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INDUSTRY 4.0 STANDARDS CELL
ROBOTICS AND AUTONOMOUS SYSTEMS

An increasing number of robots and autonomous vehicles work alongside operators.

But, what's new on the standardisation front?

What does the future hold in the field?

Would you like to find out which standards are of particular concern to your own activity?

With support from Federal Public Service Economy, Sirris initiated the Industry 4.0 Standards Cell, to inform Belgian businesses – essentially SMEs – of existing standards and those pending publication.

The most pertinent standards in the field of robotics in industrial environments are coordinated by ISO, in particular via its technical committees ISO/TC 299 'Robotics' and ISO/TC 199 'Safety of machinery'.

This document provides an insight into currently applicable standards and their projected evolution

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DISCOVER THE POTENTIAL OFFERED BY SMART PRODUCTION

Currently applicable standards, ongoing or future projects?

Contact our experts:

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Initially attached to ISO/TC 184: Automation Systems and Integration, via a specific sub-committee (SC 2), robotics was acknowledged as a strategically important technological field. The theme has therefore been allocated its own technical committee (ISO/TC) since late 2015. This transformation of the ISO/TC 184/SC 2 into a new independent technical committee, gave way to the **ISO/TC 299**.

The ISO/TC 299 is active in the field of robotics for manufacturing, healthcare and consumers, excluding toys and military applications. The technical committee has links with: ISO/TC 199 Safety of machinery, ISO/TC 184 Automation systems and integration, ISO/TC 173 Assistive products, and ISO/IEC JTC 1/SC 35 User interfaces.

Within the **ISO/TC 199** committee, most ISO workgroups or ISO-IEC liaison groups intervene on aspects likely to impact the safety of collaborative robots: WG 5 works on general machine design principles and risk assessment, WG 6 intervenes on safe distances and ergonomic aspects, WG 8 works on secure control systems and WG 12 on man-machine interaction.

Robotic standardisation activities dealt with by these 2 technical committees cover three fields:

1. Terminology
2. Robotic application safety
3. Mechanical interfaces

TERMINOLOGY

The standards **ISO 9787:2013** (Coordinate Systems and motion nomenclatures), **ISO 19649:2017** (Vocabulary for Mobile Robots), **ISO 8373:2012** (General terms and Definitions) and **ISO 14539:2000** (Manipulating industrial robots - Object handling with grasp-type grippers - Vocabulary and presentation of characteristics) define the terminology referenced in other standards. The same applies to **ISO 11593** (Robots for industrial environments–Automatic end-effector exchange systems – Vocabulary and presentation of characteristics) which is currently being developed.

ROBOTIC APPLICATION SAFETY

Most standards relating to robotics are in line with standards pertaining to the safety of people and machines, such as **EN/ISO 13849-1** and **IEC/EN 62061**. However, the specificities of robotics and its applicability within industrial (and non-industrial) environments have led to the necessity to develop the following, more specific standards (for further information, we invite you to click on the hyperlinks in the document).

- Safety standard: ISO 10218-1,2:2011 (ISO/TC 299)
- Technical report: ISO/TR 20218-1:2018, Robotics - Safety design for industrial robot systems - Part 1: End-effectors (ISO/TC 299)
- Technical report: ISO/TR 20218-2 :2017, Robotics — Safety design for industrial robot systems — Part 2: Manual load/unload stations (ISO/TC 299)
- Technical report: ISO/TR 21260 Safety of Machinery – Mechanical safety data for physical contacts between moving machinery and people (ISO/TC 199)

MECHANICAL INTERFACES

The standards **ISO 9409-1:2004** (Manipulating industrial robots – Mechanical interfaces – Part 1: Plates) and **ISO 9409-2:2002** Manipulating industrial robots-Mechanical interfaces – Part 2: Shafts) define the main dimensions, designation and marking of circular plates and cylindrical projection shafts as mechanical interfaces. They are designed to ensure interchangeability and orientation of manually assembled terminals. They define no other requirements pertaining to the terminal coupling mechanism. They contain no indication of the payload capacity, since the appropriate interface can be selected according to the application and the robot's payload capacity.

