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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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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 13857 was prepared by Technical Committee ISO/TC 199, *Safety of machinery*.

This first edition of ISO 13857 cancels and replaces ISO 13852:1996 and ISO 13853:1998, of which it constitutes a technical revision. Annex A, giving guidance on how to use Tables 1 and 2 with intermediate values, has been added, and the former Annex A of ISO 13853 has become Annex B.

Introduction

This document is a type B standard as stated in ISO 12100-1.

The provisions 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 provisions of that standard, the provisions of that type C standard take precedence over the provisions of this type B standard.

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 have 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 could 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 International Standard 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 4.3).

This International Standard 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   Data for preventing lower limb access for children is not considered.

The distances apply when adequate safety can be achieved by distance alone. Because safety distances depend on size, there will be some people of extreme dimensions who will be able to reach hazard zones even when the requirements of this International Standard are complied with.

NOTE 2   These safety distances will not provide sufficient protection against certain hazards, for example, radiation and emission of substances. For such hazards, additional or other measures need to be taken.

The clauses of the International Standard covering lower limbs apply when access by the upper limbs 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 3   This International Standard is not intended to provide measures against reaching a hazard zone by climbing over.

2 Normative references

The following referenced documents are indispensable for the application 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 12100-1, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

3   Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100-1 and the following apply.

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
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 access by upper and lower limbs

4.1   General

4.1.1   Assumptions

The safety distances in this International Standard 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;

⸺ persons may force parts of the body over protective structures or through openings in an attempt to reach the hazard zone;

⸺ the reference plane is a level at which persons would normally stand, but is not necessarily the floor (e.g. a working platform could be the reference plane);

⸺ 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

Before determining the safety distance that prevents people from reaching hazard zones it is necessary to decide whether to use values for high or low risk. Thus a risk assessment (see ISO 12100-1 and ISO 14121-1) shall be conducted. The risk assessment shall be based on the probability of occurrence of an injury and the foreseeable severity of that injury. An analysis of the technical and human elements on which the risk assessment is dependent is essential to achieving the appropriate selection of data from this International Standard. The risk assessment shall take into account all accesses. Where several tables are used, the most restricting values shall be taken (see examples in Annex A).

NOTE 1   Aspects of frequency, duration, energy, speed and shape of contact surface need to be taken into account when establishing the risk of injury (see ISO 14121-1).

Where there is a low risk, at least the values in Table 1 shall be used (see 4.2.2.1.1).

Where the risk is not low, Table 2, the high risk table, shall be used (see 4.2.2.1.2).

NOTE 2   Only risks arising from hazards such as friction or abrasion, where long-term or irreversible damage to the body is not foreseeable, can lead to low risks.

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.

If the requirements of this International Standard cannot be complied with, then other safety measures shall be used.

4.2   Safety distances to prevent access by upper limbs

4.2.1   Reaching upwards

4.2.1.1   Figure 1 shows the safety distance for reaching upwards.

4.2.1.2   If there is a low risk from the hazard zone, then the height of the hazard zone, h, shall be 2 500 mm or more.

4.2.1.3   If there is a high risk (see 4.1.2) from the hazard zone, then the height of the hazard zone, h, shall be 2 700 mm or more.
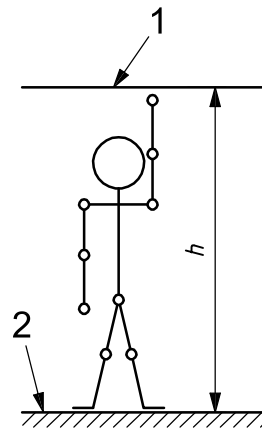
Key

1   hazard zone
2   reference plane
h height of hazard zone

Figure 1 — Reaching upwards

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4.2.2 Reaching over protective structures

Figure 2 shows the safety distance for reaching over a protective structure.
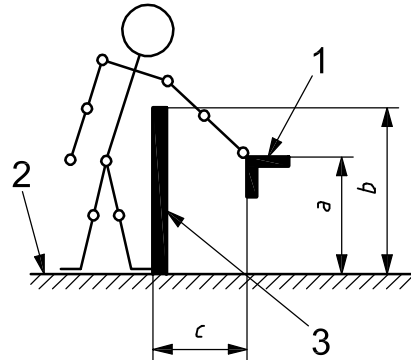
Key

a	height of hazard zone	1	hazard zone (nearest point)
b	height of protective structure	2	reference plane
c	horizontal safety distance to hazard zone	3	protective structure

Figure 2 — Reaching over protective structure

4.2.2.1 Values

4.2.2.1.1 The values given in Table 1 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. If there is a low risk (see 4.1.2) from a hazard zone, the values given in Table 1 shall be used as minimum values.

