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Cobot Safety

Our 5 steps to building the best cobot application for your business

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CLICK FOR A COBOTS OVERVIEW

Cobots an overview

Productivity

Collaborative robots (cobots) can operate at various speeds, opening possibilities by enhancing productivity in a wide range of applications. This augments capabilities for workers by taking over dull and repetitive tasks.

Safety

Built with inherent safety, cobots feature intelligent joints, software collision detection, and inherent flexibility to prevent contact with a human or robot.

Flexibility

Adapt to future changes or expand operations to become cost effective with the added the flexibility provided by cobots.

Ease of use

Set up tasks, robot programs and new positions in minutes with no prior coding skills thanks to the lead through programming feature.

Portability

Small in size, weight, and footprint; cobots' lean and compact design mean they can be mounted in any direction giving users the advantage of a slim, compact and portable robot.

CLICK AND SEE AN INTRODUCTION TO COBOT SAFETY

An introduction to cobot safety

Collaborative robots (cobots) represent a significant milestone in robotic automation for their ability to work alongside human beings. Easy to install, program and operate, they offer safe performance with no need for cages or safety fences, helping to lower the barriers for small- and medium-sized enterprises (SMEs) to automating their operations.

Nevertheless, there is still a need to spend time and effort in safety risk assessments before deploying them in an application.

Cobots, just like industrial robots, are defined as incomplete machinery by themselves and their safe usage needs to be considered together with the application they are installed in, along with additional peripheral equipment and workpieces.

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CHECK OUT OUR 5 STEPS TO COBOT SAFETY

Our 5 steps to cobot safety

To eliminate the risk of potential harm, a comprehensive risk assessment is required, which identifies risks in the possible interactions of the cobot system with the human operator and its surrounding environment while running the intended application. To help guide you through the process, we have developed a five-step guide covering key points to consider when carrying out a risk assessment.

1. Determine the scope of the system
2. Identify the hazards
3. Eliminate the risk
4. Reduce the risk
5. Determine the residual risk

