



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS B 9715 : 2013

(ISO 13855 : 2010)

(JMF)

**Safety of machinery—Positioning of
safeguards with respect to the
approach speeds of parts of the
human body**

ICS 13.110

Reference number : **JIS B 9715 : 2013 (E)**

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B 9715 : 2013 (ISO 13855 : 2010)

Date of Establishment: 2006-11-25

Date of Revision: 2013-05-25

Date of Public Notice in Official Gazette: 2013-05-27

Investigated by: Japanese Industrial Standards Committee

Standards Board

Technical Committee on Industrial Machinery

JIS B 9715:2013, First English edition published in 2013-11

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Printed in Japan

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Health, Labour and Welfare and the 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 9715:2006** is replaced with this Standard.

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Safety of machinery—Positioning of safeguards with respect to the approach speeds of parts of the human body

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **ISO 13855** published in 2010 without any modifications of the technical contents and the structure.

The portions with dotted underlines are the matters not given in the corresponding International Standard.

This Standard is a type-B standard as stated in the Foreword of **JIS B 9700**.

The effectiveness of certain types of safeguard described in this Standard to minimize risk relies, in part, on the relevant parts of that equipment being correctly positioned in relation to the hazard zone. In deciding on these positions, a number of aspects are taken into account, such as:

- the necessity of a risk assessment according to **JIS B 9700**;
- the practical experience in the use of the machine;
- the overall system stopping performance;
- the time taken to ensure the safe condition of the machine following operation of the safeguard, for example to stop the machine;
- the bio-mechanical and anthropometric data;
- any intrusion by a part of the body towards the hazard zone until the protective device is actuated;
- the path taken by the body part when moving from the detection zone towards the hazard zone;
- the possible presence of a person between the safeguard and the hazard zone;
- the possibility of undetected access to the hazard zone.

1 Scope

This Standard establishes the positioning of safeguards with respect to the approach speeds of parts of the human body.

It specifies parameters based on values for approach speeds of parts of the human body and provides a methodology to determine the minimum distances to a hazard zone from the detection zone or from actuating devices of safeguards.

The values for approach speeds (walking speed and upper limb movement) in this Standard are time tested and proven in practical experience. This Standard gives guidance for typical approaches. Other types of approach, for example running, jumping or falling, are not considered in this Standard.

NOTE 1 Other types of approach can result in approach speeds that are higher or lower than those defined in this Standard.

Safeguards considered in this Standard include:

- a) electro-sensitive protective equipment (see **JIS B 9704** series), including:
 - light curtains and light grids (AOPDs);
 - laser scanners (AOPDDRs) and two-dimensional vision systems;
- b) pressure-sensitive protective equipment (see **JIS B 9717-1**, **ISO 13856-2** and **ISO 13856-3**), especially pressure-sensitive mats;
- c) two-hand control devices (see **JIS B 9712**);
- d) interlocking guards without guard locking (see **JIS B 9710**).

This Standard specifies minimum distances from the detection zone, plane, line, point or interlocking guard access point to the hazard zone for hazards caused by the machine (e.g. crushing, shearing, drawing-in).

Protection against the risks from hazards arising from the ejection of solid or fluid materials, emissions, radiation and electricity are not covered by this Standard.

NOTE 2 Anthropometric data from the 5th to the 95th percentile of persons of 14 years and older were used in the determination of the intrusion distance value “C” in the equations.

NOTE 3 The data in this Standard are based on experience of industrial application; it is the responsibility of the designer to take this into account when using this Standard for non-industrial applications.

NOTE 4 Data specifically for children have not been used in this Standard. Until specific data are available for approach speeds for children, it is the responsibility of the designer to calculate the distances taking into account that children might be quicker and that a child might be detected later.

The Standard is not applicable to safeguards (e.g. pendant two-hand control devices) that can be moved, without using tools, nearer to the hazard zone than the calculated minimum distance.

The minimum distances derived from this Standard are not applicable to safeguards used to detect the presence of persons within an area already protected by a guard or electro-sensitive protective equipment.

NOTE 5 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows:

ISO 13855:2010 *Safety of machinery—Positioning of safeguards with respect to the approach speeds of parts of the human body* (IDT)

The 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 21-1**.

2 Normative references

The following standard contains provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standard (including amendments) indicated below shall be applied.

JIS B 9700 *Safety of machinery—General principles for design—Risk assessment and risk reduction*

NOTE : Corresponding International Standard: ISO 12100 *Safety of machinery—General principles for design—Risk assessment and risk reduction* (IDT)

JIS B 9718 *Safety of machinery—Safety distances to prevent hazard zone being reached by upper and lower limbs*

NOTE : Corresponding International Standard: ISO 13857 *Safety of machinery—Safety distances to prevent hazard zones being reached by upper and lower limbs* (IDT)

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this Standard, the terms and definitions given in **JIS B 9700** and the following apply.

