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

Part 2:
Robot systems, robot applications and robot cells integration

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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.

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

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

— incorporating safety requirements for collaborative applications (formerly, the content of ISO/TS 15066:2016);

— 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.

Introduction

This document has been created in recognition of the hazards that are presented by robots when they are integrated and installed into robot systems, robot applications and robot cells. Part 1 of ISO 10218 addresses robots as partly completed machines, while this document addresses robots integrated into complete machines (systems) for specific 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 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.

Robot systems and robot applications, and the extent to which hazards, hazardous situations and events, are covered are 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 systems and robot applications are well recognized, but the sources of the hazards are frequently unique to a 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 way in which it is integrated, installed, programmed, used, and maintained. This document provides requirements for safety in the integration and installation of robots into robot systems and robot applications. 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.

Both parts of ISO 10218 deal with robotics in an industrial environment, which is comprised of workplaces where the public is excluded or restricted from access because the people (operators) are working adults. 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 system" and "robot application" refer to "industrial robot system" and "industrial robot application" as defined in ISO 10218-1 and ISO 10218-2. "Robot" refers to "industrial robot".

For understanding requirements in this document, a word syntax is used to distinguish requirements from guidance or recommendations. The word "shall" is used for mandatory requirements to comply with this document. The word "should" is used to identify guidance, suggestions, recommended actions or possible solutions for requirements, but alternatives are possible.

This document has been updated based on experience gained since the release of ISO 10218-1 and ISO 10218-2 in 2011. This document remains aligned with minimum requirements of a harmonized type-C standard for robot systems and robot applications in an industrial environment. Providing for a safe robot system or application depends on the cooperation of a variety of "stakeholders" – those entities that share in a responsibility for the ultimate purpose of providing a safe working environment. Stakeholders may be identified as manufacturers, suppliers, integrators, and users (the entity responsible for using robots), but all share the common goal of a safe (robot) machine. The requirements in this document can be assigned to one of the stakeholders but overlapping responsibilities can involve multiple stakeholders in the same requirements. While using this document, the reader is cautioned that all the requirements identified could apply to them, even if not specifically addressed by "assigned" stakeholder tasks.

It is important to emphasize that the term "collaborative robot" is not used in ISO 10218 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.

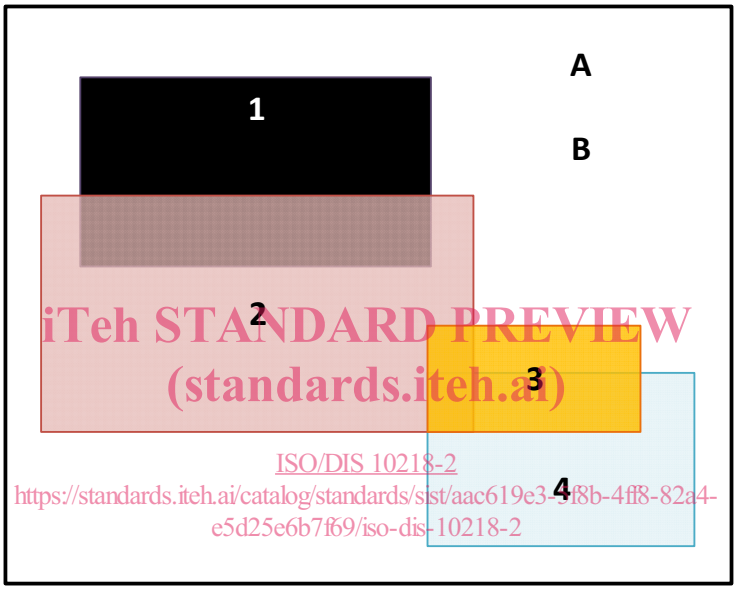
Revisions include:

- category 2 stopping functions;
- cybersecurity;
- definitions and abbreviations;
- details within the information for use clause;
- functional safety requirements;
- risk estimation parameters and thresholds;
- integrating the requirements of
  - ISO/TS 1506:2016 — Robots and robotic devices — Collaborative robots
    - — hand-guided controls (HGC) requirements for collaborative applications;
    - — power and force limiting (PFL) requirements for collaborative applications;
    - — speed and separation monitoring (SSM) requirements for collaborative applications;
  - ISO/TR 20218-1:2018 — Robotics — Safety design for industrial robot systems — Part 1: End-effectors
  - ISO/TR 20218-2:2017 — Robotics — Safety design for industrial robot systems — Part 2: Manual load/ unload stations
  - RIA TR R15.806:2018 — A Guide to Testing Pressure and Force in Collaborative Robot Applications
- marking;
- mechanical strength and stability requirements;
- mode selection;
- power loss requirements;

— risk estimation parameters.