There shall be no interpolation of the values given in Table 1. Consequently, when the known values of a, b or c are between two values in Table 1, the greater safety distance or higher protective structure or change in the height (higher or lower) of the hazard zone shall be used.

Annex A gives examples of the use of Tables 1 and 2.

Table 1 — Reaching over protective structures — Low risk

Dimensions in millimetres

Height of hazard zone [b] a	Height of protective structure [a] b								
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500
	Horizontal safety distance to hazard zone, c								
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.

[b] For hazard zones above 2 500 mm, refer to 4.2.1.

4.2.2.1.2 The values given in Table 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. If there is a high risk (see 4.1.2) from a hazard zone, then the values given in Table 2 shall be used.

There shall be no interpolation of the values given in Table 2. Consequently, when the known values of a, b or c are between two values in Table 2, the greater safety distance or higher protective structure or change in the height (higher or lower) of the hazard zone shall be used.

Annex A gives examples of the use of Tables 1 and 2.

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Table 2 — Reaching over protective structures — High risk

Dimension in millimetres

Height of hazard zone [c] a	Height of protective structure [a, b] b									
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500	2 700
	Horizontal safety distance to hazard zone, c									
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]   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 safety measures.

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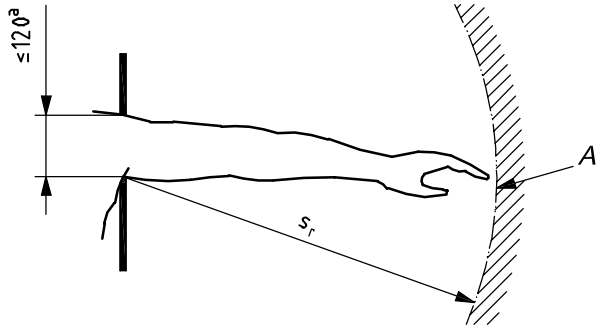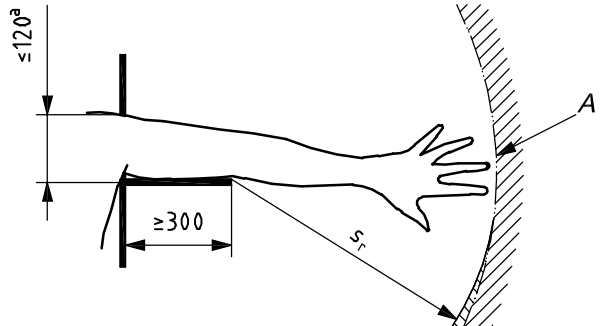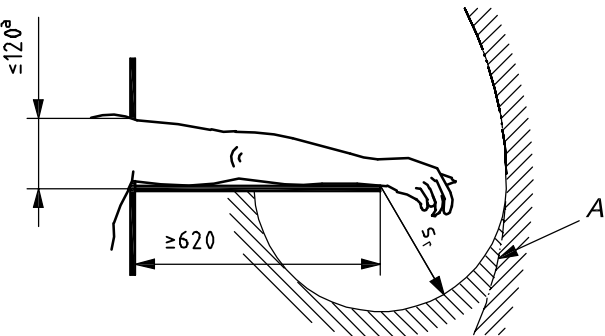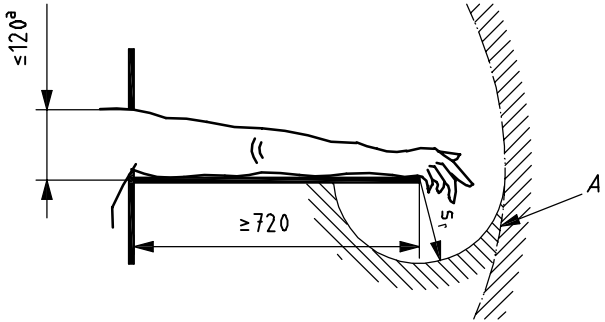
4.2.3   Reaching around

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 (see Table 4) may be used when the obstacle limiting the movement is at least 300 mm long.