Determine the scope of the system

1 2 3 4 5

Plan how the system fits into your production flow

Consider the installation environment

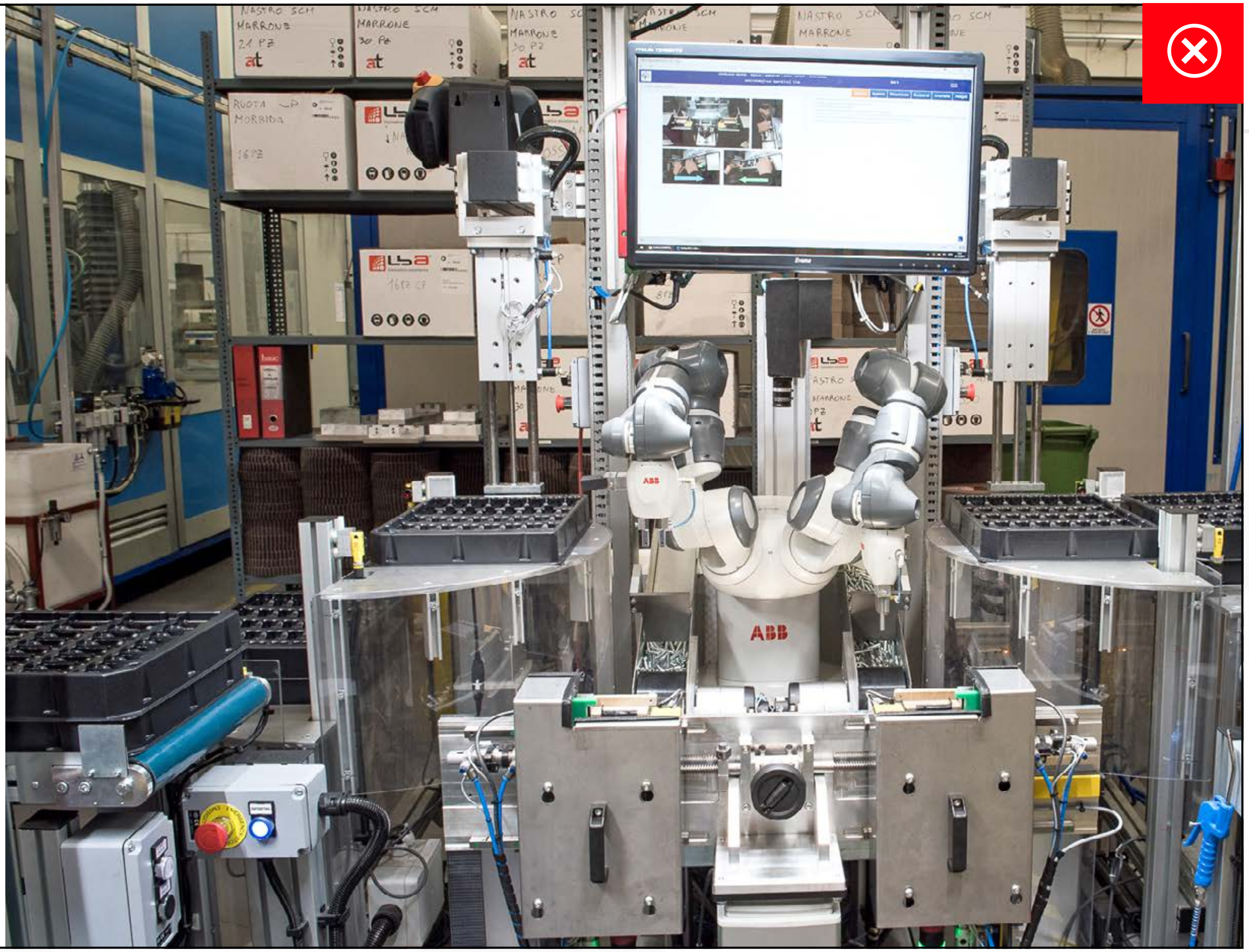
Define the intended use of the cobot

Identify the level of collaboration

Determine the scope of the system

Plan how the system fits into your production flow

Have a clear idea of what you want the automation solution to do, whether it is moving objects from one point to another or assembling parts of a product, etc. Plan how the system shall fit into your overall production flow.



