BS EN 999:1999

Incorporating Corrigendum No. 1

Safety of machinery — The positioning of protective equipment in respect of approach speeds of parts of the human body

The European Standard EN 999:1998 has the status of a British Standard

ICS 13.110; 13.180

National foreword

This British Standard is the English language version of EN 999:1998.

The UK participation in its preparation was entrusted to Technical Committee MCE/3, Safeguarding of machinery, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Summary of pages

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Descriptors: safety of machines, accident prevention, work safety, control devices, safety devices, ports: openings, distance, safe service life, computation, minimum value

English version

Safety of machinery — The positioning of protective equipment in respect of approach speeds of parts of the human body

Sécurité des machines — Positionnement des équipements de protection en fonction de la vitesse d'approche des parties du corps

Sicherheit von Maschinen — Anfordnung von Schutzeinrichtungen im Hinblick auf Annäherungsgeschwindigkeiten von Körperteilen

This European Standard was approved by CEN on 20 September 1998.

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This European Standard exists in three official version (Enlgish, French, German). A version in any other language made by translation under the responsibility pf a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Ref. No. EN 999:1998 E

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 114, Safety of machinery, the Secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 1999, and conflicting national standards shall be withdrawn at the latest by April 1999.

It is a type B1 standard and is intended to be an accompaniment to the European Standards EN 292-1 and EN 292-2.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative annex ZA, which is an integral part of this standard.

According to CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom

Contents

0 Introduction

The effectiveness of certain types of protective equipment described in this standard to minimize risk relies, in part, on the relevant parts of that equipment being correctly positioned in relation to the danger zone. In deciding on these positions a number of aspects will need to be taken into account, such as:

— a need for the identification of hazards and an assessment of all the risks;

— practical experiences of users including accident statistics and existing national standards;

— the state of the art and possible future technical developments;

— type of equipment to be used;

— response times of protective equipment used;

— time taken to ensure the safe condition of the machine following operation of the protective equipment, e.g. to stop the machine;

— bio-mechanical and anthropometric data of body parts;

— path taken by body part when moving from the sensing or actuating means towards the danger zone;

— the possible presence of a person between the device and the danger zone;

— the possibility of undetected access to the danger zone.

If these aspects are further developed the current state of the art, reflected in this standard, will be improved.

1 Scope

1.1 This European Standard provides parameters based on values for hand/arm and approach speeds and the methodology to determine the minimum distances from specific sensing or actuating devices of protective equipment to a danger zone.

1.2 These specific devices are:

— trip devices as defined in **3.23.5** of EN 292-1:1991 (specifically electro-sensitive protective equipment, including those used additionally to initiate operation, and pressure sensitive mats);

— two-hand control devices as defined in **3.23.4** of EN 292-1:1991 and covered by EN 574.

NOTE For the purposes of this standard, hold-to-run controls, which are designed to be actuated with one hand, are not considered to be protective equipment.

1.3 This standard gives guidance based on the assumption that the correct device has been chosen either by reference to the appropriate type C standard or by carrying out a risk assessment.

1.4 The calculated distances, when implemented, will provide sufficient protection for persons against the risks caused by approaching a danger zone which generate any of the following mechanical hazards, such as:

— crushing, shearing, cutting or severing, entanglement, drawing-in or trapping, friction or abrasion, stabbing or puncture and impact.

Protection against the risks from mechanical hazards arising from the ejection of solid or fluid materials and non-mechanical hazards such as toxic emissions, electricity, radiation, etc., are not covered by this standard.

1.5 The distances are derived from data that take into account population groups likely to be found in European countries and are consequently applicable to those groups.

NOTE 1 If this standard is to be used for non-industrial purposes then the designer should take into account that these data are based on industrial experience.

NOTE 2 Until specific data is available for approach speeds for children, this standard uses adult speeds and lower detection factors, where relevant, to calculate the distances that could be within the reach of children.

1.6 This standard does not apply to protective equipment which is intended to be moved, without tools, nearer to the danger zone than the calculated distance, e.g. pendant two-hand control devices.

1.7 The minimum distances derived from this standard do not apply to protective equipment used to detect the presence of persons within an area already protected by a guard or electro-sensitive protective equipment.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 292-1:1991, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology.*

EN 292-2, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles and specifications.*

EN 294:1992, *Safety of machinery — Safety distances to prevent danger zones being reached by the upper limbs.*

EN 574, *Safety of machinery — Two-hand control devices — Functional aspects, principles for design.*

EN 1050, *Safety of machinery — Principles for risk assessment.*

EN 61496-1:1997, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests.* (IEC 61496-1:1997)

3 Definitions

For the purposes of this standard the following definitions apply. Other definitions are given in EN 292-1 and EN 292-2.

