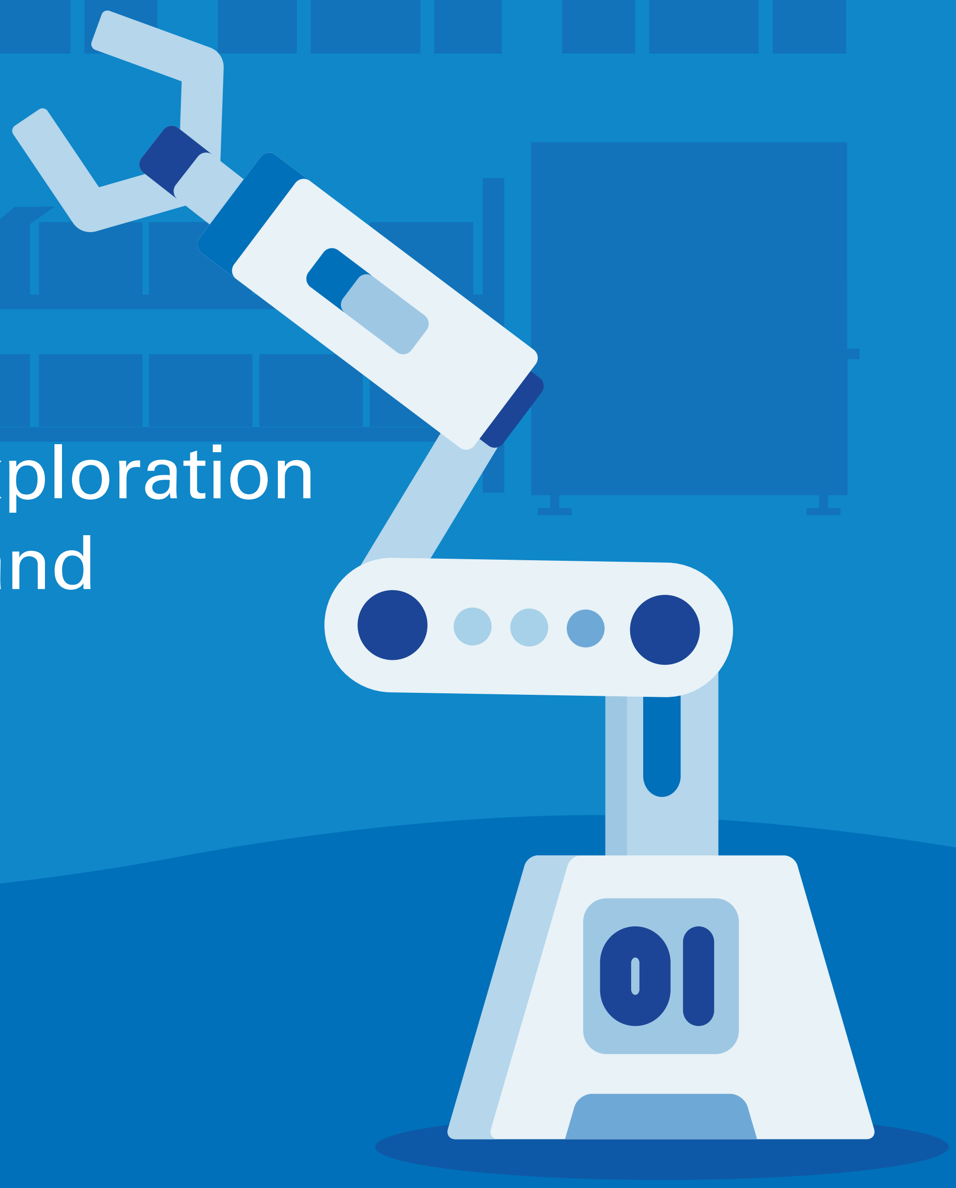
E-BOOK

Robot Safety: An In-depth Exploration of Categories and Standards



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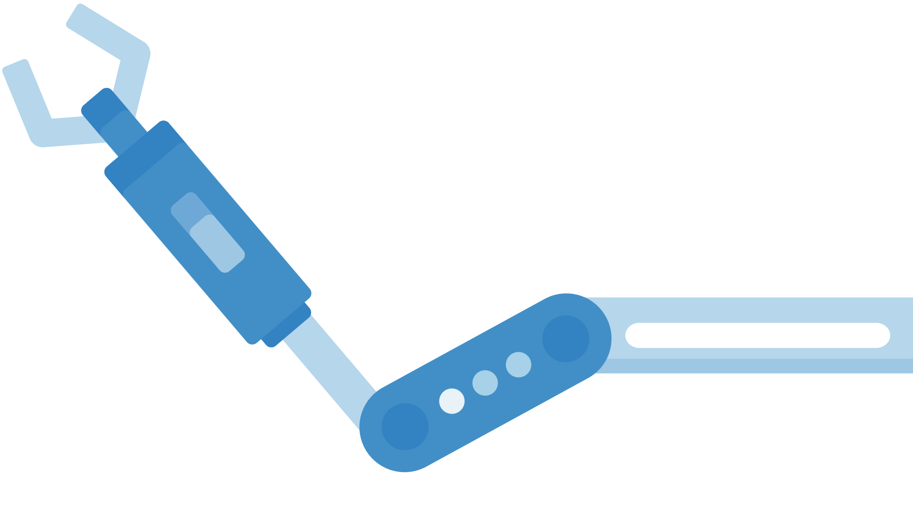
Introduction

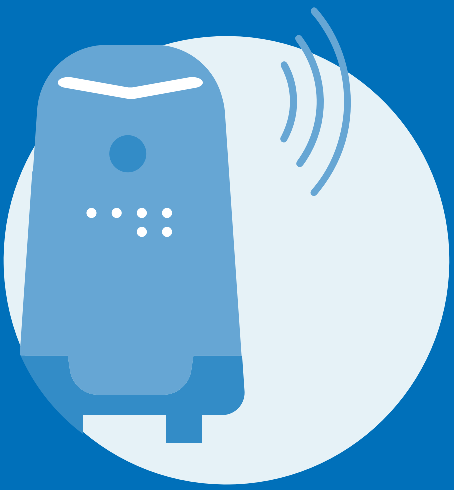
The pandemic has greatly accelerated innovation in robotics and is driving the adoption of robotic technologies into ever new areas.

As one might expect, manufacturers and other organizations have turned to automation and robotics in order to create environments where the virus can't spread. But organizations are doing more than simply replacing human labor with robots in situations where conditions are especially dangerous or where robots can do something faster. Today, robots increasingly work side by side with people in industrial settings, healthcare, the home, and elsewhere.