Table 3 — Reaching around with limitation of movement

Limitation of movement	Safety distance, s_r	Illustration
Limitation of movement only at shoulder and armpit	$\geqslant 850$	≤120[a] ... s_r ... A
Arm supported up to elbow	$\geqslant 550$	≤120[a] ... ≥300 ... s_r ... A
Arm supported up to wrist	$\geqslant 230$	≤120[a] ... ≥620 ... s_r ... A
Arm and hand supported up to knuckle joint	$\geqslant 130$	≤120[a] ... ≥720 ... s_r ... A
A range of movement of arm		
s_r radial safety distance		
[a] This is either the diameter of a round opening, or the side of a square opening, or the width of a 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 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 > 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, s_r		
			Slot	Square	Round
Fingertip		$e \leqslant 4$	$\geqslant 2$	$\geqslant 2$	$\geqslant 2$
		$4 < e \leqslant 6$	$\geqslant 10$	$\geqslant 5$	$\geqslant 5$
Finger up to knuckle joint		$6 < e \leqslant 8$	$\geqslant 20$	$\geqslant 15$	$\geqslant 5$
		$8 < e \leqslant 10$	$\geqslant 80$	$\geqslant 25$	$\geqslant 20$
		$10 < e \leqslant 12$	$\geqslant 100$	$\geqslant 80$	$\geqslant 80$
		$12 < e \leqslant 20$	$\geqslant 120$	$\geqslant 120$	$\geqslant 120$
Hand		$20 < e \leqslant 30$	$\geqslant 850$ [a]	$\geqslant 120$	$\geqslant 120$
Arm up to junction with shoulder		$30 < e \leqslant 40$	$\geqslant 850$	$\geqslant 200$	$\geqslant 120$
		$40 < e \leqslant 120$	$\geqslant 850$	$\geqslant 850$	$\geqslant 850$
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 $\leqslant 65$ mm, the thumb will act as a stop and the safety distance can be reduced to 200 mm.					

4.2.4.2 Regular openings for 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 (5th percentile stature of 3 year olds is approximately 900 mm).
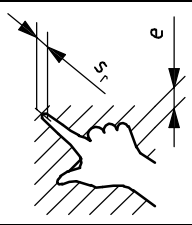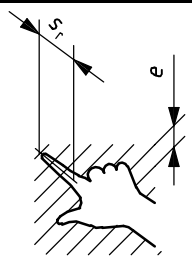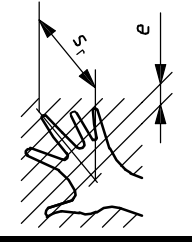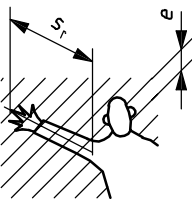
The dimensions of openings, e, correspond to the side of a square opening, the diameter of a round opening and the narrowest dimension of a slot opening.

For openings > 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 International Standard.

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

Dimensions in millimetres

Part of body	Illustration	Opening	Safety distance, s_r		
			Slot	**Square**	**Round**
Fingertip		$e \leqslant 4$	$\geqslant 2$	$\geqslant 2$	$\geqslant 2$
		$4 < e \leqslant 6$	$\geqslant 20$	$\geqslant 10$	$\geqslant 10$
Finger up to knuckle joint		$6 < e \leqslant 8$	$\geqslant 40$	$\geqslant 30$	$\geqslant 20$
		$8 < e \leqslant 10$	$\geqslant 80$	$\geqslant 60$	$\geqslant 60$
		$10 < e \leqslant 12$	$\geqslant 100$	$\geqslant 80$	$\geqslant 80$
Hand		$12 < e \leqslant 20$	$\geqslant 900$ [a]	$\geqslant 120$	$\geqslant 120$
Arm up to junction with shoulder		$20 < e \leqslant 30$	$\geqslant 900$	$\geqslant 550$	$\geqslant 120$
		$30 < e \leqslant 100$	$\geqslant 900$	$\geqslant 900$	$\geqslant 900$
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 $\leqslant 40$ mm, the thumb will act as a stop and the safety distance can 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 3 b)].

b) Select the corresponding three distances according to either Table 4 or Table 5.

