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Second edition
2019-10

Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs

Sécurité des machines — Distances de sécurité empêchant les membres supérieurs et inférieurs d'atteindre les zones dangereuses

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 199, *Safety of machinery*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This second edition cancels and replaces the first edition (ISO 13857:2008) which has been technically revised. The main change compared to the previous edition is that the document has been made more readable and more in line with ISO 12100:2010.

Introduction

The structure of safety standards in the field of machinery is as follows:

a) **type-A standards** (basic safety standards) giving basic concepts, principles for design, and general aspects that can be applied to all machinery;

b) **type-B standards** (generic safety standards) dealing with one safety aspect or one or more type(s) of safeguard that can be used across a wide range of machinery:

   — type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);

   — type-B2 standards on safeguards (e.g. two-hand controls, interlocking devices, pressure sensitive devices, guards).

c) **type-C standards** (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

This document is a type-B1 standard as stated in ISO 12100:2010.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance etc.);

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e. g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

In addition, this document is intended for standardization bodies elaborating type-C standards.

The requirements of this document can be supplemented or modified by a type-C standard.

For machines which are covered by the scope of a type-C standard and which have been designed and built according to the requirements of that standard, the requirements of that type-C standard take precedence.

One method of eliminating or reducing risks caused by machinery is to make use of safety distances preventing hazard zones from being reached by the upper and lower limbs.

In specifying safety distances, a number of aspects need to be taken into consideration, such as:

— reach situations occurring when machinery is being used;

— reliable surveys of anthropometric data, taking into account population groups likely to be found in the countries concerned;

— biomechanical factors, such as compression and stretching of parts of the body and limits of joint rotation;

— technical and practical aspects; and

— additional measures for particular groups of persons (e.g. persons with special needs), which can be required due to a deviation from the specified body dimensions.

Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs

1 Scope

This document establishes values for safety distances in both industrial and non-industrial environments to prevent machinery hazard zones being reached. The safety distances are appropriate for protective structures. It also gives information about distances to impede free access by the lower limbs (see Annex B).

This document covers people of 14 years and older (the 5th percentile stature of 14-year-olds is approximately 1 400 mm). In addition, for upper limbs only, it provides information for children older than 3 years (5th percentile stature of 3-year-olds is approximately 900 mm) where reaching through openings needs to be addressed.

NOTE 1 It is not practical to specify safety distances for all persons. Therefore, the values presented are intended to cover the 95th percentile of the population.

Data for preventing lower limb access for children is not considered.

The distances apply when sufficient risk reduction can be achieved by distance alone. Because safety distances depend on size, some people of extreme dimensions will still be able to reach hazard zones even when the requirements of this document are met.

Compliance with the requirements in this document will prevent access to the hazard zone. Nevertheless the user of this document is advised that it does not provide the required risk reduction for every hazard (e.g. hazards related to machine emissions such as ionizing radiation, heat sources, noise, dust).

The clauses covering lower limbs apply on their own only when access by the upper limbs to the same hazard zone is not foreseeable according to the risk assessment.

The safety distances are intended to protect those persons trying to reach hazard zones under the conditions specified (see 4.1.1).

NOTE 2 This document is not intended to provide measures against reaching a hazard zone by climbing over (see ISO 14120:2015, 5.18).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100:2010 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
protective structure
safeguard (e.g. a guard, an impeding device) or other physical obstruction (e.g. a part of a machine) which restricts the movement of the body and/or a part of it in order to prevent reaching hazard zones

3.2
reference plane
level at which persons would normally stand during the use of the machine or access to the hazard zone

Note 1 to entry: The reference plane is not necessarily the ground or the floor (for example a working platform can be the reference plane).

3.3
safety distance
safe separation distance
s_r
minimum distance a protective structure is required to be placed from a hazard zone

4 Safety distances to prevent reach or access by upper and lower limbs

4.1 General

4.1.1 Assumptions

The safety distances in this document have been derived by making the following assumptions:

— the protective structures and any openings in them retain their shape and position;

— safety distances are measured from the surface restricting the body or the relevant part of the body;

— the body is forced over protective structures or through openings in an attempt to reach the hazard zone;

— there is some contact with the reference plane while wearing shoes (use of high-soled shoes, climbing and jumping are not included);

— no aids such as chairs or ladders are used to change the reference plane;

— no aids such as rods or tools are used to extend the natural reach of the upper limbs.

4.1.2 Risk assessment

4.1.2.1 General

Safety distances are determined if the hazard to be considered has been identified as significant (see ISO 12100:2010, 3.8). All reasonably foreseeable access means shall be taken into account. When the possibility of access or the variety of hazard zones requires the application of more than one table, all safety distances shall be taken into account. When more than one safety distance is determined for the same means of access, the greatest safety distance shall be applied.

The safety distances, s_r, given in Table 7 apply to persons reaching through openings using the lower limbs in an attempt to reach a hazard zone.