While safety matters regardless of the context, safety concerns assume a critical importance when people work directly with robots or receive care from them. These concerns must, in the first instance, inform the design of these robots. To ensure that these robots are indeed safe, companies designing robots for non-technical, "everyday" users must also comply with a stringent set of safety standards enforced by a variety of regulatory authorities.

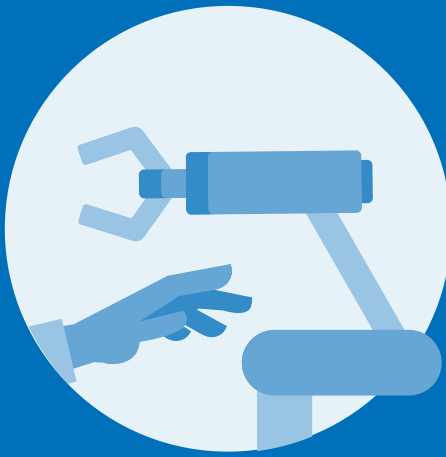
A deep and practical understanding of this complex, international regulatory landscape is necessary to ensure compliance with all relevant safety standards. As a foundation for that understanding, in this e-book we'll provide an overview of the five main categories of robots and the specific standards governing their manufacture, integration, and use.





Personal Care Robots

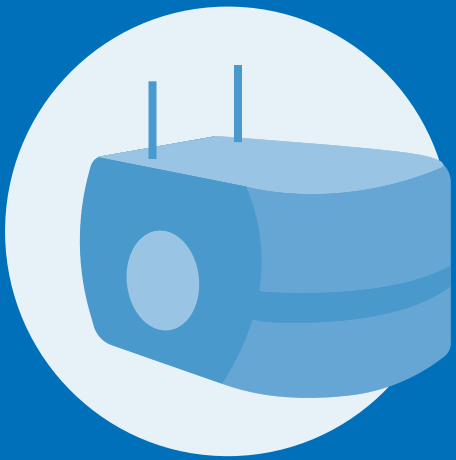
Traditional Industrial Robots and Robot Cells



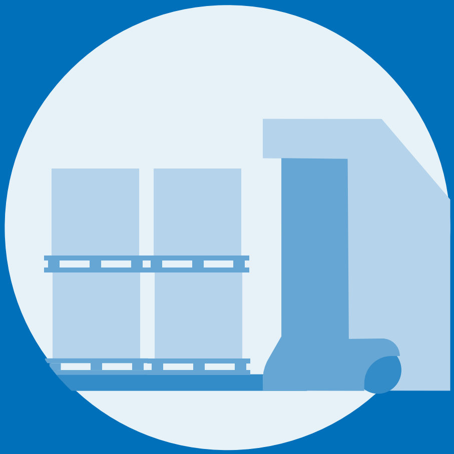
Collaborative Robots

Categories of Robots

SELECT ANY ROBOT TO JUMP TO ITS RESPECTIVE PAGE



Industrial Mobile Robots



Automated Guided Robots

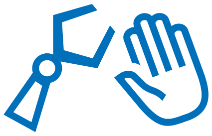
Personal Care Robots

Long seen primarily in industrial settings, robots are becoming safe enough – and consumer-friendly enough – to leave the factory floor and interact with humans in daily life. Whether used by delivery services to move packages, or through the use of screens and sensors to identify people and exchange information, personal care robots interact with humans like no other class of robotics.

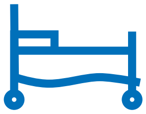
The market for personal care robots currently boasts an annual growth rate around 19%, with $10 billion in annual sales predicted by 2024. While this makes these robots attractive for manufacturers, the standards they must follow to produce them differ significantly from those applied to industrial robots.

Given that personal care robots frequently interact with non-trained people in non-industrial contexts, safety standards are extremely strict. The International Standards Organization has developed a standard, ISO 13482, explicitly for such robots. The ISO identifies three different types of personal care robots:

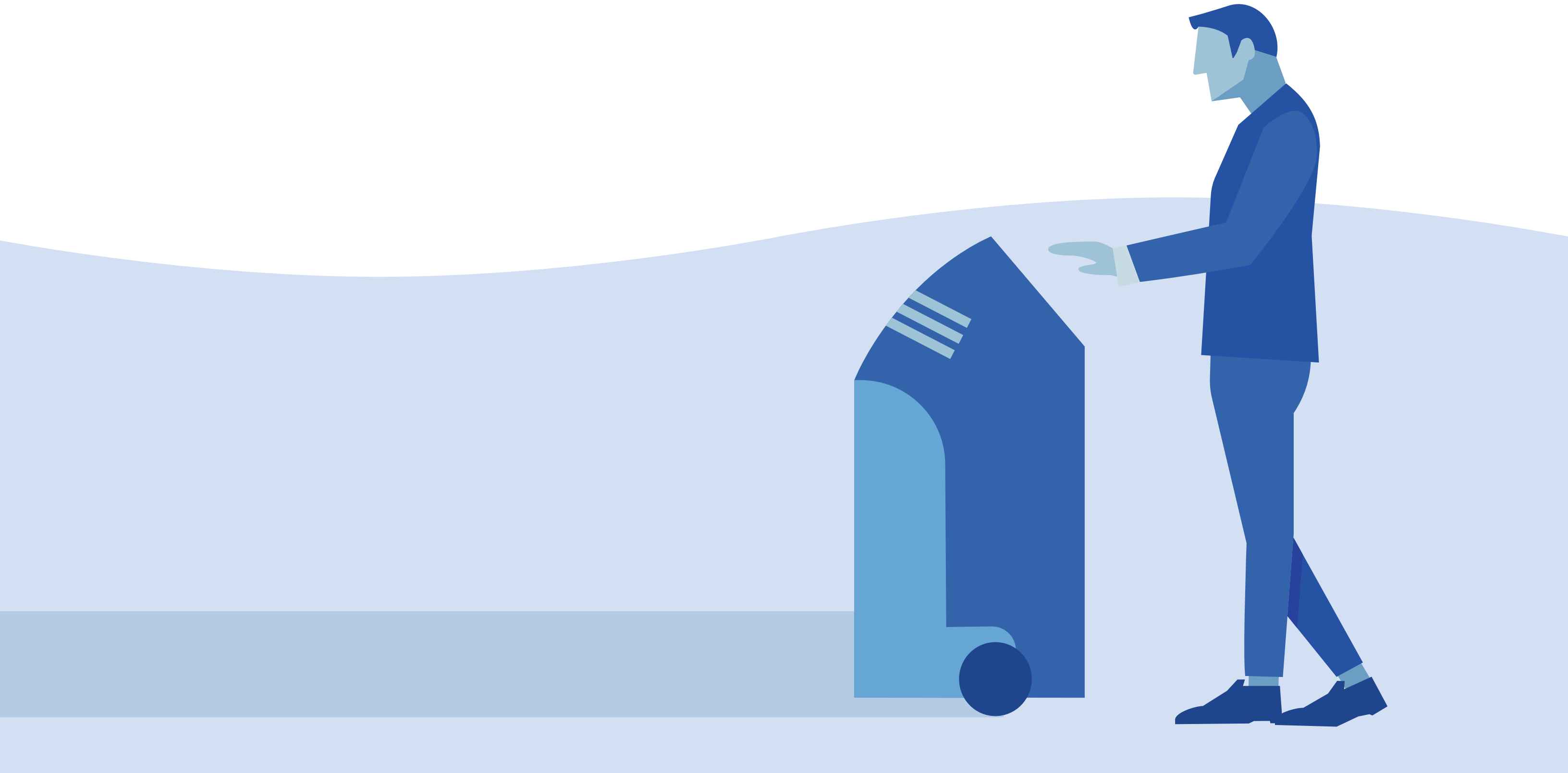
MOBILE SERVANT ROBOT
A robot that moves around as it performs tasks for humans, such as handling objects or exchanging information