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

a)   **b)**
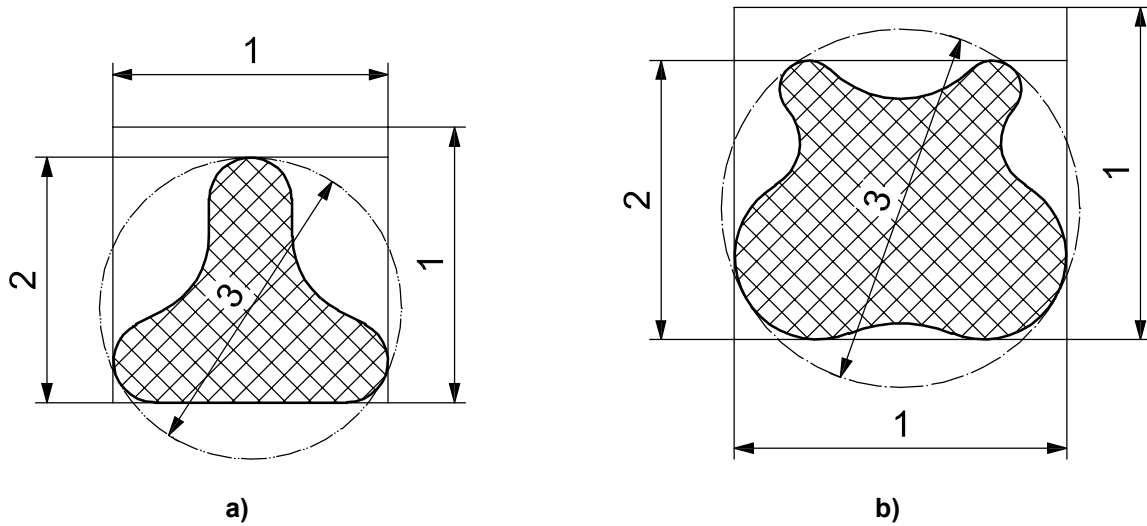
Key

1   side
2   width
3   diameter

Figure 3 — Openings of irregular shape

4.2.5 Effect of additional protective structures on safety distances

In Tables 1 to 5 the protective structures referred to are located in one plane. It should be borne in mind that 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 may be achieved are shown in Tables 3 and 6.

Protective structures and surfaces upon 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, 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.	$s_{r1} \geqslant 230$ $s_{r2} \geqslant 550$ $s_{r3} \geqslant 850$	
Limitation of movement at shoulder and armpit: one separate protective structure, which permits movement from the fingers up to the knuckle joint.	$s_{r3} \geqslant 850$ $s_{r4} \geqslant 130$	
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 not foreseeable that the upper limbs can have access to the opening then it is permissible to use the values given in Table 7 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, s_r	
			Slot	**Square or round**
Toe tip		$e \leqslant 5$	0	0
		$5 < e \leqslant 15$	$\geqslant 10$	0
Toe		$15 < e \leqslant 35$	$\geqslant 80$ [a]	$\geqslant 25$
Foot		$35 < e \leqslant 60$	$\geqslant 180$	$\geqslant 80$
		$60 < e \leqslant 80$	$\geqslant 650$ [b]	$\geqslant 180$
Leg (toe tip to knee)		$80 < e \leqslant 95$	$\geqslant 1\ 100$ [c]	$\geqslant 650$ [b]
Leg (toe tip to crotch)		$95 < e \leqslant 180$	$\geqslant 1\ 100$ [c]	$\geqslant 1\ 100$ [c]
		$180 < e \leqslant 240$	Not admissible	$\geqslant 1\ 100$ [c]

[a] If the length of the slot opening is $\leqslant 75$ mm, the distance can be reduced to $\geqslant 50$ 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 (see also Clause 1, final paragraph).