ISO 10218 deals with safety of 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.

Figure 1 is a figurative representation of the relationship of machinery safety standards that can be used to support a robot application. The robot (**1**) is the scope of ISO 10218-1, while the robot system/ application/ cell (**2**) is covered by this document. A robot cell can include machines subject to their own type-C standards (**3**). Machines can be integrated into an integrated manufacturing system addressed by ISO 11161 (**4**). Relevant type-A and -B standards are depicted by **A** and **B** in Figure 1.



Key

1 robots (ISO 10218-1)

2 robot systems/ robot applications/ robot cells (ISO 10218-2)

3 machine type-C standards, as applicable

4 integrated manufacturing systems (ISO 11161)

A type-A standard, i.e. ISO 12100 Risk assessment and risk reduction

B type-B standards, e.g. safety aspects (type-B1) and safety device (type-B2)

Figure 1 — Graphical view of relationships between standards relating to the robot system, robot application and robot cell

Robotics — Safety requirements for robot systems in an industrial environment — Part 2: Robot systems, robot applications and robot cells integration

1 Scope

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

— the design, integration, commissioning, operation, maintenance, decommissioning and disposal of the industrial robot system, application or cell;

— integration of machines and components to the industrial robot system, application or cell;

— information for use for the design, integration, commissioning, operation, maintenance, decommissioning and disposal of the industrial robot system, application or cell;

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

— 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;

— mobile platforms;

— tele-operated manipulators.

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 manufacturer.

Robot systems can be used for a broad range of applications and integrated into robot cell(s). Therefore, it is not possible to provide a list of all significant hazards, hazardous situations or events into which a robot and robot application can be integrated. Moreover, 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).

This document also provides basic requirements for industrial robots used in applications as following, but does not cover the entirely the hazards related to:

— underground use;

— hygienic requirements;

— due to the processing of any material, e.g. food, cosmetics, pharmaceutical, metal;

— nuclear environments;

— potentially explosive environments;

— use of robot systems 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.

Acoustic noise has been identified to be a significant hazard with industrial robot systems and is included in the scope of this document.

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

2 Normative references

The following documents are referred to in the text in such a way that some or all their content constitutes requirements of this document. For dated references, only the edition cited 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 8995-1:2002, *Lighting of work places — Part 1: Indoor*

ISO/DIS 10218-1:2020, *Robotics — Safety requirements for robotics in an industrial* environment *— Part 1: 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 13732-3:2005, Ergonomics of the thermal environment — *Methods for the assessment of human responses to contact with surfaces — Part 2: Cold surfaces*

ISO 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13850:2015, *Safety of machinery — Emergency stop — 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 13856-1:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors*

ISO 13856-2:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars*

ISO 13856-3:2013, *Safety of machinery — Pressure-sensitive protective devices —* ISO 13856-2:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 3: General principles for design and testing of pressure-sensitive bumpers, plates, wires and similar 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 14119:2013, *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 14122-1:2016, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means and general requirements of access*

ISO 14122-2:2016, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

ISO 14122-3:2016, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails*

ISO 14122-4:2016, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders*

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

ISO 15534-1:2000, *Safety of machinery — 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, *Safety of machinery — Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings*

ISO 19353:2005, *Safety of machinery — Fire prevention and protection*

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

ISO 20643:2005, *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, *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 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 location and operation of actuators*

IEC 61496-1:2012, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests*

IEC 61496-2:2013, *Safety of machinery — Electro-sensitive protective equipment — Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)*

IEC 61496-3:2018, *Safety of machinery — Electro-sensitive protective equipment — Part 3: Particular requirements for active opto-electronic protective devices responsive to diffuse Reflection (AOPDDR)*

