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**Safety of machinery—
Electro-sensitive protective
equipment—Part 2 : Particular
requirements for equipment using
active opto-electronic protective
devices (AOPDs)**

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Contents

	Page
Introduction.....	1
1 Scope.....	1
2 Normative references	2
3 Terms and definitions	3
4 Functional, design and environmental requirements	4
4.1 Functional requirements	4
4.2 Design requirements	9
4.3 Environmental requirements.....	10
5 Testing	10
5.1 General.....	10
5.2 Functional tests	11
5.4 Environmental tests.....	18
6 Marking for identification and safe use.....	26
6.1 General.....	26
7 Accompanying documents	26
Annex A (normative) Optional functions of the ESPE	28
Annex B (normative) Catalogue of single faults affecting the electrical equip- ment of the ESPE, to be applied as specified in 5.3.....	29
Annex D (normative) Verifying effective aperture angle (EAA) using the prism method.....	30
Annex E (normative) Verifying optical performance using the mirror method and misalignment test	34
Annex F (informative) AOPD detection capability based on complete obscu- ration	38
Annex JA (informative) List of the clauses of Part 1 and Part 2 applicable to the equipment using AOPDs	39

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Health, Labour and Welfare and Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Machinery Federation (JMF) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently **JIS B 9704-2:2000** is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Ministers and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS B 9704 consists of the following parts under the general title “*Safety of machinery—Electro-sensitive protective equipment*”;

Part 1: General requirements and tests

Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)

Part 3: Particular requirements for Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR)

Safety of machinery—Electro-sensitive protective equipment— Part 2 : Particular requirements for equipment using active opto-electronic protective devices (AOPDs)

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **IEC 61496-2** published in 2006 without modifying the technical contents.

The portions given dotted underlines and Annex JA are the matters not stated in the original International Standard.

Electro-sensitive protective equipment (hereafter referred to as “ESPE”) is applied to machinery that presents a risk of personal injury. It provides protection by causing the machine to revert to a safe condition before a person can be placed in a hazardous situation. General requirements and tests for ESPE are specified in **JIS B 9704-1** (hereafter referred to as “Part 1”).

ESPE is classified into several types based on various detection principles. This Standard provides particular requirements for the design, construction and testing of ESPE for the safeguarding of machinery, employing active opto-electronic protective devices (hereafter referred to as “AOPDs”) for the sensing function.

This Standard is to be used in conjunction with Part 1. This Standard supplements or modifies the corresponding clauses in Part 1. Where a particular clause or subclause of Part 1 is not mentioned in this Standard, that clause or subclause applies as far as is reasonable. Where this part states “addition” or “replacement”, the relevant text of Part 1 is to be adapted accordingly. All the clauses of **JIS B 9704** Part 1 and Part 2 applicable to the equipment using AOPDs are listed in Annex JA.

This Standard specifies type 2 and type 4 ESPE employing AOPDs but not type 1 and type 3 ESPE.

Each type of machine presents its own particular hazards, and it is not the purpose of this Standard to recommend the manner of application of the ESPE to any particular machine. The application of the ESPE should be a matter for agreement between the equipment supplier, the machine user and the enforcing authority; in this context, attention is drawn to the relevant guidance established, for example, **JIS B 9700-1** or **JIS B 9700-2**.

1 Scope

(Replacement. This clause of Part 1 is replaced by the following:)

This Standard specifies requirements for the design, construction and testing of ESPE designed specifically to detect persons as part of a safety-related system, employing AOPDs 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.

This Standard does not specify the dimensions or configurations of the detection zone and its disposition in relation to hazardous parts for any particular application, nor what constitutes a hazardous state of any machine. It is restricted to the functioning of the ESPE and how it interfaces with the machine.

Excluded from this Standard are AOPDs employing radiation at wavelengths outside the range 400 nm to 1 500 nm.

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

NOTE : The International Standard corresponding to this Standard is as follows.