4.1.2.2 Selection of safety distances when reaching upwards and reaching over

Prior to selecting a suitable safety distance in case of reaching upwards (see 4.2.1) or reaching over protective structures (see 4.2.2), it is necessary to consider the severity of harm and the probability of occurrence of this harm caused by the hazard.

In case of reaching upwards, the higher value according to 4.2.1.2 shall be applied. In the case of reaching over protective structures, the values of Table 2 shall be applied.

The lower value according to 4.2.1.2 or Table 1 may only be applied where both the severity of harm and the probability of occurrence of harm caused by the hazard are low (see ISO 12100:2010, 5.5.2.3).

The probability of occurrence of harm can be assumed low with, for example, slow movements which allow escape from the hazardous movement.

The severity of the harm can be assumed low in the following examples:

— when temperature and contact duration with hot surfaces is below the burn threshold value (for burn threshold values, see ISO 13732-1);

— for hazards which do not cause permanent harm or irreversible damages to the body, for example such as haematomas, slight contusions or breaking of parts of the body which grow again, like finger nails.

More guidance on risk estimation is given in ISO/TR 14121-2:2012, Clause 6.

4.2 Safety distances to prevent access by upper limbs

4.2.1 Reaching upwards

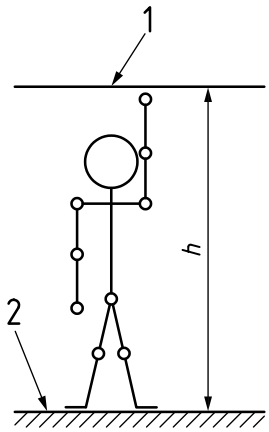
4.2.1.1 General

Figure 1 shows the safety distance for reaching upwards.

4.2.1.2 Height of the hazard zone

The height of the hazard zone, *h*, shall be 2 700 mm or more.

The height of the hazard zone, *h*, shall be 2 500 mm or more where both the severity of harm and the probability of occurrence of harm caused by the hazard are low.



Key

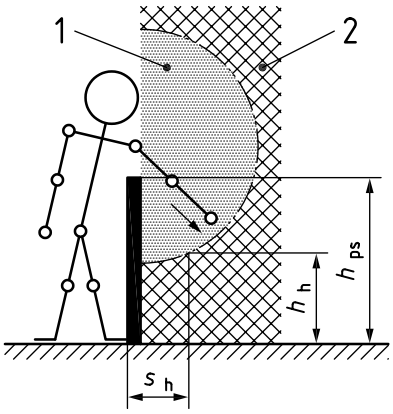
1 hazard zone
2 reference plane
h height of hazard zone

Figure 1 — Reaching upwards

4.2.2 Reaching over protective structures

4.2.2.1 General

Figure 2 shows reaching over a protective structure.



Key

1 area of upper limb reach

2 area outside of upper limb reach (hazard zone)

h_h height of the point of the hazard zone which is nearest to the area of upper limb reach

h_{ps} height of protective structure

s_h horizontal safety distance of the point of the hazard zone which is nearest to the area of upper limb reach

Figure 2 — Reaching over protective structure

The values given in Tables 1 and 2 shall be used to determine the corresponding dimension(s) of the height of the hazard zone, the height of protective structures and the horizontal safety distance to the hazard zone.

When the known values of h_h, h_{ps} or s_h are between two values, the greater safety distance or higher protective structure or change in the height (higher or lower) of the hazard zone shall be used. Consequently, there shall be no interpolation of the values given.

4.2.2.2 Values

Table 1 may be used when the injury severity is slight and there is a low probability of occurrence of the injury. Table 1 provides the relationship between the height of the hazard zone, the height of the protective structure and the horizontal safety distance (see Figure 2).

NOTE Annex A gives examples of the use of Table 1.

Table 1 — Reaching over protective structures — Only minor injuries along with a low probability of occurrence

Dimensions in millimetres

h_h, height of the point of the hazard zone which is nearest to the area of upper limb reach	h_{ps}, height of protective structure[a]								
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500
	s_h, horizontal safety distance of the point of the hazard zone which is nearest to the area of upper limb reach								
2 500	0	0	0	0	0	0	0	0	0
2 400	100	100	100	100	100	100	100	100	0
2 200	600	600	500	500	400	350	250	0	0
2 000	1 100	900	700	600	500	350	0	0	0
1 800	1 100	1 000	900	900	600	0	0	0	0
1 600	1 300	1 000	900	900	500	0	0	0	0
1 400	1 300	1 000	900	800	100	0	0	0	0
1 200	1 400	1 000	900	500	0	0	0	0	0
1 000	1 400	1 000	900	300	0	0	0	0	0
800	1 300	900	600	0	0	0	0	0	0
600	1 200	500	0	0	0	0	0	0	0
400	1 200	300	0	0	0	0	0	0	0
200	1 100	200	0	0	0	0	0	0	0
0	1 100	200	0	0	0	0	0	0	0

[a] Protective structures less than 1 000 mm in height are not included because they do not sufficiently restrict movement of the body.