3.1.1 actuation

(safeguards) physical initiation of the safeguard when it detects a body or parts of a body

3.1.2 overall system stopping performance, T

time interval between the actuation of the sensing function and the termination of the hazardous machine function

NOTE : Adapted from **JIS B 9704-1**.

3.1.3 detection capability, d

sensing function parameter limit specified by the supplier that will cause actuation of the protective equipment

[**TS B 62046**, 3.1.4]

3.1.4 electro-sensitive protective equipment, ESPE

assembly of devices and/or components working together for protective tripping or presence-sensing purposes and comprising at a minimum:

- a sensing device,
- controlling/monitoring devices,
- output signal switching devices (OSSD)

[**JIS B 9704-1**, definition 3.5]

NOTE : ESPEs refer only to non-contact sensing devices.

3.1.5 indirect approach

approach where the shortest path to the hazard zone is obstructed by a mechanical obstacle

NOTE : The hazard zone can only be approached by going around the obstacle.

3.1.6 circumventing the detection zone

reaching the hazard zone without actuation of the protective device by passing over, under or to the side of the detection zone

3.1.7 termination of the hazardous machine function

condition achieved when the hazard parameters are reduced to a level which cannot cause physical injury or damage to health

NOTE : See examples in Annex B.

3.1.8 detection zone

zone within which a specified test piece is detected by the protective equipment

NOTE 1 The detection zone may also be a point, line or plane.

NOTE 2 Adapted from **JIS B 9704-1**, definition **3.4**.

3.1.9 minimum distance, S

calculated distance between the safeguard and the hazard zone necessary to prevent a person or part of a person reaching the hazard zone before the termination of the hazardous machine function

NOTE : Different minimum distances may be calculated for different conditions or approaches, but the greatest of these minimum distances is used for selecting the position of the safeguard.

3.1.10 intrusion distance, C

distance that a part of the body (usually a hand) can move past the safeguard towards the hazard zone prior to actuation of the safeguard

3.2 Symbols and abbreviated terms

3.2.1 Symbols

Symbol	Term	Unit
T	overall system stopping performance	s
S	minimum distance	mm
C	intrusion distance	mm
t_1	reaction time of the protective device	s
t_2	stopping time of the machine	s
t_3	opening time to open the guard	s
K	approach speed parameter	mm/s
d	sensor detection capability	mm
H	height of detection zone above reference plane	mm
h	height of the step	mm
X	distance between the end of the detection zone and the hazard zone	mm
S_{RO}	minimum distance when reaching over	mm
S_{RT}	minimum distance when reaching through	mm
C_{RO}	intrusion distance to the hazard zone when reaching over	mm
C_{RT}	intrusion distance to the hazard zone when reaching through	mm
a	height of the hazard zone	mm
b	height of the safeguard (e.g. ESPE, protective structure)	mm
S^*	distance actually covered	mm
l_1, l_2, l_3	shortest distance around obstacles	mm
S_1 S_2 S_3	distance of l_1 , projected on a horizontal plane distance of l_2 , projected on a horizontal plane distance of l_3 , projected on a horizontal plane	mm
e	opening size	mm
v	speed of the opening motion of the power-operated interlocking guard	mm/s

3.2.2 Abbreviated terms

AOPD	Active opto-electronic protective device
AOPDDR	Active opto-electronic protective device responsive to diffuse reflection (e.g. laser scanners)
VBPD	Vision-based protective device
ESPE	Electro-sensitive protective equipment

4 Methodology

Figure 1 provides a schematic representation of the methodology for determining the correct positioning of sensing or actuating devices of safeguards in accordance with this Standard, which is as follows.

- a) Identify the hazards and assess the risks (as specified in **JIS B 9700**);
- b) If a type-C standard exists for the machine, select one of the specified types of safeguard from that machine-specific standard, and then use the distance specified by that standard;

NOTE 1 Type-C standards specify minimum distances directly or by reference to this Standard.

- c) If there is no type-C standard, use the equation in this Standard to calculate the minimum distance for the safeguard selected;

NOTE 2 For selection of the appropriate type of safeguard, see **JIS B 9700**, **6.3**, and **TS B 62046**.