Determine the scope of the system

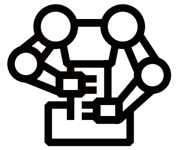
Consider the installation environment

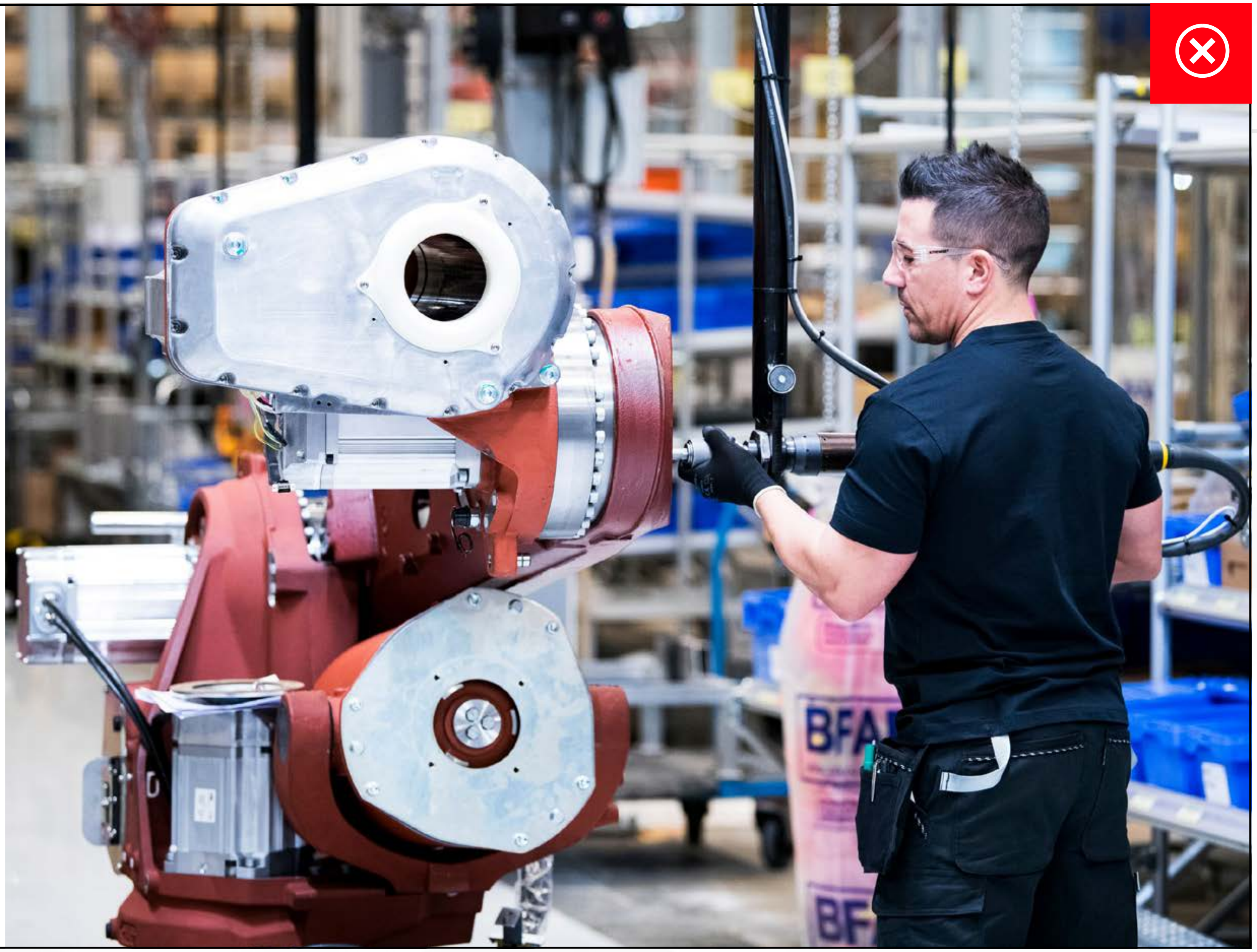
Consider the environment in which the system is going to be installed. The risks associated with a cobot application depend on whether it will be situated in a populated or a controlled area, on obstacles in the immediate environment, and on the periphery that is part of the system.

