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Robotics — Safety design for industrial robot systems —

Part 2: Manual load/unload stations

Robotique — Conception de sécurité pour les systèmes de robots industriels —

Partie 2: Stations de chargement/déchargement manuel

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 299, *Robotics*.

A list of all parts in the ISO 20218 series can be found on the ISO website.

This corrected version of ISO/TR 20218-2:2017 corrects the title of the document.

Introduction

The objective of a manual load/unload station is to allow an operator to interface directly with an industrial robot system, e.g. feed/remove material into and out of a robot cell. The layout of the robot cell is designed to provide a work area that is free of hazards and to lessen the motivation to circumvent or defeat the designed safeguarding.

This document supplements the requirements for industrial robot system safety specified in ISO 10218-2:2011, 5.10.6. It provides additional guidance for manual load/unload stations that are lower than 1 400 mm, to permit the work to be performed in an ergonomic manner while maintaining safety and providing guidance for an alternative method of impeding access to the robot cell. ISO 14738, ISO 6385 and ISO 10218-2:2011, Annex A, provide further information on potential ergonomic hazards

NOTE ISO 10218-2:2011, 5.10.6, specifies that the minimum height of a perimeter guard (distance guard) needs to be 1 400 mm. In cases where the results of the risk assessment determine that the guard cannot meet the height of 1 400 mm or more because of the design of a manual load/unload station, this document provides an alternative design which offers the same level of operator protection according to ISO 10218-2:2011.

Implementing ISO 10218-2 involves carrying out a comprehensive risk assessment, which is used to identify all hazards associated with the manual load/unload process. This document provides guidance on mitigation of the risks to the operator. The risk assessment needs to take account of foreseeable misuse, with mitigation provided.

Robotics — Safety design for industrial robot systems —

Part 2:
Manual load/unload stations

1 Scope

This document is applicable to robot systems for manual load/unload applications in which a hazard zone is safeguarded by preventing access to it. For this type of application, it is important to consider the need for both access restrictions to hazard zones and for ergonomically suitable work places.

This document supplements ISO 10218-2:2011 and provides additional information and guidance on reducing the risk of intrusion into the hazard zones in the design and safeguarding of manual load/unload installations.

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 10218-1:2011, *Robots and robotic devices — Safety requirements for industrial robots — Part 1: Robots*

ISO 10218-2:2011, *Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration*

ISO 12100, *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 10218-1, ISO 10218-2 and ISO 12100, 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
impeding device
any physical obstacle (low barrier, rail, fixture, etc.) which, without totally preventing access to a hazard zone, reduces the probability of access to this zone by offering an obstruction to free access

[SOURCE: ISO 12100:2010, 3.29]

3.2
manual load/unload station
part of the robot system designed for the direct manual intervention for the placement and removal of parts or workpieces for processing by the robot system

3.3
operator
person or persons given the task of installing, using, adjusting, maintaining, cleaning, repairing or transporting machinery

Note 1 to entry: This definition is consistent with the meaning and use as presented in ISO 10218-1, ISO 10218-2 and ISO/TS 15066.

[SOURCE: ISO 11161:2007, 3.14 modified — Note 1 to entry has been added.]

4 Risk assessment

Guidance on risk assessment is provided in ISO 12100 and ISO 10218-2. The main hazards associated with manual load/unload stations are the robot system hazards listed in ISO 10218-2:2011, Annex A. As manual load/unload stations bring the operator particularly close to these hazards, special consideration needs to be given to safeguarding.

The risk assessment for manual load/unload stations addresses the following:

a) possibility of unintentional access to the safeguarded space inside the robot cell;

b) possibility of intentional access to the safeguarded space inside the robot cell (e.g. maintenance or other manual intervention);

c) likelihood of restart of the robot system occurring while an operator is within the safeguarded space (e.g. if another person outside the robot cell restarts the system without being aware that an operator is inside);

d) normal operation with an operator in the manual load/unload station area.

5 Safety design for manual load/unload stations

5.1 General

Manual load/unload stations require operator interaction with the robot system in the same area, but not simultaneously. ISO 10218-2:2011, 5.11 and ISO/TS 15066 apply if it is a collaborative application. There are two main concerns:

a) safeguarding the operator from hazards introduced by the robot and the robot system;

b) preventing access to hazard zones beyond the manual load/unload station.

The dimensioning of safeguards and protective structures against access to hazardous areas is described in ISO 13120 and ISO 13857. To minimize ergonomic risks, manual load/unload stations can be lower than 1 400 mm. ISO 13857 states that protective structures lower than 1 400 mm should not be used without additional protective measures.

