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Collaborative Robots:
Eliminate the mystery around Safety

Robot Safety Standards for Collaborative Operation ISO 10218

Step 1: Relevant section of the standard

ISO 10218-1 Section 5.10 says: "Robots designed for collaborative operation shall provide a visual indication when the robot is in collaborative operation and shall comply with one or more of the requirements in 5.10.2 to 5.10.5"

Step 2: Universal Robots comply with section 5.10.5

ISO 10218-1 Section 5.10.5 Power and Force limiting by inherent design and control

"The power and force limiting function of the robot shall be in compliance with **5.4**. If any parameter limit is exceeded, a protective stop shall be issued. The robot is only a component in a final collaborative robot system and alone is not sufficient for a safe collaborative operation. The collaborative operation application shall be determined by the **[risk assessment]** performed during the application system design. Information for use shall include details for setting established parameter limits in the controlled robot. ISO 10218-2 shall be used for designing collaborative operations. Additional information will be contained in the **[ISO/TS 15066]**".

Risk Assessment: A risk assessment is the overall process comprising a risk analysis and a risk evaluation. This means identifying all risks and reducing them to an appropriate level (See ISO 12100).

ISO/TS 15066 published February 15, 2016. It contains valuable guidance on risk assessment for the integrators of collaborative robots. It also includes a presentation of a research study on pain thresholds that an integrator voluntarily can choose to make use of.
Universal Robots is part of ISO committee and has been an active participant in the ISO/TS 15066 development.

Step 3: EU Machine directive 2006/42/EC

Regarding Robot Safety: All machines installed within EU shall comply with the essential health and safety requirements listed in ANNEX I of the Machine Directive 2006/42/EC (MD). It is not required by any law to comply with any standard, however, the standards ISO 10218-1, ISO 10218-2 and ISO 13849-1 are harmonized under the MD. If a machine complies with such a harmonized standard, it also complies with the essential requirements of the MD.

The MD additionally requires the following documentation for the complete robot installation:

- Clear instructions for the operator
- Make a CE Declaration Of Conformity according to ANNEX II, 1., A
- Put a CE mark on the complete robot installation according to ANNEX III including manufacturer contact information, installation date, type-name and/or serial number.
- Collect all information in one big technical file and store it for at least 10 years.

2016 Current Safety Standards

Global Industrial Robots Safety Standard:

ISO 10218-1: Manufacturer of robots.

ISO 10218-2: Integrator of robot systems/applications.

ISO/TS 15066: *NOT a standard, but a Technical Specification with additional guidance on collaborative robots.*

ISO 13849-1: Provides safety requirements and guidance on the principles for the design and integration of safety-related parts of control systems (SRP/CS), including the design of software.

The European **Machinery Directive 2006/42/EC** is the machinery law relevant for all installations in Europe. It can be found on the European Commission's official homepage.

ISO 10218-1 Section 5.4: Safety related parts of control systems shall be designed so that they comply with PL=d with structure Category 3 as described in ISO 13849-1 (ISO 10218-1 section 5.2.2), or so that it complies with the PL determined by the risk assessment (ISO 10218-1 section 5.2.3).

Performance Level (PL) is a discrete level used to specify the ability of safety-related parts of a control system to perform a safety function under foreseeable conditions. In other words it is a defined measure of how likely it is for a system to fail. In a PL=d system it is very unlikely that a dangerous failure will occur. (See ISO 13849-1 for more details)

Category 3 is a term used about a system when it is designed as a dual-channel system. It is pretty common to construct Safety-related systems as dual channel systems. Safety Category 3 means that a single fault does not lead to the loss of the safety function. Furthermore, most single faults are detected and well-tested safety principles have been applied. (See ISO 13849-1 for more details)

The above is compliant with Universal Robots (UR) robots.
The safety system on all UR Robots is PL=d with Category 3 for all safety I/O's.

Summary

- It is not the robot alone that makes an application safe. It is the entire application that makes the application safe
- EVERY application needs a proper risk assessment
- Universal Robots comply with the current global safety standards for collaborative operation
- The safety system on all Universal Robots (UR) robots is designed to comply with a PL=d , Category 3 safety Interface
- The Technical Specification (TS) for collaborative robots (ISO/TS 15066) provides additional guidance for conducting risk assessment.

Universal Robots A/S | Energivej 25 | DK-5250 Odense S, Denmark | Office +45 89 93 89 89 | Fax +45 38 79 89 89

