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Robotics — Safety requirements —

Part 1:
Industrial robots

Robotique — Exigences de sécurité —

Partie 1: Robots industriels

ISO/CEN PARALLEL PROCESSING

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

The main changes are as follows:

— additional requirements for design;

— mode requirements;

— clarifying requirements for functional safety;

— robot classification (Class I and Class II) for functional safety requirements;

— test methodology to determine the maximum force per manipulator for Class I robots;

— adding requirements for cybersecurity to the extent that it applies to industrial robot safety;

— incorporating safety requirements for industrial robots intended for use in collaborative applications (formerly, the content of ISO/TS 15066).

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

The ISO 10218 series has been created in recognition of the particular hazards that are presented by robotics in an industrial environment. This document addresses robots as incomplete machines, while ISO 10218-2[1)] addresses robots integrated into complete machines (systems, applications, cells).

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

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to robot safety:

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

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

— robot system 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.

Robots and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the scope of this document.

When provisions of a type-C standard are different from those that 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.

In recognition of the variable nature of hazards with different uses of industrial robots, the ISO 10218 series is divided into two parts. This document provides requirements for safety in the design and construction of the robot. For safety in the application of industrial robots, ISO 10218-2 provides requirements for the safeguarding of operators during integration, commissioning, functional testing, programming, operation and maintenance.

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

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

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

Where appropriate, ISO/TS 15066:2016 on the safety of collaborative robot systems was added to the ISO 10218 series. Most of ISO/TS 15066 has been incorporated into ISO 10218-2, since human-robot collaboration relates to the application and not to the robot alone. Safety functions that enable a collaborative task can be part of the robot or can be provided by a protective device, or a combination.

1) Under preparation, current stage: ISO/FDIS 10218-2:2023, it will be published in conjunction with this document.

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.

Robotics — Safety requirements —

Part 1:
Industrial robots

1 Scope

This document specifies requirements for the inherently safe design, risk reduction measures and information for use of robots for an industrial environment.

This document addresses the robot as an incomplete machine.

This document is not applicable to the following uses and products:

— underwater;

— law enforcement;

— military (defence);

— airborne and space robots, including outer space;

— medical robots;

— healthcare robots;

— prosthetics and other aids for the physically impaired;

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

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

— lifting or transporting people;

— mobile platforms;

— tele-operated manipulators.

NOTE 1 Requirements for robot systems, integration, and applications are covered in ISO/FDIS 10218-2:2023.

NOTE 2 Additional hazards can be created by robot applications (e.g. welding, laser cutting, machining). These hazards are addressed during robot system and robot application design. See ISO/FDIS 10218-2:2023.

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

This document does not cover the hazards related to:

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

— underground use;

— specific hygienic requirements;

— use in nuclear environments;

— in potentially explosive environments;

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

— hazardous ionizing and non-ionizing radiation;

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

— handling or lifting or transporting people;

— where the public, all ages or non-working adults have access (e.g. service robots, consumer products).

Noise emission is generally not considered a significant hazard of the robot alone, and consequently noise is excluded from the scope of this document.

This document is not applicable to robots that are manufactured before the date of its publication.

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 3864-3:2012, *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 9283:1998, *Manipulating industrial robots — Performance criteria and related test methods*

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

ISO 14119:2013, *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 19353:2019, *Safety of machinery — Fire prevention and fire protection*

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

ISO 20643:2005/Amd 1:2012, *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 60947-5-8:2020, *Low-voltage switchgear and controlgear — Part 5-8: Control circuit devices and switching elements — Three-position enabling switches*

IEC 61310-1:2007, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

IEC 61310-2:2007, *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*

IEC 61310-3:2007, *Safety of machinery — Indication, marking and actuation — Part 3: Requirements for the location and operation of actuators*

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 62061:2021, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems*

IEC 62745:2017, *Safety of machinery — Requirements for cableless control systems of machinery*

3 Terms, definitions 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, application

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* (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)* (3.1.2.5), programmable in three or more *axes* (3.1.2.1), which can be either fixed in place or fixed to a *mobile platform* (3.1.2.8) 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(s)* (3.1.2.5), including *robot actuators* (3.1.2.10) controlled by the robot; and

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

Note 2 to entry: Industrial robot includes any *auxiliary axes* (3.1.2.2) that are *integrated* (3.1.7.1) into the kinematic solution.

3.1.1.3
robot system
industrial robot system
machine comprising an *industrial robot* (3.1.1.2), *end-effector(s)* (3.1.2.3), and any end-effector sensors and equipment needed to support the intended task and a *task program* (3.1.4.2)

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, machinery and equipment

3.1.1.5
application
intended use and purpose of the *robot* (3.1.1.2) or *robot system* (3.1.1.3), i.e. the process, the task(s)

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

3.1.1.6
collaborative application
robot applications (3.1.1.4) that implements one or more *collaborative task(s)* (3.1.1.7)

Note 1 to entry: *Collaborative applications* can include non-collaborative and *collaborative tasks* (3.1.1.7).