Determine the scope of the system

Define the intended use of the cobot

Define the intended use of the cobot installation by personnel but also consider possible deviations from this (reasonably foreseeable misuse).

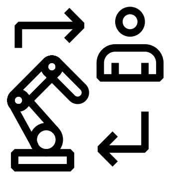


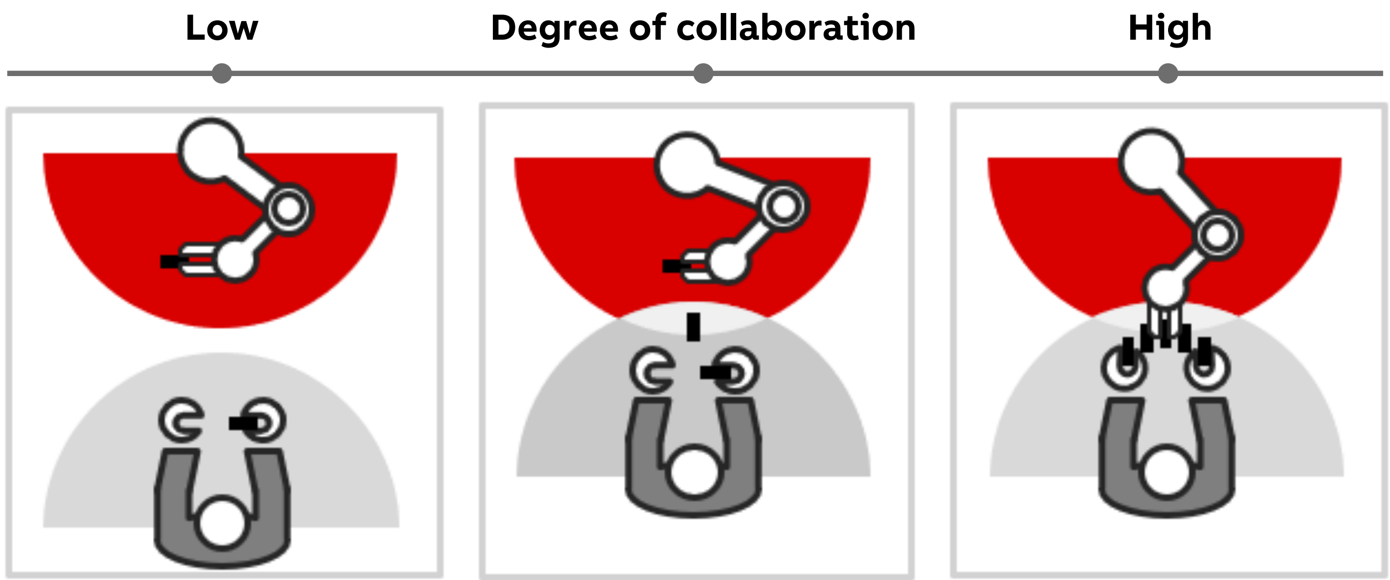


Determine the scope of the system

Identify the level of collaboration

Identify the level of collaboration required between the cobot and humans.
A useful classification is according to the categories:





Co-existence
Fenceless robot, no workspace sharing

Intermittent Collaboration
Infrequent sharing of workspace

Cooperation
Continuous sharing of workspace

Identify the hazards

1 2 3 4 5

Once the intended behavior of the cobot setup have been determined, you will need to evaluate the hazards that the system or the area surrounding it might present. These are broadly divided into:

Hazards associated with the cobot

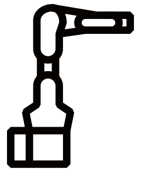
Hazards associated with the application

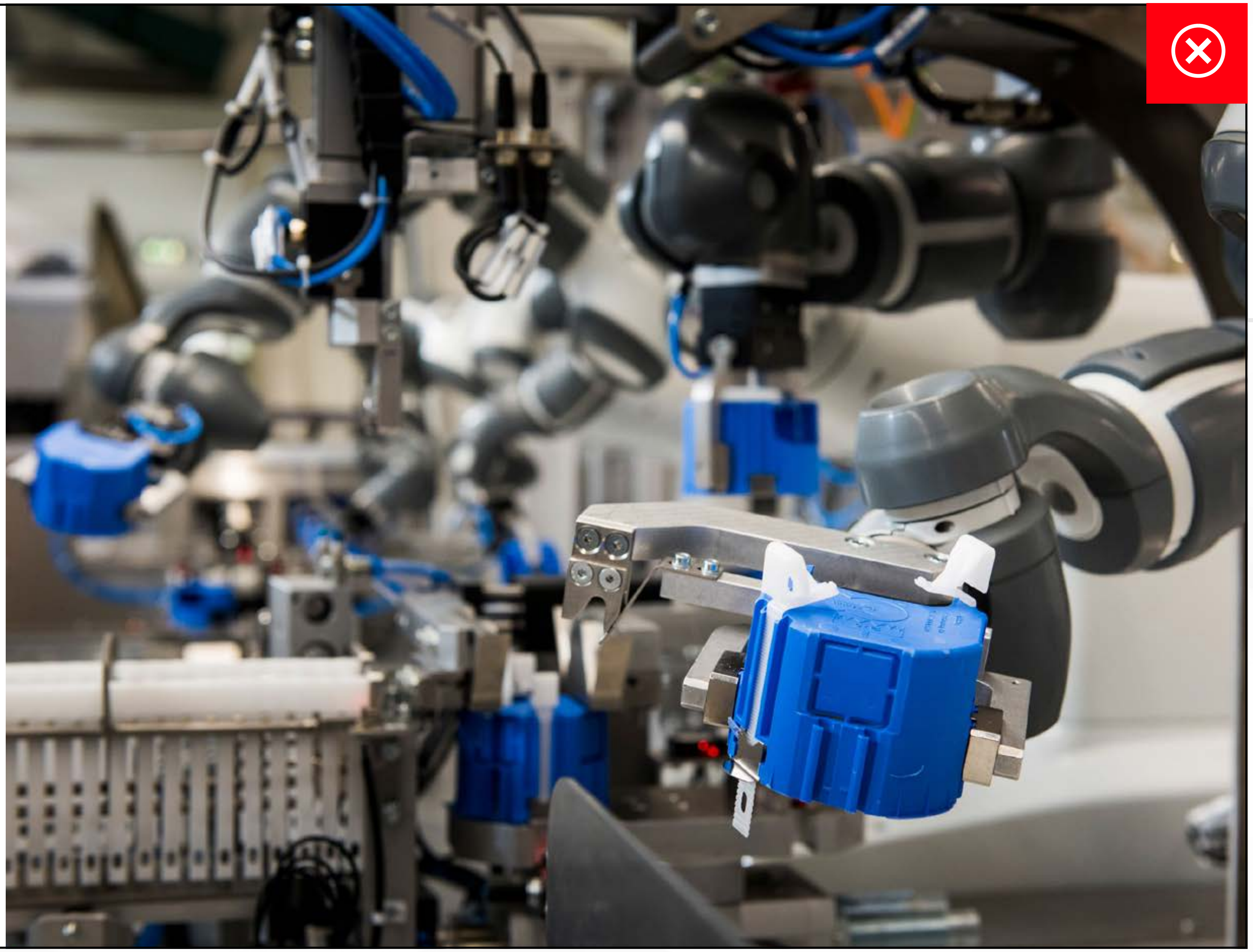
Hazards associated with the environment

Identify the hazards

Hazards associated with the cobot

Hazards associated with the cobot include hazardous geometry, sharp edges and corners that need to be protected. It can also include the capability for injury to be caused by hazardous high speeds or forces.

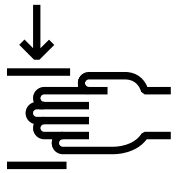




Identify the hazards

Hazards associated with the application

Hazards associated with the application such as fast movement, handling sharp tools or hot objects during the operation. In the case of intermittent and co-operative collaboration, you must evaluate whether there are chances of the human's hands or other body areas being crushed or impacted by the cobot's arms.



Identify the hazards

Hazards associated with the environment

Hazards associated with the environment such as other machinery, obstacles leading to tripping, limited egress, or the presence of hazardous substances or sources of energy that could affect the workspace, all of which require additional protective measures.

Assess the risk

1 2 3 4 5

To ensure employee safety, it's important to estimate the degree of risk and understand the safety requirements around the operation.

Risk is generally considered to be a conceptual "product" of the severity of the consequences of a hazard (harm) and the likelihood of its occurrence (exposure), as shown in this diagram.

ISO/TS 15066 sets safety requirements for cobots and the work environment with a focus on safeguarding humans against physical contact with cobots.

IDENTIFY THE BODY AREAS

Level of risk can be estimated from the severity of consequences and the likelihood of exposure to a hazard.

Risk = (severity of consequences) × (likelihood of exposure)

Severity of consequences

Low	Medium	High
Low	Medium	Medium
Low	Low	Low

Likelihood of exposure

Eliminate the risk

1 2 **3** 4 5

The initial step in estimating the specific risks in an application is to identify the body areas that are exposed to possible physical contact with the moving cobot system during operation.

Transient: this refers to contact force transients shorter than 0.5 s duration.

Quasi-static: this designates sustained contact events of longer than 0.5 s duration.

Table 1 – Limits on permissible contact pressures and forces according to ISO/TS 15066:2016 (D = dominant, ND = non-dominant sides depending on right- or left-handedness)

	Specific body area	Quasi-static contact		Transient contact	
		Maximum pressure P_s (N/cm²)	Maximum force F_s (N)	Maximum pressure P_T (N/cm²)	Maximum force F_T (N)
1	Center of forehead	contact not permitted			
2	Temple	contact not permitted			
3	Masticatory muscle	contact not permitted			
4	Neck muscle	140	150	280	300
5	7th neck vertebra	210	150	240	300
6	Shoulder joint	160	210	320	420
7	5th lumbar vertebra	210	210	420	420
8	Sternum	120	140	240	280
9	Pectoral muscle	170	140	340	280
10	Abdominal muscle	140	110	280	220
11	Pelvic bone	210	180	420	360
12	Deltoid muscle	190	150	380	300
13	Humerus	220	150	440	300
14	Radial bone	190	160	380	320
15	Forearm muscle	180	160	360	320
16	Arm nerve	180	160	360	320
17	Index finger pad D	300	140	600	280
18	Index finger pad ND	270	140	540	280
19	Index finger end joint D	280	140	560	280
20	Index finger end joint ND	220	140	440	280
21	Thenar eminence	200	140	400	280
22	Palm D	260	140	520	280
23	Palm ND	260	140	520	280
24	Back of hand D	200	140	400	280
25	Back of hand ND	190	140	380	280
26	Thigh muscle	250	220	500	440
27	Kneecap	220	220	440	440
28	Middle of shin	220	130	440	260
29	Calf muscle	210	130	420	260