Table 2 shall be used when Table 1 is not applicable. Table 2 provides the relationship between the height of the hazard zone, the height of the protective structure and the horizontal safety distance (see Figure 2).

NOTE Annex A gives examples of the use of Table 2.

Table 2 — Reaching over protective structures

Dimensions in millimetres

h_h, height of the point of the hazard zone which is nearest to the area of upper limb reach[a]	h_{ps}, height of protective structure[b,c]									
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500	2 700
	s_h, horizontal safety distance of the point of the hazard zone which is nearest to the area of upper limb reach									
2 700	0	0	0	0	0	0	0	0	0	0
2 600	900	800	700	600	600	500	400	300	100	0
2 400	1 100	1 000	900	800	700	600	400	300	100	0
2 200	1 300	1 200	1 000	900	800	600	400	300	0	0
2 000	1 400	1 300	1 100	900	800	600	400	0	0	0
1 800	1 500	1 400	1 100	900	800	600	0	0	0	0
1 600	1 500	1 400	1 100	900	800	500	0	0	0	0
1 400	1 500	1 400	1 100	900	800	0	0	0	0	0
1 200	1 500	1 400	1 100	900	700	0	0	0	0	0
1 000	1 500	1 400	1 000	800	0	0	0	0	0	0
800	1 500	1 300	900	600	0	0	0	0	0	0
600	1 400	1 300	800	0	0	0	0	0	0	0
400	1 400	1 200	400	0	0	0	0	0	0	0
200	1 200	900	0	0	0	0	0	0	0	0
0	1 100	500	0	0	0	0	0	0	0	0

[a] For hazard zones above 2 700 mm, refer to 4.2.1.

[b] Protective structures less than 1 000 mm in height are not included because they do not sufficiently restrict movement of the body.

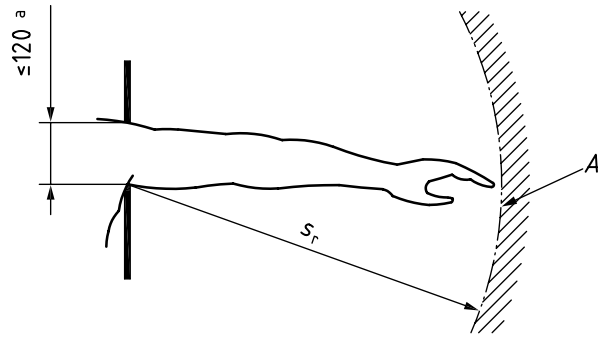
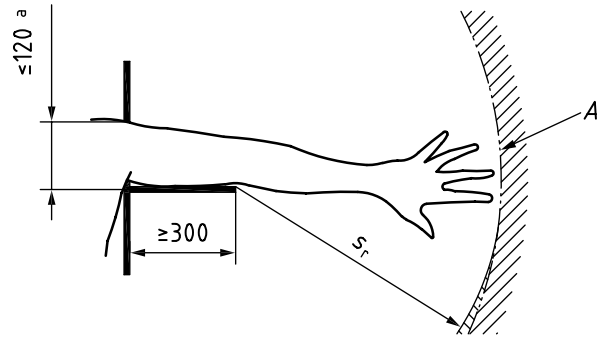
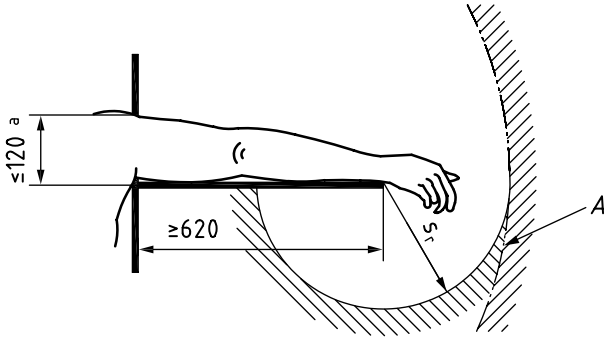
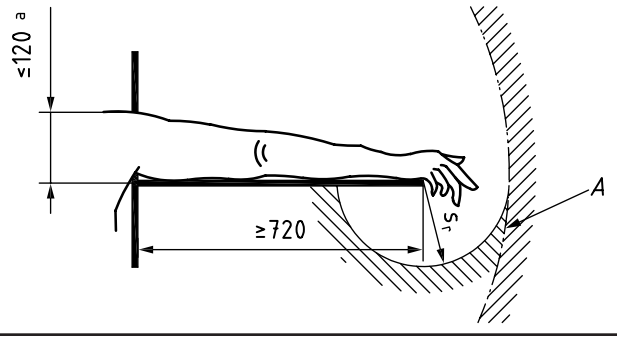
[c] Protective structures lower than 1 400 mm should not be used without additional protective measures.

4.2.3 Reaching around

Table 3 shows examples of fundamental movements for persons of 14 years and above (approximately 1,4 m height and above) (see also 4.2.5). Safety distances shorter than 850 mm may be used when the obstacle limiting the movement is at least 300 mm long.