PHYSICAL ASSISTANT ROBOT
A robot that physically assists a human to perform physical tasks, supplementing or augmenting the user's personal capabilities



PERSON CARRIER ROBOT
A robot that transports humans to an intended destination



These different types of personal care robots exhibit a range of capabilities, including:

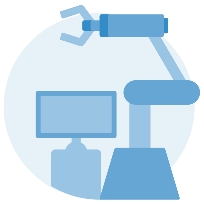
- **Traveling through homes or public buildings without colliding into stationary objects and moving obstacles that pose safety hazards.** The movement these robots are capable of runs the gamut from pose-to-pose motion to full area coverage.
- **Interacting with humans, including object exchange.** The robot may assume an active or passive role in these interactions.
- **Handling small and medium-sized objects (e.g., coffee cups, plates, and books).** Handling includes grasping, manipulating, and transporting objects, as well as placing them on a surface or passing them to a human.
- **Handling or manipulating large, constrained objects, such as opening a door, a window, a drawer or a dishwasher.** These activities may also require the robot to travel.
- **Physically transporting a person between locations on a smooth surface.** Transportation can involve a wheeled mobile platform that travels either autonomously or manually.
- **Reducing the load a person is carrying or moving.** Robots either provide support while a person moves the object or helps the person with mobility.

There is currently a single standard to follow to achieve full compliance when manufacturing and deploying personal care robots: ISO 13482. This standard addresses hazards related to batteries and charging, energy storage and supply, start-up and restarts, electrostatic potential, robot motion, environmental conditions, and more.

Unlike standards for other classes of robots, the standards here do not assume that the end user has been trained on how to interact with the robot. These standards also acknowledge that such devices won't be used in tightly controlled environments.

Recently, UL 3300 was released. This is an outline of investigation for Service, Communication, Information, Education and Entertainment (SCIEE) Robots. The document describes the requirements used to evaluate robot operational safety, focusing on multidirectional mobility, fire and shock hazards, external manipulation, user classes, and use of surroundings.

↑ JUMP BACK TO ROBOT CATEGORIES



Traditional Industrial Robots and Robot Cells

Traditional industrial robots have been on the market since the 1960s. In fact, they are the most common type of robot in use today. Largely employed for repetitive tasks in factories, most lack the sophisticated computational features of later-generation robots.

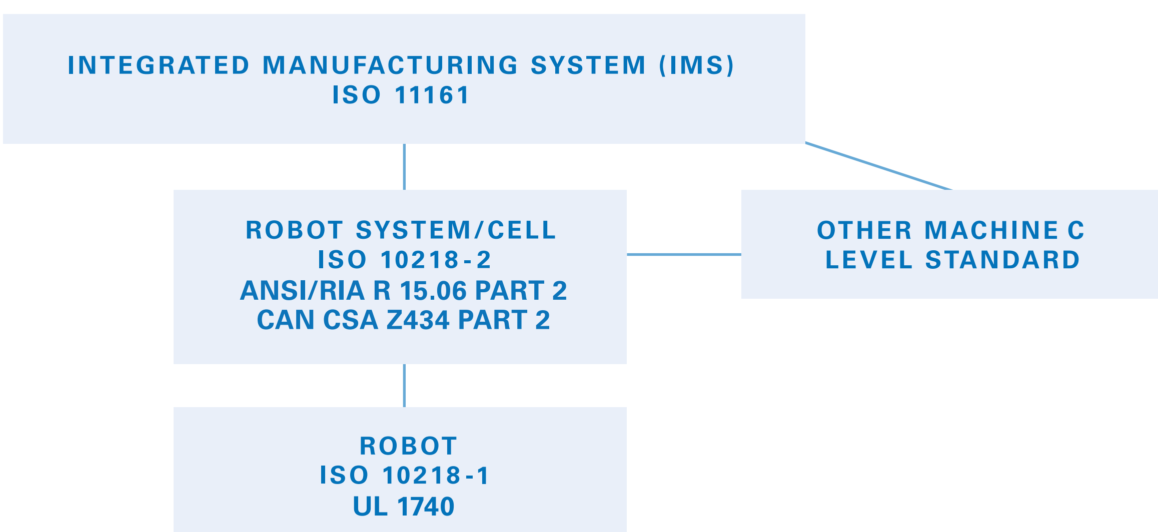
Due to their long presence in the workplace, industrial robots have well-defined safety standards and testing protocols. However, advances in technology over time have necessitated the development of additional standards. Companies manufacturing industrial robots need to keep up with the continuously evolving standards for electrical, mechanical, and functional safety in this area.

There are two main standards that apply to industrial robots, ISO 10218-1 and UL 1740. They define robots in the following ways:

ISO 10218-1 – An automatically controlled, reprogrammable multipurpose manipulator, programmable in three or more axes, which can either be fixed in place or mobile, for use in industrial automation processes.

UL 1740 – Actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment to perform intended tasks.

The figure below illustrates the relationship of the machinery standards that affect a robot system. The robot alone is covered by Part 1 of R15.06, Z434 and EN/ISO 10218-1. A robotic cell may include other machines subject to their own C level standards, and the robot system can be part of an integrated manufacturing system covered by ISO 11161, which in turn can also make reference to other relevant B and C level standards.



Robot cells used to refer to the space, often behind a barrier separating them from humans, in which traditional industrial robots would perform their tasks. A pursuit of efficiency has driven organizations to rethink ceding space to a robot on a factory floor, giving rise to a newer generation of robot cells. These cells are integrated directly into the production line, replacing the traditional barrier with protective devices situated within or attached to the robot itself.

