International Standard

ISO 10218-2

Robotics — Safety requirements —

Part 2: Industrial robot applications and robot cells

Robotique — Exigences de sécurité —

Partie 2: Applications robotisées industrielles et cellules robotisées

Second edition
2025-02

Reference number
ISO 10218-2:2025(en)

© ISO 2025



COPYRIGHT PROTECTED DOCUMENT

© ISO 2025

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

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

Published in Switzerland

Contents

Page

Foreword ... **vii**
Introduction ... **viii**
1 Scope ... **1**
2 Normative references ... **2**
3 Terms, definitions, symbols and abbreviated terms ... **4**
3.1 Terms and definitions ... 4
3.1.1 Robot, robot system, robot application, robot cell - related ... 4
3.1.2 Sub-assemblies and components ... 5
3.1.3 Controls-related ... 6
3.1.4 Program-related ... 8
3.1.5 Power-, energy-related ... 8
3.1.6 Hazard-related ... 8
3.1.7 Role-related ... 9
3.1.8 Functional safety-related ... 9
3.1.9 Spaces, zones and distances ... 10
3.1.10 Risk reduction measures ... 12
3.1.11 Verification and validation ... 13
3.1.12 Contact-related ... 14
3.2 Abbreviated terms and symbols ... 14
4 Risk assessment ... **19**
4.1 General ... 19
4.2 Characteristics of robot applications and robot cells ... 19
4.3 Characteristics of collaborative applications ... 20
4.3.1 General ... 20
4.3.2 Risk assessment for contacts between moving parts of the robot application and operator(s) ... 21
5 Safety requirements and risk reduction measures ... **22**
5.1 General ... 22
5.2 Design ... 22
5.2.1 General ... 22
5.2.2 Materials, mechanical strength and mechanical design ... 23
5.2.3 Provisions for lifting or moving ... 24
5.2.4 Hazardous substances ... 24
5.2.5 Stability ... 24
5.2.6 Temperature and fire risks ... 25
5.2.7 Special equipment ... 25
5.2.8 Position holding ... 25
5.2.9 Additional axis (axes) ... 25
5.2.10 Power loss or change ... 26
5.2.11 Component malfunction ... 26
5.2.12 Hazardous energy ... 26
5.2.13 Electrical, pneumatic and hydraulic parts ... 27
5.2.14 Tool centre point (TCP) setting ... 28
5.2.15 Payload setting ... 28
5.2.16 Cybersecurity ... 28
5.3 Robot cell integration ... 28
5.3.1 General ... 28
5.3.2 Span-of-control ... 29
5.3.3 Span-of-control of emergency stop function ... 29
5.3.4 Operational modes with multi-robot applications or robot cells ... 29
5.3.5 Local control, remote control and single-point-of-control ... 29
5.3.6 Automatic workpiece feeding ... 30
5.4 Layout ... 30

