DRAFT INTERNATIONAL STANDARD

ISO/DIS 10218-1

ISO/TC **299**	Secretariat: **SIS**
Voting begins on: **2020-02-03**	Voting terminates on: **2020-04-27**

Robotics — Safety requirements for robot systems in an industrial environment —

Part 1: Robots

ICS: 25.040.30

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/DIS 10218-1:2020(E)

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Published in Switzerland

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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 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 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*.

This third edition cancels and replaces the second edition (ISO 10218-1:2011), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Incorporating safety requirements for industrial robots intended for use in collaborative applications into the standard (formerly, the content of ISO/TS 15066:2016);

— Clarifying requirements for functional safety;

— Adding requirements for cybersecurity to the extent that it applies to industrial robot safet.

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.

Introduction

ISO 10218 has been created in recognition of the particular hazards that are presented by robotics in an industrial environment. Part 1 of ISO 10218 addresses robots as incomplete machines, while Part 2 addresses robots integrated into complete machines (systems) for specific applications.

This part of ISO 10218 is a type-C standard as outlined in ISO 12100.

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.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered and indicated in the Scope of this part of ISO 10218.

NOTE Not all of the hazards identified by ISO 10218-1 apply to every robot, nor will the level of risk associated with a given hazardous situation be the same from robot to robot. Consequently, the safety requirements, or the protective measures, or both, can vary from what is specified in ISO 10218-1. A robot manufacturer's risk assessment can be conducted to determine what the protective measures should be.

In recognition of the variable nature of hazards with different uses of industrial robots, ISO 10218 is divided into two parts. This part of ISO 10218 provides requirements for the assurance of safety in the design and construction of the robot. Since safety in the application of industrial robots is influenced by the design and application of the robot system, ISO 10218-2 provides guidelines for the safeguarding of operators during integration, installation, functional testing, programming, operation, maintenance and repair.

Both parts of ISO 10218 deal with robotics in an industrial environment. Other standards cover such topics as coordinate systems and axis motions, general characteristics, performance criteria and related testing methods, terminology, and mechanical interfaces. It is noted that these standards are interrelated and related to other International Standards.

For ease of reading this part of ISO 10218, the words "robot" and "robot system" refer to "industrial robot" and "industrial robot system" as defined in ISO 10218-1 and ISO 10218-2.

This part of ISO 10218 has been updated based on experience gained since the release of ISO 10218-1 and ISO 10218-2 in 2011. This standard remains aligned with minimum requirements of a harmonized type-C standard for robots in an industrial environment.

Where appropriate, the guidance contained in ISO/TS 15066:2016 on the safety of collaborative robot systems was added to ISO 10218. Most of ISO/TS 15066 was incorporated into ISO 10218-2, since human-robot collaborative applies to the application and not the robot alone. Safety functions that enable a collaborative task could be embedded in the robot or could be provided by a protective device, or a combination of the robot and a protective device.

It is important to note that the term "collaborative robot" is not used in ISO 10218-1 as only the application can be developed, verified and validated as a collaborative application. In addition, the term "collaborative operation" is not used in this edition.

Revisions include, but are not limited to,

- category 2 stopping functions,
- definitions,
- functional safety requirements,
- marking,
- mode selection,

- power and force limiting requirements,
- power loss requirements.

This part of ISO 10218 is not applicable to robots that were manufactured prior to its publication date.

Robotics — Safety requirements for robot systems in an industrial environment —

Part 1: Robots

1 Scope

This part of ISO 10218 specifies requirements and guidelines for the inherently safe design, protective measures and information for use of robots for an industrial environment. It describes basic hazards associated with robots and provides requirements to eliminate, or adequately reduce, the risks associated with these hazards.

This part of ISO 10218 does not address the robot as a complete machine. Noise emission is generally not considered a significant hazard of the robot alone, and consequently noise is excluded from the scope of this part of ISO 10218.

This part of ISO 10218 does not apply to undersea, defence, law enforcement, military and space robots, medical and healthcare, prosthetics and other aids for the physically impaired, service or consumer products, tele operated manipulators, and micro robots (displacement less than 1 mm).

NOTE 1 Requirements for robot systems, integration, and applications are covered in ISO 10218-2.

NOTE 2 Additional hazards can be created by specific applications (e.g. welding, laser cutting, machining). These system-related hazards need to be considered during robot system design. See ISO 10218-2.