3.1

actuation (of protective equipment)

physical initiation of the protective equipment when it detects movement of the body or a part of the body

3.2

overall system stopping performance

time or travel occurring from the actuation of the sensing function to the cessation of hazardous motion, or to the machine assuming a safe condition

[based on **3.20** of EN 61496-1:1997]

The overall system stopping performance comprises a minimum of two phases:

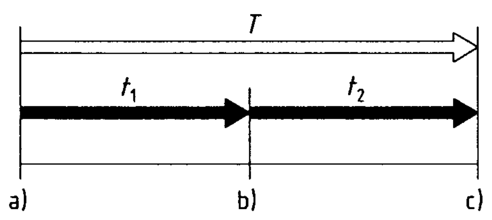
$$T = t_1 + t_2$$

where

- T is the overall system stopping performance;
- t_1 is the maximum time between the actuation of the sensing function and the output signal switching devices being in the off state;
- t_2 is the maximum response time of the machine, i.e. the time required to stop the machine or remove the risks after receiving the output signal from the protective equipment. t_2 is influenced by various factors, e.g. temperature, switching time of valves, ageing of components.

The relationship of t_1 and t_2 is given in Figure 1.

t_1 and t_2 are functions of the protective equipment and the machine respectively, and are determined by design and measurement.



a) Actuating of protective equipment

b) Operation of protective equipment

c) Elimination of risk

Figure 1 — Relationship between t_1 and t_2

3.3

detection capability

the sensing function parameter limit specified by the supplier that will cause actuation of the electro-sensitive protective equipment (ESPE)

[**3.4** of EN 61496-1:1997]

NOTE Symbol d is used throughout the standard.

3.4

electro-sensitive protective equipment (ESPE)

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

— a sensing device;

— controling/monitoring devices;

— output signal switching devices

[**3.1** of EN 61496-1:1997]

4 Methodology

Figure 2 provides a schematic representation of the methodology for determining the correct position of sensing or actuating devices of protective equipment using this standard, which is as follows.

a) Identify the hazards and assess the risks (see EN 292-1 and EN 1050).

b) If a type C standard exists for the machine, select one of the specified types of protective equipment from that machine-specific standard, and then use the distance specified by that standard.

c) If there is no type C standard or if the type C standard does not specify any minimum distances, then use the formulae in this standard to calculate the minimum distance for the protective equipment selected. The selection of the appropriate type of protective equipment should be made in accordance with the relevant type A and type B standards.

d) Incorporate the distance in the machine design.

e) Ensure the device has been installed in such a manner that access to the danger zone will not be possible without detection by the device.

f) Check if the determined position will allow persons to be between the sensing devices of the protective equipment and the danger zone without being detected. In this case supplementary measures may be required depending on the risk.