3.1.1.7
collaborative task
portion of the robot sequence where both the *robot application* (3.1.1.4) and *operator(s)* (3.1.7.2) are within the same *safeguarded space* (3.1.9.5)

3.1.1.8
robot cell
industrial robot cell
one or more *robot applications* (3.1.1.4) including any object that has influence on the risk assessment of the intended use, associated *safeguarded space(s)* (3.1.9.5) and *safeguards* (3.1.10.4)

3.1.2 Sub-assemblies and components of robots, robot systems and robot applications

3.1.2.1
axis
actuated mechanical joint (e.g. rotating about a pivot, linear) that provides at least one degree of freedom

3.1.2.2
auxiliary axis
axis (3.1.2.1) that is not physically part of the *manipulator* (3.1.2.5) and is controlled by the *robot* (3.1.1.2)

Note 1 to entry: Controlled means that there is a feedback signal(s) to enable closed loop control by the *robot* (3.1.1.2).

3.1.2.3
end-effector
device specifically designed for attachment to the *mechanical interface* (3.1.2.7) to enable the *robot* (3.1.1.2) 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).

3.1.2.4
gripper
end-effector (3.1.2.3) designed for seizing and holding workpieces

Note 1 to entry: Various types of grippers and the terms grip, grasp, grasping and releasing are defined in ISO 14539:2000.

[SOURCE: ISO 14539:2000, 4.1.2, modified — Note 1 to entry has been added.]

3.1.2.5
manipulator
mechanism consisting of an arrangement of segments, jointed or sliding relative to one another

Note 1 to entry: A *manipulator* (3.1.2.5) includes *robot actuators* (3.1.2.10).

3.1.2.6
mass per manipulator
mass of all moving parts of the *robot* (3.1.1.2)

3.1.2.7
mechanical interface
mounting surface at the end of the *manipulator* (3.1.2.5) to which the *end-effector* (3.1.2.3) is attached

3.1.2.8
mobile platform
assembly of the components which enables locomotion and provides the structure to affix a *manipulator* (3.1.2.5)

3.1.2.9
payload
mass of all that is attached to the *manipulator* (3.1.2.5), including the *end-effector* (3.1.2.3) and workpiece

Note 1 to entry: The payload can be, but is not limited to, the payload attached to the *mechanical interface* (3.1.2.7) of the *robot* (3.1.1.2).

3.1.2.10
robot actuator
powered mechanism that converts energy to effect motion

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

3.1.2.11
tool centre point
point defined for a given *robot application* (3.1.1.4) with regard to the *mechanical interface* (3.1.2.7) coordinate system.

Note 1 to entry: The TCP setting defines the location of the TCP relative to the *mechanical interface* (3.1.2.7).

3.1.3 Controls-related

3.1.3.1
control station
enclosure which contains one or more control devices intended to activate or deactivate functions

Note 1 to entry: The *control station* can be fixed in place (e.g. control panel) or can be movable (*teach pendant* (3.1.3.3) or *pendant* (3.1.3.2) which can be referred to as a portable control station).

3.1.3.2
pendant
portable hand-held *control station* (3.1.3.1)

3.1.3.3
teach pendant
pendant (3.1.3.2) with which a *robot* (3.1.1.2) can be programmed, moved or actuated

Note 1 to entry: Hand-held units or devices which only have the capability of displaying parameters (e.g. no motion and no actuation capabilities), are not considered to be *control stations* (3.1.3.1) or *teach pendants* (3.1.3.3).

3.1.3.4
direct control
movement or operation effected by the *control station* (3.1.3.1) that is part of the *robot* (3.1.1.2)

Note 1 to entry: Previously direct control was known as local control of the *robot* (3.1.1.2).

3.1.3.5
external control
movement or operation effected by the *control station* (3.1.3.1) not a part of the *robot* (3.1.1.2) but as a part of the *integration* (3.1.7.1)

Note 1 to entry: Previously external control was known as external control of the *robot* (3.1.1.2).

Note 2 to entry: See ISO/FDIS 10218-2:2023 for requirements of *integration* (3.1.7.1).

3.1.3.6
singularity
occurrence whenever the rank of the Jacobian matrix becomes less than full rank

Note 1 to entry: Mathematically, in a singular configuration, the joint velocity in joint space can become infinite to maintain Cartesian velocity. In actual operation, motions defined in Cartesian space that pass near singularities can produce high axis speeds. These high speeds can be unexpected to an *operator* (3.1.7.2).

3.1.3.7
span-of-control
predetermined portion of a *robot cell* (3.1.1.8) or machine that is under control of a specific device for a *safety function* (3.1.8.1)

Note 1 to entry: Span-of-control can apply to a component part, a portion of a machine, a *robot* (3.1.1.2), or a machine within the *robot cell* (3.1.1.8).