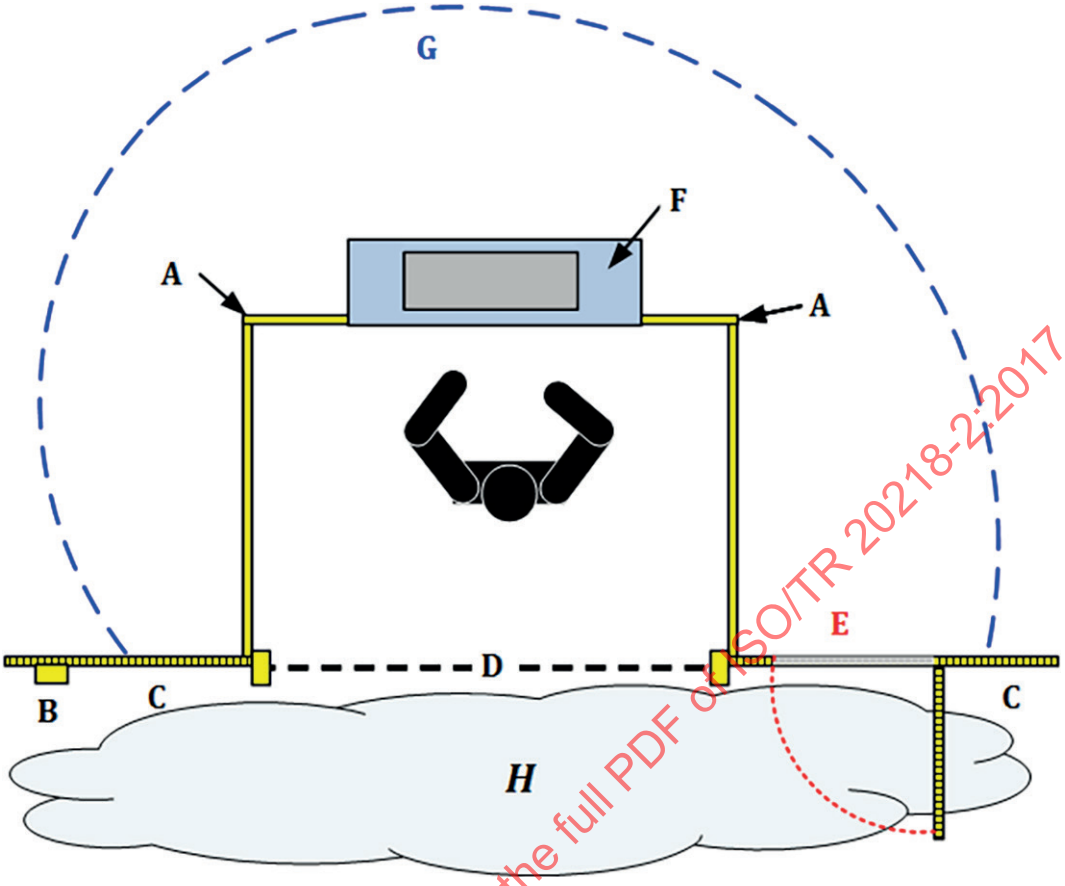
Continuous presence sensing can be used as a measure to prevent either or both of the following:

— unexpected start-up;

— contact between the operator and robot system by keeping them in separate zones.

NOTE An example of ergonomic risk is handling heavy or large workpieces during manual load/unload operations. Inadequate design of the task, machine or system could lead to increased ergonomic risk factors to the worker. Further information regarding ergonomic risk factors is given in ISO 6385, ISO 14738 and ISO 10218-2:2011, Table A.1, item 8 (ergonomic hazards).

An example layout of a manual load/unload station is illustrated in Figure 1.



Key

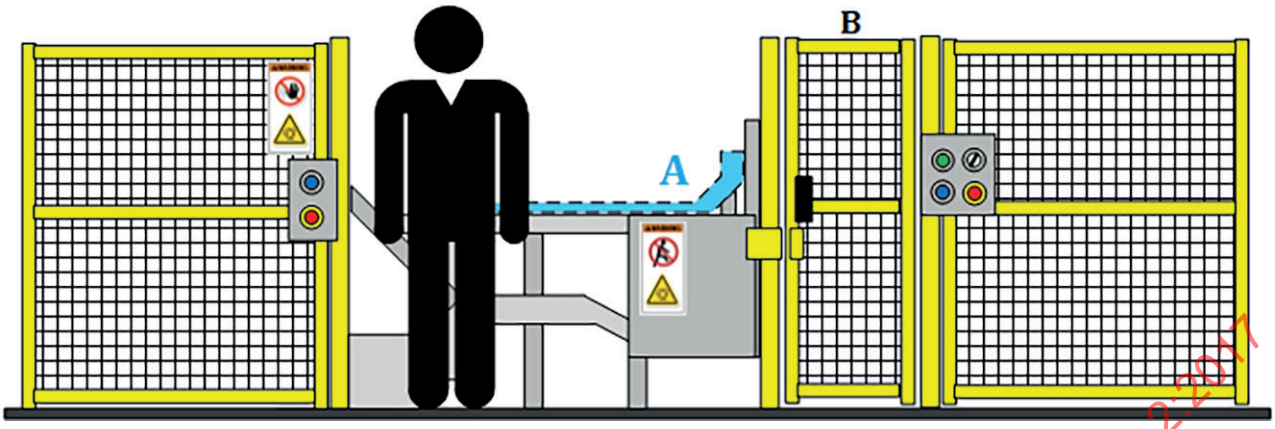
A guard
B reset
C perimeter guard
D protective device (sensitive protective equipment) or interlocked guard
E maintenance access (shown as interlocked guard)
F area where manual load/unload occurs
G hazard zone within the safeguarded space
H area outside the safeguarded space (non-hazardous area)

