INTERNATIONAL STANDARD

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

Sécurité des machines — Positionnement des moyens de protection par rapport à la vitesse d'approche des parties du corps

Reference number
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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 13855 was prepared by Technical Committee ISO/TC 199, *Safety of machinery*.

This second edition cancels and replaces the first edition (ISO 13855:2002), which has been technically revised.

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-B standard as stated in ISO 12100-1.

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.

The effectiveness of certain types of safeguard described in this International Standard to minimize risk relies, in part, on the relevant parts of that equipment being correctly positioned in relation to the hazard zone. In deciding on these positions, a number of aspects are taken into account, such as:

— the necessity of a risk assessment according to ISO 14121-1;

— the practical experience in the use of the machine;

— the overall system stopping performance;

— the time taken to ensure the safe condition of the machine 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 speeds of parts of the human body

1 Scope

This International Standard establishes the positioning of safeguards with respect to the approach speeds of parts of the human body.

It specifies parameters based on values for approach speeds of parts of the human body and provides a methodology to determine the minimum distances to a hazard zone from the detection zone or from actuating devices of safeguards.

The values for approach speeds (walking speed and upper limb movement) in this International Standard are time tested and proven in practical experience. This International Standard gives guidance for typical approaches. Other types of approach, for example running, jumping or falling, are not considered in this International Standard.

NOTE 1 Other types of approach can result in approach speeds that are higher or lower than those defined in this International Standard.

Safeguards considered in this International Standard include:

a) electro-sensitive protective equipment [see IEC 61496 (all parts)], including:

— light curtains and light grids (AOPDs);

— laser scanners (AOPDDRs) and two-dimensional vision systems;

b) pressure-sensitive protective equipment (see ISO 13856-1, ISO 13856-2 and ISO 13856-3), especially pressure-sensitive mats;

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

d) interlocking guards without guard locking (see ISO 14119).

This International Standard specifies minimum distances from the detection zone, plane, line, point or interlocking guard access point to the hazard zone for hazards caused by the machine (e.g. crushing, shearing, drawing-in).

Protection against the risks from hazards arising from the ejection of solid or fluid materials, emissions, radiation and electricity are not covered by this International Standard.

NOTE 2 Anthropometric data from the 5th to the 95th percentile of persons of 14 years and older were used in the determination of the intrusion distance value "C" in the equations.

NOTE 3 The data in this International Standard are based on experience of industrial application; it is the responsibility of the designer to take this into account when using this International Standard for non-industrial applications.

NOTE 4 Data specifically for children have not been used in this International Standard. Until specific data are available for approach speeds for children, it is the responsibility of the designer to calculate the distances taking into account that children might be quicker and that a child might be detected later.

The International Standard is not applicable to safeguards (e.g. pendant two-hand control devices) that can be moved, without using tools, nearer to the hazard zone than the calculated minimum distance.

The minimum distances derived from this International Standard are not applicable to safeguards used to detect the presence of persons within an area already protected by a guard or electro-sensitive protective equipment.

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*

ISO 13857:2008, *Safety of machinery — Safety distances to prevent hazard zones being reached by the upper and lower limbs*

ISO 14121-1:2007, *Safety of machinery — Risk assessment — Part 1: Principles*

IEC 61496-1:2004, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

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

3.1.1
actuation
⟨safeguards⟩ physical initiation of the safeguard when it detects a body or parts of a body

3.1.2
overall system stopping performance
T
time interval between the actuation of the sensing function and the termination of the hazardous machine function

NOTE Adapted from IEC 61496-1:2004.

3.1.3
detection capability
d
sensing function parameter limit specified by the supplier that will cause actuation of the protective equipment

[IEC/TS 62046:2008, 3.1.4]

3.1.4
electro-sensitive protective equipment
ESPE
assembly of devices and/or components working together for protective tripping or presence-sensing purposes and comprising at a minimum:

— a sensing device,

— controlling/monitoring devices,

— output signal switching devices

[IEC 61496-1:2004, definition 3.5]

NOTE ESPEs refer only to non-contact sensing devices.

3.1.5
indirect approach
approach where the shortest path to the hazard zone is obstructed by a mechanical obstacle

NOTE The hazard zone can only be approached by going around the obstacle.

3.1.6
circumventing the detection zone
reaching the hazard zone without actuation of the protective device by passing over, under or to the side of the detection zone

3.1.7
termination of the hazardous machine function
condition achieved when the hazard parameters are reduced to a level which cannot cause physical injury or damage to health

NOTE See examples in Annex B.

3.1.8
detection zone
zone within which a specified test piece is detected by the protective equipment

NOTE 1 The detection zone may also be a point, line or plane.

NOTE 2 Adapted from IEC 61496-1:2004, definition 3.4.