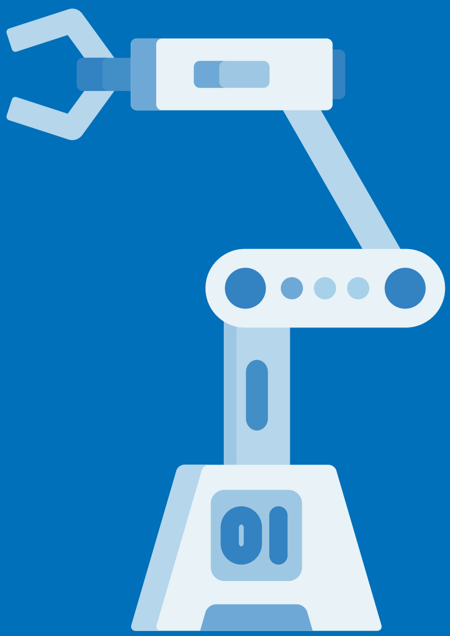
A robot cell includes the robot, the controller, and any other parts required to safely perform its function. In fact, robot cells use a variety of means to maintain safe operations and stay within their established parameters. These means include light curtains, laser scanners, and safety-rated soft axes.

Standards applying robot cells include:

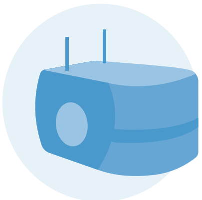
U.S. — ANSI/RIA R15.06 Part 2
Canada — CAN/CSA Z434 Part 2
Japan — JIS B 8433-2
EU and globally — EN/ISO 10218-2

The following elements are the major components of ANSI/RIA R15.06, CAN/CSA Z434, and EN/ISO 10218-2:

1. Risk assessment
2. Safety-related control system performance
3. Design and installation requirements
4. Limiting robot motion
5. Robotic cell layout and safeguarding
6. Robot system operational mode application
7. Pendant requirements
8. Collaborative robot system requirements
9. Documentation requirements



↑ JUMP BACK TO ROBOT CATEGORIES

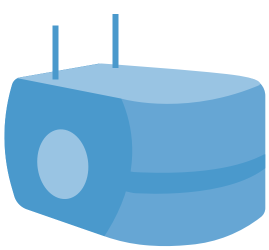


Industrial Mobile Robots

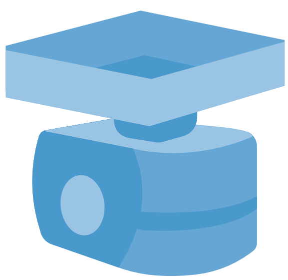
As warehousing costs have grown, supply chain leaders have begun to rely increasingly on industrial mobile robots to transport and deliver goods, with the market expected to reach $58.9 billion by 2026. The supply chain disruptions and social distancing guidelines associated with the COVID-19 pandemic have only served to accelerate adoption in this area.

Industrial mobile robots are multi-axis systems that can independently choose paths based on their environment, as opposed to being locked into a predefined path. They are unmanned, using wireless radio communication technology to operate, and may be integrated with an automated attachment.

IMRs are related to another robot type, automated guided vehicles (AGV), but offer more flexibility. Whereas AGVs typically follow preset routes and must stop until an obstacle is moved from its path, IMRs can navigate around unplanned obstacles. IMRs can also be similar in function to personal care or mobile servant robots, but IMRs are intended strictly for industrial use. However, AGVs that include a robotic manipulator are also defined as IMRs. They are separated into three categories:

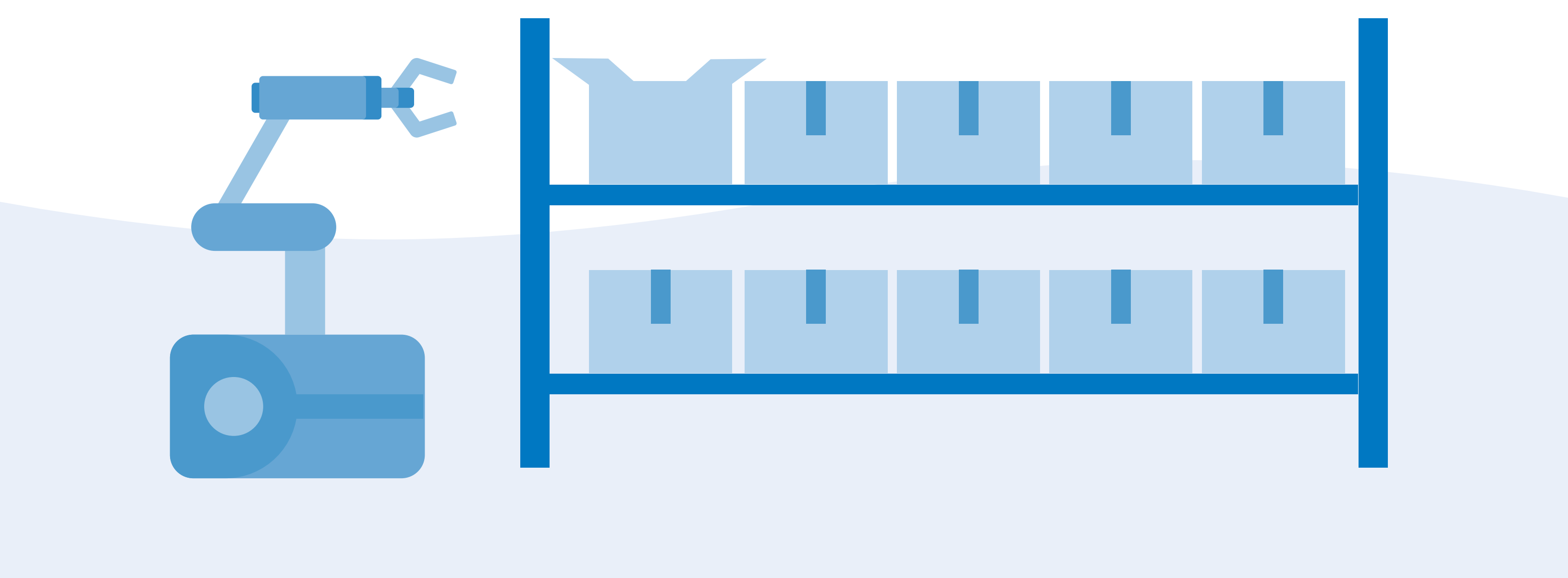


Type A IMRs
An IMR mobile platform without any kind of attachment or manipulator



Type B IMRs
An IMR with a passive attachment such as shelving or bins

Type C IMRs
An IMR with a robotic manipulator



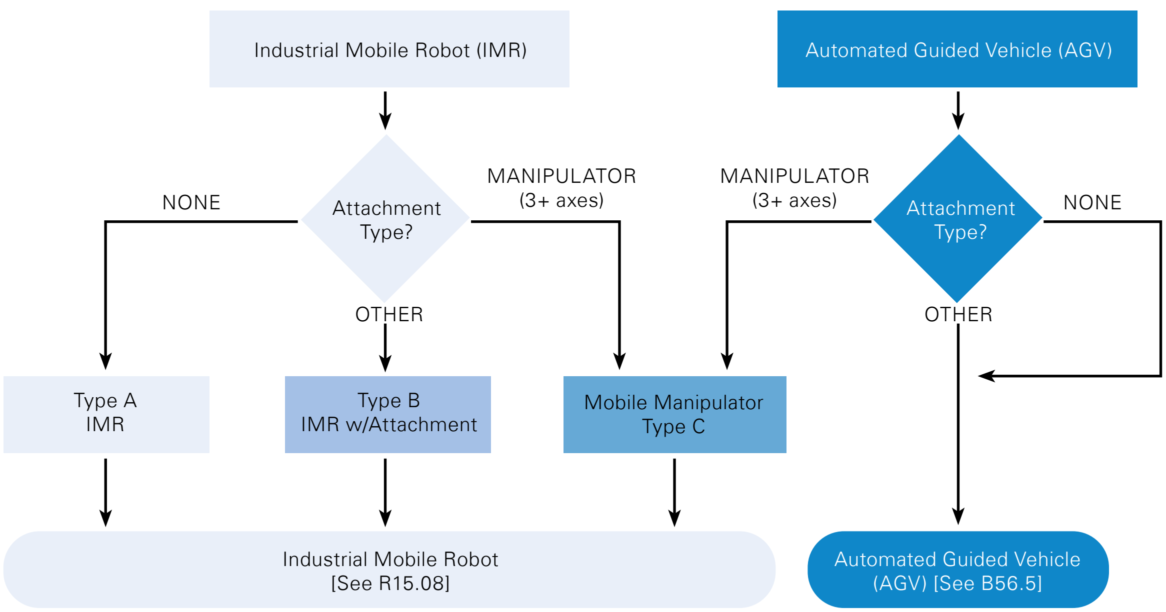
In addition to the RIA definitions, UL is developing testing requirements (UL 3100) for Autonomous Mobile Platforms (AMPs) that are intended to be the testing requirements to accompany RIA R15.08.

UL 3100 is intended to be used on mobile platforms that are not marked in accordance with NFPA 505 (Fire Safety for Powered Industrial Trucks).

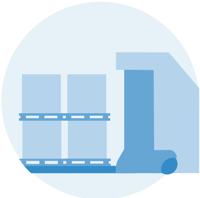
UL 583 has been modified to handle unmanned industrial trucks and shall be applied when the product is marked in accordance with NFPA 505.

Also included is ISO 10218-1, Machinery and EMC Directives. While those standards and directives mainly cover the hazards posed by the robot itself, there are also guidance and review processes for the integration of an IMR into a workplace. Those considerations cover:

- Risk assessment
- Modes of operation (automatic mode, manual mode, maintenance mode)
- Safety-related control system performance
- Battery charging
- Load handling
- Speed controls
- Braking, steering, and stability requirements
- Fitted conveyors (ISO 3691-4 only)
- Object/person detection requirements
- Static and dynamic load tests
- Site application requirements
- Documentation requirements



↑ JUMP BACK TO ROBOT CATEGORIES



Automated Guided Vehicles

Automatic Guided Vehicles are driverless, battery-operated industrial trucks or service vehicles that are unable to choose their own path or navigate around unplanned obstacles. These are unmanned and designed to operate automatically for load lifting, carrying, picking, towing, and the like. Unlike IMRs, AGVs typically rely strictly on guidance structures – which can include radio, wire, markers, or other systems or devices – to regulate movement. AGVs are not intended to operate in areas open to people who are unaware of the hazards. Due to the cost savings and efficiency that AGVs can provide, the market for them is expected to grow to $9 billion by 2027.

AGVs are similar to IMRs and have many of the same applications. However, the integrations and applications of AGVs can differ. AGVs tend to be used more strictly in industrial environments and are not as adaptable as IMRs to changing tasks. Examples of AGVs can also be known as: “driverless industrial truck,” “automated guided cart,” “tunnel tugger,“ or “under carts.”

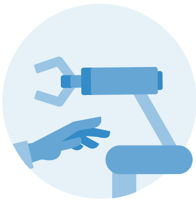
Common standards for AGVs include:

- UL 583
- ANSI/ITSDF B56.5
- ANSI/NFPA 505
- UL 3100
- EN 1175-1
- EN/ISO 3691-4
- ISO/TS 3691-7
- ISO 20898
- Machinery and EMC Directives

Like IMRs, there are also a host of considerations for integrating AGVs into the workplace:

- Risk assessment
- Modes of operation (automatic mode, manual mode, maintenance mode)
- Safety-related control system performance
- Battery charging
- Load handling
- Speed controls
- Braking, steering and stability requirements
- Fitted conveyors (ISO 3691-4 only)
- Object/person detection requirements
- Static and dynamic load tests
- Site application requirements
- Documentation requirements

↑ JUMP BACK TO ROBOT CATEGORIES



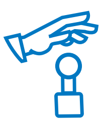
Collaborative Robots

No longer strictly segregated from humans behind protective barriers, collaborative robots, or "cobots," are becoming more commonplace, designed to work with humans in a shared workspace performing hazardous, sensitive, or mundane tasks while their human counterparts focus on higher value activities. The global collaborative robots market size was valued at $649.1 million in 2018 and is projected to expand at the CAGR of 44.5% by 2025.

Handling tasks like lift assist, part assembly, inspection, and packaging, as well as working with hazardous or heavy materials, cobots are more lightweight than traditional industrial robots and can typically be moved between tasks. Because of their close proximity to humans, however, safety is paramount.

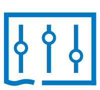
Collaborative robot operations fit generally into four types:

Safety-rated monitored stop: Used in situations where the robot is performing tasks on its own, but in a space that from time to time a person may need to enter. While the person is within the workspace the robot is in a stop condition and unable to move until the person is no longer within the workspace.



Hand-guiding: This type of operation allows the human to guide the robot at a safety-rated, monitored speed. This type of cobot is often used for teaching operations or where ergonomics is an issue, such as with lift assist. For this operation the robot must be equipped with an emergency stop and an enabling device.

Speed and separation monitoring: This method reduces risk by maintaining a sufficient distance between a worker and a robot in the collaborative workspace. This is done by tracking a robot's speed and its distance from nearby humans, typically by way of safety-rated peripheral systems such as cameras and sensors. If the prescribed separation distance or speed limit is violated, the robot will come to a stop.



