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A guide to collaborative robot safety

Strategies for ensuring safe operation in collaborative applications

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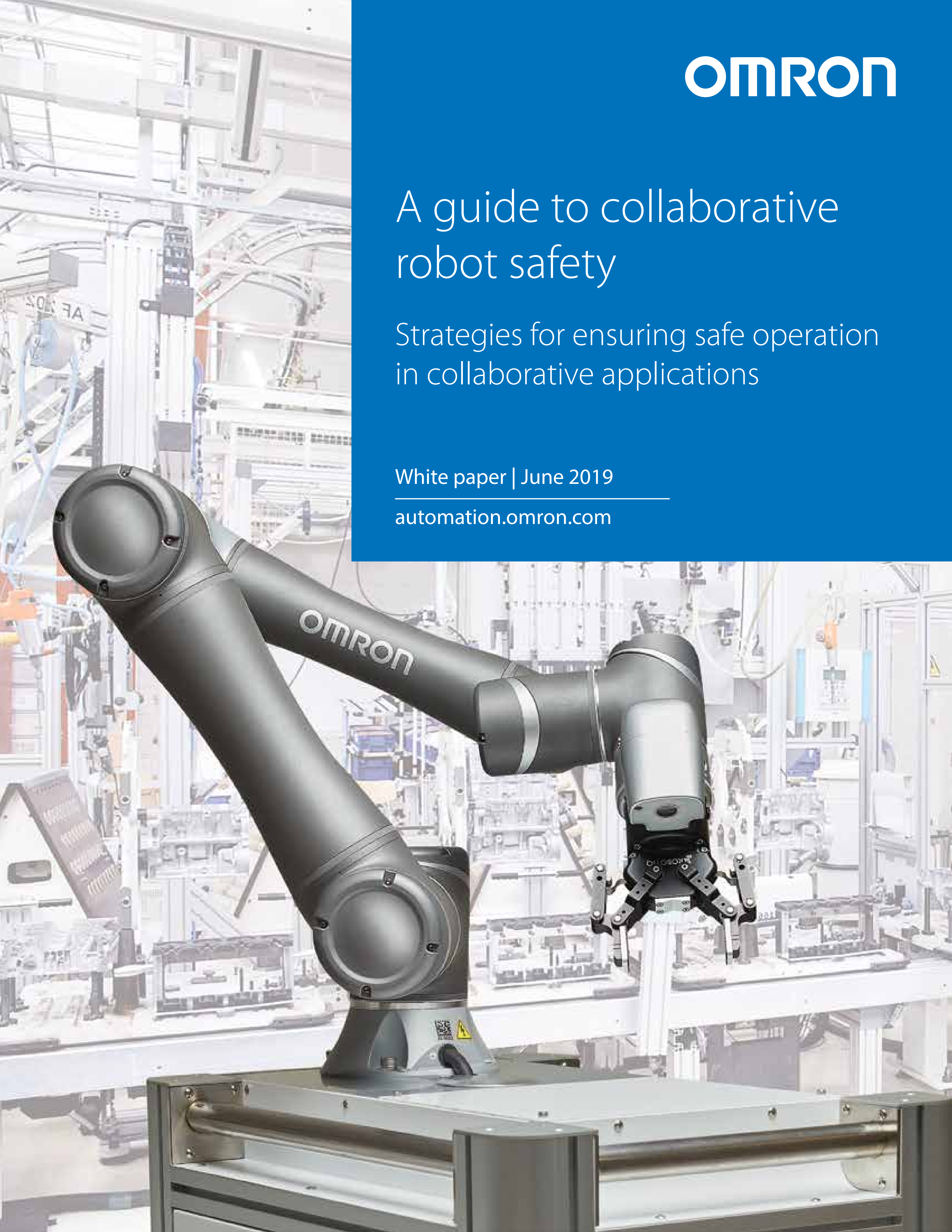

Introduction

The ability of collaborative robots to share tasks with humans and flexibly adapt to new requirements can provide high returns on investment in a wide variety of industrial applications. Manufacturers employ these robots to reap the benefits of integrated safety features that allow them to work with or close by humans and boost productivity for a wide variety of repetitive tasks.