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

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

ISO 9283, *Manipulating industrial robots — Performance criteria and related test methods*

ISO 10218-2, *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*

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

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

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

IEC 60073, *Basic and safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators*

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

IEC 61000-1-2, *Electromagnetic compatibility (EMC) - Part 1-2: General - Methodology for the achievement of functional safety of electrical and electronic systems including equipment with regard to electromagnetic phenomena*

IEC 61310-1, *Safety of machinery - Indication, marking and actuation - Part 1: Requirements for visual, acoustic and tactile signals*

IEC 62061, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems*

IEC 62745 IEC-62745, *Safety of machinery - Requirements for cableless control systems of machinery*

IEC 82079-1:2012-08, *Preparation of instructions for use - Structuring, content and presentation – Part 1: General principles and detailed requirements*

3 Terms and definitions used in ISO 10218

For the purposes of this document, the terms and definitions given in 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
application
intended use and purpose of the robot (3.17) or robot system (3.18), i.e. the process, the task(s)

EXAMPLE Manipulating. processing, machining, inspection, spot welding, painting, assembly, palletizing.

3.2
collaborative application
an application that contains one or more collaborative task(s) (3.3)

Note 1 to entry: Collaborative applications can include non-collaborative tasks

3.3
collaborative task
a portion of the robot sequence where both the robot system (3.18) and operator(s) (3.23) are within the same safeguarded space (3.40.5)

Note 1 to entry: The task can be collaborative, co-existing, or co-located.

3.4
compliant
exhibiting deformation of material or mechanism when subjected to a force; the reciprocal of stiff; e.g., compliant linkage, compliant surface

Note 1 to entry: ISO 8373:2012 contains the definition of compliance.

3.5
robot actuator
powered mechanism that converts energy to effect motion of the manipulator (3.6)

Note 1 to entry: Energy can be electrical, hydraulic, pneumatic or more.

3.6
manipulator
mechanism consisting of an arrangement of segments, jointed or sliding relative to one another

Note 1 to entry: A manipulator (3.6) includes robot actuators (3.5).

3.7
fixture
device used to fixate an item as part of the handling or assembling process in a robot system, but not as an end-effector (3.9)

3.8
mechanical interface
end-effector (3.9) flange mounting surface at the end of the manipulator (3.6) to which the end-effector is attached

3.9
end-effector
device specifically designed for attachment to the mechanical interface to enable the robot (3.17) to perform its task

EXAMPLE Gripper, welding gun, spray gun.

Note 1 to entry: End-effectors are sometimes known as end-of-arm tooling (EOAT).

3.10
gripper
end-effector (3.9) designed for grasping workpieces

Note 1 to entry: Grip, grasp, grasping and releasing are defined in ISO 14539:2000.

3.11
payload

payload is the mass of all that is attached to the manipulator (3.6), including the end-effector (3.9) and workpiece. The payload can be, but is not limited to, the payload attached to the mechanical interface (3.8) of the robot (3.17).

3.12
mechanical power
mechanical rate of doing work, or the amount of energy consumed per unit time

Note 1 to entry: Power does not pertain to the electrical power rating on an electronic device, such as a motor.

3.13
drive power
energy source or sources enabling the robot actuators (3.5) to execute force or torque

3.14
energy source
electrical, mechanical, hydraulic, pneumatic, chemical, thermal, potential, kinetic or other source of power

3.15
hazardous motion
motion that is likely to cause personal physical injury or damage to health

3.16
axis
mechanical joint

3.16.1
auxiliary axis
additional axis that is not physically part of the manipulator (3.6) and is controlled by the robot controller

Note 1 to entry: Controlled means that there is feedback signal(s) to enable closed loop control by the robot controller.

3.16.2
external axis
additional axis, not physically part of the manipulator (3.6), that is not powered and not controlled by the robot controller.

Note 1 to entry: External axis integration is in Part 2.

3.17
industrial robot
robot
automatically controlled, reprogrammable multipurpose manipulator(s) (3.6), programmable in three or more axes (3.16), which can be either fixed in place or mobile for use in industrial automation applications

Note 1 to entry: The industrial robot includes:

— the manipulator (3.6), including robot actuators (3.5) controlled by the robot controller;

— the robot controller.

Note 2 to entry: This includes any auxiliary axes (3.16.1) that are integrated into the kinematic solution.

Note 3 to entry: The following are considered industrial robots for this part of ISO 10218:

— hand-guided robots;

— the manipulating portions of mobile robots;

— power and force limited robots;

— robots with built-in speed and separation monitoring safety functions.

3.18
industrial robot system
robot system
machine comprising:

— industrial robot (3.17);

— end-effector(s) (3.9);

— any end-effector sensors and equipment (e.g. vision systems, adhesive dispensing, weld controller) needed to support the intended task;

— task program;

Note 1 to entry: The robot system requirements, including those for controlling hazards, are contained in ISO 10218-2.

3.19
robot application
industrial robot application
a machine comprising:

— industrial robot system (3.18);

— workpiece(s);

— any obstacle or object that has influence on the risk assessment of the intended use

3.20
industrial robot cell
robot cell
one or more robot systems including associated machinery and equipment and the associated safeguarded space(s) (3.40.5) and protective measures

3.21
integration
act of combining a robot (3.17) with an end-effector (3.9) and other equipment or another machine (including additional robot systems (3.18) to form a complete machine capable of performing useful work such as production of parts

Note 1 to entry: This act of machine building can include the requirements for the installation of the system.