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Question	Answer
Is it required for robots to comply with ISO 10218-1?	No, it is required to comply with the laws and regulations in the country and/or the state that the robot is installed in. Please refer to the chapter "safety" in the UR manual for more guidance.
Do UR robots comply with ISO 10218-1?	Not all guidance in ISO 10218-1 is clear and/or applicable for collaborative robots. At the time when ISO 10218-1 was written, collaborative robots were a new and developing technology. Some features described in ISO 10218-1 assume non-collaborative, big, heavy, dangerous and fenced robots. A Technical Specification titled ISO/TS 15066 with clarifications of the features described in ISO 10218-1 was published February 15, 2016.
Is it OK not to comply fully with ISO 10218-1?	One should think of a standard as a "best practice" document. ISO 10218-1 was primarily written for big heavy industrial robots. UR robots are based on state-of-the-art technology and therefore some requirements might not be applicable. Technology is typically ahead of the standards, as standards define what is "standard"/"normal" to do. Robots and robot installations must comply with the laws and regulations in the country and/or state that the robots are installed in.
Which parts of the standard ISO 10218-1 do UR robots comply with?	UR Robots specifically comply with the parts related to "Collaborative operation", section 5.10.5. This standard is harmonized under the machinery directive and it specifically states that a robot can operate as a collaborative robot (i.e. without safety guards between the robot and the operator) if it is in compliance with the article 5.10.5. The risk assessment still needs to conclude that the overall robot installation is safe. The safety system on UR robots has been certified by TÜV (The German Technical Inspection Association).
What is the difference between ISO 10218-1 and ISO 10218-2?	ISO 10218-1 is for manufacturers of robots. UR is the manufacturer of UR robots. A stand-alone robot is considered partly completed machinery and not a complete machine. ISO 10218-2 is for integrators of robot systems. The company that installs a UR robot in a specific application is the integrator. UR is not an integrator. An integrated and installed robot is considered a complete machine. ANSI/RIA R15.06 is a republication that includes both ISO 10218-1 and -2, published in the United States of America. CAN/CSA-Z434 is a republication that includes both ISO 10218-1 and -2, published in Canada.
What is ISO/TS 15066, Technical Specification on Collaborative Robots?	ISO/TS 15066 is NOT a standard, but a Technical Specification with additional guidance for collaborative robots published February 15, 2016. It contains valuable guidance on risk assessment for the integrators of collaborative robots. It also includes a presentation of a research study on pain thresholds which an integrator voluntarily can choose to make use of.
What is ISO 13849?	This is a standard that describes safety related systems. This standard has its background in mechanical and electrical systems. It consists of two parts: ISO 13849-1: provides safety requirements and guidance on the principles for the design and integration of safety-related parts of control systems (SRP/CS), including the design of software. ISO 13849-2: specifies the procedures and conditions to be followed for the validation by analysis and testing of the specified safety functions, the category achieved, and the performance level achieved by the safety-related parts of a control system (SRP/CS) designed in accordance with ISO 13849-1.
What is a stop category?	"Stop Category" is a classification of how robot motion is stopped in a safe way. There are three different types: - Stop Category 0 : Robot motion is stopped by immediate removal of power to the robot. It is an uncontrolled stop, where the robot can deviate from the programmed path as each joint brakes as fast as possible. This protective stop is used if a safety-related limit is exceeded or in case of a fault in the safety-related parts of the control system. - Stop Category 1 : Robot motion is stopped with power available to the robot to achieve the stop and then removal of power when the stop is achieved. It is a controlled stop, where the robot will continue along the programmed path. Power is removed as soon as the robot stands still. - Stop Category 2 : A controlled stop with power left available to the robot. The safety-related control system monitors that the robot stays at the stop position.
Which stop category is used for emergency stop in Universal Robots?	The UR Robots' emergency stop is designed in accordance with "Stop category 1", which means that power supply is cut, but motors are actively decelerating.
Which stop category is used for safeguard stop in Universal Robots?	The UR Robots' safeguard stop is designed according to Stop category 2, which means that it is a controlled stop, where the motors keep being powered. Safety systems monitor the stop.
What is "Cat 3" or "Category 3"?	The term "Category" should not be confused with the term "Stop Category". "Category" refers to the type of architecture used as basis for a certain "Performance Level". A significant property of a "Category 3" architecture is that a single fault cannot lead to loss of the safety function. (See ISO 13849-1 for more details).
What is "PLd" or "Performance level d"?	A Performance Level (PL) is a discrete level used to specify the ability of safety-related parts of control systems to perform safety functions under foreseeable conditions. PL=d is the second highest reliability classification, meaning that the safety function is extremely reliable. (See ISO 13849-1 for more details).
What is the difference between Emergency stop and Safeguard stop?	- Emergency stop functions are to be used for emergencies only. Emergency stop is typically activated by the use of red button with a yellow background purposely designed for emergency stop. Activating emergency stop should be infrequent and not part of a daily routine. - Safeguard stop is used to pause robot movement in a safe way as a part of procedures and protection routines. Safeguard stop is typically used in conjunction with light curtains, door switches, safety PLCs, etc. Resuming from a safeguard stop can be automatic or controlled by a push button. Both stop functions are PL=d.
Which safety level is the Emergency Stop in Universal Robots?	The Emergency stop system is designed as PL=d with Safety Category 3 system monitoring the Emergency Stop (definitions according to ISO 13849-1).
Which safety level is the Safeguard Stop in Universal Robots?	The Safeguard stop system is designed as PL=d with Safety Category 3 system monitoring the Safeguard Stop (definitions according to ISO 13849-1).