Despite the numerous safety features that include lightweight frames, collision detection technology and minimized pinch points, appropriate safety measures must still be considered for the overall application – including the gripper, end effector and other equipment located near the collaborative workspace. Safe implementation based on comprehensive risk assessments is crucial for ensuring the success of a collaborative robotic application.

This white paper will discuss industry standards, project stages and solutions for getting the greatest value from collaborative robots (commonly shortened to "cobots"). It also defines and discusses safety requirements for the robots themselves as well as the collaborative workspace and typical collaborative operations.

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What are collaborative robots, and what safety standards apply to them?

Collaborative robots are designed to work with human operators thanks to technologies like force feedback, low-inertia servo motors, elastic actuators and collision detection technology that limit their power and force capabilities to levels suitable for contact. More compact than conventional robots, cobots generally have lightweight frames with soft, rounded edges and minimized pinch points.

Force and speed monitoring are the defining abilities of collaborative robots. When they are equipped with safety devices that detect when a person has entered the collaborative workspace, they are often allowed to operate at higher speeds. This helps them maximize throughput when people are not present within the hazard zone.

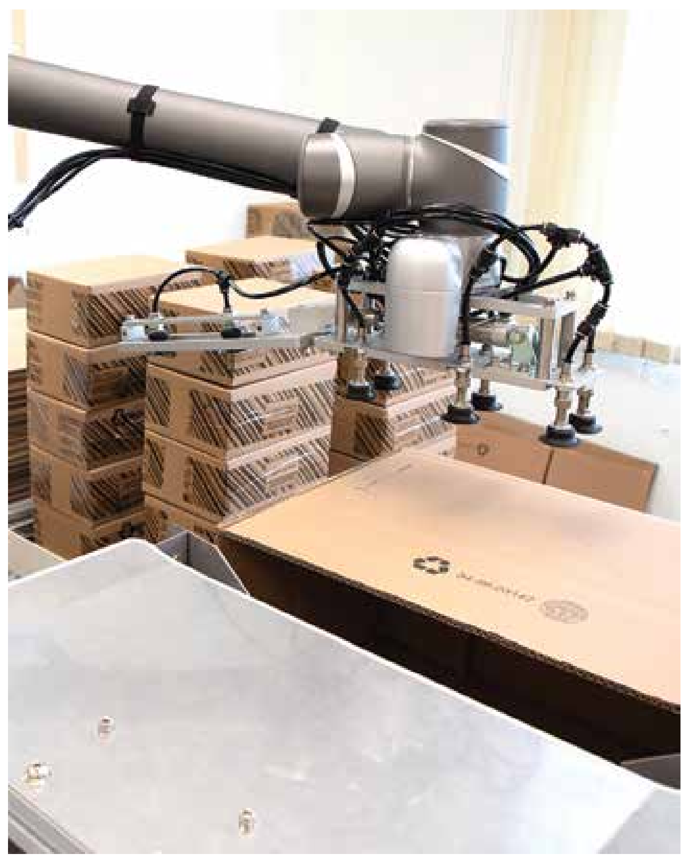
The safety standard ISO 10218 and technical specification RIA TS 15066 define the safety functions and performance of the collaborative robot. Under TS 15066, the force and speed monitoring of the cobot is set based application data, human contact area, and workspace hazards. Human contact is defined in two types: transient and quasi-static. The former refers to contact that is non-clamping, whereas the latter involves situations that can cause a body part to be clamped.

Application data, possible human contact and workspace hazards all factor into the calculated safety settings based on TS 15066. This may be a challenging task for manufacturers who are not familiar with safety standards, in which case they can hire a safety assessment provider to make the calculations and offer suggestions for improving the safety of the overall collaborative application.