Table 3 — Reaching around with limitation of movement

Dimensions in millimetres

Limitation of movement	Safety distance to hazard zone, s_r	Illustration
Limitation of movement only at shoulder and armpit	≥850	
Arm supported up to elbow	≥550	
Arm supported up to wrist	≥230	
Arm and hand supported up to knuckle joint	≥130	

Key

A range of movement of upper limb

s_r radial safety distance

[a] This is either the diameter of a round opening, or the side of a square opening, or the narrowest dimension of the slot opening.

4.2.4 Reaching through openings

4.2.4.1 Reaching through regular openings — Persons of 14 years of age and above

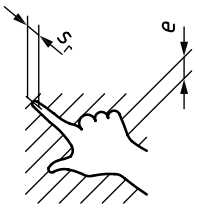
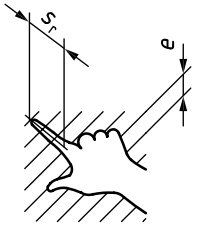
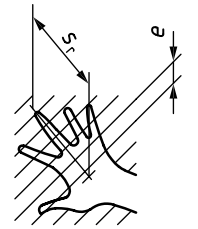
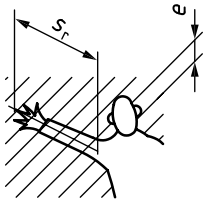
Table 4 gives safety distances to hazard zones, s_r, for regular openings for persons of 14 years of age and above.

The dimension of the opening, e, corresponds to the side of a square opening, the diameter of a round opening and the narrowest dimension of a slot opening.

For openings larger than 120 mm, safety distances in accordance with 4.2.2 shall be used.

Table 4 — Reaching through regular openings — Persons of 14 years of age and above

Dimensions in millimetres

Part of body	Illustration	Opening	Safety distance to hazard zone, s_r		
			Slot	Square	Round
Fingertip		$e \leq 4$	≥2	≥2	≥2
		$4 < e \leq 6$	≥10	≥5	≥5
Finger up to knuckle joint		$6 < e \leq 8$	≥20	≥15	≥5
		$8 < e \leq 10$	≥80	≥25	≥20
Hand		$10 < e \leq 12$	≥100	≥80	≥80
		$12 < e \leq 20$	≥120	≥120	≥120
		$20 < e \leq 30$	≥850[a]	≥120	≥120
Arm up to junction with shoulder		$30 < e \leq 40$	≥850	≥200	≥120
		$40 < e \leq 120$	≥850	≥850	≥850

NOTE The bold lines within the table delineate that part of the body restricted by the opening size.

[a] If the length of the slot opening is ≤65 mm, the thumb will act as a stop and the safety distance may be reduced to ≥200 mm.

4.2.4.2 Reaching through regular openings — Persons of 3 years of age and above

Table 5 considers the smaller dimensions of the thickness of the upper limbs and the behaviour of persons of 3 years of age and above.

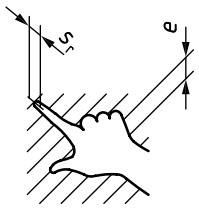
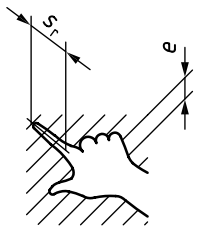
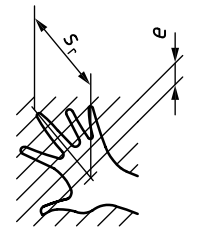
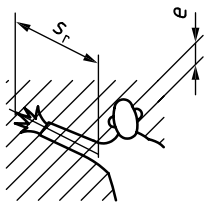
The dimensions of openings, *e*, correspond to the side of a square opening, the diameter of a round opening and the narrowest dimension of a slot opening.

For openings larger than 100 mm, safety distances in accordance with 4.2.2 shall be used.

NOTE Measures for children's protection against strangulation are not covered by this document.

Table 5 — Reaching through regular openings — Persons of 3 years of age and above

Dimensions in millimetres

Part of body	Illustration	Opening	Safety distance to hazard zone, s_r		
			Slot	Square	Round
Fingertip		$e \leq 4$	≥2	≥2	≥2
		$4 < e \leq 6$	≥20	≥10	≥10
Finger up to knuckle joint		$6 < e \leq 8$	≥40	≥30	≥20
		$8 < e \leq 10$	≥80	≥60	≥60
Hand		$10 < e \leq 12$	≥100	≥80	≥80
		$12 < e \leq 20$	≥900[a]	≥120	≥120
Arm up to junction with shoulder		$20 < e \leq 30$	≥900	≥550	≥120
		$30 < e \leq 100$	≥900	≥900	≥900

NOTE The bold line within the table delineates that part of the body restricted by the opening size.

[a] If the length of the slot opening is ≤40 mm, the thumb will act as a stop and the safety distance may be reduced to ≥120 mm.