NOTE Surrounding safeguarding not shown for simplicity of illustration.

Figure 1 — Example layout of a manual load/unload station using a reset interlock

5.2 Typical design

ISO 10218-2:2011, 5.5.2, specifies requirements for means for the safe access of the operator into the robot system or robot cell. These means of access should be near the manual load/unload stations, as shown in Figure 2.



Key

A workplace

B interlocked guard

NOTE Surrounding safeguarding is not shown, for simplicity of illustration.

Figure 2 — Interlocked guard allowing access to the robot cell

NOTE Annex A and in ISO 13857 provide guidance on preventing access through an opening in the fixture(s) of a manual load/unload station.

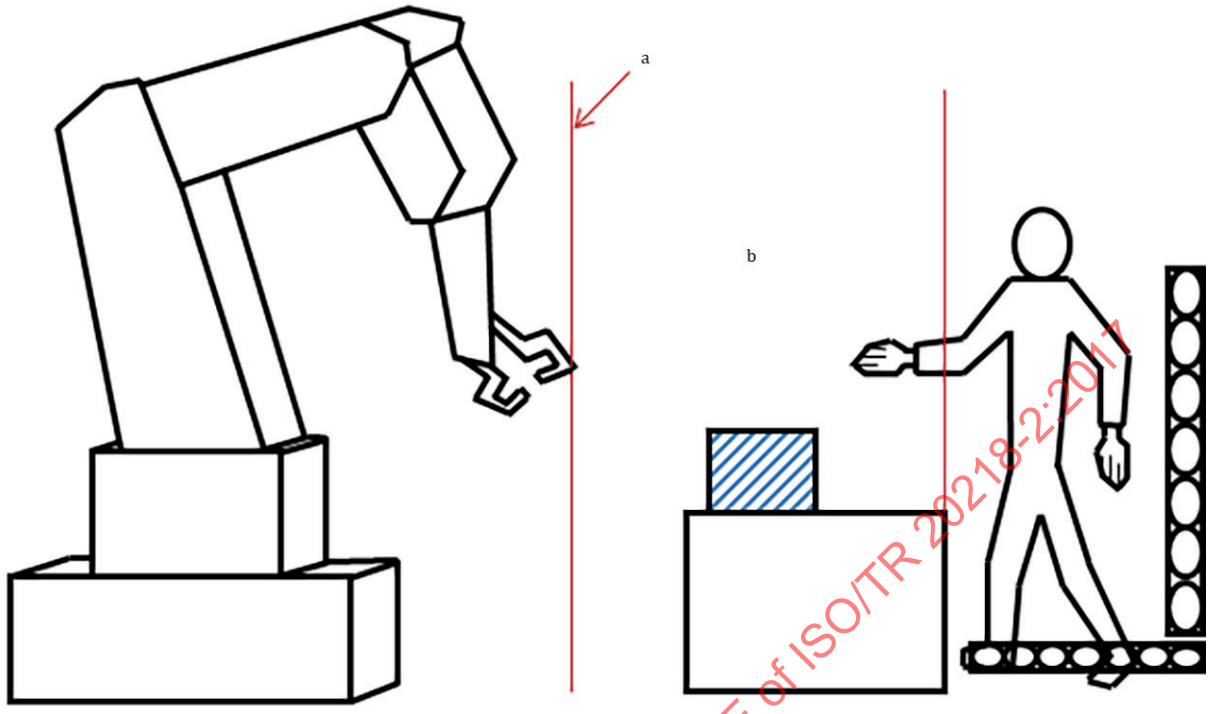
Ergonomic risk factors and robot system hazards are considered, taking into consideration the guiding principles outlined in this subclause.