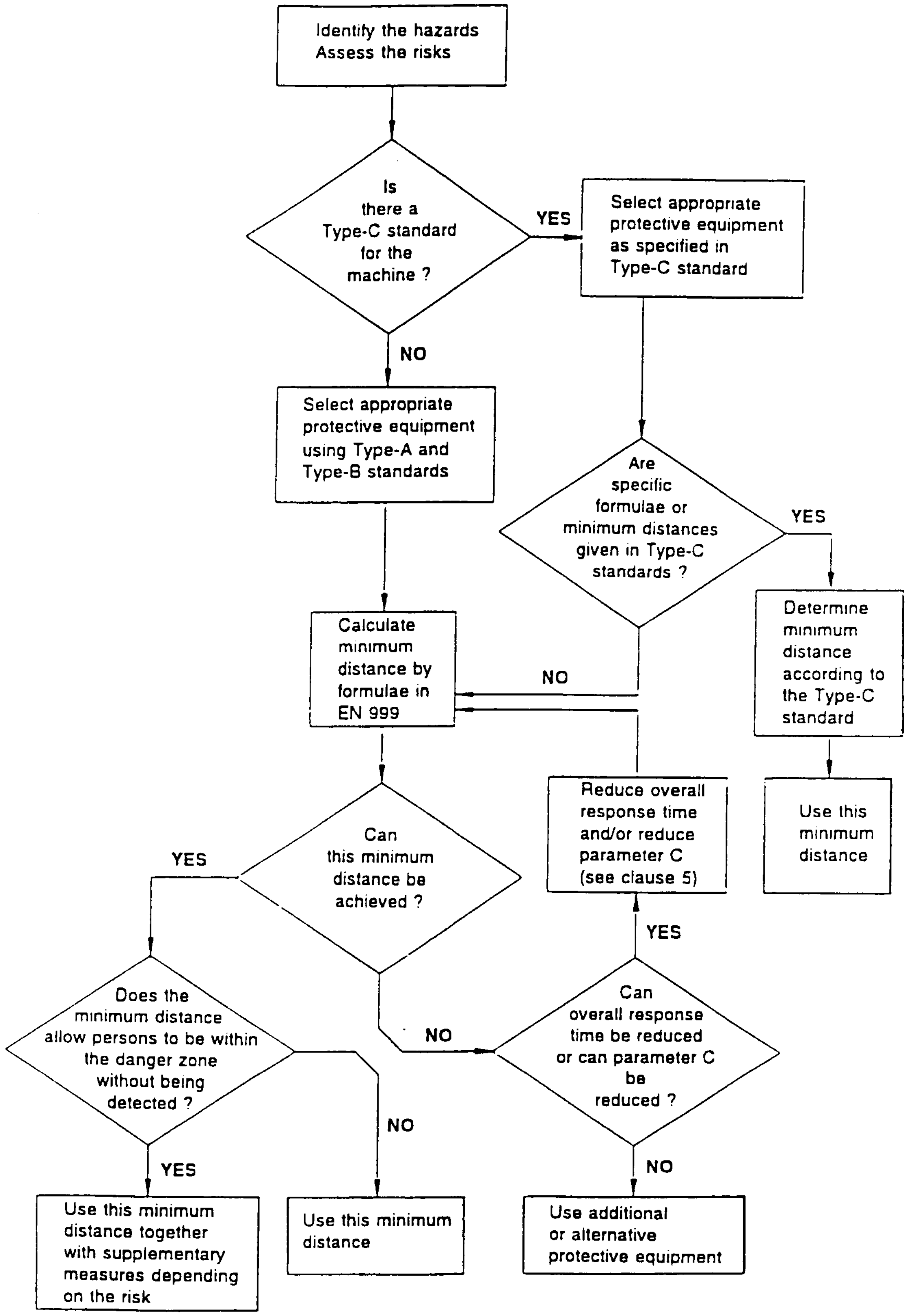


Figure 2 — Schematic of methodology

5 General formula for the calculation of minimum distances

The minimum distance from the danger zone shall be calculated by using the general formula (1).

$$S = KT + C \qquad (1)$$

where

- S is the minimum distance in millimetres, from the danger zone to the detection point, line, plane or zone;
- K is a parameter in millimetres per second, derived from data on approach speeds of the body or parts of the body (see also annex B);
- T is the overall system stopping performance in seconds (see **3.2**);
- C is an additional distance in millimetres, based on intrusion towards the danger zone prior to actuation of the protective equipment.

For worked examples see annex A.

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

Users of this standard shall select and use electro-sensitive protective equipment for a machine in accordance with the appropriate type C standard for that particular machine. If no type C standard exists, they shall undertake a risk assessment according to EN 1050.

This clause considers three main applications based on the direction of approach to the detection zone[1]:

- — normal approach (see Figure 3);
- — parallel approach (see Figure 4);
- — angled approach (see Figure 5).

Where it is foreseeable that any gaps adjacent to or within the detection zone of the electro-sensitive protective equipment will allow access to the danger zone then this should be taken into account in the correct positioning of the protective equipment and additional safeguards considered.

Access to the danger zone by reaching over or round the electro-sensitive protective equipment, together with any other protective equipment and additional safeguards, shall be prevented.

6.1 Direction of approach normal to the detection zone

6.1.1 ***Electro-sensitive protective equipment employing active opto-electronic protective devices with a maximum detection capability of 40 mm diameter***

The minimum distance from the detection zone to the danger zone shall not be less than that calculated using formula (2).

$$S = KT + C \text{ (see clause } \mathbf{5}\text{)} \qquad (1)$$

where

K = 2 000 mm/s;

C = 8(d − 14 mm), but not less than 0;

d is the detection capability of the device, in millimetres.

i.e.:

$$S = (2\,000 \text{ mm/s} \times T) + 8(d - 14 \text{ mm}) \qquad (2)$$

This formula applies for all minimum distances of S up to and including 500 mm. The minimum value of S shall not be less than 100 mm.

If S is found to be greater than 500 mm using formula (2), then formula (3) can be used. In this case the minimum value of S shall not be less than 500 mm.

$$S = KT + C \text{ (see clause } \mathbf{5}\text{)} \qquad (1)$$

where

K = 1 600 mm/s;

C = 8(d − 14 mm), but not less than 0.

i.e.:

$$S = (1\,600 \text{ mm/s} \times T) + 8(d - 14 \text{ mm}) \qquad (3)$$

Where it is foreseeable that electro-sensitive protective equipment employing active opto-electronic protective devices will be used in non-industrial applications, e.g. in the presence of children, the minimum distance S calculated with formula (2) shall be increased by at least 75 mm. It shall be noted that in such cases formula (3) is not applicable.