4.2.4.3 Openings of irregular shape

In the case of irregular openings, the following steps shall be carried out in the order given.

a) Determine:

— the diameter of the smallest round opening;

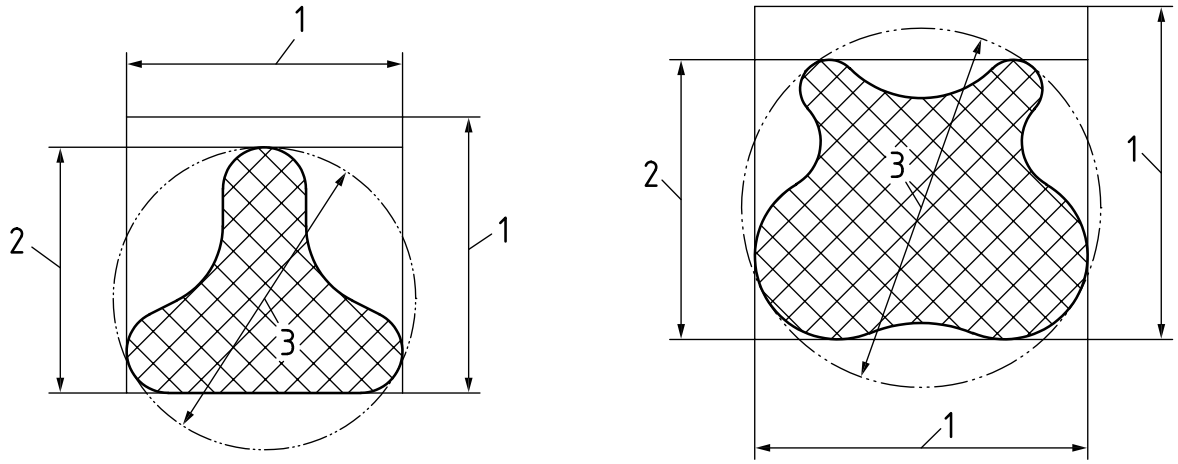
— the side of the smallest square opening; and

— the width of the narrowest slot opening;

into which the irregular opening can be completely inserted [see hatched area in Figures 3 a) and b)].

b) Using Table 4 (14 years and older) or Table 5 (3 years and older) as appropriate, select the corresponding safety distances to hazard zone for each of the openings determined in step a).

c) The shortest safety distance of the three values selected in b) may be used.



Key

1 side of the smallest square opening
2 width of the narrowest slot opening
3 diameter of the smallest round opening

Figure 3 — Openings of irregular shape

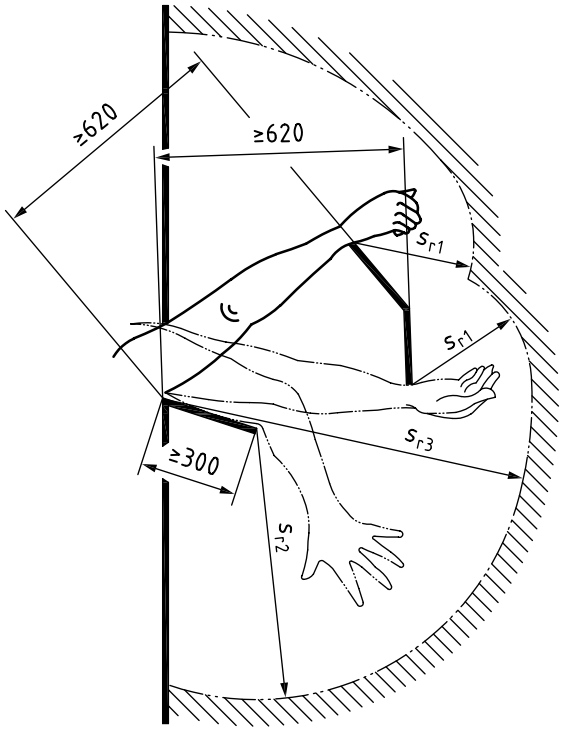
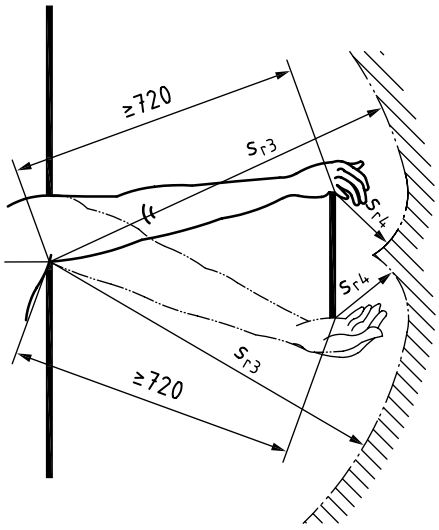
4.2.5 Effect of additional protective structures on safety distances

In Tables 1 to 5, the referenced protective structures are located in one plane. Additional protective structures or surfaces which function as such can reduce the free movement of the arm, the hand or the fingers and can increase the zone where hazard points can be admissible. Examples of how this can be achieved are shown in Tables 3 and 6.

Protective structures and surfaces on which the arm can rest may be inclined at any angle.