© ISO 2025 – All rights reserved

5.4.1 General 30
5.4.2 Use and limits 31
5.4.3 Design 31
5.4.4 Design for collaborative applications 32
5.4.5 Prevention of trapping within the safeguarded space 32
5.4.6 Establishing restricted spaces 33
5.4.7 Limiting motion 33
5.5 Safety functions 34
5.5.1 General 34
5.5.2 Functional safety standards 35
5.5.3 Performance 35
5.5.4 Failure or fault detection 36
5.5.5 Parameterization of safety functions 36
5.5.6 Speed limit(s) monitoring 36
5.5.7 Start / restart interlock and reset 37
5.5.8 Monitored-standstill 38
5.5.9 Communications 38
5.5.10 Electromagnetic requirements 39
5.6 Stopping 39
5.6.1 General 39
5.6.2 Emergency stop 39
5.6.3 Protective stop 40
5.6.4 Normal stop 40
5.6.5 Associated equipment stopping 41
5.7 Control functions 41
5.7.1 General 41
5.7.2 Modes 41
5.7.3 Protection from unexpected start-up 44
5.7.4 Status indication and warning devices 44
5.7.5 Single-point-of-control 44
5.7.6 Local and remote control 45
5.7.7 Enabling devices 46
5.7.8 Control stations 47
5.7.9 Simultaneous motion 49
5.8 Safeguards and their use 49
5.8.1 General 49
5.8.2 Establishing a safeguarded space 50
5.8.3 Perimeter safeguarding 50
5.8.4 Overriding of protective devices 50
5.8.5 Guards 50
5.8.6 Sensitive protective equipment 51
5.8.7 Muting 53
5.8.8 Overriding of SPE 53
5.8.9 Minimum distances 53
5.8.10 Safeguarding to protect from unexpected restart 54
5.9 End-effectors 54
5.9.1 General 54
5.9.2 Risk reduction measures 55
5.9.3 Shape and surfaces 56
5.9.4 Protective devices and/or safety functions 56
5.9.5 End-effectors and robot application design 57
5.9.6 End-effectors exchange systems 57
5.10 Vertical transfer components 58
5.10.1 Mechanical design 58
5.10.2 Prevention of falling hazards 58
5.10.3 Prevention of crushing hazards 58
5.10.4 Control of movements 59
5.11 Lasers and laser equipment 59
5.12 Material handling, manual load/unload stations and material flow 59

© ISO 2025 – All rights reserved

5.12.1 Material handling 59
5.12.2 Manual load/unload stations and other manual stations 59
5.12.3 Material flow 60
5.13 Adjacent robot cells 61
5.14 Collaborative applications 61
5.14.1 General 61
5.14.2 Safeguarded spaces 62
5.14.3 Transitions 63
5.14.4 Hand-guided control (HGC) 63
5.14.5 Speed and separation monitoring (SSM) 64
5.14.6 Power and force limiting (PFL) 66
5.15 Assembly, installation and commissioning 69
5.15.1 Commissioning of robot applications 69
5.15.2 Environmental conditions 70
5.15.3 Power 70
5.15.4 Lighting 70
5.15.5 Labelling 70
5.16 Maintenance 71
5.16.1 General 71
5.16.2 Movement without drive power 71

6 Verification and validation 71
6.1 General 71
6.2 Verification and validation methods 71
6.3 Verification and validation of guards, protective devices, safety function parameter settings and biomechanical threshold limits 72
6.3.1 Guards and protective devices 72
6.3.2 Safety function parameter settings 72
6.3.3 Biomechanical limits 72
6.4 Complementary protective measures 72

7 Information for use 73
7.1 General 73
7.2 Signals and warning devices 73
7.3 Marking 73
7.4 Signs (pictograms) and written warnings 74
7.5 Instruction handbook 74
7.5.1 General 74
7.5.2 Identification 74
7.5.3 Intended use 74
7.5.4 Transport, handling and lifting 75
7.5.5 Installation 75
7.5.6 Commissioning and programming 75
7.5.7 Abnormal and emergency situations 76
7.5.8 Settings and operation 77
7.5.9 Maintenance 77
7.5.10 Decommissioning 78
7.5.11 Remote interventions 78
7.5.12 Hazardous energy 78
7.5.13 Limiting devices and restricted space 78
7.5.14 Movement without drive power 79
7.5.15 Control station(s) 79
7.5.16 Functional safety 79
7.5.17 Operating modes 80
7.5.18 Enabling devices 80
7.5.19 Vibration 81
7.5.20 End-effector(s) 81
7.5.21 Manual load/ unload stations 81
7.5.22 Collaborative applications 81
7.5.23 Cybersecurity 82