In some cases (e.g. mobile agricultural machines designed to move over uneven ground), the safety distances given in this International Standard 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 distances given in Annex B can be used.
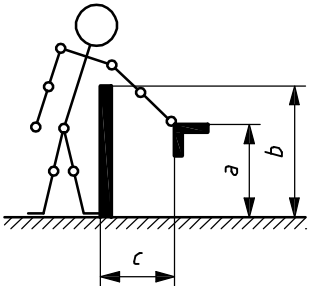
Annex A
(informative)

Use of Tables 1 and 2 with intermediate values

The following examples explain the use of Tables 1 and 2 when values other than those given in the tables themselves will be used. For the examples, Table 2 is used.

EXAMPLE 1   To determine the height, b, of the protective structure with known values for a and c.

If the height, a, of the hazard zone is 1 500 mm and its horizontal distance, c, from the proposed protective structure is 800 mm, then, using Table 2, the height, b, of the protective structure can be determined as follows. The value a = 1 600 mm (see ①) is selected as being closest to 1 500 mm while having safety distances in that row that are greater (safer) than a = 1 400. The value c = 800 mm (see ② is selected. The corresponding value for the height, b, of the protective structure is 1 800 mm (see ③).

Dimensions in millimetres

Height of hazard zone [c] a	Height of protective structure [a, b] b									
	1 000	1 200	1 400	1 600	1 800 ③	2 000	2 200	2 400	2 500	2 700
	Horizontal safety distance to hazard zone, c									
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	1 500	1 400	1 100	900	800 ②	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				
800	1 500	1 300	900	600	0	0				
600	1 400	1 300	800	0	0	0				
400	1 400	1 200	400	0	0	0				
200	1 200	900	0	0	0	0				
0	1 100	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 safety measures.

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

Figure A.1 — Example 1 — Table 2
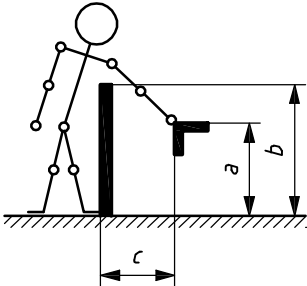
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EXAMPLE 2   To determine the horizontal safety distance, c, from the hazard zone with known values for a and b.

If the height, b, of the protective structure is 1 300 mm and the height, a, of the hazard zone is 2 300 mm, then, using Table 2, the horizontal safety distance, c, from the hazard zone can be determined as follows.

The value b = 1 200 mm (see ①) is selected as being closest to 1 300 mm while having safety distances in that column that are greater (safer) than b = 1 400. The value a = 2 200 (see ②) is selected as being closest to 2 300 mm while having safety distances that are greater (safer) than for a = 2 400. The corresponding value for c is 1 200 mm (see ③).

See Footnote b.

Dimensions in millimetres

Height of hazard zone [c] a	Height of protective structure [a, b] b									
	1 000	1 200 ①	1 400	1 600	1 800	2 000	2 200	2 400	2 500	2 700
	Horizontal safety distance to hazard zone, c									
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 ②	1 300	1 200 ③	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				
800	1 500	1 300	900	600	0	0				
600	1 400	1 300	800	0	0	0				
400	1 400	1 200	400	0	0	0				
200	1 200	900	0	0	0	0				
0	1 100	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 safety measures.

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

Figure A.2 — Example 2 — Table 2

EXAMPLE 3   To determine the height, a, of the hazard zone with known values for b and c.

If the height, b, of the protective structure is 1 700 mm and the horizontal safety distance, c, from the hazard zone is 850 mm, then, using Table 2, the height, a, of the hazard zone can be determined as follows. The value b = 1 600 mm (see ①) is selected as being closest to 1 700 mm while having safety distances in that column that are greater (safer) than b = 1 800. The value c = 900 (see ②) is selected as being closest to (and greater than) 850 mm, and several possible positions are highlighted in Figure A.3. The corresponding value for a is 2 400 mm or more, or 1 000 mm or less (see ③). Hazard zones over 1 000 mm and below 2 400 mm will not be protected by the position of this protective structure.