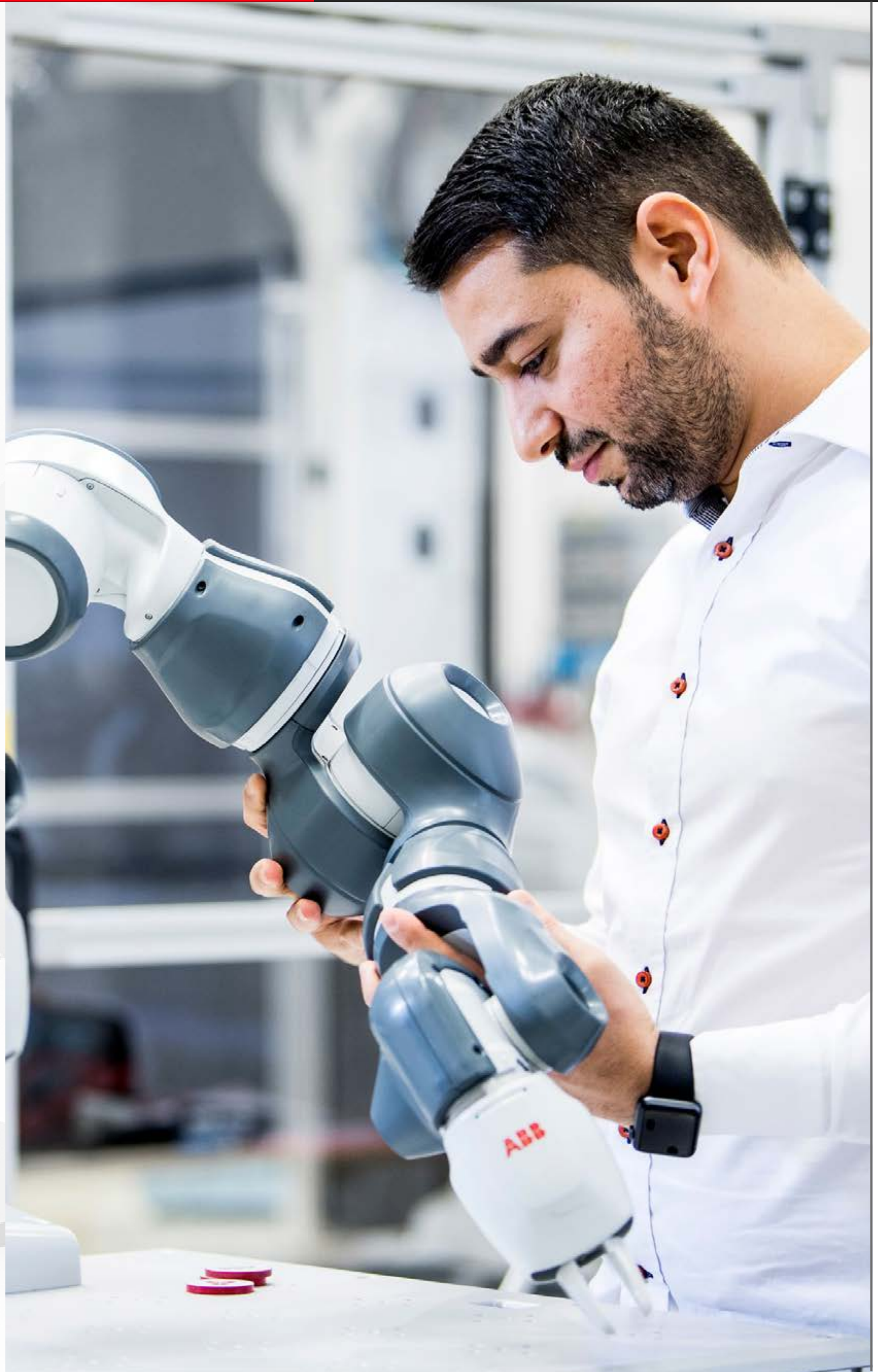
Reduce the risk

1 2 3 **4** 5

While they are designed and built with safety functions such as capabilities to reduce the impact of contact with a human including detecting presence, and slowing down or stopping as a person approaches; cobots are not automatically safe by default.