© ISO 2025 – All rights reserved

Annex A (informative) **List of significant hazards** **83**
Annex B (informative) **Illustrations of spaces** **91**
Annex C (normative) **Safety function performance requirements** **97**
Annex D (Informative) **Required safety function information** **119**
Annex E (informative) **Example of determination of the PL_r or required SIL** **121**
Annex F (informative) **Comparison of stop functions** **124**
Annex G (informative) **Graphical symbols** **126**
Annex H (informative) **Means of verification and validation of the design and protective measures** **128**
Annex I (informative) **End-effectors** **163**
Annex J (informative) **Safeguarding manual load and unload stations** **167**
Annex K (informative) **Safeguarding material entry and exit point** **179**
Annex L (normative) **Speed and separation monitoring (SSM) – separation distance** **184**
Annex M (informative) **Limits for quasi-static and transient contact** **188**
Annex N (informative) **Validation of PFL collaborative applications** **199**
Annex O (informative) **Optional features** **216**
Annex P (informative) **Implementation of start/restart interlock and reset functions** **218**
Annex Q (informative) **Relationship of standards related to safeguards** **220**
Bibliography **221**

© ISO 2025 – All rights reserved

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.

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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 299, *Robotics,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 310, *Advanced automation technologies and their applications,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 10218-2:2011), which has been technically revised.

The main changes are as follows:

— emphasising robot application and not robot system, as the robot application includes the workpieces, task program, and the machinery and equipment to support the application and intended tasks;

— incorporating safety requirements for collaborative applications (formerly, the content of ISO/TS 15066);

— clarifying requirements for functional safety;

— adding requirements for cybersecurity to the extent that it applies.

A list of all parts in the ISO 10218 series can be found on the ISO website.

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.

© ISO 2025 – All rights reserved

Introduction

This document has been created in recognition of the hazards that are presented by robots when they are integrated and installed with end-effectors into robot applications and robot cells. ISO 10218-1 addresses robots as partly completed machinery, while this document addresses robots integrated into completed machinery for specific robot applications.

This document is a type-C standard according to ISO 12100.

This document is of relevance for the following stakeholder groups representing the market players regarding safety of robot applications and robot cells:

— robot manufacturers (small, medium and large enterprises);

— robot application integrators (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance, etc).

Others can be affected by the level of safety achieved with the means of the document by the above-mentioned stakeholder groups:

— robot application users/employers (small, medium and large enterprises);

— robot application users/employees (e.g. trade unions);

— service providers, e.g. for maintenance (small, medium and large enterprises);

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

Robot applications, and the extent to which hazards, hazardous situations and events, are covered and indicated in the Scope of this document.

When provisions of a type-C standard are different from those which are stated in type-A or type-B standards, the provisions of the type-C standard take precedence over the provisions of the other standards for machines that have been designed and built in accordance with the provisions of the type-C standard.

Hazards associated with robot applications are well recognized, but the sources of the hazards are frequently unique to each robot application. The number and type(s) of hazard(s) are directly related to the nature of the automation process and the complexity of the application. The risks associated with these hazards vary with the robot used, its safety functions, and the integration, installed, programs, use, and maintenance. This document provides requirements for safety in the integration of robots into robot applications and robot cells. The requirements include safeguarding of operators during integration, commissioning, functional testing, programming, operation, maintenance and repair. Requirements for the robot can be found in ISO 10218-1.

The ISO 10218 series deals with robotics in an industrial environment, which is comprised of workplaces where the public is excluded or restricted from access and the allowed people (operators) are working adults. Other standards cover such topics as general characteristics, coordinate systems and axis motions, mechanical interfaces, performance criteria and related testing methods, and end-effectors.

There are a broad range of robot applications and robot cell(s). Therefore, it is not possible to provide a list of all significant hazards, hazardous situations or events into which a robot application can be integrated. Moreover, the same kind of applications can have different levels of risk, resulting from different designs which correspond to the intended application (e.g. paint spraying on large or small parts, handling of a small harmful payload like a hot metal bolt or a large harmless payload like a box of paper tissues).

Other standards can be applicable to associated machinery and equipment in robot applications and robot cells.

For ease of reading this document, the words “robot”, “robot system” and “robot application” refer to “industrial robot”, “industrial robot system” and “industrial robot application” as defined in ISO 10218-1 and this document.