3.1.9
minimum distance
S
calculated distance between the safeguard and the hazard zone necessary to prevent a person or part of a person reaching the hazard zone before the termination of the hazardous machine function

NOTE Different minimum distances may be calculated for different conditions or approaches, but the greatest of these minimum distances is used for selecting the position of the safeguard.

3.1.10
intrusion distance
C
distance that a part of the body (usually a hand) can move past the safeguard towards the hazard zone prior to actuation of the safeguard

3.2 Symbols and abbreviated terms

3.2.1 Symbols

Symbol	Term	Unit
T	overall system stopping performance	s
S	minimum distance	mm
C	intrusion distance	mm
t_1	reaction time of the protective device	s
t_2	stopping time of the machine	s
t_3	opening time to open the guard	s
K	approach speed parameter	mm/s
d	sensor detection capability	mm
H	height of detection zone above reference plane	mm
h	height of the step	mm
X	distance between the end of the detection zone and the hazard zone	mm
S_{RO}	minimum distance when reaching over	mm
S_{RT}	minimum distance when reaching through	mm
C_{RO}	intrusion distance to the hazard zone when reaching over	mm
C_{RT}	intrusion distance to the hazard zone when reaching through	mm
a	height of the hazard zone	mm
b	height of the safeguard (e.g. ESPE, protective structure)	mm
S^*	distance actually covered	mm
l_1; l_2; l_3	shortest distance around obstacles	mm
S_1; S_2; S_3	distance of l_1, projected on a horizontal plane distance of l_2, projected on a horizontal plane distance of l_3, projected on a horizontal plane	mm
e	opening size	mm
v	speed of the opening motion of the power-operated interlocking guard	mm/s

3.2.2 Abbreviated terms

AOPD Active opto-electronic protective device

AOPDDR Active opto-electronic protective device responsive to diffuse reflection (e.g. laser scanners)

VBPD Vision-based protective device

ESPE Electro-sensitive protective equipment

4 Methodology

Figure 1 provides a schematic representation of the methodology for determining the correct positioning of sensing or actuating devices of safeguards in accordance with this International Standard, which is as follows.

a) Identify the hazards and assess the risks (as specified in ISO 12100-1 and ISO 14121-1);

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

NOTE 1 Type-C standards specify minimum distances directly or by reference to this International Standard.

c) If there is no type-C standard, use the equations in this International Standard to calculate the minimum distance for the safeguard selected;

NOTE 2 For selection of the appropriate type of safeguard, see ISO 12100-2:2003, Clause 5, and IEC/TS 62046.

d) If it is possible to circumvent (go around) the detection zone, an additional calculation using the equations in 6.5 shall be made;

e) Where combinations of safeguards are used, a calculation of the minimum distance shall be made, taking into account each safeguard and possible circumventing;

f) Calculate the minimum distances for each possibility of reaching the hazard zone. Then select the most protective (greatest) of the minimum distances;

g) If possible, incorporate the distance(s) in the machine design, otherwise see step i);

h) Check that the installation of the safeguard does not allow access without detection. If undetected access is possible, redesign [step i)], otherwise go to step j);

i) Can parameters be modified or alternative safeguards be used? If neither is possible, additional safeguards shall be used;

j) Check whether the determined position allows persons to remain between the safeguard and the hazard zone without being detected. In this case, supplementary measures will be required depending on an additional risk assessment.

NOTE 3 An example of a supplementary measure is a manual reset switch positioned outside the hazard zone and the space between the safeguard and the hazard zone. Its position is selected to allow someone operating it to readily check that no one is within the hazard zone or in the space between the safeguard and the hazard zone. For the requirements of a manual reset function, see ISO 13849-1:2006, 5.2.2.