Safeguarding against hazards that the worker could reach from the manual load/unload station is ensured by means of guards according to ISO 14120, with adequate safety distances according to ISO 13857:2008, Table 2. The robot system is prevented from violating the safety distance by non-mechanical limiting devices [e.g. safety-rated axis limiting, electro-sensitive protective equipment (ESPE)] according to ISO 10218-2:2011, 5.4. This means that the integrator needs to take account of the robot system stopping distance when establishing the dynamic restricted space of the robot system.

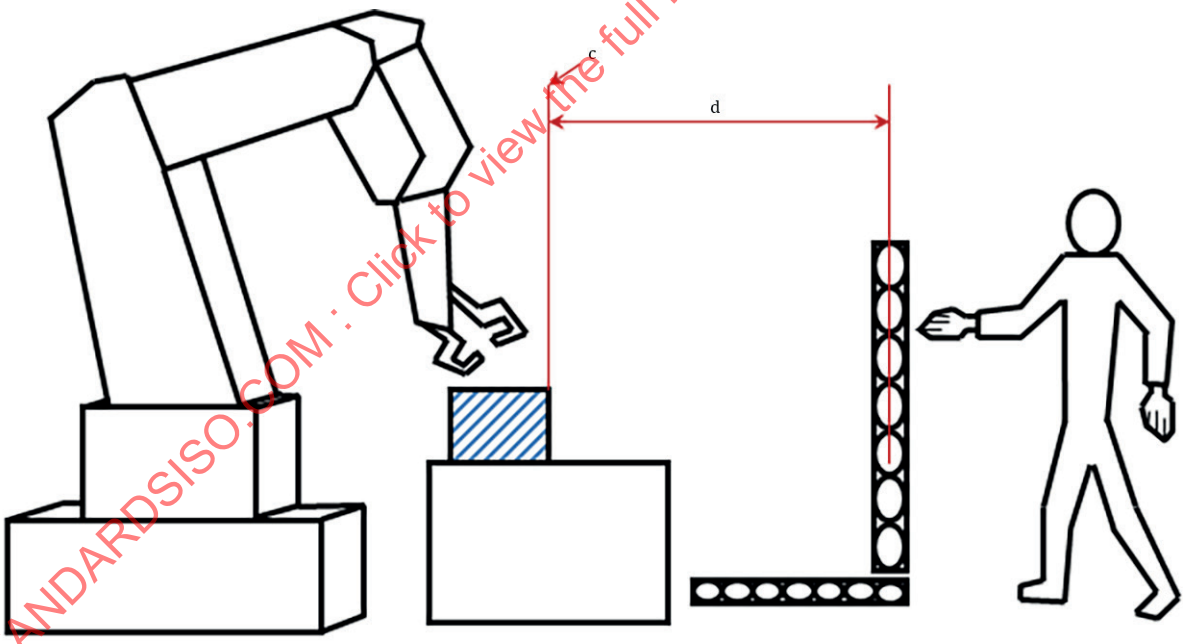
NOTE The initial robot system stopping distance can be determined by simulation, but is later verified and validated on the actual installation.

Safeguarding against hazards that the worker could reach while standing outside the manual load/unload station is accomplished by sensitive protective equipment (SPE) and one or more interlocking guards, installed according to ISO 14119, ISO 14120 and ISO 13855.

See Figure 3.



a) Scenario 1: Operator working in manual load/unload station with robot system approaching



b) Scenario 2: Robot working in manual load/unload area with operator approaching

Key

a Robot system "dynamic" zone limit, e.g. safety-rated soft limit, ESPE.

b Safe distance when fixture acts as protective structure.

c Robot system restricted space.

d Safe distance according to ISO 13855.

NOTE Surrounding safeguarding not shown for simplicity of illustration.

Figure 3 — Example showing safe distances under two scenarios

Stepping behind and remaining undetected by the protective device at the entry of the manual load/unload station is prevented by design measures (i.e. distance between the entry protective device and perimeter safeguarding) or by additional safeguards (e.g. by using ESPE). The system restarts according to ISO 10218-2:2011, 5.6.3.4.

5.3 Impeding devices of height greater than or equal to 1 400 mm

ISO 10218-2 provides guidance regarding the robot cell design for cases where the height of the impeding device is greater than or equal to 1 400 mm.

5.4 Impeding devices of height from 1 000 mm to 1 400 mm

If the impeding device height of 1 400 mm cannot be achieved due to system design, reduction of the impeding device height to 1 000 mm might be possible depending on the protection effect given by the shape of the impeding device and the results of the risk assessment. The deviation from the height of 1 400 mm should be as small as possible. The areas where the height of 1 400 mm is not achieved should be kept to a minimum.