The safety functionality of the robot is key in the overall risk reduction scheme. This should address both the cobot and additional application related risks induced by the gripper, workpiece, fixtures, and other periphery. In general, risk reduction seeks both to reduce the severity of the hazards identified and to reduce the probability of their occurrence.

ISO/TS 15066 sets safety guidelines for protecting against incidental physical contact in applications where humans and cobots share a workspace. The principal risk reduction methods for reducing any risks of injury are described by ISO/TS 15066 as power and force limiting (PFL) and speed and separation monitoring (SSM).



Also in this section take a look at:

Power and force limiting (PFL)
>> Read more

Speed and separation monitoring (SSM)
>> Read more

Combining PFL and SSM
>> Read more

Reduce the risk

1 2 3 4 5

Power and force limiting

This risk reduction principle assumes that a human may come into physical contact with a moving cobot.

All possibilities for contact with the human body during operation must be considered. Intentional or incidental contacts can occur in intermittent or co-operative collaboration, and the safety measures of the application must ensure these are always handled safely.

Contact situations are classified according to their **configuration** and their **duration**.

LEARN MORE ABOUT CONFIGURATION

LEARN MORE ABOUT DURATION

Key properties of contact situations between moving cobot and human body region.

Configuration	Duration: Long	Duration: Short
Constrained	**Constrained quasi-static contact** • Limit values on quasi-static forces and pressures in ISO/TS 15066 • Driving forces important	**Constrained transient contact** • Limit values on peak transient forces and pressures in ISO/TS 15066 with $m_H \rightarrow \infty$ • Inertial and driving forces important
Unconstrained		**Unconstrained transient contact** • Limit values on peak transient forces and pressures in ISO/TS 15066 • Inertial forces important

Also in this section take a look at:

Power and force limiting (PFL)
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Speed and separation monitoring (SSM)
>> Read more