IEC 61496-2 : 2006 *Safety of machinery—Electro-sensitive protective equipment—Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)* (IDT)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

2 Normative references

(Addition:)

JIS B 9715 : 2006 *Safety of machinery—Positioning of protective equipment with respect to the approach speeds of parts of the human body*

NOTE : Corresponding International Standards: ISO 13855 : 2002 *Safety of machinery—Positioning of protective equipment with respect to the approach speeds of parts of the human body* (IDT)

JIS C 6802 *Safety of laser products*

NOTE : Corresponding International Standards: IEC 60825-1 *Safety of laser products—Part 1: Equipment classification and requirements* and user's guide (IDT)

TS B 62046 : 2006 *Safety of machinery—Application of protective equipment to detect the presence of persons*

NOTE : Corresponding International Standards: IEC/TS 62046 : 2004 *Safety of machinery—Application of protective equipment to detect the presence of persons* (IDT)

EN 471 : 2003 *High-visibility warning clothing for professional use—Test methods and requirements*

3 Terms and definitions

(Addition:)

3.201 active opto-electronic protective device (AOPD)

device whose sensing function is performed by opto-electronic emitting and receiving elements detecting the interruption of optical radiations generated, within the device, by an opaque object present in the specified detection zone (or for a light beam device, on the axis of the light beam)

NOTE : "Active" means that the device itself discharges the energy for detection (irradiation light).

3.202 beam centre-line

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

NOTE 1 The optical axis of a light beam is not always on the beam centre-line.

NOTE 2 Physical displacement of the beam centre-line may occur as a consequence of normal operation (for example, by the use of a motor-driven mirror).

NOTE 3 For an AOPD that operates on a retro-reflective technique, the optical path is defined by the retro-reflector target together with the emitting and receiving elements.

3.203 effective aperture angle (EAA)

maximum angle of deviation from the optical alignment of the emitting element(s) and the receiving element(s) within which the AOPD continues in normal operation

3.204 light beam device

single light beam device or a multiple light beam device

- **single light beam device:** AOPD comprising one emitting element and one receiving element, where a detection zone is not specified by the supplier;
- **multiple light beam device:** AOPD comprising multiple emitting elements and corresponding receiving elements, and where a detection zone is not specified by the supplier

3.205 light curtain

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

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

3.206 test piece

opaque cylindrical element used to verify the detection capability of the AOPD

3.207 monitored blanking

configuration of the detection capability and/or detection zone in such a way that the presence of an object(s) within a defined part of the detection zone will not cause an OFF-state of the output signal switching device(s) [hereafter referred to as “OSSD(s)”] but the absence (or, in some cases, a change in size or location) of the object will cause the OSSD(s) to go to the OFF-state

3.3 detection capability

(Replacement:)

dimension representing the diameter of the test piece which:

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

NOTE 1 Can also be used to mean the ability to detect a test piece of the specified diameter.

NOTE 2 “A large detection capability” means that the size of detectable element is large and not that the detection capability is superior.

In this Standard, detection probability is not considered. The test piece which has diameter corresponding to the detection capability should be 100 % detected.

4 Functional, design and environmental requirements

(This clause of Part 1 is applicable except as follows:)

4.1 Functional requirements

4.1.2 Sensing function

(Replacement:)

4.1.2.1 General

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

The sensing device of a light curtain shall be actuated and the OSSD(s) shall go to the OFF-state when a test piece in accordance with **4.2.13** is placed anywhere within the detection zone either static (at any angle) or moving (with the axis of the cylinder normal to the plane of the detection zone), at any speed between 0 m/s and 1.6 m/s.

The sensing device of a light beam device shall be actuated and the OSSD(s) shall go to the OFF-state when a test piece in accordance with **4.2.13** is present in the beam centre-line, at any point throughout the operating distance¹⁾, with the axis of the cylinder normal to the axis of the beam.

Note ¹⁾ “An operating distance” means the distance between the emitter assembly and the receiver assembly. The minimum (maximum) operating distance means the minimum (maximum) distance within which AOPD is normally operable. The range of operating distance means the range between the minimum operating distance and the maximum operating distance within which AOPD is normally operable.

When the OSSD(s) go to the OFF-state, they shall remain in the OFF-state while the test piece is present in the detection zone (or light beam) or for at least 80 ms, whichever is greater.

NOTE : The purpose of this requirement is to ensure that the OSSD(s) go to the OFF-state when a person or part of a person passes through the detection zone or light beam. Based on a dimension of 150 mm and a walking speed of 1.6 m/s, a minimum OFF time of 80 ms was determined to be adequate.