Force and power limiting by inherent design or control: The most popular type of collaborative operation today is one in which the force and power of the robot is limited by inherent design or by the use of a safety-rated controller. Unlike earlier robot designs, force- and power-limited robots reflect the understanding that contact between a moving robot and a human can occur intentionally or unintentionally. These robots rely on low inertia, suitable geometry, and specific materials to account for that.

The international community established ISO/TS 15066 in 2016 and, shortly after, RIA/TR 15.606. These provided the first data points for limits on physical contact between human and robot, acknowledging the fact that, given the collaborative nature of these types of machines, contact was almost certain to happen. The goal of these standards, therefore, was to ensure that if contact does occur between humans and robots, the force and pressure exerted by the contact stays below specific limits for pain such that the risk of injury is sufficiently low.

Very recently, RIA/TR 15.806 was released, providing testing procedures to complement ISO/TS 15066 and RIA/TR 15.606. There are also additional standards that provide specifications for specific hazards that can exist in cobot systems. These standards include: UL 1740 (Robotics and Robotics Equipment), ANSI/RIA R15.06 Part 2 (Industrial Robot Systems, CAN/CSA

↑ JUMP BACK TO ROBOT CATEGORIES

BY REGIONS

International

United States

Canada

Europe

Japan

List of Standards

KEY

TIR	Traditional Industrial Robots
IMR	Industrial Mobile Robots
CR	Collaborative Robots
AGV	Automated Guided Vehicles
PCR	Personal Care Robots

Keeping up with regulations and standards associated with robotics design and manufacture isn’t easy. To help, we’ve created this list of standards, organized by region and tagged by robot type.

International

ISO 10218-1

Robots and Robotic Devices - Safety Requirements for Industrial Robots - Part 1: Robots

TIR IMR CR

Part 1 of ISO 10218 is for manufacturers of robots, detailing the requirements and guidelines for the safe design, required protective measures, and use of industrial robots. The standard outlines basic hazards it aims to eliminate or reduce. As it applies to manufacture, and not integration, which is covered in ISO 10218-2, the standard does not apply to the robot as a complete machine.

ISO 10218-2

Robots and Robotic Devices - Safety Requirements for Industrial Robots - Part 2: Robot Systems and Integration

TIR IMR CR

ISO 10218-2 is for integrators of robot systems, rather than manufacturers. It details safety and information requirements for the integration of industrial robots, robot systems, and robot cells – as defined by ISO 10218-1. These requirements cover the lifecycle of the robot system or cell from design, manufacture, and installation to operation, maintenance, and decommissioning. This standard may potentially be used as an alternative approach for AGVs but may be challenged by regulators.

↑ JUMP BACK TO REGION LIST

ISO 13482

Robots and Robotic Devices - Safety Requirements for Personal Care Robots

PCR

ISO 13482 addresses safe design and protective measures for personal care robots, covering their use in human-robot physical contact applications but not medical or military activities. This standard is harmonized under the Machinery Directive (2006/42/EC) and has been adopted in Japan as JIS B 8445. There is also an applications guide (ISO/TR 23482-2) on designing personal care robots so they conform with the requirements of ISO 13482.

IEC 60204-1

Safety of machinery - Electrical Equipment of Machines - Part 1: General Requirements

TIR IMR CR PCR

IEC 60204-1 details the requirements for the electrical equipment of machines. It is meant to ensure that users are safe, the machine's control responses are consistent, and that it can easily be maintained throughout its lifetime. The standard covers areas including control device selection, electrical isolation, termination and wiring, shock protection, and more.

IEC/EN/UL/CSA 60335-1

Safety of Household and Similar Appliances Part 1: General Requirements

PCR

IEC 60335-1 addresses requirements for electronic household appliances and other applications, including, in some cases, personal care robots. The standard applies to devices with voltages up to 250 V for single phase and up to 480 V for multi-phase.

ISO/TS 15066

Robots and Robotic Devices - Collaborative Robots

CR

ISO/TS 15066 was the first to specify safety requirements for collaborative robot applications, with the goal of ensuring that if contact does occur between humans and robots, no one is hurt. The requirements cover areas like force, pressure, and speed limits, as well as design criteria specific to collaborative robots.

KEY

- TIR Traditional Industrial Robots
- IMR Industrial Mobile Robots
- CR Collaborative Robots
- AGV Automated Guided Vehicles
- PCR Personal Care Robots

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ISO 3691-4

International - Industrial Trucks - Safety Requirements and Verification - Part 4: Driverless Industrial Trucks and Their Systems

IMR AGV

ISO 3691-4 covers safety requirements for industrial trucks, defining the different zones in which they are used, the associated risks, and dangers, and the correct implementation of safety systems. Prior to ISO 3691, the leading standard for industrial trucks was EN 1525. That standard is still valid, but shall no longer be used.

ISO 20898

International - Industrial Trucks - Electrical Requirements

AGV

ISO 20898 covers electrical safety for industrial trucks and is intended to be used with ISO 3691-4 internationally.

United States

ANSI/RIA R15.06 Part 1

Industrial Robots – Safety Requirements

TIR IMR CR

The United States adoption of ISO 10218, ANSI/RIA R15.06 is for the manufacturers of robots, detailing the requirements and guidelines for necessary protective measures as well as the safe design and use of industrial robots. The standard outlines basic hazards with the aim of eliminating or reducing them. As it applies to manufacture, and not integration, covered in ANSI/RIA R15.06 Part 2, the standard does not address the robot as a complete machine.

ANSI/RIA R15.06 Part 2

Industrial Robot Systems and Integration

TIR IMR CR

The United States adoption of ISO 10218-2, ANSI/RIA R15.06 is for integrators of robot systems, rather than manufacturers. It details safety and information requirements for the integration of industrial robots, root systems, and robot cells, covering the entire lifecycle from design, manufacture, and installation to operation, maintenance, and decommissioning.

KEY

TIR Traditional Industrial Robots
IMR Industrial Mobile Robots
CR Collaborative Robots
AGV Automated Guided Vehicles
PCR Personal Care Robots

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NFPA 79

Electrical Standard for Industrial Machinery

TIR

NFPA 79, applying to the electrical/electronic equipment, apparatus, or systems of industrial machines operating from a nominal voltage of 600 V or less, intends to minimize hazards due to shock and electrical fire. Applicable to more than industrial robots, the standard also covers industrial metalworking machine tools, woodworking machinery, plastics machinery, and some mass produced equipment.

UL 1740

Robots and Robotic Equipment

TIR IMR CR

A rewrite in 2018 aligned UL 1740 much closer to the international robotics standard, ISO 10218, significantly revising the definition of the term "robot" and addressing new advancements in safety technologies. UL 1740 was developed as a certification standard for ANSI/RIA R15.06. As a result, it contains requirements that extend beyond ANSI/RIA R15.06, including specific construction requirements and tests. These construction requirements cover things like flammability, electrical spacings, and component requirements.