© ISO 2025 – All rights reserved

This document has been updated based on experience gained since the release of the first edition of ISO 10218-2 in 2011. This document remains aligned with minimum requirements of a harmonized type-C standard for robot applications and robot cells in an industrial environment. Providing for a safe robot application and a safe robot cell depends on the cooperation of a variety of “stakeholders”. Stakeholders can include designers, manufacturers, suppliers and integrators. Users are the entity responsible for using robot applications and robot cells. Users can also be any of the other stakeholder roles.

Where appropriate, ISO/TS 15066:2016 on the safety of collaborative robot applications was added to the ISO 10218 series. Because human-robot collaboration relates to the application and not to the robot alone, most of the requirements of ISO/TS 15066 have been incorporated into this document. Safety functions that enable a collaborative application can be part of the robot (e.g. PFL), or can be provided by a protective device, or a combination.

It is important to emphasize that the term “collaborative robot” is not used in this document. Only the application can be developed, verified, and validated as a collaborative application. In addition, the term “collaborative operation” is not used in this document.

© ISO 2025 – All rights reserved

Robotics — Safety requirements —

Part 2: Industrial robot applications and robot cells

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This document specifies requirements for the integration of industrial robot applications and industrial robot cells. The following are addressed:

— the design, integration, commissioning, operation, maintenance, decommissioning and disposal;

— integration of machines and components;

— information for use for the design, integration, commissioning, operation, maintenance, decommissioning and disposal.

This document is not applicable to the following uses and applications of industrial robots:

— underwater;

— law enforcement;

— military (defence);

— airborne and space, including outer space;

— medical;

— healthcare of a person;

— prosthetics and other aids for the physically impaired;

— service robots, which provide a service to a person and as such the public can have access;

— consumer products, as this is household use to which the public can have access;

— lifting or transporting people;

— multi-purpose lifting devices or machinery, e.g. cranes, forklift trucks.

NOTE Applications for the automation of laboratories are not considered as medical or healthcare of a person.

This document deals with the significant hazards, hazardous situations or hazardous events when used as intended and under specified conditions of misuse which are reasonably foreseeable by the integrator.

This document provides basic requirements for industrial robot applications, but does not cover the hazards related to the following:

— emission of airborne noise;

— severe conditions (e.g. extreme climates, freezer use, strong magnetic fields) outside of manufacturer's specifications;

© ISO 2025 – All rights reserved

— underground use;

— use that has hygienic requirements;

— processing of any material (e.g. food, cosmetics, pharmaceutical, metal);

— use in nuclear environments;

— use in potentially explosive environments;

— mobility when robots or manipulators are integrated with driverless industrial trucks;

— mobility when robots or manipulators are integrated with mobile platforms;

— use in environments with hazardous ionizing and non-ionizing radiation levels;

— hazardous ionizing and non-ionizing radiation;

— handling loads the nature of which could lead to dangerous situations (e.g. molten metals, acids/bases, radiating materials);

— when the public or non-working adults have access.

Emission of acoustic noise could be identified to be a significant hazard, but emission of noise is not covered in this document.

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 3864-1:2011, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 3864-2:2016, *Graphical symbols — Safety colours and safety signs — Part 2: Design principles for product safety labels*

ISO 3864-3:2024, *Graphical symbols — Safety colours and safety signs — Part 3: Design principles for graphical symbols for use in safety signs*

ISO 3864-4:2011, *Graphical symbols — Safety colours and safety signs — Part 4: Colorimetric and photometric properties of safety sign materials*

ISO 4413:2010, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4414:2010, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

ISO 7010:2019, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 8995-1:2002, *Lighting of work places — Part 1: Indoor*

ISO/CIE 8995-3:2018, *Lighting of work places — Part 3: Lighting requirements for safety and security of outdoor work places*

ISO 10218-1:2025, *Robotics – Safety requirements – Part 1: Industrial robots*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13732-1:2006, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces*

