristics within the following limits (operating without a reflector or diffuser):
   - size: T8 × 600 mm (25 mm nominal diameter);
   - rated power: 18 W to 20 W;
   - colour temperature: 5 000 K to 6 000 K;
   - operated at its rated supply voltage: ±5% sinussoidal a.c. (50/60Hz).

c) High-frequency fluorescent light source: a linear fluorescent tube having characteristics within the following limits (operating without a reflector or diffuser):
   - size: T8 x 600 mm (25 mm nominal diameter);
   - rated power: 18 W to 20 W;
   - colour temperature: 5 000 K to 6 000 K;
   - operated at its rated supply voltage ± 5 %, sinussoidal a.c. (50/60Hz) in combination with an electronic ballast having an operating frequency within the range of 30 kHz to 40 kHz.

d) Flashing-beacon light source: a flashing beacon employing a xenon flash tube (without enclosure, reflector or filter) having characteristics within the following limits:
   - flash duration: from 40 µs to 120 µs (measured to the half-intensity point);
   - flash frequency: 0,5 Hz to 2 Hz;

– input energy per flash: 3 joules to 5 joules.

e) Stroboscopic light source: a stroboscope employing a xenon flash tube (without enclosure, reflector or filter) having characteristics within the following limits:

– flash duration: from 5 µs to 30 µs (measured to the half-intensity point);
– flash frequency: 5 Hz to 200 Hz (adjustable range);
– input energy per flash: 0,05 joules (at 200Hz) to 0,5 joules (at 5 Hz).

5.4.6.3 Test sequences

NOTE The A, B, and C tests below are defined in IEC 61496 -1, 5.2.3.

Test sequence 1:

1 – ESPE in normal operation
2 – Switch on interfering light
3 – B-test
4 – Switch off ESPE for 5 s. Restore power. Reset start interlock, if fitted
5 – B-test
6 – Switch off interfering light
7 – B-test

Test sequence 2:

1 – ESPE in normal operation
2 – Switch on interfering light
3 – C-tests repetitively for 1 min
4 – Switch off ESPE for 5 s. Restore power. Reset start interlock, if fitted
5 – C-tests repetitively for 1 min
6 – Switch off interfering light
7 – C-tests repetitively for 1 min

Test sequence 3:

1 – ESPE in normal operation
2 – Switch on the interfering light
3 – C-tests repetitively for 3 min

5.4.6.4 Normal operation

The ESPE should continue in normal operation throughout test sequence 1 in 5.4.6.3 using each of the following types of interfering light, positioned outside the sensing zone. Tests should be carried out with the maximum detection zone at the distances shown in Table 1. Lux measurements should be at the centre of the detection zone.

– The incandescent light source of 5.4.6.2 producing a uniform light intensity increase of 250 lux over ambient light of 500 lux reflected from the background surface (see Figure 3 showing white background and lux meter (held 1 m above the background surface) measuring reflected light).
– The flashing-beacon light source of 5.4.6.2 should be placed at the outer limit of the sensing zone but at least at a distance of 3 m from the optical axis of the sensor and 2 m in height from the floor of the sensing zone.
– The fluorescent light sources of 5.4.6.2 producing a uniform light intensity increase of 250 lux over ambient light of 500 lux reflected from the background surface (see Figure 3 showing white background and lux meter (held 1 m above background surface) measuring reflected light).

– Single incandescent light source of 5.4.6.2 with a round object held in front of the light source and outside the sensing zone producing a shadow on the passive pattern. The size of the shadow should be larger than the detection capability but less than 50 % of the area of the passive pattern and the contrast relative to the lightest part of the passive pattern should be a ratio of approximately 5 to 1.

The tests are carried out without the white background.