6.1.2 ***Electro-sensitive protective equipment employing active opto-electronic protective devices used for reinitiation of machine operation***

Electro-sensitive protective equipment employing active opto-electronic protective devices used for reinitiation of machine operation shall have a detection capability equal to or less than 30 mm, formula (2) (see **6.1.1**) shall apply, and the minimum distance S shall be greater than 150 mm.

If the detection capability is equal to or less than 14 mm, formula (2) shall apply, and the minimum distance S shall be greater than 100 mm.

NOTE 1 Conditions for using electro-sensitive protective equipment in the reinitiation of machine operation are given in EN 292-1 and EN 292-2[2] and relevant type C standards.

NOTE 2 Additional requirements for electro-sensitive protective equipment are given in EN 61496-1.

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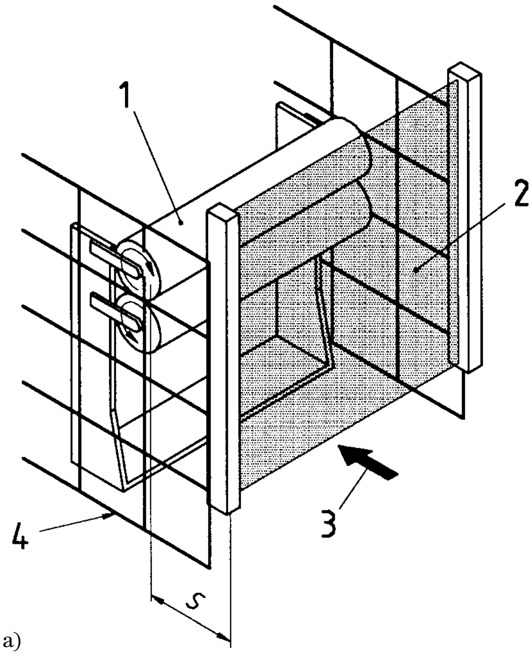
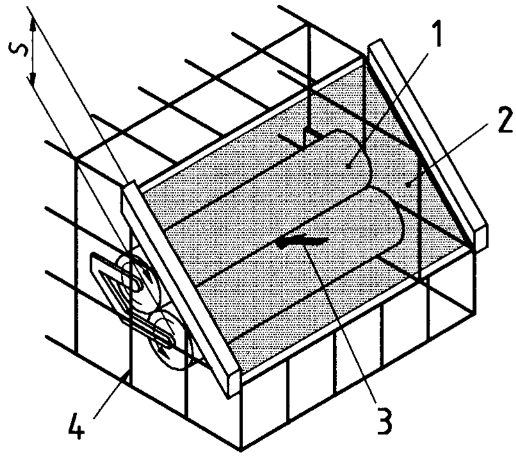
[1] Definition see EN 61496-1.

[2] These requirements are under preparation and will be contained in the revision of EN 292-1 and EN 292-2.

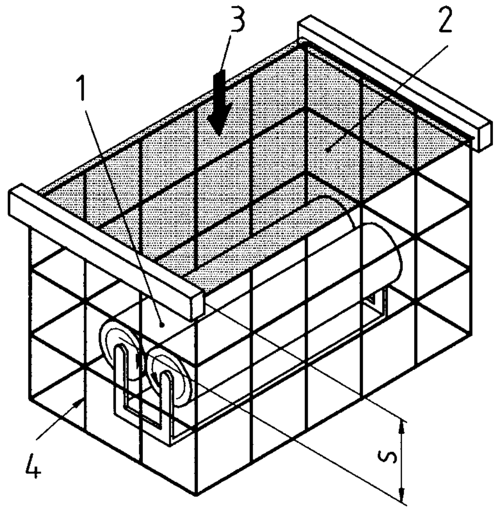


a)



b)

S) Minimum distance
1) Danger zone
2) Detection zone
3) Direction of approach
4) Fixed guard



c)

Figure 3 — Three examples of normal approach

6.1.3 ***Electro-sensitive protective equipment employing active opto-electronic protective devices with detection capability greater than 40 mm and less than or equal to 70 mm***

Such pieces of equipment will not detect intrusion of the hands and therefore shall only be used where the risk assessment indicates that detection of intrusion of the hands is not necessary.

This equipment shall be installed in accordance with the following parameters.

The minimum distance from the detection zone to the danger zone is in part dependent on the part of body to be detected and shall be calculated using formula (4).