Table 6 — Reaching around with additional protective structures

Dimensions in millimetres

Limitation of movement	Safety distance to hazard zone, s_r	Illustration
Limitation of movement at shoulder and armpit: two separate protective structures — one permits movement from the wrist, the other movement from the elbow.	$s_{r1} \geq 230$ $s_{r2} \geq 550$ $s_{r3} \geq 850$	
Limitation of movement at shoulder and armpit: one separate protective structure, which permits movement from the fingers up to the knuckle joint.	$s_{r3} \geq 850$ $s_{r4} \geq 130$	
Key s_r radial safety distance		

4.3 Safety distances to prevent access by lower limbs

In general, safety distances should be determined using Tables 1 to 6 for the upper limbs. Where it is foreseeable that the upper limbs cannot have access to openings, Table 7 may be used alone to determine safety distances for the lower limbs.

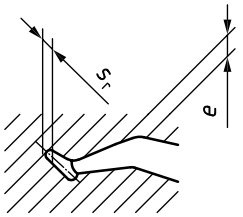
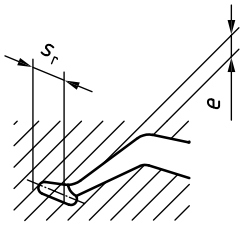
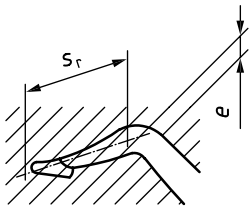
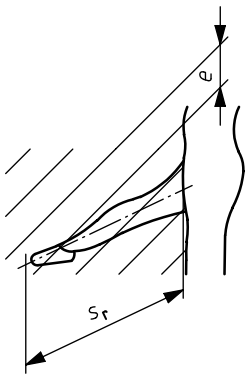
The dimension, *e*, of openings corresponds to the side of a square opening, the diameter of a round opening or the narrowest dimension of a slot opening.

The values given in Table 7 are independent of whether clothing or footwear is being worn and are applicable for persons of 14 years of age and above.

For reaching through openings of irregular shape, see 4.2.4.3.

Table 7 — Reaching through openings of regular shape by lower limbs

Dimensions in millimetres

Part of lower limb	Illustration	Opening	Safety distance to hazard zone, s_r	
			Slot	Square or round
Toe tip		$e \leq 5$	0	0
		$5 < e \leq 15$	≥10	0
Toe		$15 < e \leq 35$	≥80[a]	≥25
Foot		$35 < e \leq 60$	≥180	≥80
		$60 < e \leq 80$	≥650[b]	≥180
Leg (toe tip to knee)		$80 < e \leq 95$	≥1 100[c]	≥650[b]
Leg (toe tip to crotch)		$95 < e \leq 180$	≥1 100[c]	≥1 100[c]
		$180 < e \leq 240$	Not admissible	≥1 100[c]

[a] If the length of the slot opening is ≤75 mm, the distance may be reduced to ≥50 mm.

[b] The value corresponds to leg (toe tip to knee).

[c] The value corresponds to leg (toe tip to crotch).

NOTE Slot openings with $e > 180$ mm and square or round openings with $e > 240$ mm will allow access for the whole body.

In some cases (e.g. mobile agricultural machines designed to move over uneven ground), the safety distances given in this document cannot be applied. In such cases, at least protective structures to restrict the free movement of the lower limbs should be used. For this method, the values given in Annex B can be used.

4.4 Consideration of whole body access

Protective structures with slot openings with e > 180 mm and square or round openings with e > 240 mm (see 4.2.4.1) shall not be used without additional protective measures since they can allow whole body access.

Protective structures less than 1 400 mm in height, according to Table 2, shall not be used without additional protective measures.

NOTE 1 The consideration of the full body access either by climbing over or by crouching under protective structures is indispensable for the application of this document.

NOTE 2 Examples can also be found in ISO/TR 20218-2.

Annex A
(informative)

Use of Tables 1 and 2 with intermediate values

The following examples explain the use of the tables referred to in 4.2.2.2 when values other than those given in these tables themselves will be used. For the examples, Table 2 is used.

EXAMPLE 1

Task: To determine the height, h_{ps}, of the protective structure with known values for h_h and s_h.

Assumptions:

— The height, h_h, of the hazard zone is 1 500 mm

— The horizontal distance, s_h, from the proposed protective structure is 800 mm

Method: the height, h_{ps}, of the protective structure can be determined as follows:

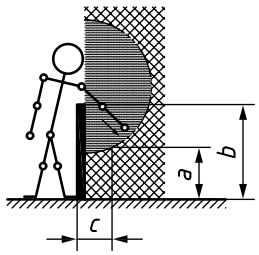
① For h_h, the value 1 600 mm is selected as the closest value to 1 500 mm while having safety distances in that row that are greater (safer) than h_h = 1 400 mm.

② The value s_h = 800 mm is selected.

③ The corresponding value for the height, h_{ps}, of the protective structure is 1 800 mm.