Where the supplier states that an AOPD can be used to detect objects moving at speeds greater than 1.6 m/s, the above requirements shall be met at any speed up to and including the stated maximum speed(s).

4.1.2.2 Optical performance

The AOPD shall be designed and constructed to:

- a) limit the possibility of failure to danger resulting from extraneous reflections [for example, for operating range up to 3 m, see figure 1 ²⁾];

Note ²⁾ This means that the failure to danger resulting from a reflective surface existing in the outside of limit area is prevented by diminishing any reflective surfaces in the limit area shown in figure 1.

- b) limit the misalignment at which normal operation is possible;
- c) limit the possibility of malfunction during exposure to extraneous light in the range of 400 nm to 1 500 nm;
- d) control the size of the emitted beam to minimize the effects on other equipment (AOPD).

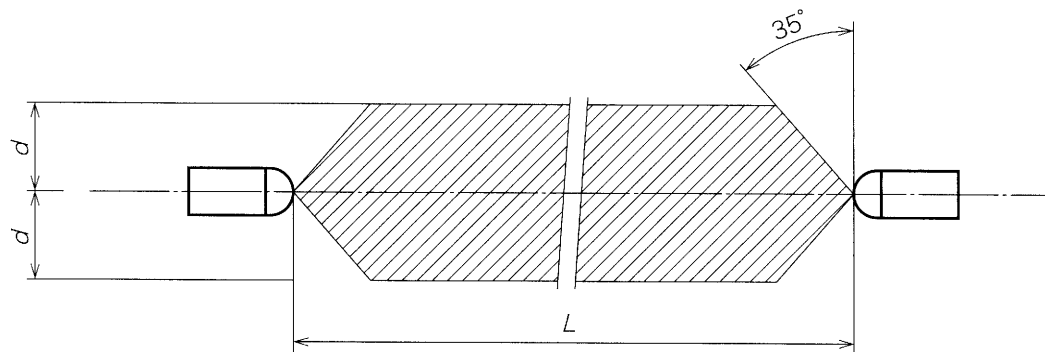
One method of achieving these requirements is by ensuring that the effective aperture angle of each emitting and each receiving element does not exceed the values given in figure 2. When this method is used, the requirements are met with the AOPD conforms to the tests in **5.2.9.2** and Annex D.

There are other technical means alternative to the restriction of the EAA to achieve equivalent performance for the characteristics in items **a)**, **b)**, **c)** and **d)** above. In such cases, the requirements are met when the AOPD conforms to the tests in **5.2.9.2** and Annex E.

Acceptable optical performance shall be verified by passing the appropriate tests of **5.2.9** and **5.4**.

If the AOPD is intended to provide protection when mounted very close to a reflective surface (i.e. inside the shaded area of figure 1), the AOPD shall be designed in such a manner that no optical bypassing can occur on the reflective surfaces. For such a device, an EAA much less than 2.5° (for example, less than 0.1°) can be necessary.

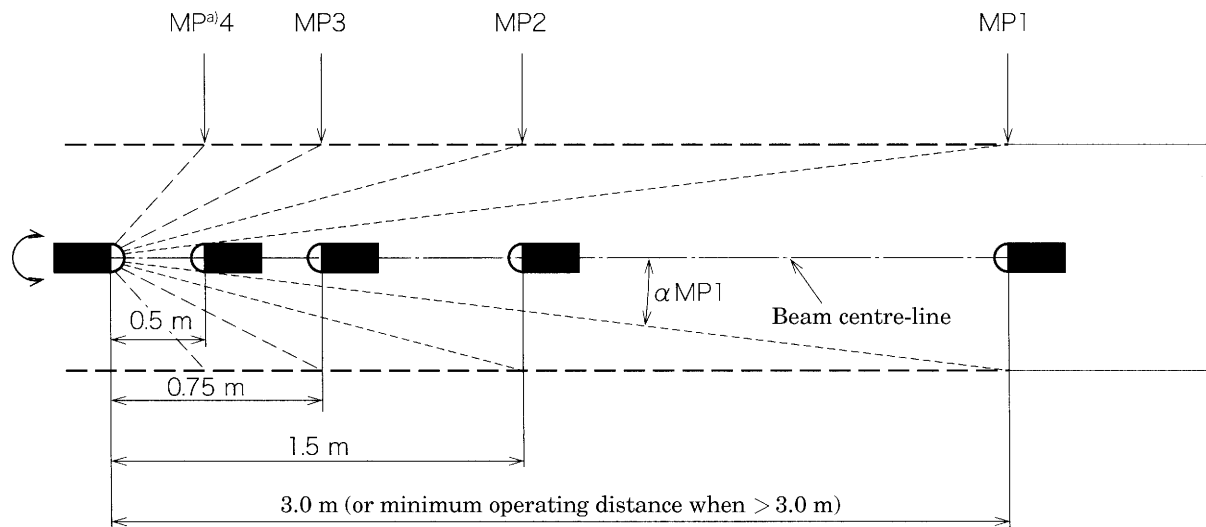
In this case, figures 1 and 2 do not apply and the limits of protection against optical bypassing shall be as specified by the manufacturer.