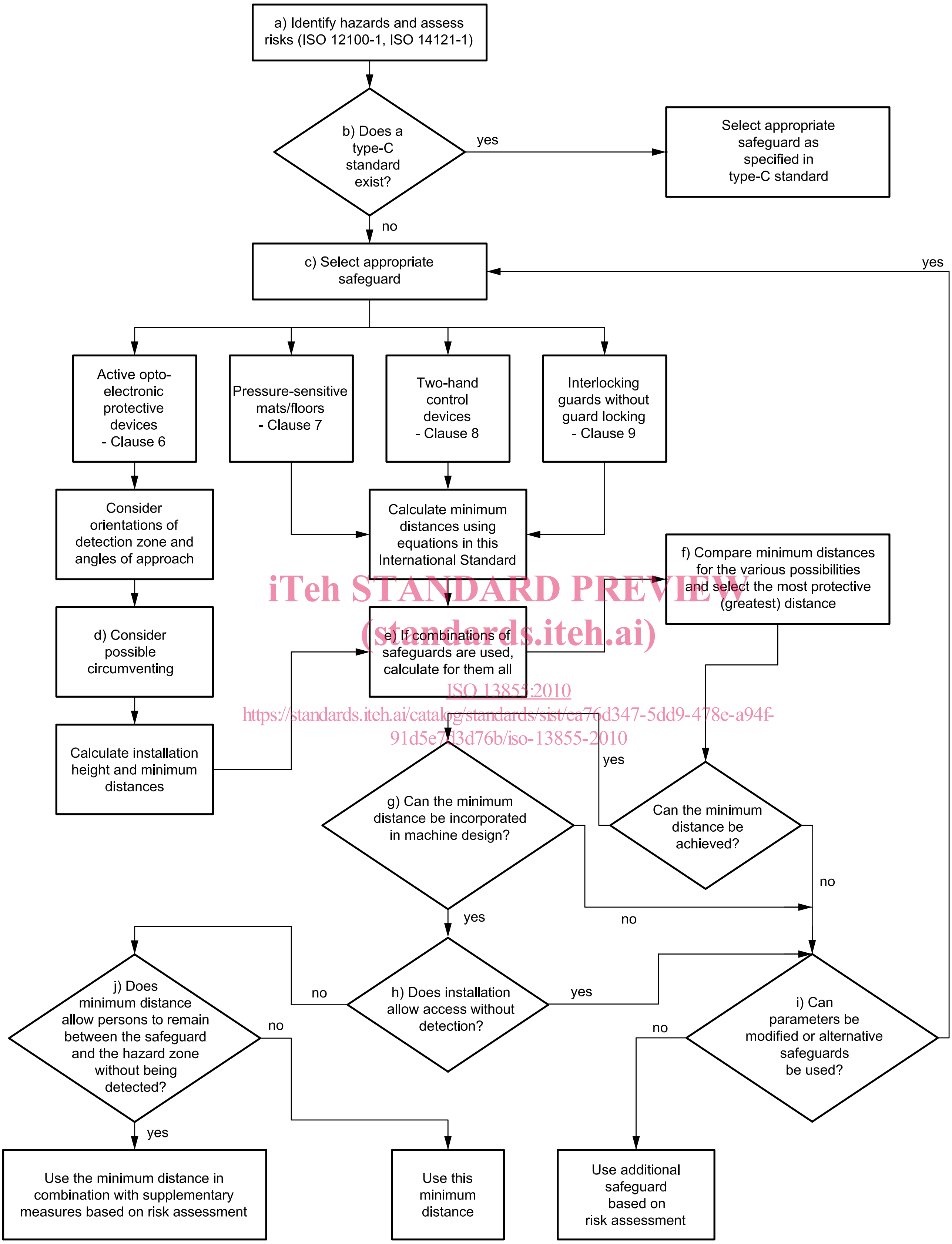


Figure 1 — Methodology

5 General equation for the calculation of the overall system stopping performance and minimum distances

5.1 Overall system stopping performance

The overall system stopping performance comprises at least two phases. The two phases are linked by Equation (1):

$$T = t_1 + t_2 \tag{1}$$

where

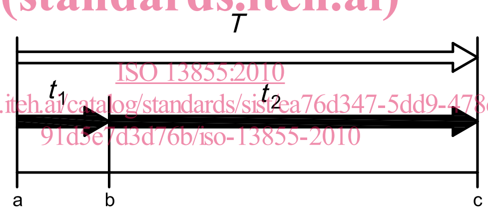
T is the overall system stopping performance;

t_1 is the maximum time between the occurrence of the actuation of the safeguard and the output signal achieving the OFF-state;

t_2 is the stopping time, which is the maximum time required to terminate the hazardous machine function after the output signal from the safeguard achieves the OFF-state. The response time of the control system of the machine shall be included in t_2.

t_1 and t_2 are influenced by various factors, e.g. temperature, switching time of valves, ageing of components.

t_1 and t_2 are illustrated in Figure 2. t_1 and t_2 are functions of the safeguard and the machine, respectively, and are determined by design and evaluated by measurement. The evaluation of these two values shall include the uncertainties resulting from the measurements, calculations and/or construction.



a Actuation of safeguard.

b Operation of safeguard (OFF signal generated).

c Termination of hazardous machine function (safe condition).

Figure 2 — Relationship between t_1 and t_2

The overall system stopping performance, T, is an essential characteristic for the location of the protective device. Any deviation of the stopping time of the machine, t_2, shall be taken into account during the estimation of T (see Annex D). Where the stopping time can deteriorate during the lifetime of the machine, technical or organizational measures should be taken to ensure the correct overall system stopping performance. These measures can be, for example:

— braking performance control devices;

— checks, the nature and the frequency of which should be defined in the user's manual.

NOTE There can be additional aspects to take into account, e.g.:

a) integrity of the protective function (safety in case of faults) (see ISO 13849-1, ISO 13849-2 and IEC 62061);

b) stopping performance monitoring (see, e.g. IEC/TS 62046);