Dimensions in millimetres

Height of hazard zone [c] a	Height of protective structure [a, b] b									
	1 000	1 200	1 400	1 600 ①	1 800	2 000	2 200	2 400	2 500	2 700
	Horizontal safety distance to hazard zone, c									
2 700 ③	0	0	0	0	0	0	0	0	0	0
2 600 ③	900	800	700	600	600	500	400	300	100	0
2 400 ③	1 100	1 000	900	800	700	600	400	300	100	0
				900 ②	800	600	400	300	0	0
				900 ②	800	600	400	0	0	0
				900 ②	800	600	0	0	0	0
				900 ②	800	500	0	0	0	0
				900 ②	800	0	0	0	0	0
				900 ②	700	0	0	0	0	0
1 000 ③	1 500	1 400	1 000	800	0	0				
800 ③	1 500	1 300	900	600	0	0				
600 ③	1 400	1 300	800	0	0	0				
400 ③	1 400	1 200	400	0	0	0				
200 ③	1 200	900	0	0	0	0				
0 ③	1 100	500	0	0	0	0				

(Row group labels: rows 2 700 ③, 2 600 ③, 2 400 ③ = ^{d}; gray middle rows = ^{e}; rows 1 000 ③ … 0 ③ = ^{d})

[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 safety 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**

EXAMPLE 4   For a high risk: if height, a, of the hazard zone equals 1 800 mm, and if the protective structure is a grid of height b = 2 000 mm (Table 2), the safety distance will be c = 600 mm. The grid has square openings (50 mm × 50 mm), the safety distance as proposed by Table 4 gives s_r = 850 mm. This larger safety distance should be taken.

Annex B
(informative)

Distances to impede free access by lower limbs

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.

NOTE   These distances are not safety distances and additional precautions could be required to restrict access.

Case 1   Case 2   Case 3
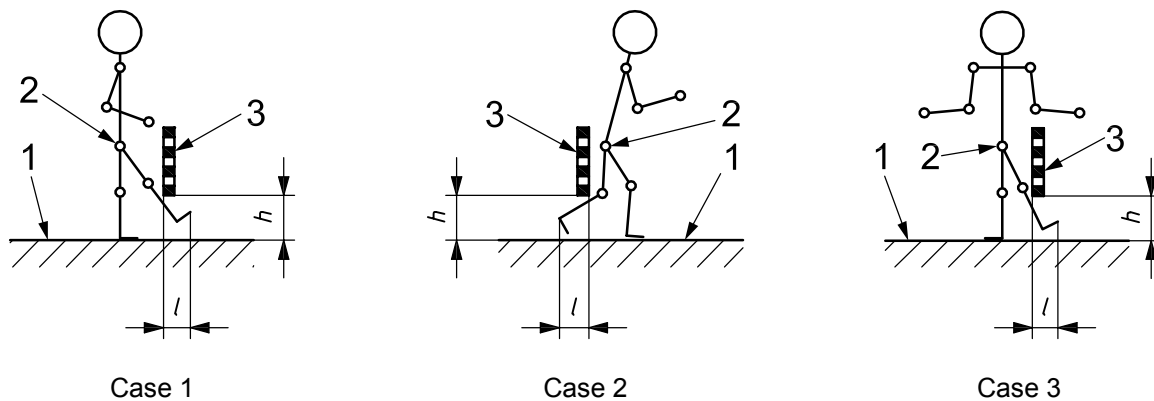
Key

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

Figure B.1 — Impeding free movement under protective structures

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
$h \leqslant 200$	$\geqslant 340$	$\geqslant 665$	$\geqslant 290$
$200 < h \leqslant 400$	$\geqslant 550$	$\geqslant 765$	$\geqslant 615$
$400 < h \leqslant 600$	$\geqslant 850$	$\geqslant 950$	$\geqslant 800$
$600 < h \leqslant 800$	$\geqslant 950$	$\geqslant 950$	$\geqslant 900$
$800 < h \leqslant 1\,000$	$\geqslant 1\,125$	$\geqslant 1\,195$	$\geqslant 1\,015$
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 13855, *Safety of machinery — Positioning of protective equipment with respect to the approach speeds of parts of the human body*

[2]   ISO 14121-1, *Safety of machinery — Risk assessment — Part 1: Principles*

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

[4]   EN 547-3, *Safety of machinery — Human body measurements — Part 3: Anthropometric data*

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