$S = KT + C$ (see clause **5**) (1)

where

K = 1 600 mm/s;

C = 850 mm.

i.e.:

S = (1 600 mm/s × T) + 850 mm (4)

The risk of inadvertent access shall be taken into account during the risk assessment stage but in all cases, the height of the uppermost beam shall be ≥ 900 mm and the height of the lowest beam shall be ≤ 300 mm.

Where it is foreseeable that electro-sensitive protective equipment will be used in non-industrial applications, e.g. in the presence of children, the height of the lowest beam shall be ≤ 200 mm.

6.1.4 ***Multiple separate beams***

Multiple separate beams, e.g. a combination of 2, 3 or 4 separate beams, are often used to detect intrusion of the whole body rather than parts of the body.

If the risk assessment indicates that separate beams are appropriate, they shall be positioned at a minimum distance from the danger zone in accordance with formula (4) (see **6.1.3**).

During risk assessment, methods which can possibly be used to bypass such equipment shall be taken into account, e.g.:

— crawling below the lowest beam;

— reaching over the top beam;

— reaching through between two of the beams;

— bodily access by passing between two beams.

The heights for 2, 3 and 4 beams given in Table 1 have been found to be the most practical in application.

Table 1

Dimensions in millimetres

No. of beams	Heights above reference plane, e.g. floor
4	300, 600, 900, 1 200
3	300, 700, 1 100
2	400, 900

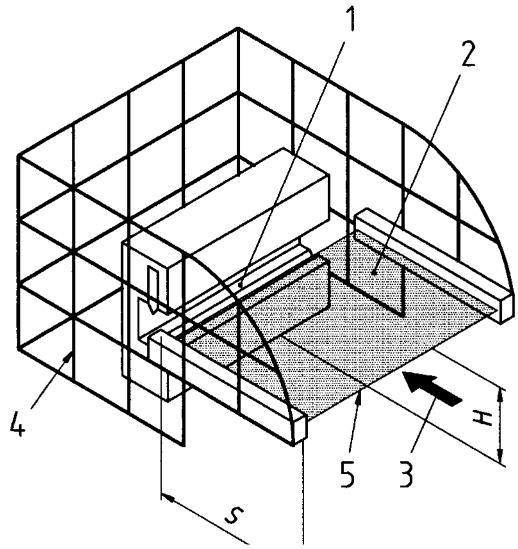
6.1.5 ***Single height beams***

These beams have only been considered when they are used parallel to the ground and the beam is broken by a person's body in the upright position.

Where the risk assessment allows a single height beam to be used alone then the minimum distance shall be calculated using formula (5).

S = (1 600 mm/s × T) + 1 200 mm (5)

A height of 750 mm from the ground or reference plane (see **4.1.1** of EN 294:1992) has been found in industry to be a practical solution to the problems of inadvertent access from stepping over or bending under the beam.



H) Height of detection zone above reference plane

S) Minimum distance

1) Danger zone

2) Detection zone

3) Direction of approach

4) Fixed guard

5) Beginning of the detection zone

Figure 4 — Parallel approach to the detection zone

6.2 Direction of approach parallel to the detection zone

This minimum distance shall be calculated using formula (6).

$S = KT + C$ (see clause **5**) (1)

where

K = 1 600 mm/s;

C = 1 200 mm − 0,4H, but not less than 850 mm, where H is the height of the detection zone above the reference plane, e.g. floor, in millimetres.

i.e.:

S = (1 600 mm/s × T) + (1 200 mm − 0,4H) (6)

For this type of protective equipment the height H of the detection zone shall not be greater than 1 000 mm. However, if H is greater than 300 mm (200 mm for non-industrial applications, e.g. in the presence of children), there is a risk of inadvertent undetected access beneath the detection zone. This shall be taken into account in the risk assessment.

The lowest allowable height of the detection zone shall be calculated using formula (7).

$H = 15(d - 50\text{ mm})$ (7)

Thus for a given height of the detection zone, the corresponding detection capability d shall be calculated using formula (8).

$$d = \frac{H}{15} + 50\text{ mm} \quad (8)$$

That means, where the height of the detection zone is known or fixed, a maximum detection capability can be calculated, e.g. when calculating the horizontal section of "L" shaped electro-sensitive protective equipment; or

if a detection capability is known or fixed, a minimum height can be calculated, up to the allowable maximum of 1 000 mm.