When the height of the manual load/unload station is between 1 400 and 1 000 mm, the fixture can become the impeding device to entry into the robot cell (see ISO 13857). While the fixture might be an adequate impeding device, ISO 10218-2 requires that a risk assessment address both hazards presented by the robot and the robot system and any additional safeguarding needed for the fixture (e.g. forklift pockets creating natural steps for climbing). If impeding devices are below 1 400 mm in height, they should be provided with additional safeguarding measures according to ISO 13857. Such measures comprise a combination of technical and instructional measures, e.g.

a) keeping guards and impeding devices at manual load/unload stations as high as practicable;

b) keeping guard openings/slots as small as practicable;

c) including additional protective devices (e.g. ESPE, see ISO 13855) to safely control hazards within the robot cell (minimum distance requirements are described in ISO 10218-2:2011, 5.10.3.3 and 5.10.3.4).

The following can be used to supplement the safeguarding outlined above:

— warning signs;

— written instructions at the manual load/unload stations;

— supplementary measures to further reduce the residual risk of circumvention of the fixture by providing a nearby safe means of entry and related training to operators (see ISO 10218-2:2011, Annex C).

The flowchart shown in Figure 4 provides guidance to achieve the risk reduction. It supplements the guidance on performance and design of the risk reduction measures given in this clause.

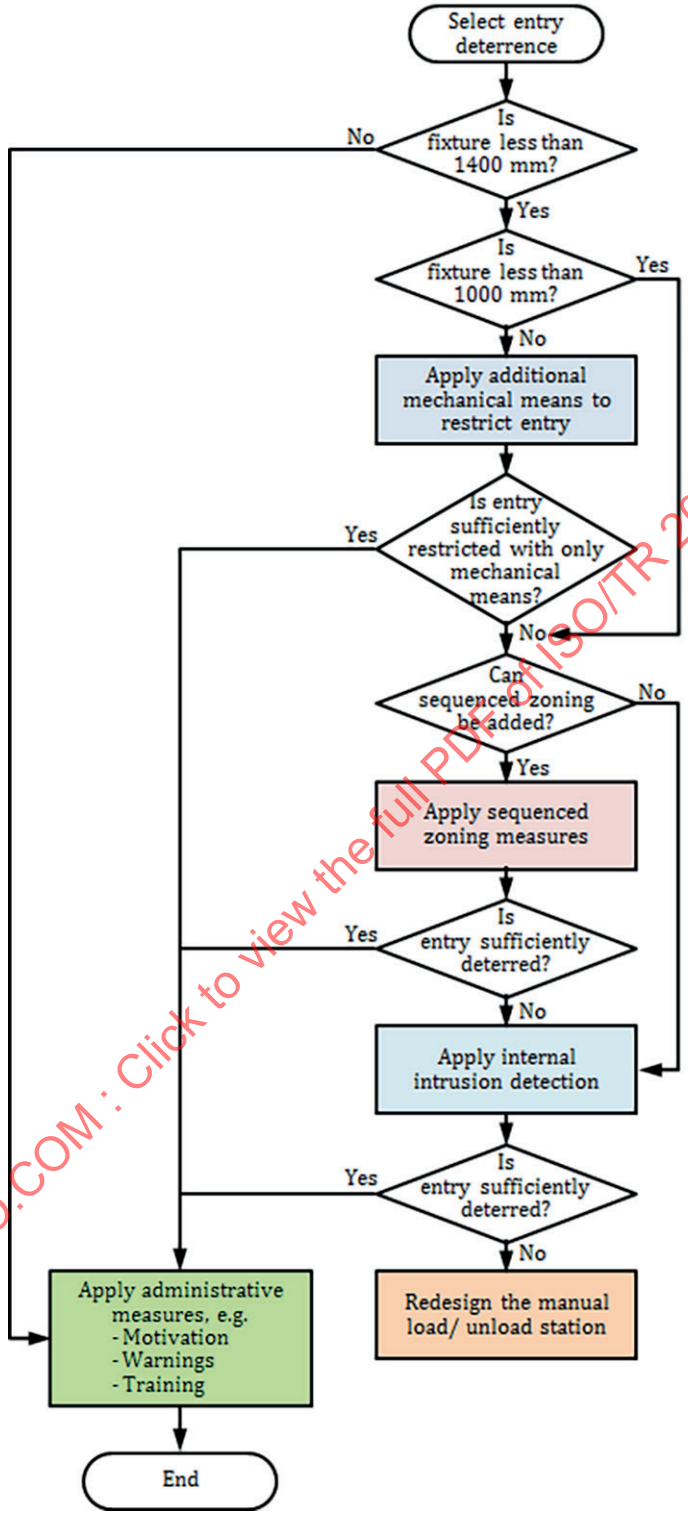


Figure 4 — Risk reduction strategy flowchart

5.5 Impeding devices of height less than 1 000 mm

ISO 13857 specifies that a manual load/unload station that is lower than 1 000 mm does not sufficiently restrict entry and needs an additional protective device.

