International Standard

ISO 13855

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

Sécurité des machines — Positionnement des moyens de protection par rapport à l'approche du corps humain

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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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This document was prepared by Technical Committee ISO/TC 199, *Safety of machinery*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 114, *Safety of machinery,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 13855:2010), which has been technically revised.

The main changes are as follows:

— document expanded for applicable cases and partly revised to be state-of-the-art;

— figures revised for clarity and better understanding;

— scope wording improved to better focus on the document’s content;

— Clause 4 improved for better explanation of the methodology;

— document restructured from Clause 5;

— calculation of reaching distances separated for those applications which are initiating a safety function and those which are not initiating a safety function;

— dynamic separation distance calculation included for mobile applications with unknown human direction of approach;

— improvements for better distinction of different paths of approach;

— requirements for single control devices (hand- and foot-operated) and interlocking guards added;

— annexes revised in order to match with the body text of this document;

— Annexes D to G added.

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.

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 type 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 control devices, 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.

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).

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 in 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 type-C standard, the following applies: if the requirements of that type-C standard deviate from the requirements in type-B standards, the requirements of that type-C standard take precedence over the provisions of other standards.

Correct positioning of protective devices is critical for them to be effective. In deciding on these positions, a number of aspects are taken into account, such as:

— the necessity of a risk assessment according to ISO 12100;

— the practical experience in the use of the machine;

— the time taken to achieve the intended risk reduction following operation of the safeguard, for example, to stop the machine;

— the bio-mechanical and anthropometric data;

— any intrusion by a part of the body towards the hazard zone until the protective device is actuated;

— the path taken by the body part when moving from the detection zone towards the hazard zone;

— the possible presence of a person between the safeguard and the hazard zone;

— the possibility of undetected access to the hazard zone.

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

1 Scope

This document specifies requirements for the positioning and dimensioning of safeguards with respect to the approach of the human body or its parts towards hazard(s) within the intended span-of-control as follows:

— the position and dimension of the detection zone(s) of ESPE and pressure-sensitive mats and pressure-sensitive floors;

— the position of two-hand control devices and single control devices;

— the position of interlocking guards.

This document also specifies requirements for the positioning of safety-related manual control devices (SRMCD) with respect to the approach of the human body or its parts from within the safeguard space relative to:

— the position and dimension of the detection zone(s) of ESPE and pressure-sensitive mats and pressure-sensitive floors; and

— the position and dimension of interlocking guards.

When evaluating the ability of the human body or its parts to access SRMCD from within the intended safeguarded space, the requirements of this document are also applicable to determine the dimensions of safeguard(s). Approaches such as running, jumping or falling, are not considered in this document.

NOTE 1 The values for approach speeds (walking speed and upper limb movement) in this document are time tested and proven in practical experience.

NOTE 2 Other types of approach can result in approach speeds that are higher or lower than those defined in this document.

This document applies to safeguards used on machinery for the protection of persons 14 years and older.

Safeguards considered in this document include:

a) electro-sensitive protective equipment (ESPE) such as:

   — active opto-electronic protective devices (AOPDs) (see IEC 61496-2);

   — AOPDs responsive to diffuse reflection that have one or more detection zone(s) specified in two dimensions (AOPDDRs-2D) (see IEC 61496-3);

   — AOPDs responsive to diffuse reflection that have one or more detection zone(s) specified in three dimensions (AOPDDRs-3D) (see IEC 61496-3);

   — vision based protective devices using reference pattern techniques (VBPDPP) (see IEC/TS 61496-4-2);

   — vision based protective devices using stereo vision techniques (VBPDST) (see IEC/TS 61496-4-3);

b) pressure-sensitive mats and pressure-sensitive floors (see ISO 13856-1);

c) two-hand control devices (see ISO 13851);

d) single control devices;

e) interlocking guards (see ISO 14120).

This document is not applicable to:

— safeguards (e.g. pendant two-hand control devices) that can be manually moved, without using tools, nearer to the hazard zone than the separation distance;

— protection against the risks from hazards arising from emissions (e.g. the ejection of solid or fluid materials, radiation, electric arcs, heat, noise, fumes, gases);

— protection against the risks arising from failure of mechanical parts of the machine or gravity falls.

The separation distances derived from this document do not apply to safeguards used solely for presence sensing function.

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*

ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

3 Terms, definitions, symbols and abbreviated terms

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

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

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

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

3.1 Terms and definitions

3.1.1
overall system response time
DEPRECATED: overall system stopping performance
T
time interval between the actuation of the sensing function and achieving the intended risk reduction

Note 1 to entry: This time typically includes tolerance factors (e.g. due to uncertainty of measurements, consideration of environmental factor such as friction).