- d) If it is possible to circumvent (go around) the detection zone, an additional calculation using the equations in **6.5** shall be made;
- e) Where combinations of safeguards are used, a calculation of the minimum distance shall be made, taking into account each safeguard and possible circumventing;
- f) Calculate the minimum distances for each possibility of reaching the hazard zone. Then select the most protective (greatest) of the minimum distances;
- g) If possible, incorporate the distance(s) in the machine design, otherwise see step **i**);
- h) Check that the installation of the safeguard does not allow access without detection. If undetected access is possible, redesign [step **i**)], otherwise go to step **j**);
- i) Can parameters be modified or alternative safeguards be used? If neither is possible, additional safeguards shall be used;
- j) Check whether the determined position allows persons to remain between the safeguard and the hazard zone without being detected. In this case, supplementary measures will be required depending on an additional risk assessment.

NOTE 3 An example of a supplementary measure is a manual reset switch positioned outside the hazard zone and the space between the safeguard and the hazard zone. Its position is selected to allow someone operating it to readily check that no one is within the hazard zone or in the space between the safeguard and the hazard zone. For the requirements of a manual reset function, see **JIS B 9705-1**, **5.2.2**.

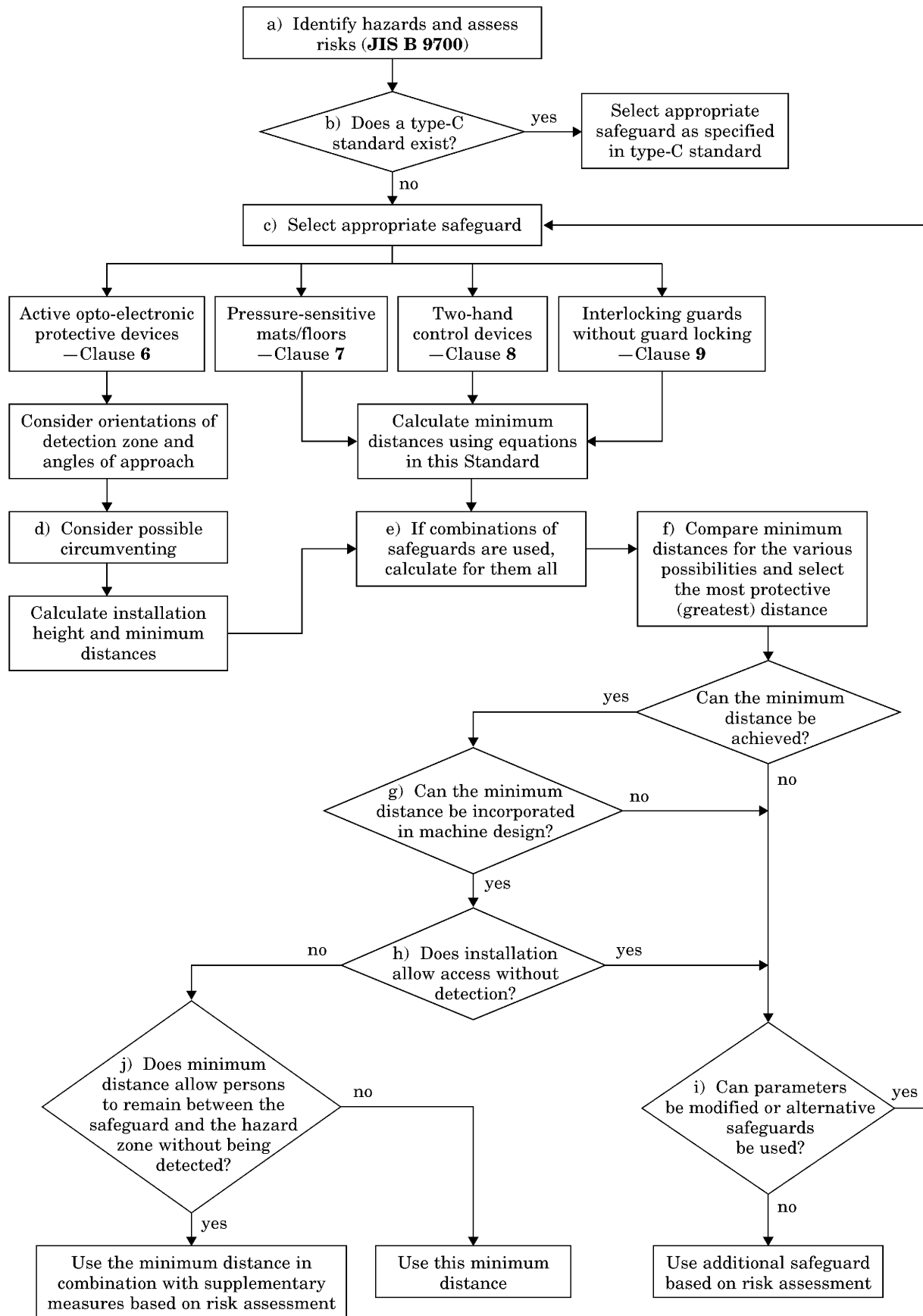


Figure 1 Methodology

5 General equation for the calculation of the overall system stopping performance and minimum distances

5.1 Overall system stopping performance

The overall system stopping performance comprises at least two phases. The two phases are linked by Equation (1):

