A simple guide to robot safety

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Industrial robots are automated moving devices with multiple axes. Motion paths, sequences and angles can be freely programmed and controlled by sensors. Robots can also be fitted with grippers and other tools, enabling them to manipulate objects and carry out production tasks. Robots are well suited to carry out many different automated tasks and make frequent changes to batches and products.

Traditionally, the automotive industry has led the way to use robots on a large scale. However, if used without care, robots can be dangerous to humans. Back in 1961 when General Motors introduced the first industrial robot to its production line, humans were at high risk inside a robot’s work zone. Since that time, robot manufacturers such as FANUC have spent enormous effort and money to produce models with the best possible safety levels.

As robots have become more refined, and applied across more industry sectors, mainly for heavy work, devices are used to monitor a robot’s surroundings, such as vision and force sensors that allow robots to see and feel what is around them. Using smart synthetic skins, scientists are even looking to endow future robots with a human-like sense of touch.

Collaborative robots

In recent years, collaborative robots (Cobots) have emerged: in contrast to traditional robots, which cannot operate in an operator-occupied workspace without safety fencing, these cage-free robots can work side by side with humans on shared or separate tasks.

Although collaborative robots do not eliminate the need for workplace risk assessments, the increased adoption of peripheral safety devices is enabling robots and humans to work in close proximity of each other, eradicating the fear of interrupting production or worse, an accident.

Cobots are equipped with force sensing to limit their power and force: in any situation they can feel or detect an abnormal force and stop their motion immediately. Although they still cannot avoid a crash, Cobots can reduce its impact and avoid certain types of incidents, like crushing accidents. This makes them safer to work alongside humans.

Dual Check Safety (DCS) Position Speed Check

Dual Check Safety (DCS) Position/Speed Check features check the speed and positional data of motors with two independent CPUs within the robot controller. These functions can detect any position and speed errors immediately and shut down the motors power. Safety data and processes are cross-checked by two CPUs. Self-diagnosis of safety hardware and software is executed periodically to prevent potential failure accumulation.

The DCS position speed check software monitors allows safety zones to be quickly and easily designed:

- **DCS Position Check** ensures that the robot stays in the designated safe areas, with adaptive zones that allow for more compact cell layouts and which allow robots and humans to share a common space in a controlled way.

- **DCS Speed Check** monitors the speed of the robot to ensure safe operation. Using the inputs from devices such as floor scanners, the robot slows down to a safe speed, which is then safely monitored by the DCS function. If the robot goes over the monitored speed, the DCS function will stop the robot.

Avoiding heavy lifting

Another aspect of safety where robots can help is preventing injury to humans through heavy lifting. With health and
safety regulations stipulating 25kg as the maximum load an operator may handle, there is a real requirement for a robotic solution to handle loads that exceed this limit.

FANUC has extended the application field for collaborative robots with a model that has a higher payload than any other on the market. The human-safe CR-3SiA has a 35kg payload, opening up applications that have previously been off limits for both traditional industrial robots and lighter duty collaborative robots, particularly in difficult-to-access areas where conventional assist machinery cannot fit or where a six-axis robot adds dexterity.

Risk assessments
As collaborative robots are working alongside humans without any type of shield or guarding, it raises a new level of complexity.

In line with ISO 10218 and ISO/TS 15066 standards which relate to the collaborative operation and safety functions, end users or integrators will need to do a complete risk assessment to prove that their robotic application using a collaborative robot is safe.

When doing a risk assessment, while the robot itself may be safe, the entire robotic system has to be considered, including grippers and any other peripheral equipment.

Gripper technology
Grippers are handling equipment that secure position and orientation in relation to the handling device when picking up and depositing objects. Most grippers work on a mechanical, pneumatic, electric or adhesive principle. Grippers also include vacuum suckers.

The gripper must cope with the physical and mechanical properties of the object and handle it without leaving any visible marks or damage.

From a safety point of view, grippers can cause pinching or crushing injuries and the risks of these should be taken into account in any risk assessment.

Safety standards
In 2013, the first safety standards for collaborative robotics, ANSI/RIA R15.06, were published. More recently, the ISO/TS 15066 standard was published in March 2016. It specifically outlines guidance for and the requirements of collaborative industrial
robot systems, such as contact forces and pressures that can be applied to different regions of the body.

**Practical measures**

In order to ensure that humans are not exposed to unacceptable risks when working collaboratively, the current standards describe four separate measures that can be used to provide risk reduction.

It is required that at least one of these is fulfilled, in addition to having visual indication that the robot is in collaborative operation.

The four measures are:

- **SAFETY-RATED MONITORED STOP:** when it is detected that a human has entered the collaborative workspace, the robot should stop. The stop condition should then be maintained until the human leaves the workspace.
- **HAND GUIDING:** the human can guide the robot by hand. Additional requirements for safety include safe-limited speed monitoring and a local emergency stop.
- **SPEED AND SEPARATION MONITORING:** the robot must maintain a specified separation distance from the human and operate at a pre-determined speed. This measure requires careful risk assessment and needs to take account of safety distances.
- **POWER AND FORCE LIMITING BY INHERENT DESIGN OR CONTROL:** the power and force of the robot actuators need to be monitored by safety-related control systems to ensure that they are within limits established by a risk assessment.

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TOP TIPS FOR KEEPING YOUR WORKFORCE SAFE WHEN WORKING ALONGSIDE ROBOTS

• SCOPE OUT ALL POTENTIAL HAZARDS - Safety risks will vary depending on your chosen robot and application. Start with a well-documented risk assessment. It is worth noting that most robot-related accidents occur during non-routine operating conditions, for example, operators entering the cell for programming, maintenance, testing, setup, or adjustment tasks.

• REVISIT THE REGULATIONS - The Health and Safety Executive (HSE) offers industrial robot safety guidance in the HSG43, Industrial Robot Safety publication. International standards are set out in EN ISO 10218 - Part 1 Robots and robotic devices - Safety requirements for industrial robots, while EN ISO 10218 - Part 2 goes into more detail about robot systems and integration.

• USE SIMULATION SOFTWARE to plan out and test robotic concepts. Software (e.g. FANUC's Roboguide) can model all of the variable robotic movements, obstacles and potential collision scenarios, in a 3D virtual world.

• INTRODUCE SAFEGUARDS - Seek expert guidance when building a safety related control system (SRCs) early in the design phase, as there are many different concepts to consider, including whether it should be a dedicated system or integrated within your robot controller or robot safety software.

• PROVIDE EMPLOYEES WITH CLEAR INSTRUCTIONS - Reduce the risks of incidents by ensuring employees receive regular operator training and are issued with appropriate personal protective equipment (PPE).

• CONSIDER THE COST BENEFIT AND EFFECTIVENESS OF SOFTWARE-ENABLED TECHNOLOGY - Having less hardware means that safety can be integrated more cost-effectively. FANUC's latest DCS software can monitor the robot’s position and speed. The removal of limit and zone switches also makes work cell configurations tighter and simpler.

• DEFINE MAXIMUM ROBOT SPEED - This can be done during normal operation or adjusted to a defined event, enabling an operator to work safely within the proximity of the robot.

• COMPLIANCE WITH MACHINE SAFETY STANDARDS - Check the system meets the PL (performance level) safety standards specified in BS EN ISO 13849-1.

• STAY ON TOP OF SAFETY REQUIREMENTS - Robotic work cells and plant layouts evolve quickly, which is when a software-based robot comes into its own.