Unit: mm

Type of ESPE	d	L
Type 4	131	250 to 3 000
Type 2	262	500 to 3 000

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



	α Limit values (°)			
	MP1	MP2	MP3	MP4
Type 2 AOPD	5	10	19.3	27.7
Type 4 AOPD	2.5	5	10	14.7
Note ^{a)} MP: measuring point				

NOTE 1 The EAA should be determined according to **5.2.9.2**.

NOTE 2 Measurements should be carried out at each of the measuring points MP1 to MP4 within the range of the operating distance specified by the supplier (or if minimum distance is greater than 3.0 m, at the minimum operating distance only).

Example : If the range of operating distance is within 1 m to 3.5 m, measurement should be carried out at points MP2 (1.5 m) and MP1 (3.0 m), but not at MP4 (0.5 m) and MP3 (0.75 m). Measurement at point 1.0 m is also recommended. If the range of operating distance is within 4 m to 10 m, measurement should be carried out only at point 4.0 m.

NOTE 3 The limit values for other distances than MP1, MP2, MP3 and MP4 can be calculated using the formula:

$$\alpha = \arctan (d/L)$$

where $d = 262$ mm (for Type 2)

or $d = 131$ mm (for Type 4)

and L is the distance between emitter and receiver (or DUT and retro-reflector target).

NOTE 4 For retro-reflector systems, the value of α is one-half of the value shown in the table above.

Figure 2 Measurement of the effective aperture angle (EAA)

4.1.2.3 Additional requirements for an AOPD using retro-reflective techniques

An AOPD using retro-reflective techniques where the light beam traverses the detection zone more than once (over the same path) shall not fail to danger if a reflective

object (for example, reflective clothes) is placed at any position in the detection zone and shall not be bypassed by an easily available reflector (for example, mirror).

NOTE 1 The use of mirrors to return the light beam is not considered to be a retro-reflective technique.

Retro-reflection means the reflection in which radiation is returned in directions close to the opposite of the direction from which it came, this property being maintained over wide variations of the direction of the incident rays. Retro-reflector means a surface of device from which most of the reflected radiation is retro-reflected (see JIS Z 8113). In this Standard, it indicates the retro-reflector as the component of AOPD.

The OSSD(s) of a single light beam device shall go to, and remain in, the OFF-state when a reflective object of a size greater than, or equal to, the diameter and length of the test piece (see 4.2.13) is placed in the beam at any position as specified in 5.2.1.1.

The reflective objects considered shall consist of:

- the retro-reflector target;
- a retro-reflecting material conforming to the requirements for retro-reflection of **EN 471** class 2 or equivalent;

NOTE 2 Table 5 in **EN 471** defines the minimum coefficient of retro-reflection for class 2 material as 330 cd lx m^{-2} with an entrance angle of 5° and an observation angle of 0.2° ($12'$).

- a mirror-type reflective surface having a reflection factor greater than, or equal to, 90 % at the operating wavelength, for example polished chrome plating or polished aluminium;
- a diffuse reflective surface, for example, white paper.

Under normal operating conditions the OSSD(s) of a light curtain and of a multiple light beam device using retro-reflective techniques shall go to and remain in the OFF-state when an identical reflector is placed as close as practicable in front of the sensing surface of the emitting/receiving element(s).