$$T = t_1 + t_2 \dots\dots\dots (1)$$

- where,
- T : the overall system stopping performance;
 - t_1 : the maximum time between the occurrence of the actuation of the safeguard and the output signal achieving the OFF-state;
 - t_2 : the stopping time, which is the maximum time required to terminate the hazardous machine function after the output signal from the safeguard achieves the OFF-state. The response time of the control system of the machine shall be included in t_2 .

t_1 and t_2 are influenced by various factors, e.g. temperature, switching time of valves, ageing of components.

t_1 and t_2 are illustrated in figure 2. t_1 and t_2 are functions of the safeguard and the machine, respectively, and are determined by design and evaluated by measurement. The evaluation of these two values shall include the uncertainties resulting from the measurements, calculations and/or construction.

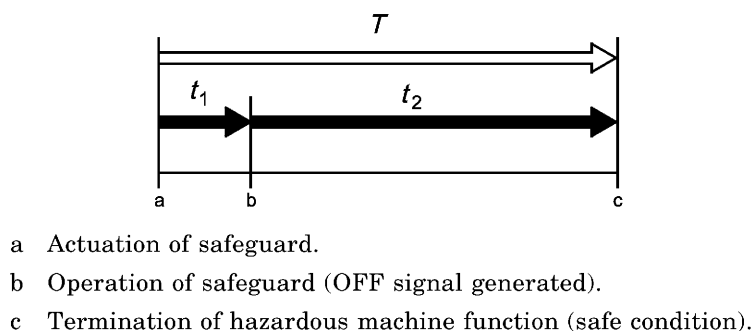


Figure 2 Relationship between t_1 and t_2

The overall system stopping performance, T , is an essential characteristic for the location of the protective device. Any deviation of the stopping time of the machine, t_2 , shall be taken into account during the estimation of T (see Annex D). Where the stopping time can deteriorate during the lifetime of the machine, technical or organizational measures should be taken to ensure the correct overall system stopping performance. These measures can be, for example:

- braking performance control devices;
- checks, the nature and the frequency of which should be defined in the user's manual.

NOTE : There can be additional aspects to take into account, e.g.:

- a) integrity of the protective function (safety in case of faults) (see **JIS B 9705-1**, **ISO 13849-2** and **JIS B 9961**);
- b) stopping performance monitoring (see, e.g. **TS B 62046**);
- c) cases where inadequate stopping performance prevents the application of this Standard, e.g.
 - 1) it is not possible to stop the machine during a cycle, or
 - 2) the stopping performance cannot be predicted.

Measurements of stopping performance of a system require careful consideration in order to obtain accurate and relevant values. Annex D gives guidance on the steps to take to ensure appropriate results.

5.2 Minimum distance

The minimum distance to the hazard zone shall be calculated by using the general Equation (2).

$$S = (K \times T) + C \dots\dots\dots (2)$$

- where,
- S : the minimum distance, in millimetres (mm);
 - K : a parameter, in millimetres per second (mm/s), derived from data on approach speeds of the body or parts of the body;
 - T : the overall system stopping performance, in seconds (s), (see **3.1.2** and **5.1**);
 - C : the intrusion distance, in millimetres (mm).

Clauses **6** to **9** show how this equation is used with particular types and arrangements of protective devices. For worked examples, see Annex A.

6 Calculation of minimum distances for electro-sensitive protective equipment employing active opto-electronic protective systems

6.1 General

6.1.1 This clause specifies requirements for two main situations based on the direction of approach of the person or part of the person's body being:

- a) orthogonal (at right angles or normal) to the detection zone (see **6.2**), or
- b) parallel to the detection zone (see **6.3**).

Requirements are also provided for arrangements where:

- an angled approach (between orthogonal and parallel) needs to be considered (see **6.4**);
- it is necessary to address possible circumventing of the electro-sensitive protective equipment (see **6.5**);

- the path from the detection zone to the hazard zone is restricted by obstacles (indirect approach) (see **6.6**).

NOTE 1 These situations also appear in combination.

Where the minimum distance is such that it would allow a person to remain undetected between the detection zone and the hazard zone, additional presence-sensing equipment or other solutions should be provided to prevent this.