3.1.2
response time
t_x
maximum time between the occurrence of the event leading to the actuation of the safeguarding device and the achieving of its intended state

Note 1 to entry: This time typically includes tolerance factors (e.g. due to uncertainty of measurements, consideration of environmental factor such as friction).

[SOURCE: IEC 61496-1:2020, 3.21, modified — The wording “output signal switching devices OSSD achieving the OFF state” has been replaced by “achieving of its intended state”. The wording “sensing” has been

replaced by “safeguarding”. The original Notes 1, 2 and 3 to entry have been deleted and a new Note 1 to entry has been added.]

3.1.3
detection capability
d
ability to detect the specified test piece(s) in the specified detection zone

[SOURCE: IEC 61496-3:2018, 3.3, modified — Notes to entry and references have been removed.]

3.1.4
effective detection capability
d_e
sensing function parameter limit set by the integrator of the device that will cause its actuation

3.1.5
electro-sensitive protective equipment
ESPE
assembly of devices and/or components working together for protective tripping or presence-sensing purposes and comprising as a minimum:

— a sensing device;

— controlling/monitoring devices;

— output signal switching devices and/or a safety-related data interface.

Note 1 to entry: ESPEs refer only to non-contact sensing devices.

[SOURCE: IEC 61496-1:2020, 3.5, modified — The original Notes 1 and 2 to entry have been deleted and a new Note 1 to entry has been added.]

3.1.6
indirect approach
approach where the shortest path to the hazard zone is obstructed by a mechanical obstacle

Note 1 to entry: The hazard zone can only be approached by going around the obstacle.

3.1.7
detection zone
zone within which a specified test piece is detected by the sensitive protective equipment

Note 1 to entry: The detection zone can also be a point, line or plane.

Note 2 to entry: ISO 13856-1 uses the term “effective sensing area” when describing pressure-sensitive mats and pressure-sensitive floors. In this document, the terms “detection zone” and “effective sensing area” are used synonymously.

[SOURCE: IEC 61496-1:2020, 3.4, modified — “electro-” has been removed before “sensitive protective equipment” and Note 2 to entry has been added.]

3.1.8
separation distance
DEPRECATED: minimum distance
S
minimum distance required between the actuation position of the protective devices and the hazard zone to prevent the human body or its parts from reaching the hazard zone before the cessation of the hazardous machine function

Note 1 to entry: Examples of protective devices are found in ISO 12100:2010, 3.28.

Note 2 to entry: The separation distance is always the shortest distance between the detection zone and the hazard zone, independent from the entry point of the person through the detection zone.

3.1.9
reaching distance associated with a protective device
DEPRECATED: intrusion distance
D_{DS}
distance that a part of the body can move through or past the safeguard prior to actuation of the safeguard, either towards the hazard zone or towards a *safety-related manual control device (SRMCD)* (3.1.14) from within the safeguarded space

3.1.10
reference plane
level at which persons would normally stand during the use of the machine or access to the hazard zone or *safety-related manual control device (SRMCD)* (3.1.14)

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

[SOURCE: ISO 13857:2019, 3.2, modified — "or safety-related manual control device (SRMCD)" and its definition reference "(3.1.14)" have been added.]

3.1.11
span-of-control
predetermined portion of the machinery under control of a specific device or safety function

Note 1 to entry: A protective device can initiate a stop function of a machine or a portion of a machine.

3.1.12
safeguarded space
area or volume enclosing a hazard zone(s) where guards and/or protective devices are intended to protect persons

3.1.13
whole body access
situation where a person can be completely inside a *safeguarded space* (3.1.12)

Note 1 to entry: The term *whole body access* is used differently in other documents to specify the opening size for ergonomic access.

3.1.14
safety-related manual control device
SRMCD
control device which requires deliberate human action and whose actuation can result in an immediate increase of the risk(s)

Note 1 to entry: Examples include actuating devices such as pushbuttons, selector switches, or foot pedals designed for functions such as reset, start/restart, unconditional guard unlocking or hold-to-run control (e.g. jog, inching).

3.1.15
single control device
control device which requires actuation by either a single hand or foot in order to initiate hazardous machine functions, thus providing a protective measure only for the person who actuates it

Note 1 to entry: Examples include actuating devices such as pushbuttons or foot pedals designed to control hazardous machine functions only during actuation, or incremental movement upon each actuation.