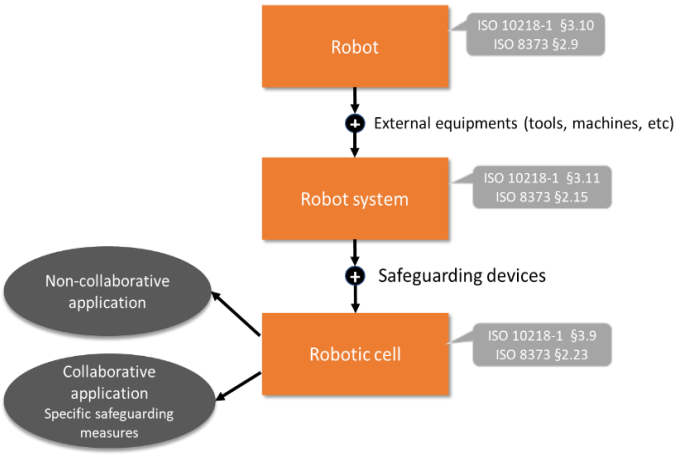
Safety standard: ISO 10218-1,2:2011 (ISO/TC 299)

Since 2011, the collaborative operation of industrial robots is described via the standards ISO 10218-1:2011 (focusing on quasi-machine design) and ISO 10218-2:2011 (focusing on robot system integration and use).

These 2 standards provide presumption of conformity with the 2006/42/EC Machinery Directive.

Published in 2 parts (Figure 1 Hierarchy of industrial robots), this document describes the safety requirements that must be taken into account by robot manufacturers and system integrators.

PRINCIPAL DEFINITIONS ASSOCIATED WITH ROBOTICS



Robot

According to the ISO 10218-1 standard, it is a programmable handling arm designed for multiple applications. It moves in at least three directions and can be fixed or mobile. When a robot is used in an industrial environment, it is referred to as an industrial robot. A robot is not considered as a machine in its own right, but as a quasi-machine, when it is sold with neither tools nor dedicated application.

Robot system

According to the ISO 10218-1 standard, it is a robot completed by all external equipment (tools, external axes, machines, etc.), which enable it to accomplish its task. A robot system is therefore a machine, as per the 2006/42/EC directive definition.

Robotic cell

According to the ISO 10218-2 standard, it is one or several robotic systems completed by adequate preventive measures. The implementation of a robotic cell requires a clear definition of the maximum space needed for the robotic system's operation, of the shared space (also referred to as collaborative workspace) and the controlled space (perimeter protection).

Physical assistance robot

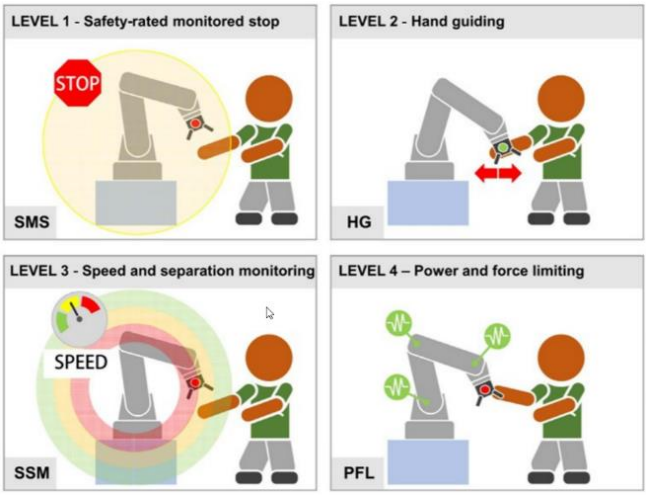
Robot used to provide the operator with physical assistance. In the case of a manually controlled industrial robot arm, it is considered as a collaborative industrial robot and must satisfy requirements pertaining to machine safety.

Figure 1: Hierarchy of industrial robots

Part 1 of the 10218 standard deals with requirements pertaining to the 'naked' robot (i.e. without tools) and the importance for robot manufacturers.

Part 2 deals with global robotic system safety requirements and is useful to system integrators. Suppliers in the robotics industry and final users of robotic systems are encouraged to understand these documents, to help them to be more efficient in their commercial relationships with robot manufacturers and integrators.

Four modes of collaborative operation are described:



Since February 2016, the **ISO/TS 15066:2016** technical specification completes ISO 10218-1 and -2. It specifies the safety requirements for man-robot collaborative applications and provides an essential reference document, equally for the design of the cobot application as for its validation. This technical specification stands as a temporary measure and shall shortly be integrated within the robot standard. However, it has the same legal force and companies applying the specification consequently abide by the requirements of the Machinery Directive.