© ISO 2025 – All rights reserved

ISO 13732-3:2005, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 3: Cold surfaces*

ISO 13849-1:2023, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13850:2015, *Safety of machinery — Emergency stop function — Principles for design*

ISO 13854:2017, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

ISO 13855:2010, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 13856:2013, *Safety of machinery — Pressure-sensitive protective devices*

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

ISO 14118:2017, *Safety of machinery — Prevention of unexpected start-up*

ISO 14119:2024, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

ISO 14120:2015, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

ISO 14122:2016, *Safety of machinery — Permanent means of access to machinery*

ISO 14738:2002, *Safety of machinery — Anthropometric requirements for the design of workstations at machinery*

ISO 15534-1:2000, *Ergonomic design for the safety of machinery — Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery*

ISO 15534-2:2000, *Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings*

ISO 19353:2019, *Safety of machinery — Fire prevention and fire protection*

ISO 20607:2019, *Safety of machinery — Instruction handbook — General drafting principles*

ISO 20643:2005, *+ AMD1:2021, Mechanical vibration — Hand-held and hand-guided machinery — Principles for evaluation of vibration emission*

IEC 60073:2002, *Basic and safety principles for man-machine interface, marking and identification — Coding principles for indication devices and actuators*

IEC 60204-1:2016, *+ AMD1:2021, Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60825-1:2014, *Safety of laser products — Part 1: Equipment classification and requirements*

IEC 60947-5-8:2020, *Low-voltage switchgear and controlgear — Part 5-8: Control circuit devices and switching elements — Three-position enabling switches*

IEC 61000-6-7:2014, *Electromagnetic compatibility (EMC) — Part 6-7: Generic standards — Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations*

IEC 61310:2007, *Safety of machinery — Indication, marking and actuation*

IEC 61496-1:2020, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests*

© ISO 2025 – All rights reserved

IEC 61508-2:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems — Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems*

IEC 62046:2018, *Safety of machinery — Application of protective equipment to detect the presence of persons*

IEC 62061:2021, *Safety of machinery — Functional safety of safety-related control systems*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 12100:2010 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 Robot, robot system, robot application, robot cell - related

3.1.1.1
industrial environment
workplace where the public is restricted from access or not reasonably expected to be present for the intended tasks and *robot application(s)* (3.1.1.4)

Note 1 to entry: This includes manufacturing, laboratory, pharmaceutical, warehousing, logistics, and more.

3.1.1.2
industrial robot
robot
automatically controlled, reprogrammable multipurpose *manipulator(s)* (3.1.2.7), programmable in three or more *axes* (3.1.2.1), which can be either fixed in place or fixed to a *mobile platform* (3.1.2.10) for use in automation *applications* (3.1.1.5) in an *industrial environment* (3.1.1.1)

Note 1 to entry: The industrial robot includes:

— the *manipulator* (3.1.2.7), including *robot actuators* (3.1.2.12) controlled by the robot control;

— the robot control; and

— the means to teach or program the robot, including any communications interface (hardware and software).

Note 2 to entry: This includes any axes that are integrated into the kinematic solution.

Note 3 to entry: A mobile robot consists of a *mobile platform* (3.1.2.10) with an integrated *manipulator* (3.1.2.7) or robot.

3.1.1.3
industrial robot system
robot system
industrial robot (3.1.1.2), an *end-effector(s)* (3.1.2.3), any *end-effector* sensors and equipment needed to support the *end-effector(s)* (3.1.2.3)

Note 1 to entry: Examples of equipment are vision systems, adhesive dispensing, weld control.

3.1.1.4
robot application
industrial robot application
machine comprising an *industrial robot system* (3.1.1.3), workpieces, *task program* (3.1.4.1), and machinery and equipment to support the *application* (3.1.1.5) and the intended task(s)

Note 1 to entry: The *application* (3.1.1.5) can be a *collaborative application* (3.1.1.6).

© ISO 2025 – All rights reserved