In such cases, entry is detected using one or more protective devices. ISO 10218-2:2011 specifies that the design and construction of the work station needs to provide effective measures to prevent entry

into the hazardous zone within the robot cell, or, if intrusion occurs, that the risks associated with such entry are adequately reduced. To achieve this, the design strategy to prevent, impede or detect entry into the robot cell via the manual load/unload station ensures that the risks associated with such entry are adequately reduced by applying the following principles, in the following order.

— 1. Mechanical fixture is designed to be an impeding device.

— 2. Multiple zone sequencing determines if someone is moving through the detection zones and entering the robot cell, as shown in Figure 6.

— 3. Internal intrusion detection sensing is used, to detect a person trying to enter beyond the fixture.

These supplemental measures are considered to be sufficient to prevent the reasonably foreseeable circumvention of the safeguards, e.g. adding angled components to prevent walking on ESPE to enter the robot cell.

5.6 Mechanical deterrent in fixture design

5.6.1 Full-body access prevention

The fixture design is such that the operator cannot gain full body access into the robot cell by crawling/squeezing through an opening within the fixture. The fixture design applies principles specified in ISO 13857 and ISO 14120, specifically the characteristics and limitations outlined below.

ISO 13857 addresses reaching through guard openings. As specified in the Note to ISO 13857:2008, Table 7, slot openings greater than 180 mm and square/round openings with openings greater than 240 mm allow access for the whole body. Openings designed within these limitations prevent access by crawling.

A risk assessment can determine if a larger opening is effective in preventing access by crawling, by an analysis of the following:

— existing anthropometric data (see ISO 7250);

— the dimensions needed to provide entry by crawling (see EN 547);

— other physical aspects of the opening that might be an impedance to entry.

EXAMPLE If the passage through the fixture involves a 90° turn by the individual, entry by crawling is highly unlikely.

NOTE It is not sufficient to post warning labels prohibiting entry by crawling/squeezing through openings within the fixture.

5.6.2 Step elimination

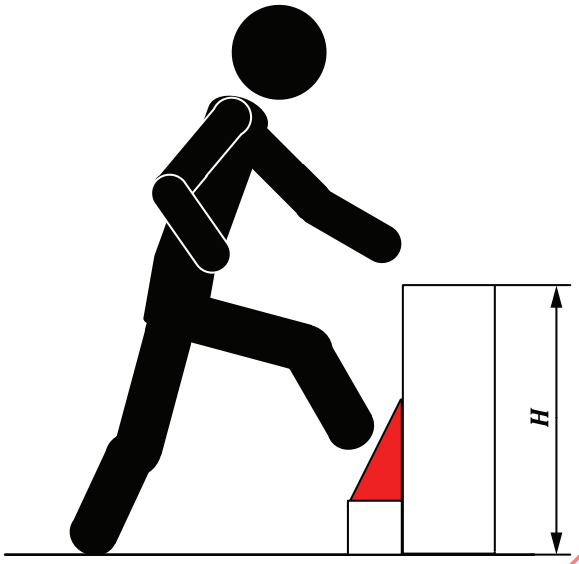
The vertical surfaces of the fixture frame are designed to eliminate the possibility of climbing over the fixture, as follows.

a) There is no step and no portion where the person can climb by gripping something. If this condition is not fulfilled, then intrusion by a person needs to be detected by either:

   — electro-sensitive protective equipment according to IEC 61496, or

   — an interlocking guard according to ISO 14120 and ISO 14119.

b) It is not possible to climb up a slope even if the person grips something (see Figure 5).



Key

H 1 000 mm minimum height

NOTE Surrounding safeguarding is not shown, for simplicity of illustration.

Figure 5 — Example of step elimination by use of sloped plates

According to ISO 14120, the design of guarding and supporting structures should not include features that could assist in climbing over or circumventing the guard.