ANSI/RIA R15.08

American National Standard for Industrial Mobile Robots

IMR

ANSI/RIA R15.08 is a critical step toward common guidelines in mobile robotics. While R15.06 allowed for the safe use of mobile robots, it didn't detail how they should be implemented. R15.08 specifically addresses how to combine an industrial manipulator with a mobile platform.

UL 3100

Outline of Investigation for Automated Mobile Platforms (AMPs)/ Automated Guided Vehicles (AGVs)

IMR AGV

UL 3100 covers battery-operated mobile platforms, with or without payloads, intended to be used indoors in commercial and industrial environments. The applications covered include lifting, carrying, product picking, towing, and similar uses. This is a bi-national document (USA and Canada) and is intended to be used when mobile platforms are not marked (Type E, CGH, E or CGH, EE, ES, and EX) in accordance with NFPA 505 (instead of UL 583).

KEY

- TIR Traditional Industrial Robots
- IMR Industrial Mobile Robots
- CR Collaborative Robots
- AGV Automated Guided Vehicles
- PCR Personal Care Robots

↑ JUMP BACK TO REGION LIST

UL 3300

Outline of Investigation for Service, Communication, Information, Education and Entertainment Robots

PCR

UL 3300 covers service, communication, information, education, and entertainment robots, SCIEE (pronounced "sky") for short. The outline details requirements for evaluating safety, focusing on multidirectional mobility, fire and shock hazards, external manipulations, user classes, and use of surroundings. The document reflects the heightened safety requirements for robots used in non-industrial and non-traditional places such as grocery stores, airports, hotels, and other public spaces.

RIA/TR R15.606

Robots and Robotic Devices - Collaborative Robots

CR

Similar to its predecessor, ISO/TS 15066, RIA/TR R15.606 provides safety guidelines for environments in which collaborative robot systems and people share the same workspace. The report addresses four types of collaborative robot safety operations: safety-rated monitored stop; hand-guiding; speed and separation monitoring; and force and power limiting by inherent design or control.

RIA/TR R15.806

Guide to Testing Pressure and Force in Collaborative Robot Applications

CR

RIA/TR R15.806 is a technical report that specifies the methods and metrics to measure pressure and force associated with quasi-static and transient human-to-robot contact in collaborative robots. The methods, measurement devices, and metrics allow for comprehensive testing to ensure the pressure and force limits set forth in ISO/TS 15066 and RIA/TR R15.606.

ANSI/ITSDF B56.5

Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles

AGV

ANSI/ITSDF B56.5 outlines the safety requirements for design, operation, and maintenance of powered, mechanically unrestrained, unmanned automatic guided vehicles. In addition to machines that are designed to be unmanned, the standard also applies to machines originally designed to operate with an operator that are later modified to operate in an unmanned fashion.

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↑ JUMP BACK TO REGION LIST

ANSI/NFPA 505

Fire Safety Standard for Powered Industrial Trucks

AGV

ANSI/NFPA 505 is a fire safety standard meant to reduce the risks around fire and explosion hazards associated with powered industrial trucks like fork trucks, platform lift trucks, motorized hand trucks, and others. Whether or not AGVs are marked in accordance with ANSI/NFPA 505 dictates whether they fall under UL 583 or ANSI/CAN/UL 3100.

UL 583

Electric-Battery-Powered Industrial Trucks

AGV

UL 583 details safety guidelines for electric-battery-powered industrial trucks, which was modified to handle unmanned trucks in addition to manned ones. The guidelines mitigate risk of fire, electric shock, and explosion. The standard applies when the product is marked in accordance with NFPA 505.

Canada

CAN/CSA Z434

Industrial Robots and Robot Systems

TIR IMR CR

CAN/CSA Z434 is an adoption of ISO 10218 parts 1 and 2, with Canadian deviations. Like ISO 10218, the Canadian standard is divided into two parts, the first providing guidance for safety in the design and construction of robots, and the second detailing safeguards for personnel during integration, installation, testing, programming, operation, maintenance, and repair.

CAN/CSA C22.2.301

Industrial Electrical Machinery

TIR

Intended to be used in conjunction with Part II of the Canadian Electrical Code, CAN/CSA C22.2.301 provides specific guidance on electrical requirements for industrial machinery, aligning as much as possible with existing global machinery standards.

KEY

TIR	Traditional Industrial Robots	CR	Collaborative Robots	PCR	Personal Care Robots
IMR	Industrial Mobile Robots	AGV	Automated Guided Vehicles		

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UL 583

Electric-Battery-Powered Industrial Trucks

AGV

UL 583 details safety guidelines for electric-battery-powered industrial trucks, which was modified to handle unmanned trucks in addition to manned ones. The guidelines mitigate risk of fire, electric shock, and explosion. The standard applies when the product is marked in accordance with NFPA 505.

UL 3100

Outline of Investigation for Automated Mobile Platforms (AMPs)/ Automated Guided Vehicles (AGVs)

IMR AGV

UL 3100 covers battery-operated mobile platforms, with or without payloads, intended to be used indoors in commercial and industrial environments. The applications covered include lifting, carrying, product picking, towing, and similar uses. This is a bi-national document (USA and Canada) and is intended to be used when mobile platforms are not marked (Type E, CGH, E or CGH, EE, ES, and EX) in accordance with NFPA 505 (instead of UL 583)

ANSI/ITSDF B56.5

Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles

AGV

ANSI/ITSDF B56.5 outlines the safety requirements for design, operation, and maintenance of powered, mechanically unrestrained, unmanned automatic guided vehicles. In addition to machines that are designed to be unmanned, the standard also applies to machines originally designed to operate with an operator that are later modified to operate in an unmanned fashion.

ANSI/RIA R15.08

American National Standard for Industrial Mobile Robots

IMR

ANSI/RIA R15.08 is a critical step toward common guidelines in mobile robotics. While R15.06 allowed for the safe use of mobile robots, it didn't detail how they should be implemented. R15.08 specifically addresses how to combine an industrial manipulator with a mobile platform.

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Europe

2011/65/EU

Restriction of Hazardous Substances Directive

TIR IMR CR AGV PCR

Europe's 2011 ban on heavy metals and other dangerous substances in electrical equipment restricts the use of several hazardous substances, including lead, mercury, cadmium, hexavalent chromium, and the flame retardants Polybrominated biphenyls (PBB) and Polybrominated diphenyl ethers (PBDE). The 2011 recasting of the standard extended the restrictions from household appliances and other limited equipment to all electronic equipment, cables, and spare parts.

