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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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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).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

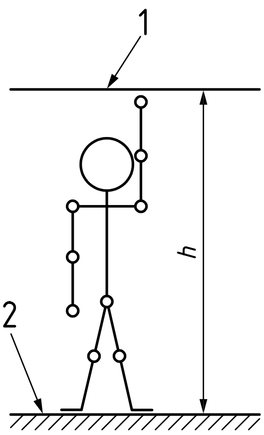
4.2.1.1 General

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

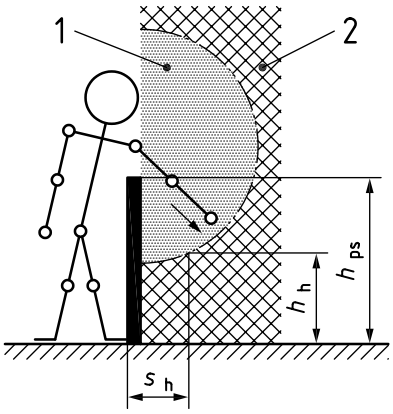
h height of hazard zone

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.