Dimensions in millimetres

Height of hazard zone [c] *a*	Height of protective structure [a, b] *b*									
	1000	1200	1400	1600	1800 ③	2000	2200	2400	2500	2700
	Horizontal safety distance to hazard zone, *c*									
2700	0	0	0	0	0	0	0	0	0	0
2600	900	800	700	600	600	500	400	300	100	0
2400	1100	1000	900	800	700	600	400	300	100	0
2200	1300	1200	1000	900	800	600	400	300	0	0
2000	1400	1300	1100	900	800	600	400	0	0	0
1800	1500	1400	1100	900	800	600	0	0	0	0
1600 ①	1500	1400	1100	900	800 ②	500	0	0	0	0
1400	1500	1400	1100	900	800	0	0	0	0	0
1200	1500	1400	1100	900	700	0	0	0	0	0
1000	1500	1400	1000	800	0	0				
800	1500	1300	900	600	0	0				
600	1400	1300	800	0	0	0				
400	1400	1200	400	0	0	0				
200	1200	900	0	0	0	0				
0	1100	500	0	0	0	0				



[a] Protective structures less than 1 000 mm in height are not included because they do not sufficiently restrict movement of the body.

[b] Protective structures lower than 1 400 mm should not be used without additional protective measures.

[c] For hazard zones above 2 700 mm, refer to 4.2.1.

Figure A.1 — Example 1 — Table 2

EXAMPLE 2

Task: To determine the horizontal safety distance, s_h, from the hazard zone with known values for h_h and h_{ps}.

Assumptions:

— The height, h_h, of the hazard zone is 2 300 mm

— The height, h_{ps}, of the protective structure is 1 500 mm

Method: The horizontal safety distance, s_h, from the hazard zone can be determined as follows:

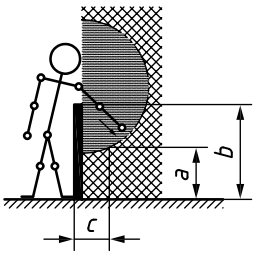
① The value h_{ps} = 1 400 mm is selected as being closest to 1 500 mm, while having safety distances in that column that are greater (safer) than h_{ps} = 1 600 mm.

② The value h_h = 2 200 mm is selected as being closest to 2 300 mm, while having safety distances that are greater (safer) than for h_h = 2 400 mm.

③ The corresponding value for s_h is 1 000 mm.

Dimensions in millimetres

Height of hazard zone [c] *a*	Height of protective structure [a, b] *b*									
	1000	1200	1400 ①	1600	1800	2000	2200	2400	2500	2700
	Horizontal safety distance to hazard zone, *c*									
2700	0	0	0	0	0	0	0	0	0	0
2600	900	800	700	600	600	500	400	300	100	0
2400	1100	1000	900	800	700	600	400	300	100	0
2200 ②	1300	1200	1000 ③	900	800	600	400	300	0	0
2000	1400	1300	1100	900	800	600	400	0	0	0
1800	1500	1400	1100	900	800	600	0	0	0	0
1600	1500	1400	1100	900	800	500	0	0	0	0
1400	1500	1400	1100	900	800	0	0	0	0	0
1200	1500	1400	1100	900	700	0	0	0	0	0
1000	1500	1400	1000	800	0	0				
800	1500	1300	900	600	0	0				
600	1400	1300	800	0	0	0				
400	1400	1200	400	0	0	0				
200	1200	900	0	0	0	0				
0	1100	500	0	0	0	0				



a Protective structures less than 1 000 mm in height are not included because they do not sufficiently restrict movement of the body.

b Protective structures lower than 1 400 mm should not be used without additional protective measures.

c For hazard zones above 2 700 mm, refer to 4.2.1.

Figure A.2 — Example 2 — Table 2

EXAMPLE 3

Task: To determine the height, h_h, of the hazard zone with known values for h_{ps} and s_h.

Assumptions:

— The horizontal safety distance, s_h, from the hazard zone is 850 mm

— The height, h_{ps}, of the protective structure is 1 700 mm

Method: the height, h_h, of the hazard zone can be determined as follows:

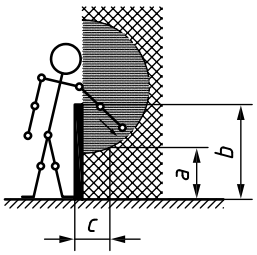
① The value h_{ps} = 1 600 mm is selected as being closest to 1 700 mm while having safety distances in that column that are greater (safer) than h_{ps} = 1 800 mm.

② The value s_h = 800 mm is selected as being closest to (and lower than) 850 mm, and therefore several improper positions are determined as highlighted in Figure A.3.

③ The corresponding value for h_h is 2 400 mm or more, or 1 000 mm or less.