Types of contact defined by RIA TS 15066

Transient contact:
non-clamping contact

Quasi-static contact:
contact that can cause a body part to be clamped



In a collaborative application, risk assessments must take into account any surrounding equipment in addition to the robot itself.

How does hand-guided teaching work, and what are the important safety considerations?

ISO 10218 and ISO/TS 15066 provide standards and guidance for collaborative robot teaching functionality. Many collaborative robots, such as Omron's TM Series robot, employ intuitive hand guiding mechanisms for teaching new tasks without the need to explicitly program the movements of the robotic arm. Hand guiding mode monitors force and speed to ensure that the teaching process complies with safety standards.

The safety of hand-guided teaching meet safety standards in the following manner.

1. Enabling hand guiding

Before an operator enters the robot's workspace for teaching, the robot must be stopped even if its force and speed limiting functionality is activated. Otherwise, a protective stop must be executed upon detection of the operator by a safety device like an area scanner.

Unlike with high-speed robots, the operator can activate the teaching mode using a simple trigger, button or mode selection as long as safety force and speed monitoring are active. Otherwise, a three-position safety enable is required.

Safety standards require the teaching mode transition to be deliberate, to not lead to unexpected motion, and to avoid creating additional hazards.

2. Ensuring safe teaching

Since the operator is responsible for the robots motion, he or she must be aware of surrounding equipment and safety concerns at all times.

It is possible to enforce limits in motion, such as space and soft axis limits, to help keep the operator safe.

3.Enabling safe operation

The operator must first vacate the safeguarded space. This can be detected by safety sensors or additional operator verification.

To re-enable the robot for operation, intentional mode selection must be provided.

Collaborative robots can work with a variety of end effectors, each of which must be evaluated for safe operation.

What is the collaborative workspace, and what are the important safety considerations?

Collaborative robots perform automated tasks around other equipment that could potentially cause harm. The area in which a collaborative robot operates, including any tooling or additional equipment, is known as the collaborative workspace. As defined by the ISO 10218 / ANSI RIA 15.06, this the space within the safeguarded area where the robot and human can perform tasks simultaneously during production operations. Similarly, TS 15066 defines it as the area within the operating space where the robot system can perform tasks concurrently with a human operator during production.

Definition of the collaborative workspace (ISO 10212 / ANSI RIA 15.06)

The space within the safeguarded area where a collaborative robot and a human operator can perform tasks simultaneously during production operations.

It is important to list and map out all additional equipment in the complete collaborative automation project. Manufacturers should be sure to evaluate each device for potential hazards and safety sensors to use prevent human and equipment damage. In addition, the collaborative workspace must be clearly marked.

The following are examples of non-collaborative safety-rated equipment that can be part of the workspace requiring safety devices:

- Material handling
- Tooling
- Grippers/actuators
- Machines

Safety devices are generally quite easy to integrate into a collaborative robotic application. Following are a few solutions for safeguarding the collaborative workspace.

1. Open area safety guarding solutions

Safety area scanners and mats are the most popular safe guarding for collaborative robots. They are also some of the simplest items to integrate into applications with low hazards and few additional pieces of equipment.

2. Gated/limited area safety guarding solutions

Safety light curtains and safety switches are used for applications with hazards or high-speed operation enablement for increased productivity.

3. Active hazards safety guarding solutions

When a hazard is present, or operation could cause a hazard, operators can enable the "deadman" switch – a switch that automatically goes back to the "off" position if the user fails to exert pressure – to provide safeguarding.

Maximizing safety in collaborative operations

It is essential for manufacturers to validate their collaborative robot applications for safety across all operations. Every application is unique, but there are some guidelines manufacturers can follow when evaluating the safety of a robot while performing a given task in collaboration with a human operator. Drive and power hazards may still exist even if the robot is not moving.

1. Safe robot enable

Whether starting up the robot or recovering from an emergency stop, there must an intentional act to enable the robot that ensures operators are safe and no hazards are present. For example, when an e-stop is activated by an operator, the robot should not perform an automatic re-enable. Instead, it should require input from a second operator verification action.