4.1.2.4 Additional requirements for an AOPD using emitters and receivers in the same assembly

Under normal operating conditions the OSSD(s) of an AOPD shall go to, and remain in, OFF-state when a reflective object whose size is greater than, or equal to, the diameter and length of the test piece is placed normal to the optical axes anywhere within the detection zone.

NOTE 1 This subclause does not apply to an AOPD using retro-reflective techniques.

The reflective objects considered shall consist of

- a retro-reflecting material conforming to the requirements for retro-reflection of **EN 471** class 2 or equivalent;

NOTE 2 Table 5 in **EN 471** defines the minimum coefficient of retro-reflection for class 2 material as 330 cd lx m^{-2} with an entrance angle of 5° and an observation angle of 0.2° ($12'$).

- a mirror-type reflective surface having a reflection factor greater than or equal to 90 % at the operating wavelength, for example, polished chrome plating or polished aluminium;
- a diffuse reflective surface, for example, white paper.

4.2 Design requirements

4.2.2 Fault detection requirements

4.2.2.3 Particular requirements for a type 2 ESPE

(Replacement of first paragraph:)

A type 2 ESPE shall have a means of periodic test to reveal a failure to danger (for example, loss of sensing unit detection capability, response time exceeding that specified). The test shall verify that each light beam operates in the manner specified by the supplier. 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).

4.2.12 Integrity of the AOPD detection capability

(Addition:)

The design of the AOPD shall be such that the AOPD detection capability remains less than, or equal to, the value stated by the supplier when the AOPD is operated under any and all combinations of the following:

- any condition within the specification of the supplier;
- the environmental conditions specified in **4.3** (of Part 1 and this Standard);
- at the limits of alignment and/or adjustment.

If a single fault (as specified in Annex B), which under normal operating conditions (see **5.1.2.1** of Part 1) would not result in a loss of AOPD detection capability but, when occurring with a combination of the conditions specified above, would result in such a loss, that fault together with that combination of conditions shall be considered as a single fault, and the AOPD shall respond to such a single fault as required in **4.2.2**. An example of a method for determining detection capability is shown in Annex F.

4.2.13 Test piece

(Addition:)

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

For an AOPD detection capability of not more than 40 mm, the test piece for a light curtain shall be provided by the supplier and shall be marked with the following:

- diameter in millimetres;
- type reference and an indication of the AOPD with which the test piece is intended to be used.

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

Verification shall be by inspection.

4.2.14 Wavelength

(Addition:)

AOPDs shall operate at a wavelength within the range 400 nm to 1 500 nm.

4.2.15 Radiation intensity

(Addition:)

The radiation intensity generated and emitted by the AOPD shall at no time exceed the maximum power or energy levels for a class 1M device in accordance with **8.2** of **JIS C 6802**.

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

4.3 Environmental requirements

(Addition:)

4.3.5 Light interference

The ESPE shall continue in normal operation when subjected to

- incandescent light;
- flashing beacons;
- fluorescent light operated with high-frequency electronic power supply.

The ESPE shall not fail to danger when subjected to

- incandescent light (simulated daylight using a quartz lamp);
- stroboscopic light;
- fluorescent light operated with high-frequency electronic power supply;
- for a type 4 ESPE, radiation from an emitting element of identical design.

NOTE : Requirements for protection of type 2 ESPEs from radiation from an emitting element of identical design are under consideration.

These requirements shall be met when the ESPE conforms to the tests in **5.4.6**.

No requirements are given for immunity to other extraneous light sources which may cause abnormal operation or failure to danger. A requirement for the supplier to inform the user of potential problems is given in **af)** of clause **7**.

5 Testing

(This clause of Part 1 is applicable except as follows:)

5.1 General

(Addition:)

In the following tests, it shall 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 light beam) or for at least 80 ms, whichever is greater. If the AOPD incorporates a restart interlock, the restart interlock shall be disabled during the tests of this clause.

5.1.1 Type tests

5.1.1.2 Operating condition

(Addition:)

For the purpose of these tests, the plane of the light curtain detection zone may be either vertical or horizontal as preferred for a test.