6.3 Direction of approach angled to the detection zone

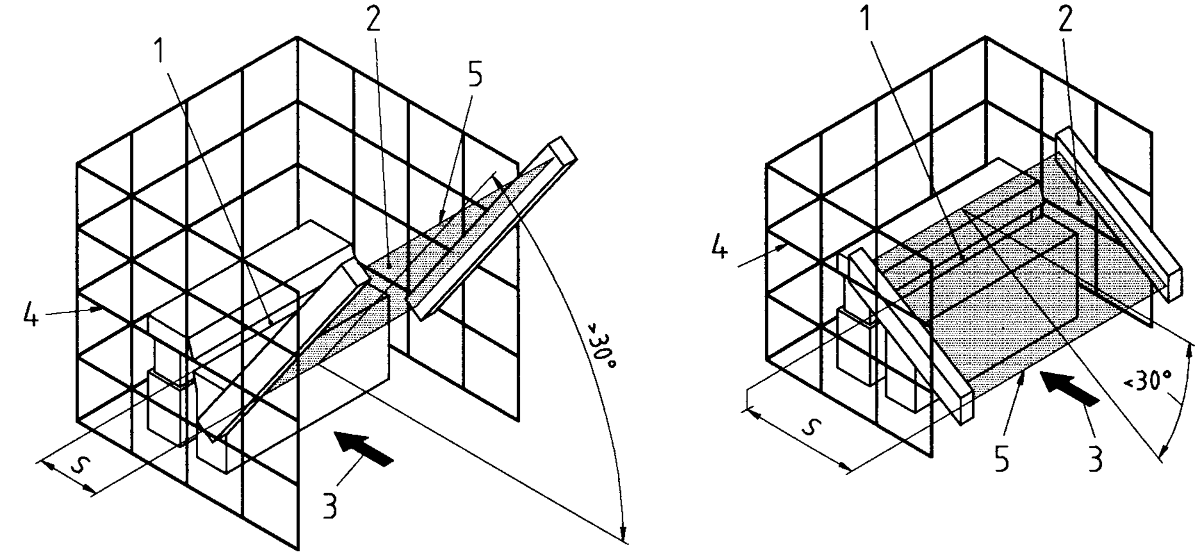
If the protective equipment has been installed so that the angle of approach to the detection zone is within ±5° of their designed approach (either normal or parallel), then it need not be considered as an angled approach detection zone and the relevant formulae will apply (see **6.1**, **6.2** and **6.4**).

For detection zones which are positioned at angles greater than ±5° to the direction of approach the account shall be taken of the risks associated with the foreseeable methods of approach and the most appropriate formula used.

Foreseeable angles of approach greater than 30° should be considered normal approach [see **6.1** and Figure 5a)], and foreseeable angles of approach less than 30° should be considered parallel approach [see **6.2** and Figure 5b)].

When angled approach detection zones are considered as parallel approach, then formula (7) linking H and d in **6.2** shall apply to the lowest beam or the beam closest to the reference plane (see H in Figure 6).

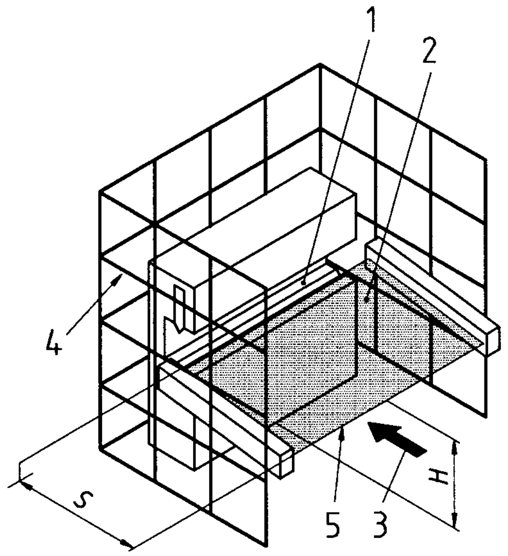
In the case of parallel approach, the formula to derive the minimum distance S shall apply to the beam furthest from the danger zone. This beam may be used up to a maximum height of the detection zone of 1 000 mm.



a) b)

S) Minimum distance
1) Danger zone
2) Detection zone
3) Direction of approach
4) Fixed guard
5) Beginning of the detection zone

Figure 5 — Angle of approach to the detection zone



H) Height of the detection zone (lowest beam)
S) Minimum distance
1) Danger zone
2) Detection zone
3) Direction of approach
4) Fixed guard
5) Beginning of the detection zone

Figure 6 — Height of the detection zone (lowest beam)

6.4 Dual position equipment

When the detection zone can be readily converted to a position either normal or parallel to the direction of approach then the minimum distances for both directions of approach shall be applied (see example 3 in **A.3**).

The axis of rotation of the detection zone shall be at a point where both requirements can be achieved. This need not necessarily be the last beam.