2. Safe hand guiding

During design and safety setup, manufacturers must ensure that hand guiding can only occur after (1) the robot has stopped, (2) intentional mode selection has occurred, and (3) speed and force monitoring are active. For example, if the hand guiding activation occurs without a stop command or safety input, this should initiate a safety stop and fault.

3. Safe operation

Enabling the automatic or run operation of the collaborative robot must be an international mode selection by the operator that requires all safety devices and conditions to be validated for operation. For example, operators must be protected from hazards on the end of tooling before enabling operation.

4. Safety validation

It is important for manufacturers to have a safety assessment service group review all the surrounding areas and equipment and to have a safety remediation service performed if necessary. Safety service groups will perform an on-site inspection to assess the safety of equipment, confirm certifications, verify safety parameter settings and document that safety validation has been completed.

A collaborative robot's arm is lightweight and flexible, with minimal pinch points to ensure safe operation.

Safety considerations for collaborative machine tending applications

Machine tending is the most common application for collaborative robots due to the ease of installation, the high return on investment, and the benefits from the robots' flexible manufacturing capabilities. Machine tending applications can be misleading in their appearance of safety – in fact, they are one of the industry's top safety concerns for experts who have completed many inspections and safety assessments.

To maximize safety in automated machine tending applications, manufacturers should be sure to use a safety-rated gripper to safeguard against operator injury, and they should also investigate whether the product itself presents any dangers (such as extreme heat or sharp edges).

Other things to consider include:

- Do other machines need to be safety control-linked to prevent either from operating when the other is in a safety stop condition?
- Is material handling equipment being used? If so, what are the necessary safety considerations?
- Since collaborative robots used in machine tending can be moved from machine to machine, how is the safety setting and program validated?
- Are there warning zones for the operator that will indicate hazards or operation interference?

It is also extremely important to review the entire area for any circumstances where an operator could be trapped or clamped by the robot and surrounding pieces of equipment.

Collaborative robots generally support lighter payloads than standalone robots, but they offer greater flexibility.

Safety considerations for collaborative material handling applications

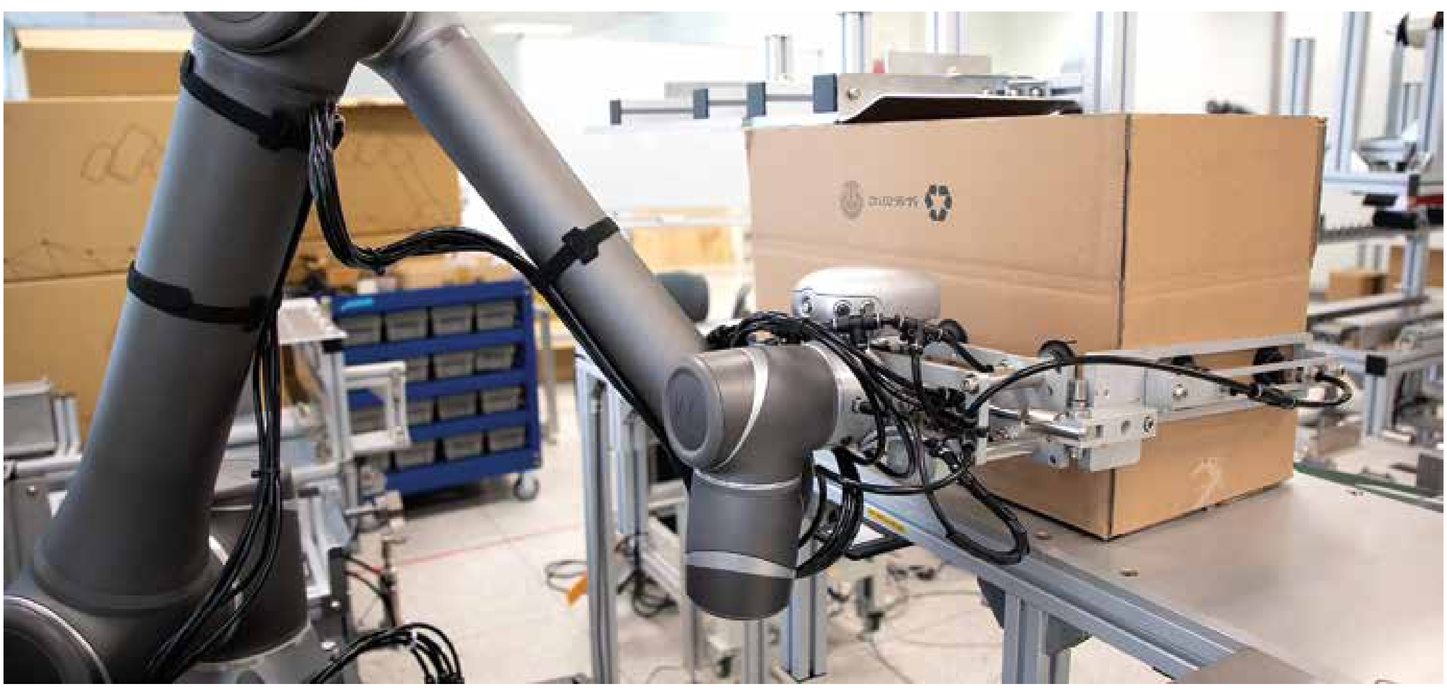
Material handling applications that benefit from the incorporation of collaborative robots encompass picking, packing, palletizing, sorting and more. The wide-ranging use of these applications makes them a more site-specific solution for safety implementation. Operators and other workers are often moving or transporting other materials around the collaborative robot, requiring additional planning to avoid hazardous contact.