IEC/TS 61496-4-2:2014, *Safety of machinery — Electro-sensitive protective equipment — Part 4-2: Particular requirements for equipment using vision based protective devices (VBPD) — Additional requirements when using reference pattern techniques (VBPDPP)*

IEC/TS 61496-4-3:2015, *Safety of machinery — Electro-sensitive protective equipment — Part 4-3: Particular requirements for equipment using vision based protective devices (VBPD) — Additional requirements when using stereo vision techniques (VBPDST)*

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 62061:2005 +A1:2012+A2:2015, *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*

IEC/TS 62998-1:2019, *Safety of machinery — Safety-related sensors used for the protection of persons*

3 Terms, definitions and abbreviations

For the purposes of this document, the terms, definitions and abbreviations given in ISO 12100, ISO 10218-1 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 Robot, robot system, robot application, application, collaborative, robot cell

3.1.1
industrial environment
workplace where the public is restricted from access or not reasonably expected to be present for the intended tasks and robot applications (3.1.4)

NOTE 1 to entry: This includes manufacturing, laboratory automation/ production, pharmaceutical automation/ production, packing, packaging, palletizing, warehousing, logistics, loading/ unloading and more.

3.1.2
industrial robot
robot
automatically controlled, reprogrammable multipurpose manipulator(s) (3.2.5), programmable in three or more axes (3.2.1), which can be either fixed in place or fixed to a mobile platform (3.2.8) for use in automation applications in an industrial environment (3.1.1)

NOTE 1 to entry: The industrial robot includes:

— the manipulator (3.2.5), including robot actuators (3.2.10) controlled by the robot controller;

— the robot controller.

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

NOTE 3 to entry: The following are considered industrial robots:

— the manipulating portion(s) of mobile robots, where a mobile robot consists of a mobile platform (3.2.8) with an integrated manipulator (3.2.5) or robot;

— robots with hand-guided controls (HGC);

— robots with power and force limited (PFL) capabilities;

— robots with built-in speed and separation monitoring (SSM) safety functions (3.10.3).

3.1.3
industrial robot system
robot system
machine comprising:

— industrial robot (3.1.2);

— end-effector(s) (3.2.2);

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

— task program (3.4.1.1)

3.1.4
robot application
industrial robot application
a machine comprising:

— industrial robot system (3.1.3);

— workpiece(s);

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

3.1.5
application
intended use and purpose of the robot (3.1.2) or robot system (3.1.3), i.e. the process, the task(s)

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

3.1.6 3.1.5
collaborative application
an application (3.1.5) that contains one or more collaborative task(s) (3.1.7)

NOTE 1 to entry: Collaborative applications (3.1.6) can include collaborative tasks (3.1.7) and non-collaborative tasks.

3.1.7
collaborative task
a portion of the robot sequence where both the robot application (3.1.4) and operator(s) (3.9.2) are within the same safeguarded space (3.11.1.4)

3.1.8
industrial robot cell
robot cell
one or more robot applications (3.1.4) including associated:

- machinery and equipment;
- safeguarded space(s) (3.11.1.4);
- safeguards (3.14)

3.2 Robot, robot system, robot application – sub-assemblies and components

3.2.1
axis
actuated (e.g. rotating about a pivot, linear) mechanical joint that provides at least one degree of freedom

3.2.2
end-effector
device specifically designed for attachment to the mechanical interface (3.2.7) to enable the robot (3.1.2) 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).

3.2.2.1
gripper
end-effector (3.2.2) 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, definition 4.1.2. Modified with addition of the note.]

3.2.3
fixture
device used to hold in position an item as part of the handling or assembling process in a robot application (3.1.4), but not as an end-effector (3.2.2)

3.2.4
manual load/unload station
part of the robot application (3.1.4) designed for the direct manual intervention for the placement and removal of parts or workpieces for processing by the robot system (3.1.3)

3.2.5
manipulator
mechanism consisting of an arrangement of segments, jointed or sliding relative to one another

NOTE 1 to entry: A manipulator (3.2.5) includes robot actuators (3.2.10).

3.2.6
mass per manipulator (*M*)
mass of all moving parts of the robot (3.1.2)