5.7 Detection of intrusion in hazardous areas

As stated in IEC 61496, IEC/TS 62046, ISO 13855 and ISO 13856, SPEs can be used to detect the intrusion of a person into the hazardous area. The SPE or a combination of SPEs can be used, taking into consideration the following:

a) the SPE is installed to detect the entry of a person in the safeguarded space;

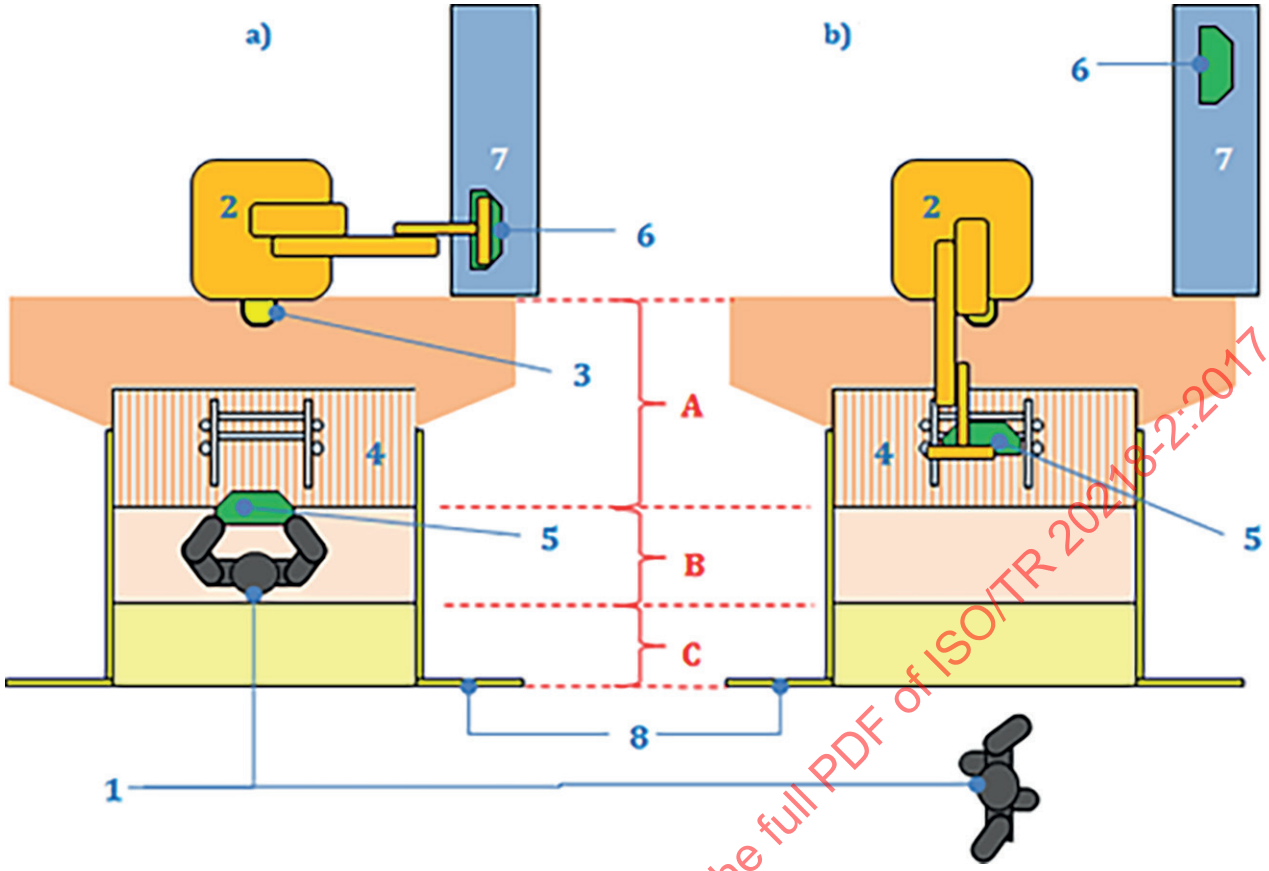
b) the SPE is installed to determine the person's movement (inwards or backwards to the hazard zone) by evaluation of the person's position at different times or by sensing the person's movement direction;

c) the evaluation method of the person's movement and position provides a reliable estimation if a person has entered the hazardous area and, in such a case, the protective device initiates a protective stop.

Where there is a risk of more than one person entering the loading station and one person accesses the hazard zone, the system detects this situation and initiates a protective stop.

The minimum distance requirements are described in ISO 10218-2:2011, 5.10.3.3 and 5.10.3.4.

Figure 6 illustrates an example of intrusion detection using sequential zoning to detect intrusion by SPE.



a) Operator loading **b) Robot processing**

Key

1	operator loading the manual load/unload station	operator performing other tasks
2	industrial robot system transferring	industrial robot system processing
3	laser scanner (AOPDDR)	
4	area where manual load/unload occurs	
5	workpiece loading	workpiece processing
6	workpiece transferring	workpiece conveying
7	conveyor	
8	perimeter guard	
A	inner detection field (also under the manual load/unload station)	
B	loading area detection field	
C	entry-exit detection area detection field	

Figure 6 — Scanner with three zones

5.8 Presence sensing

Intrusion detection is used to detect a person trying to enter beyond the fixture (see 5.6). Presence sensing is the detection of a person inside the hazardous area.