The 10218 standard currently undergoes periodic updates. The contents of ISO/TS 15066:2016 shall be partly integrated in the revised versions of the two standards and/or shall be completed. New versions of ISO 10218-1 and ISO 10218-2 should be drafted **by May 2021**.

Several themes and requirements are being discussed within the context of this revision. Here is a brief overview:

- Creation of a list of all important safety functions (e.g. emergency stop, safety speed reduction, etc.) and determination of minimum requirements as per ISO 13849 / IEC 62061 for corresponding safety functions (e.g. the emergency stop must be installed in a dual channel version).

- Drafting of precise safety requirements in the field of brakes.
- A more detailed specification for requirements pertaining to collaborative applications as per ISO TS 15066 (e.g. hand guiding, safety-rated monitored stop, speed and separation monitoring, and power and force limiting).
- Consideration and revision of biomechanical threshold values for limiting power and force and for quasi-static and transient contact as per ISO TS 15066.
- Cybersecurity.
- Drafting of safety requirements for mobile robots.
- Consideration and detailed drafting of safety requirements for effectors / effector systems (based on the ISO/TR 20218-1 technical report).

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Technical report: ISO/TR 20218-1:2018, Robotics - Safety design for industrial robot systems - Part 1: End-effectors (ISO/TC 299)

This document is designed for use with the 10218 standard.

This document is a type B standard as indicated in its ISO 12100 standard.

The aim of this document is to describe the best safety practice with regard to end-effectors (end-of-arm-tooling, or EOAT). The industrial robot per se can execute no task; it must be integrated within a global robotic system, including the end-effectors that handle the part and execute the task. Certain end-effectors are adapted to collaborative man-robot work and others are not - the risks they present are too high. This document examines a vast range of different end-effectors, gives examples of potential dangers associated with end-effectors and provides advice on how to reduce risks associated with end-effectors.

This document is useful to robotised system integrators, as well as suppliers of end-effectors and tool changers. The final users of industrial robots can also find useful information to ensure the safety of their workers around end-effectors in the document.

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Technical report: ISO/TR 20218-2 :2017, Robotics — Safety design for industrial robot systems — Part 2: Manual load/unload stations (ISO/TC 299)

This document is designed for use with the 10218 standard.

ISO/TR 20218-2:2017 aims at solving difficulties likely to occur when industrial robot safety requirements conflict with safety requirements pertaining to ergonomics. For example, a safety requirement for traditional (protected) industrial robot systems consists in enclosing the robotised cell within a peripheral screen of a height of 1,400mm.

But what happens when an employee must interact with the robotised system, either to load or unload? From an ergonomic viewpoint, it is not reasonable to expect that the entrance or exit be raised to a height of 1,400mm. How can the individuals involved solve or minimise these two distinct but associated risk sources (robotised system vs. ergonomic risk)? The present ISO TR document has been elaborated in an aim to answer this question.

This document is of particular use to robotised system integrators and users.

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Technical report: ISO/TR 21260 Safety of Machinery – Mechanical safety data for physical contacts between moving machinery and people (ISO/TC 199)

There are several applications in which robot-to-person contact is necessary. For any person involved in risk assessment and control, the question of awareness of what force level can be tolerated by operators remains topical. In 2012, **ISO/TC 199** launched work aimed at drafting a new ISO 21260 standard to help designers of machines of all types to apply the first level of control hierarchy, i.e. intrinsically safe design.

The document will specify force and power limits for physical contact between the machine or machine parts and people, caused by machine or machine part movement, within the context of its intended use or of any predictable inappropriate use. This document will only define threshold values to avoid damage caused by physical contact. It will not deal with thermal or electrical effects, which all require more in-depth study.

The WG 12 Man-machine interactions workgroup specific to this subject was created in 2016.

Late April 2020, difficulties on reaching a consensus on the document's contents led the workgroup to abandon the ISO/DIS 21260:2018 'Safety of machinery – Mechanical safety data for physical contacts between moving machinery or moving parts of machinery and persons' project and to initiate a new ISO/TR 21260 project (technical report, non-prescriptive) by using the (informative) contents of the ISO/DIS 21260:2018 standard as a basis. Publication of the technical report is scheduled for late April 2023.

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