Safety-rated grippers are rare in the market at the present time. Currently, manufacturers typically use pneumatic grippers, which require safety considerations for impacts and the loss of power or suction. Application designers must also investigate whether the product itself presents any damagers like being heavy or containing hazardous material – characteristics that could be especially problematic if the product were to be dropped.

Other things to consider include:

- Do other machines need to be safety control-linked to prevent either from operating when the other is in a safety stop condition?
- Since collaborative robots can be moved from application to application, how could this affect validation of the safety settings and program?
- Are there warning zones for operator that will indicate hazards or operation interference?

As with automated machine tending applications, manufacturers must review the entire area for any circumstances where an operator can be trapped or clamped.



Collaborative robots provide a highly flexible solution for packaging applications.

Safety considerations for collaborative assembly applications

Assembly applications employing collaborative robots often involve special tooling and close collaboration with operators while also requiring high-speed operation zones to be present. The extensive variety of custom end-of-arm tooling makes these applications especially complex. If multiple robots are involved, application designers must carefully coordinate the safety solutions for each one.

As with material handling applications, it is important to consider safety requirements for pneumatic grippers, places were an operator could be trapped or clamped, and any products that are heavy or that contain hazardous substances.

Other things to consider include:

- Do other machines need to be safety control-linked to prevent either from operating when the other is in a safety stop condition?
- Since collaborative robots can be moved from application to application, how could this affect validation of the safety settings and program?
- Are there warning zones for operator that will indicate hazards or operation interference?

Adaptable and capable of supporting a wide variety of end-effectors, collaborative robots are an optimal solution across numerous industries.

Summary

Designed with a human collaborator in mind, cobots are generally considered to be safe. Nonetheless, they still require risk assessments to guarantee the safety of human operators throughout their use. It is crucial for manufacturers to consider all the possible hazards associated with hand-guided teaching, including transient and quasi-static contact, as well as what may happen when the robot is involved in an emergency stop.

Designers of automated machine tooling, material handling and assembly applications must consider all the ways in which the robot would interact with an operator, what aspects of the surroundings might cause clamping or entrapment, and what characteristics of the end-of-arm tooling might pose a risk due to high heat, sharp edges or other hazards. If a risk assessment is performed thoroughly and requisite safety measures are implemented, it will ensure the successful efficiency gains of an application and boost performance.

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