When in position normal to the direction of approach (vertical detection zone), the minimum distance *S* shall be calculated using formula (2) (see **6.1.1**) up to $S \leq 500$ mm.

If *S* is found to be greater than 500 mm using formula (2), then formula (3) (see **6.1.1**) may be used but with a minimum distance of 500 mm.

When in position parallel to the direction of approach (horizontal detection zone), the minimum distance *S* shall be calculated using formulae (6), (7) and (8) (see **6.2**) up to a maximum height of 1 000 mm.

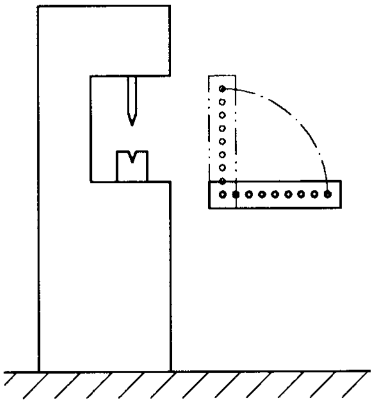


Figure 7 — Dual position equipment

7 Method of calculating the minimum distances for ground level trip devices

7.1 General method

The selection and use of ground level trip devices actuated by the feet is dependent on the appropriate type C standard, or a risk assessment in accordance with EN 1050 if no type C standard exists.

Examples of ground level trip devices include pressure sensitive mats, pressure sensitive floors and active opto-electronic protective devices.

The minimum distances derived in this clause for ground level trip devices assume that the approach speed to the danger zone will be at walking speed. Regarding the risk of stepping over the detection zone see annex B.

The minimum distance shall be calculated using formula (6) (see **6.2**).

$$S = (1\,600 \text{ mm/s} \times T) + (1\,200 \text{ mm} - 0{,}4H) \qquad (6)$$

where

S is the minimum distance in millimetres in a horizontal plane from the danger zone to the detecting edge of the device furthest from the danger zone;

H is the distance above the reference plane, e.g. floor, in millimetres (see **7.3**).

7.2 Floor mounting

In most situations the trip device will be fitted directly onto the floor, i.e. $H = 0$. Therefore the minimum distance for trip devices installed on the floor shall be calculated using formula (9) derived from formula (6) (see **6.2**).

$$S = (1\,600 \text{ mm/s} \times T) + 1\,200 \text{ mm} \qquad (9)$$

7.3 Step mounting

If the trip device is mounted onto a step or raised platform then the minimum distance may be reduced by $0{,}4H$, where *H* is the height of the step in millimetres.

8 Two-hand control devices

The minimum distance from the nearest actuator to the danger zone shall be calculated using formula (10).

$$S = KT + C \text{ (see clause 5)} \qquad (1)$$

where

K = 1 600 mm/s;

C = 250 mm.

i.e.:

$$S = (1\,600 \text{ mm/s} \times T) + 250 \text{ mm} \qquad (10)$$

If the risk of encroachment of the hands or part of the hands towards the danger zone is eliminated while the actuator is being operated, e.g. by adequate shrouding, then *C* may be zero, with a minimum allowable distance for *S* of 100 mm.

NOTE EN 574 gives advice on shrouding to prevent defeating the intended operation of a control. Measures described there are not adequate in all applications to prevent encroachment of the hands or parts of the hands towards the danger zone.

Annex A (informative)

Worked examples

The following examples show how this standard can be used.

It is assumed in these examples that either the appropriate type C standard or the risk assessment for the relevant machine will allow the protective equipment chosen for these examples.

A.1 Example 1

A machine has a stopping time of 60 ms (t_2). It is fitted with electro-sensitive protective equipment employing a vertical active opto-electronic protective device having a detection capability of 14 mm and a response time of 30 ms (t_1).

Using formula (2):

$$S = (2\,000 \text{ mm/s} \times T) + 8(d - 14 \text{ mm}) \quad (2)$$

where

S is the minimum distance from the danger zone to the detection zone in millimetres;

T is the overall response time of (60 + 30) ms = 90 ms;

d = 14 mm.

Then:

S = (2 000 mm/s × 0,09 s) + 8(14 − 14) mm

S = 180 mm

A.2 Example 2

The same machine as in example **A.1** but with a detection capability of 30 mm.

Using formula (2):

$$S = (2\,000 \text{ mm/s} \times T) + 8(d - 14 \text{ mm}) \quad (2)$$

where

T is the overall response time of (60 + 30) ms = 90 ms;

d = 30 mm.

Then:

S = (2 000 mm/s × 0,09 s) + 8(30 − 14) mm

S = 180 mm + 128 mm

S = 308 mm

A.3 Example 3

A dual position detection zone is required for a machine with a table height of 1 000 mm. Overall system stopping performance T is 100 ms and the detection capability of the curtain d is 40 mm.