Dimensions in millimetres

	Height of hazard zone [c] *a*	Height of protective structure [a, b] *b*									
		1000	1200	1400	1600 ①	1800	2000	2200	2400	2500	2700
		Horizontal safety distance to hazard zone, *c*									
d	2700 ③	0	0	0	0	0	0	0	0	0	0
d	2600 ③	900	800	700	600	600	500	400	300	100	0
d	2400 ③	1100	1000	900	800	700	600	400	300	100	0
e					900 ②	800	600	400	300	0	0
e					900 ②	800	600	400	0	0	0
e					900 ②	800	600	0	0	0	0
e					900 ②	800	500	0	0	0	0
e					900 ②	800	0	0	0	0	0
e					900 ②	700	0	0	0	0	0
d	1000 ③	1500	1400	1000	800	0	0				
d	800 ③	1500	1300	900	600	0	0				
d	600 ③	1400	1300	800	0	0	0				
d	400 ③	1400	1200	400	0	0	0				
d	200 ③	1200	900	0	0	0	0				
d	0 ③	1100	500	0	0	0	0				



a Protective structures less than 1 000 mm in height are not included because they do not sufficiently restrict movement of the body.

b Protective structures lower than 1 400 mm should not be used without additional protective measures.

c For hazard zones above 2 700 mm, refer to 4.2.1.

d Possible.

e Not possible.

Figure A.3 — Example 3 — Table 2

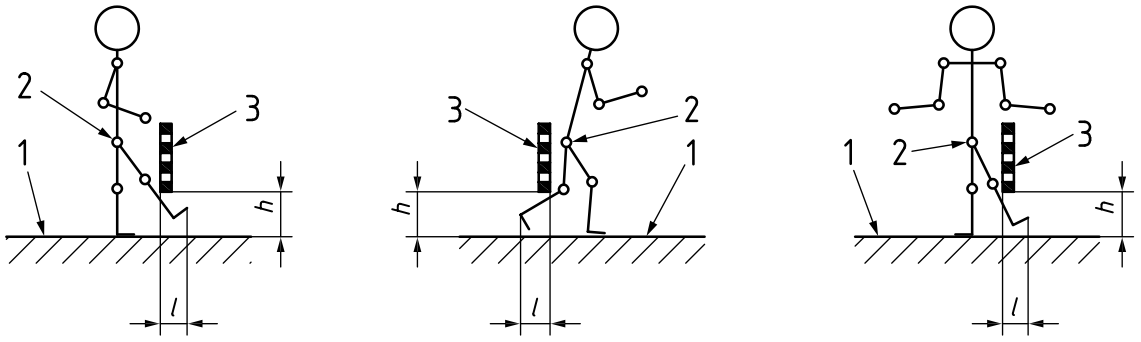
Annex B
(informative)

Distances to impede free access by lower limbs

In some cases (e.g. mobile agricultural machines designed to move over uneven ground), the safety distances given in this document cannot be applied. In such cases, at least protective structures to restrict the free movement of the lower limbs should be used. For this method, the values given in this Annex can be used.

An additional protective structure can be used to restrict the free movement of the lower limbs under existing protective structures. For this method, the distances given in this annex relate to the height from the ground or reference plane to the protective structure. This method provides limited protection; in many cases other methods will be more appropriate.

The distance, *h*, from the reference plane to the protective structures should not exceed 180 mm (see 4.4).



Case 1 **Case 2** **Case 3**

Key

1 reference plane
2 hip joint
3 protective structure
h height up to protective structure
l distance for impedance

Figure B.1 — Impeding free movement under protective structures

NOTE These distances are not safety distances and additional protective measures can be required to restrict access.

Table B.1 gives distances for particular cases where access of the lower limbs is impeded when the person remains in a standing position (see Figure B.1) without any additional support.

Where there is a risk of slipping or misuse, applying the values given in Table B.1 can be inappropriate.

There should be no interpolation between the values in this table. If the height, *h*, up to the protective structure lies between two values, then the distance for the higher value of *h* should be used.

Table B.1 — Distances where access of the lower limbs is restricted

Dimensions in millimetres

Height h **up to protective structure**	**Distance** l		
	Case 1	**Case 2**	**Case 3**
$h \leq 200$	≥340	≥665	≥290
$200 < h \leq 400$	≥550	≥765	≥615
$400 < h \leq 600$	≥850	≥950	≥800
$600 < h \leq 800$	≥950	≥950	≥900
$800 < h \leq 1\,000$	≥1 125	≥1 195	≥1 015
NOTE Slot openings with $e > 180$ mm and square or round openings with $e > 240$ mm will allow access for the whole body.			

Bibliography

[1] ISO 7250 (all parts), *Basic human body measurements for technological design*

[2] ISO 13732-1, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces*

[3] ISO 13855, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

[4] ISO 14119, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

[5] ISO 14120, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

[6] ISO/TR 14121-2:2012, *Safety of machinery — Risk assessment — Part 2: Practical guidance and examples of methods*

[7] ISO 14738, *Safety of machinery — Anthropometric requirements for the design of workstations at machinery*

[8] ISO/TR 20218-2, *Robotics — Safety design for industrial robot systems — Part 2: Manual load/unload stations*

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