NOTE 2 This Standard is not intended to provide measures against reaching a hazard zone by climbing over.

6.1.2 Safeguards shall be configured and positioned such that undetected access to the hazard zone is not possible.

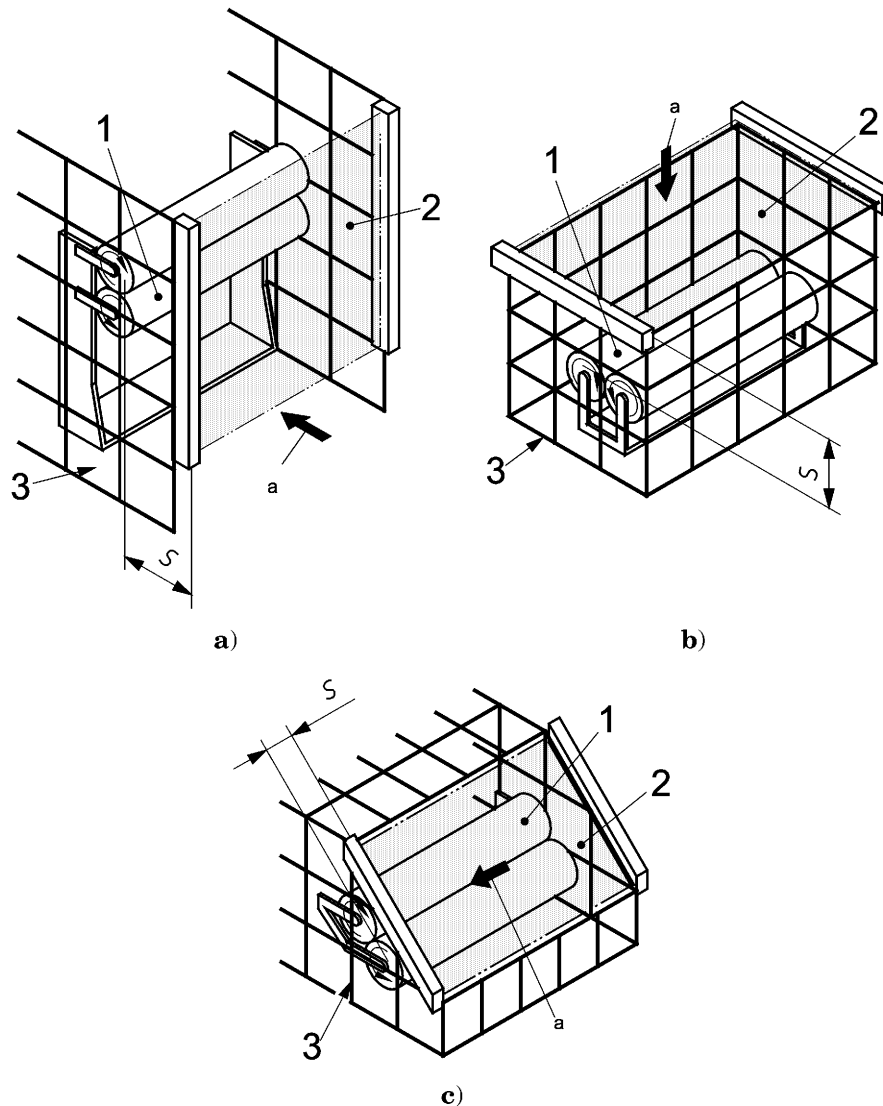
6.1.3 Where necessary, additional safeguards shall be provided to prevent circumventing the detection zone of the safeguard (see figure 9).

6.1.4 For the use of laser scanners (AOPDDR) or vision-based protective devices (VBPD) with a two-dimensional protection zone, the calculation of the minimum distance shall be in line with **6.2**, **6.3** or **6.4**, depending on the approach direction.

6.2 Detection zone orthogonal to the direction of approach

6.2.1 General

Figure 3 gives three examples where the detection zone is orthogonal to the direction of approach.



Key	
1	hazard zone
2	detection zone
3	fixed guard
S	minimum distance
a	direction of approach

Figure 3 Three examples where the detection zone is orthogonal to the direction of approach

6.2.2 Vertical detection zones detecting whole body access

When the safeguard is used only for the detection of whole body access:

- the height of the lowest beam shall be ≤ 300 mm to prevent access under the detection zone. Where it is foreseeable that electro-sensitive protective equipment will be used in non-industrial applications, for example in the presence of children, the height of the lowest beam shall be < 200 mm;
- the height of the uppermost beam shall be ≥ 900 mm to prevent stepping over the detection zone. This is not applicable for single beams or for detection zones parallel to the direction of approach (see 6.3).