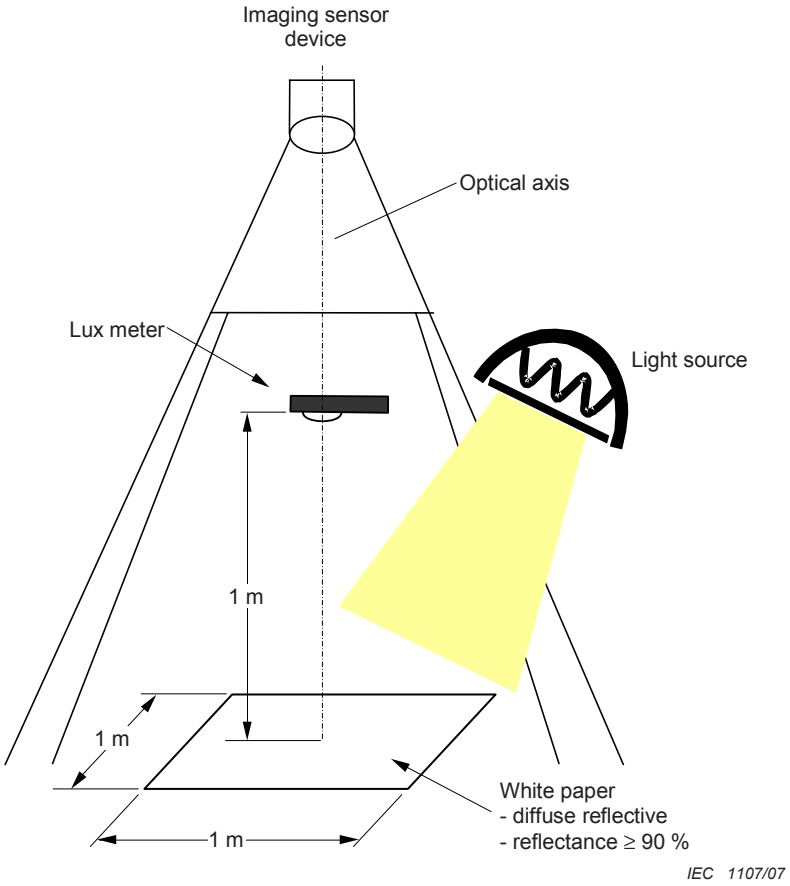


Figure 3 – Lux measurement setup at indirect light tests

5.4.6.5 Failure to danger caused by indirect light (pattern)

The ESPE should not fail to danger throughout test sequence 2 in 5.4.6.3 using each of the following types of interfering light, positioned outside the sensing zone. Tests should be carried out with the maximum detection zone for respective operating distance shown in Table 1. Lux measurements should be at the centre of the detection zone.

– The incandescent light source of 5.4.6.2 producing a uniform light intensity increase of 1000 lux over an ambient light of 500 lux reflected from the background surface (see Figure 3 showing white background and lux meter (held 1 m above the background surface) measuring reflected light).

– The stroboscopic light source of 5.4.6.2 should be placed at the outer limit of the sensing zone but at least at a distance of 3 m from the optical axis of the sensor and 2 m in height from the floor of the sensing zone.

– The fluorescent light sources of 5.4.6.2 producing a uniform light intensity increase of 500 lux over an ambient light of 500 lux reflected from the background surface (see Figure 3

showing white background and lux meter (held 1 m above the background surface) measuring reflected light).

– The single incandescent light source of 5.4.6.2 with a round object held in front of the light source and outside the sensing zone producing a shadow on the passive pattern. The size of the shadow should be larger than the detection capability but less than 50 % of the area of the passive pattern and the contrast relative to the lightest part of the passive pattern should be a ratio of 10 to 1.

The tests are carried out without the white background.

5.4.6.6 Failure to danger caused by direct light interference (sensor)

The ESPE should not fail to danger throughout test sequence 2 in 5.4.6.3 using each of the following types of interfering light, positioned outside the detection zone at its border line. If the detection zone can be configured, it should be limited that the light source is outside the detection zone but inside the sensing zone. Tests should be carried out for respective operating distance shown in Table 1. Lux measurements should be made near the image sensor.

– The incandescent light source of 5.4.6.2 producing a uniform light intensity of 3 000 lux.

– The stroboscopic light source of 5.4.6.2 should be placed at the outer limit of the sensing zone but at least at a distance of 3 m from the optical axis of the sensor and 2 m in height from the floor of the sensing zone.

– The fluorescent light sources of 5.4.6.2 producing an intensity of 1 000 lux.

5.4.6.7 Failure to danger caused by fading illumination

With the VBPD in normal operation, the intensity of ambient light is decreased stepwise over a range of intensities determined by the analysis of 5.2.9.1. A C test should be carried out at each step of intensity level.

5.4.7 Pollution interference

A systematic analysis of the design of the VBPD should be carried out to decide which tests and test methods are appropriate to satisfy the requirements of 4.3.6. These tests should be carried out to test for no failure to danger.

5.4.8 Changes of passive pattern

A systematic analysis of the design of the VBPD should be carried out to decide which tests and test methods are appropriate to satisfy the requirements of 4.3.7. These tests should be carried out to test for no failure to danger.

5.4.9 Manual interference

A systematic analysis of the design of the VBPD should be carried out to decide which tests and test methods are appropriate to satisfy the requirements of 4.3.8. These tests should be carried out to test for no failure to danger.

5.4.10 Optical occlusion in the detection zone

A systematic analysis of the design of the VBPD should be carried out to decide which tests and test methods are appropriate to satisfy the requirements of 4.3.9. These tests should be carried out to test for no failure to danger.

6 Marking for identification and safe use

This clause of Part 1 is applicable except as follows:

6.1 General

Addition:

aa) indication of the zone of detection;

The markings required by 6.1 b), c) and d) and j) of IEC 61496-1 may alternatively be given in the accompanying documents.

7 Accompanying documents

This clause of Part 1 is applicable except as follows:

Additions:

aaaa) the installer should verify that the view of the passive pattern is not blocked by parts of the machine or other objects;

bbbb) instruction that the detection capability dimension should be added to the safe distance calculations of ISO 13855. This is because response time specifications assume that the object can be entirely within the detection zone before it is detected;

cccc) the manufacturer should inform the user of potential problems not covered by the requirements of this technical report.

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