3.1.16
industrial environment
workplace where the public is restricted from access or not reasonably expected to be present for the intended tasks and machine applications

3.1.17
dynamic hazard
source of harm that changes its location either by the movement of parts of the machine or the machine itself

Note 1 to entry: The dimensions and shape of the hazard zone associated with the dynamic hazard result from the range of the moving parts of the machine (operating space) or the moving range of the machine itself.

3.1.18
stopping distance
distance travelled by the hazard, hazardous point or part of the machine or the machine itself, from the initiation of the safety function until the intended risk reduction is achieved

Note 1 to entry: Situations are possible in which the intended risk reduction is achieved even if the hazardous machine parts are still moving.

Note 2 to entry: Hazards can also travel even if machine parts do not (e.g. a rotating laser beam).

3.1.19
speed and separation control
SSC
safety function that achieves the intended risk reduction by maintaining the separation distance by changing the speed and or the trajectory of the machine or its parts relative to the detected position of parts of the human body

Note 1 to entry: The separation distance depends on several parameters, e.g. the speed and approach direction of the parts of the human body; the speed, direction, and orientation of moving hazard zones; the *effective detection capability* (3.1.4) of the protective devices; the *response time* (3.1.2) of the safety-related parts of the control system involved.

3.1.20
safety-related part of a control system
SRP/CS
part of a control system that performs a safety function, starting from a safety-related input(s) to generating a safety-related output(s)

[SOURCE: ISO 13849-1:2023, 3.1.1, modified — Note 1 to entry has been deleted.]

3.2 Symbols and abbreviated terms

3.2.1 Symbols

See Annex E.

3.2.2 Abbreviated terms

AOPD	active opto-electronic protective device
AOPDDR	active opto-electronic protective device responsive to diffuse reflection (e.g. laser scanner)
VBPD	vision-based protective device
ESPE	electro-sensitive protective equipment
SPE	sensitive protective equipment (see ISO 12100:2010, 3.28.5)
SRMCD	safety-related manual control device
SRP/CS	safety-related part of a control system
SCS	safety-related control system (see IEC 62061:2021, 3.2.3)

SSC speed and separation control

4 Methodology

4.1 General

Safeguards shall be configured and positioned such that access to the hazard zone to be safeguarded shall be detected in time to achieve the intended risk reduction.

In an application using an SPE where two or more hazard zones are present, the separation distance for each hazard zone shall be calculated. Where necessary, additional safeguards shall be provided to prevent circumventing the detection zone of the safeguard (see Figure 12).

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

a) Determine if the considered safeguard is appropriate to achieve the intended risk reduction for the identified hazard (as specified in ISO 12100).

NOTE 1 Intended risk reduction can include detection of access toward a hazard zone, as well as reaching toward an SRMCD from within the safeguarded space.

b) If a type-C standard exists for the machinery, select one of the specified types of safeguards from that standard, and then use the distance specified by that standard. If no type-C standard exists, continue to Step c).

If there is no type-C standard, use the formulae in this document to calculate the separation distance for the safeguard selected.

NOTE 2 Type-C standards can specify minimum distances (referred to as separation distance in this document) directly or by reference to this document.

c) Confirm that the application of the safeguard is within the assumptions identified within this document.

d) Identify the hazard zones associated with the safeguard.

e) Determine the separation distances between the safeguard and its hazard zone(s). Then select the largest (most protective) of the separation distances. Consideration shall be given to possible circumvention of the safeguard (e.g. reaching over, through, around or under).

f) Determine if whole body access is possible. If whole body access is possible, apply additional protective measures to prevent unexpected reset/restart with person(s) inside the safeguarded space according to step g). If whole body access is not possible or is not applicable (e.g. two-hand control device), continue to step i).

NOTE 3 ISO 12895 is under preparation specifically for the topic of whole body access and its derived risks.

g) When no additional detection of persons within the safeguarded space is used, SRMCD(s) shall be identified and step h) applies. Where additional detection of persons within the safeguarded space is used for those additional detection means, the separation distances of this document do not apply, continue to step i).

h) Determine the reaching distances for each possible approach (over, through, around or under) from the safeguard toward the SRMCD(s). Then select the largest (most protective) of the reaching distances such that circumvention is prevented.

i) Determine if the separation and reaching distances are feasible for the application. If feasible, the process is completed, otherwise a design modification is required. Where this modification only applies to the considered safeguard, the process shall be repeated starting at step e). Where the modification consists of the application of a different safeguard or a modification of the machinery design (including additional safeguards), the process shall be repeated starting at step a).