Depending on the results of the risk assessment, continuous presence sensing of the operator inside the manual load/unload station could be needed.

The following are means by which to accomplish intrusion detection:

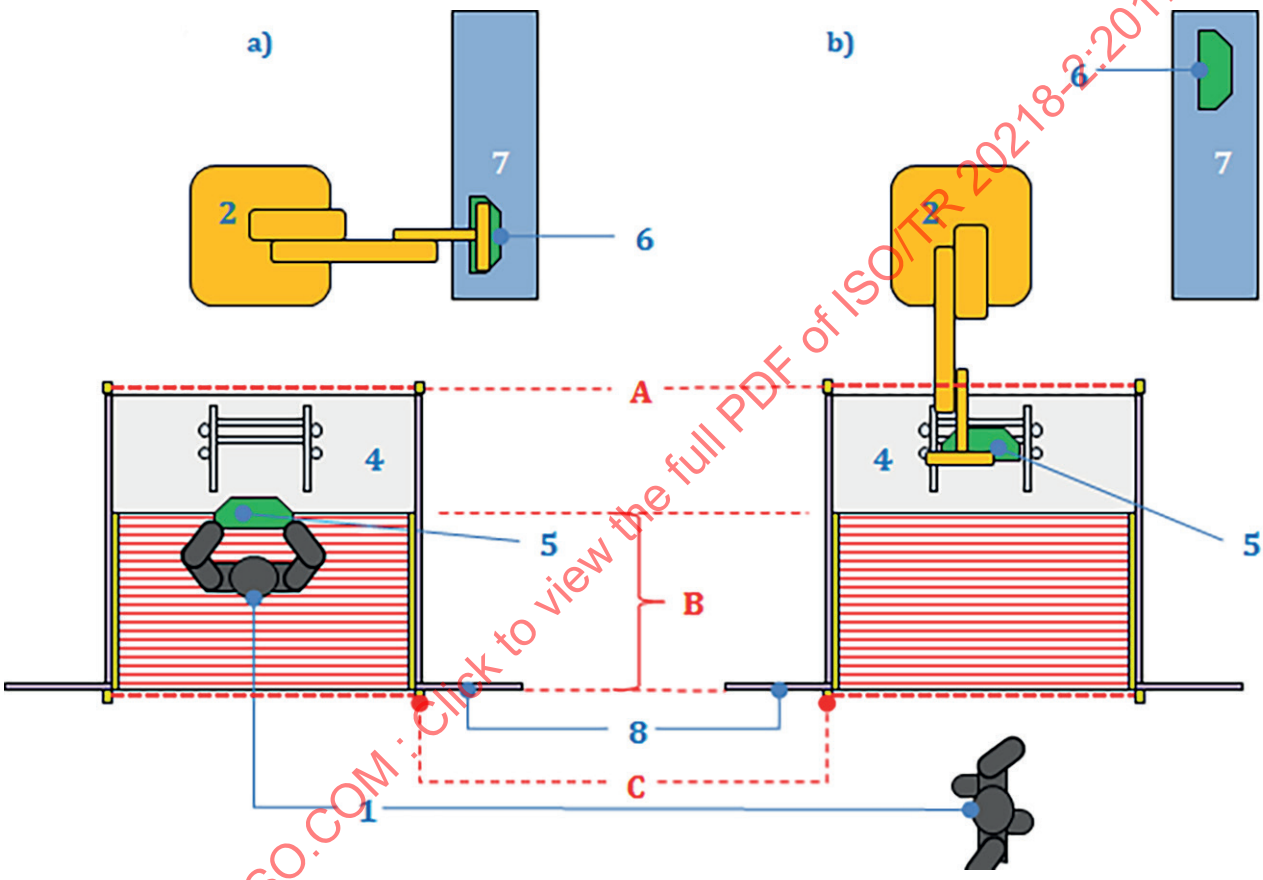
— internal zone just inside of fixture using an SPE device;

NOTE See Figure 6, item 3, and Figure 7, item A.

— scanners under positioners and fixtures to detect persons crossing from the load/unload side of the fixture to the inside of the robot cell;

NOTE See Figure 6, item 3.

— sensitive protective equipment installed according to ISO 10218-2:2011, 5.10.5.



a) Operator loading **b) Robot processing**

Key

1	operator loading the manual load/unload station	operator performing other tasks
2	industrial robot system transferring	industrial robot system processing
4	area where manual load/unload occurs	
5	workpiece loading	workpiece processing
6	workpiece transferring	workpiece conveying
7	conveyor	
8	perimeter guard	
A	inner safety light curtain (AOPD)	
B	loading area safety light curtain – presence sensing (AOPD)	
C	entry-exit safety light curtain (AOPD)	

Figure 7 — Light curtain inside of station