If it can be demonstrated that the results will be the same, testing at long operating distances may be simulated by the use of neutral density (ND) filters.

NOTE : ND filters have an approximately-constant transmittance in a specific wavelength region and are used to reduce the light intensity without changing the spectral distribution.

5.1.2 Test conditions

5.1.2.2 Measurement accuracy

(Addition to first paragraph:)

- for angular measurement: $\pm 0.1^\circ$;
- for light intensity measurement: $\pm 10\%$.

5.2 Functional tests

5.2.1 Sensing function and detection capability

(Replacement:)

5.2.1.1 Sensing function

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

For a light curtain:

- by slowly moving the test piece in the detection zone across the beams at an angle of 45° and at an angle of 90° (see figures 3 and 4) at each end of the detection zone [as near as practical to the emitter and receiver (or retro-reflector)] and midway between the ends (see figure 5);
- by placing the test piece in the detection zone, stationary, at any position and/or angle considered critical as a result of the analysis in **5.2.9.1**;
- by moving the test piece in the detection zone, across the beams at the maximum speed in the range specified in **4.1.2.1** (0 m/s to 1.6 m/s), and at any other speed in that range which is considered critical as a result of the analysis in **5.2.9.1**;

- by moving the test piece (having a length of 150 mm) through the detection zone at 1.6 m/s such that the direction of movement and the axis of the test piece are normal to the detection plane, at the extremities of the detection zone (for example, at each corner) and in any other position that is considered critical as a result of the analysis in **5.2.9.1**.

For a light beam device:

- by placing the test piece in the beam at each end of the beam and midway along the beam such that the axis of the test piece is normal to the axis of the beam;
- by moving the test piece (having a length of 150 mm) through the beam at 1.6 m/s such that the direction of movement and the axis of the test piece are normal to the axis of the beam, at each end of the beam midway along the beam, and at any point throughout the operating distance which is considered critical as a result of the analysis in **5.2.9.1**.

The above tests shall be performed with the AOPD operating at the minimum specified operating distance or 0.5 m, whichever is the greater, and at the maximum specified operating distance.

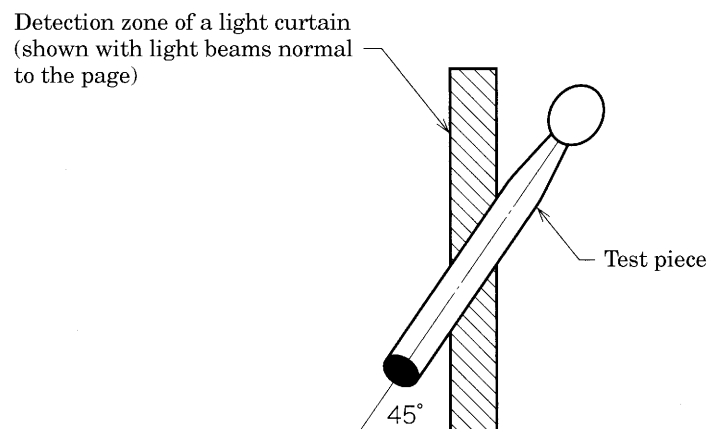


Figure 3 Test piece at 45°

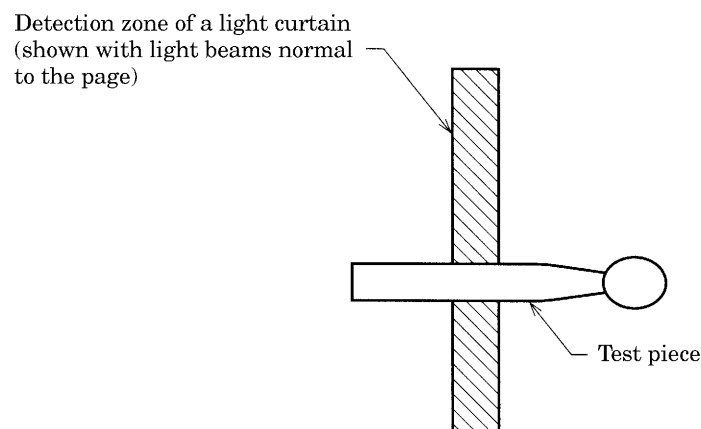


Figure 4 Test piece at 90°