3.22
integrator
entity that designs, provides, manufactures, or assembles robot systems or integrated manufacturing systems and oversees the safety strategy, including the protective measures, control interfaces and interconnections of the control system

Note 1 to entry: The integrator can be a manufacturer, assembler, engineering company or the user.

3.23
operator
person or persons using, operating, adjusting, maintaining, cleaning, repairing, troubleshooting, transport, commissioning and dismantling

Note 1 to entry: This definition includes person or persons that can be expected at or near machinery, even if not performing a task associated with the specific machinery.

3.24
user
entity that uses robot systems (3.18) and is responsible for the operator(s) (3.23) associated with the robot system (3.18)

3.25
industrial environment
workplace where the public is restricted from access or not reasonably expected to be present for the intended tasks and robot applications (3.19)

3.26
mode
operating mode
characterization of the way and the extent to which the operator (3.23) intervenes in the control equipment

Note 1 to entry: In the context of this standard, mode refers to the control state of the robot, e.g. automatic, manual, other.

3.26.1
manual mode
control state that allows for the direct control by an operator (3.23)

Note 1 to entry: Sometimes referred to as teach mode where program points and robot attributes are set.

3.26.2
automatic mode
control state that allows executing programmed tasks

[SOURCE: ISO 8373:2012, definition 5.3.10.1]

3.27
span-of-control
predetermined portion of the machinery that is under control of a specific device for safety function (3.26)

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

EXAMPLE An emergency stop pushbutton could cause a local stop or a global stop. See ISO 13850 for span-of-control of emergency stops.

3.28
single point of control
ability to operate the robot (3.17) such that initiation of robot motion is only possible from one source of control and cannot be overridden from another initiation source

[SOURCE: ISO 8373:2012, 5.19]

3.29
local control
state of the system or portions of the system in which operation is affected from the control panel or teach pendant (3.31) of the individual machine(s) only

3.30
control station
part of the robot system (3.18) which contains one or more control devices intended to activate or deactivate functions of the system or parts of the system

Note 1 to entry: The control station can be fixed in place (e.g. control panel) or movable (e.g. teach pendant).

3.31
pendant
teach pendant
hand-held unit linked to the control system with which a robot (3.17) can be programmed, moved, or actuated

3.32
program

3.32.1
control program
inherent set of instructions which defines the capabilities, actions, and responses of a robot (3.17)

Note 1 to entry: This type of program is fixed and usually not modified by the user.

3.32.2
task program
set of instructions for motion and auxiliary functions that define the specific intended task of the robot system (3.18)

Note 1 to entry: This type of program is generated by the integrator or user.

Note 2 to entry: An application *(3.1)* is a general area of work; a task is specific within the application.

3.33
task programming
teach
teach programming
programming of the task performed r by

a) manually by lead-through; or

b) using a teach pendant (3.31) to move the robot (3.17) through the desired positions; or

c) using a teach pendant (3.31) to program without causing motion; or

d) using algorithm(s) with sensor data

3.34
program verification
execution of a task program for confirming the robot path and process performance

Note 1 to entry: Verification can include the total path traced by the tool centre point during the execution of a task program or a segment of the path. The instructions can be executed in a single instruction or continuous instruction sequence. Verification is used in new applications and in fine tuning/editing of existing ones.

3.35
safe state
state of the Equipment Under Control (EUC) when safety is achieved

Note 1 to entry: In going from a potentially hazardous condition to the final safe state, the EUC may have to go through a number of intermediate safe states. For some situations, a safe state exists only so long as the EUC is continuously controlled. Such continuous control may be for a short or an indefinite period of time.

[SOURCE: IEC 61508-4:2010, 3.1.13, modified]

3.36
safety function
function of the machine whose failure can result in an immediate increase of the risk(s)

[SOURCE: ISO 12100:2010, 3.30 and ISO 13849-1:2015, 3.1.20]

3.36.1
monitored standstill
safety function (3.36) that monitors a condition where the robot (3.17) is stopped with drive power active

Note 1 to entry: In ISO 10218-1:2011, this type of stop was called "safety-rated monitored stop".

3.36.2
output, safety function
output signal having a specified safety-related performance

3.36.3
input, safety function
input signal having a specified safety-related performance

3.36.4
soft axis and space limiting
soft limit
safety function(s) (3.36) with monitored limit(s) placed on the range of motion of the robot (3.17)

3.36.5
output, soft axis and space limiting
output, soft limit
safety function output of the state of the robot position relative to a soft axis or space safety function limit

Note 1 to entry: For example, the robot position can be inside or outside the limit(s) of the soft axis and space limiting safety function(s).

3.37
protective stop
type of interruption of operation that causes a cessation of motion for protective and safeguarding purposes and which retains the program logic to facilitate a restart