2012/19/EU

Waste from electrical and electronic equipment (WEEE) Directive

TIR IMR CR AGV PCR

This Directive lays down measures to protect the environment and human health. This is done by preventing or reducing the adverse impacts of the generation and management of waste from electrical and electronic equipment (WEEE), and by reducing the overall impacts of resource use and improving the efficiency of such use.

Regulation EC 1907/2006

REACH

TIR IMR CR AGV PCR

This regulation aims to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances. This is done by the four processes of REACH, namely the registration, evaluation, authorization and restriction of chemicals. REACH also aims to enhance innovation and competitiveness of the EU chemicals industry.

2006/42/EC

Machinery Directive

TIR IMR CR AGV PCR

The Machinery Directive 2006/42/EC requires manufacturers of machinery to meet the Essential Health & Safety Requirements (EHSRs). Manufacturers must identify and evaluate hazards and risks at design stage, apply relevant harmonized EN standards, implement safety-related control systems, create technical files that are available to market surveillance authorities, and affix a CE marking.

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2014/30/EU

EMC Directive

TIR IMR CR AGV PCR

Compliance with the EU's EMC directive is required for many electronic products that are imported, marketed, or sold in the EU. Products bearing the CE Mark are presumed compliant with the requirements of the electromagnetic compatibility directive as well as the requirements of other applicable regulations. Compliance prevents interference with radio reception, for example, and ensures adequate immunity of the electrical and electronic equipment to electromagnetic noise within the environment.

EN 1175-1

Safety of Industrial Trucks - Electrical Requirements - Part 1: General Requirements for Battery-Powered Trucks

AGV

EN 1175-1 applies to the electrical systems of AGVs. The standard, applicable to battery-powered industrial trucks, specifies requirements for the design and construction of electrical installations with nominal voltages of up to 240 V.

EN/ISO 10218-1

Robots and Robotic Devices - Safety Requirements for Industrial Robots - Part 1: Robots

TIR IMR CR

Part 1 of ISO 10218 is for manufacturers of robots, detailing the requirements and guidelines for the safe design, required protective measures, and use of industrial robots. The standard outlines basic hazards it aims to eliminate or reduce. As it applies to manufacture, and not integration, which is covered in ISO 10218-2, the standard does not apply to the robot as a complete machine.

EN/ISO 10218-2

Robots and Robotic Devices - Safety Requirements for Industrial Robots - Part 2: Robot Systems and Integration

TIR IMR CR AGV PCR

ISO 10218-2 is for integrators of robot systems, rather than manufacturers. It details safety and information requirements for the integration of industrial robots, robot systems, and robot cells – as defined by ISO 10218-1. These requirements cover the lifecycle of the robot system or cell from design, manufacture, and installation to operation, maintenance, and decommissioning.

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EN/ISO 3691-4

International - Industrial Trucks - Safety Requirements and Verification - Part 4: Driverless Industrial trucks and Their Systems

IMR AGV

ISO 3691-4 covers safety requirements for industrial trucks, defining the different zones in which they are used, the associated risks and dangers, and the correct implementation of safety systems. Prior to ISO 3691, the leading standard for industrial trucks was EN 1525. That standard is still valid, but shall no longer be used.

EN/ISO 13482

Robots and Robotic Devices - Safety Requirements for Personal Care Robots

PCR

ISO 13482 addresses safe design and protective measures for personal care robots, covering their use in human-robot physical contact applications but not medical or military activities. This standard is harmonized under the Machinery Directive (2006/42/EC) and has been adopted in Japan as JIS B 8445. There is also an applications guide (ISO/TR 23482- 2) on designing personal care robots so they conform with the requirements of ISO 13482.

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Japan

JIS B 8445

Robots and Robotic Devices - Safety Requirements for Personal Care Robots

PCR

JIS B 8445 addresses safe design and protective measures for personal care robots, covering their use in human-robot physical contact applications but not medical or military activities. This standard is harmonized and identical to ISO 13482 under the Machinery Directive (2006/42/EC).

JIS C 9335-1

Household and Similar Electrical Appliances - Safety - Part 1: General Requirements

PCR

Modified from IEC 60335-1, JIS 9335-1 addresses requirements for electronic household appliances and other applications, including, in some cases, personal care robots. The standard applies to devices with voltages up to 250 V for single phase and up to 480 V for multi-phase.

JIS B 8433-1

Robots and Robotic Devices - Safety Requirements for Industrial Robots - Part 1: Robots

TIR IMR CR

JIS B 8433-1 is for manufacturers of industrial robots, detailing requirements and guidelines for necessary protection measures, safe design, and usage. It also includes requirements for reducing or eliminating risks.

JIS B 8433-2

Robots and Robotic Devices - Safety Requirements for Industrial Robots - Part 2: Robot Systems and Integration

TIR CR

JIS B 8433-2 is for integrators of robot systems, rather than manufacturers. It details safety and information requirements for the integration of industrial robots, robot systems, and robot cells, covering the lifecycle from design, manufacture, and installation to operation, maintenance, and decommissioning.

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JIS TS B 0033

Robots and Robotic Devices - Collaborative Robots

CR

The Japanese adoption of ISO/TS 15066 details safety requirements for collaborative robot applications with the goal of ensuring that, if contact does occur between humans and robots, no one is hurt. The requirements cover force, pressure, and speed limits, as well as design criteria specific to collaborative robots.

JIS D 6001-1

Fork lift trucks - Safety Requirements and Verification - Part 1: Fork Lift Trucks

AGV

Consistent with ISO 3691-1, JIS D 6001-1 covers safety requirements for industrial trucks, defining the different zones in which they can be used, the associated risks and dangers, and the correct implementation of safety systems.

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How TÜV Rheinland Can Help

Robotics relies on rapid advances in technology, innovation, and a vision for the future.

To reach global markets, companies must make sure that their products are safe, reliable, and sustainable. TÜV Rheinland's experts understand the factors at work and provide services to boost your competitive edge. With state-of-the-art laboratories located around the world and an international reputation for excellence, TÜV helps you achieve compliance, safety, and functionality from start to finish.

TÜV Rheinland is a global leader in independent inspection services, founded more than 145 years ago. Based in Cologne, Germany, we maintain a worldwide presence of more than 20,000 employees working to ensure quality and safety. Our network of experts participate in the entire process of getting robots and robot cells to market, from development to deployment. Not only does our team understand the key industry standards for robotics, we help create them. TÜV Rheinland has participated in or contributed to multiple prominent industry committees, including ISO/TC 299, and is a member of the Robotic Industries Association (RIA) and participates on the ANSI/RIA R15.06 committees, among others.

A Global Safety Leader

TÜV Rheinland is a global leader in independent testing, inspection, and certification services, ensuring quality and safety for people, the environment and technology in nearly all aspects of life for over 145 years. The group maintains a worldwide presence of more than 20,000 people.

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