Vertical application

Using formula (2):

$$S = (2\,000 \text{ mm/s} \times T) + 8(d - 14 \text{ mm}) \quad (2)$$

where

T = 100 ms;

d = 40 mm.

Then:

S = (2 000 mm/s × 0,1 s) + 8(40 − 14) mm

S = 200 mm + 208 mm

S = 408 mm

This is not greater than 500 mm so the formula is valid.

Horizontal application

Using formula (6):

$$S = (1\,600 \text{ mm/s} \times T) + (1\,200 \text{ mm} - 0{,}4H) \quad (6)$$

where

(1 200 mm − 0,4H) is not less than 850 mm.

Then:

S = (1 600 mm/s × 0,1 s) + 850 mm

S = 160 mm + 850 mm

S = 1 010 mm

The pivot point will therefore be at a horizontal distance of 408 mm from the danger zone.

The minimum length of the detection zone will be (1 010 − 408) mm = 602 mm.

Risk assessment will indicate if additional safeguarding is required; in this example for the resulting gap of 408 mm between the pivot point and the danger zone.

A.4 Examples comparing different devices

A.4.1 *Example 4*

Inadvertent access to the danger zone of an automated machine system is detected by active opto-electronic protective device.

The risk assessment indicates that a multiple separate individual beam device would be appropriate and a three-beam device is selected.

The stopping time of the machine system is 300 ms and the response time of the protective equipment is 35 ms.

From Table 1, the beams should be set at 300, 700 and 1 100 mm from the floor. The minimum distance is given by formula (4).

$$S = (1\,600 \text{ mm/s} \times T) + 850 \text{ mm} \quad (4)$$

where T = 335 ms.

Then:

S = (1 600 mm/s × 0,335 s) + 850 mm

S = 536 mm + 850 mm

S = 1 386 mm

A.4.2 ***Example 5***

The same machine as in example 4 but installing a floor mounted pressure sensitive mat or a floor mounted active opto-electronic protective device instead of a three-beam device.

$$S = (1\,600\ \text{mm/s} \times T) + 1\,200\ \text{mm} \qquad (9)$$

Then:

$$S = (1\,600\ \text{mm/s} \times 0{,}335\ \text{s}) + 1\,200\ \text{mm}$$

$$S = 536\ \text{mm} + 1\,200\ \text{mm}$$

$$S = 1\,736\ \text{mm}$$

A.5 Example 6

Risk assessment indicates that a two-hand control device is appropriate to prevent access to a danger zone. The overall response time of the device and the machine is 90 ms.

Using formula (10):

$$S = (1\,600\ \text{mm/s} \times T) + 250\ \text{mm} \qquad (10)$$

Then:

$$S = (1\,600\ \text{mm/s} \times 0{,}09\ \text{s}) + 250\ \text{mm}$$

$$S = 144\ \text{mm} + 250\ \text{mm}$$

$$S = 394\ \text{mm}$$

If adequate shrouding is used, S can be reduced to 144 mm (see clause **8**).

Annex B (informative)

Walking speeds and stride lengths

The positioning of equipment which is activated by a person walking into the detection zone, e.g. by stepping onto a pressure sensitive mat, is affected by speed of approach and stride length.

The walking speed and stride length depend on the physical and anthropometric data of the population.

Speed of approach

This standard assumes that the approach of persons towards the danger zone will be at walking speed. Other types of approach, e.g. running or jumping, should be considered in the risk assessment.

Stride length

Available research data has shown that the 95th percentile of two steps (i.e. starting and finishing with the same foot) measured from heel contact at walking speed is approximately 1 900 mm. By dividing by 2 and subtracting the 5th percentile shoe length, this gives a stride length of 700 mm. If it is assumed that an allowance has to be made, for example, between the detection zone and the stride length of, e.g., 50 mm, this gives a minimum width of 750 mm for the detection zone.

Annex ZA (informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EU directives:

— Council Directive of 14 June 1989 on the approximation of the laws of the Member States relating to Machinery (89/392/EEC);

— Council Directive of 20 June 1991 amending Directive 89/392/EEC on the approximation of the laws of the Member States relating to machinery (91/368/EEC);

— Council Directive of 14 June 1993 amendmeng Directive 89/392/EEC on the approximation of the laws of the Member States relating to machinery (93/44/EEC).

The clauses of this standard are likely to support requirements of the three directives mentioned above.

WARNING. Other requirements and other EU directives may be applicable to the products falling within the scope of this standard.

Compliance with this standard provides one means of conforming with the specific essential requirements of the directives concerned and associated EFTA regulations.

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