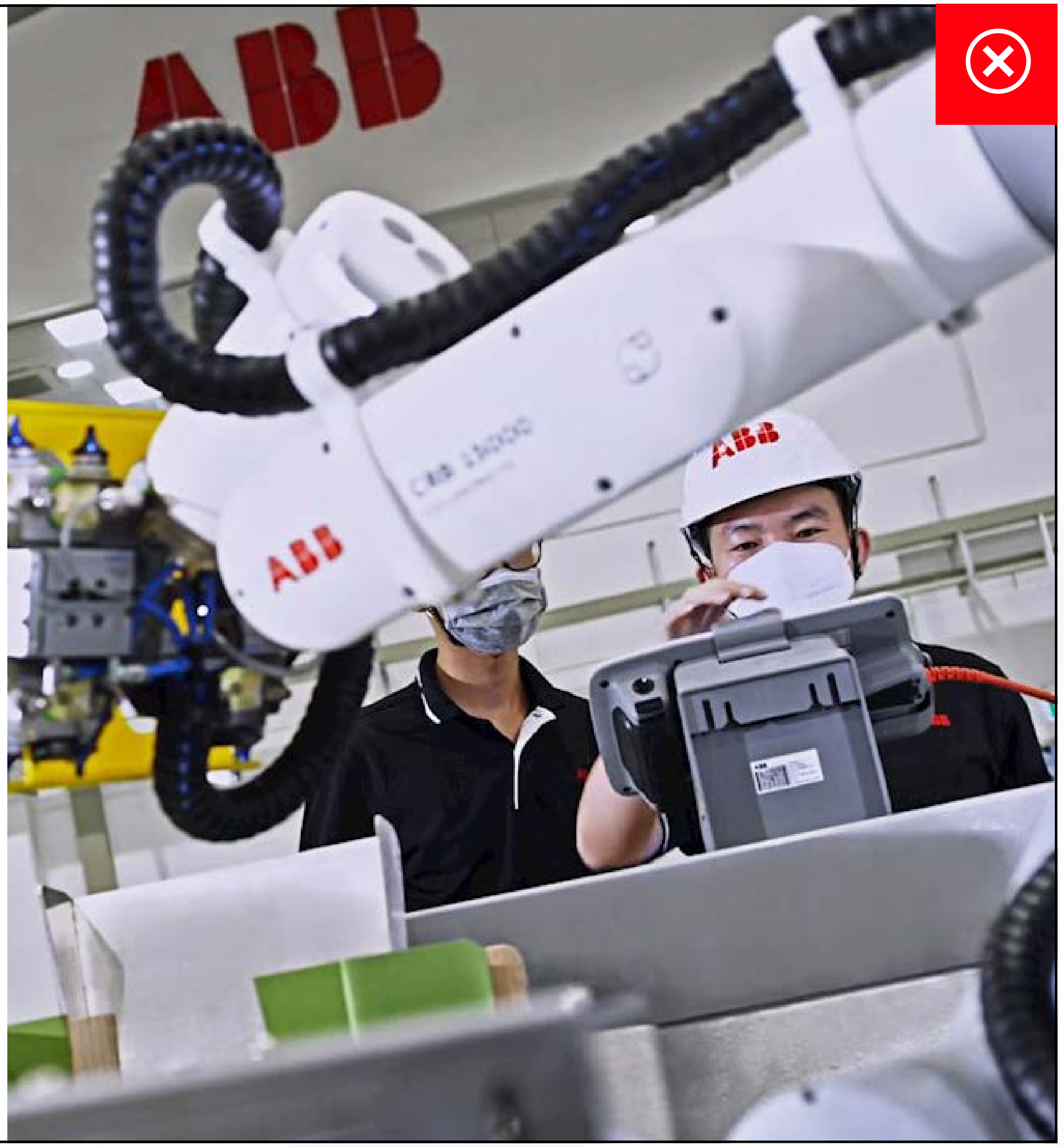
Combining PFL and SSM
>> Read more

Power and force limiting

Configuration

The configuration of a contact event between cobot and human body region can be either

- **Unconstrained:** in this case the body region is free to recoil or retract from the contact event
- **Constrained:** here, the body region is trapped between the cobot and a fixed obstacle, such as a fixture or workbench surface



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Power and force limiting

Duration

The duration of a contact event between cobot and human body region according to ISO/TS 15066 can be either:

- **Transient:** this refers to contact events shorter than 0.5s duration. In this case, the inertial forces dominate the contact, as the cobot is carrying appreciable kinetic energy. Risk can be reduced by limiting the kinetic energy in the cobot i.e. limiting the speed of its motion, and using rounded, padded, larger surfaces to reduce the impact forces.
- **Quasi-static:** this designates sustained contact events of longer than 0.5s duration. These occur when the cobot pushes and clamps a body part against a fixed object, such as a table. In this case, the driving forces of the cobot dominate the contact while inertial forces are negligible. Risks can be reduced by properly configuring and using the cobot safety functions to limit contact force and speed.

Also in this section take a look at:

Power and force limiting (PFL)
>> Read more

Speed and separation monitoring (SSM)
>> Read more

Combining PFL and SSM
>> Read more

Reduce the risk

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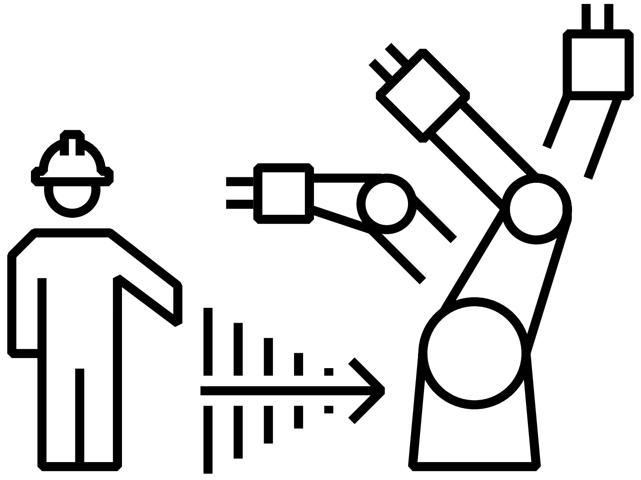
Speed and separation monitoring

This risk reduction principle uses external safety sensors such as safety laser scanners to detect approaching persons in a defined area within the collaborative workspace. They are used to reduce the speed of the cobot to prevent the human operator from touching any part of the cobot system while in motion.



To maintain good productivity, the control system adapts the cobot's velocity in response to the measured distance to the nearest operator. This is known as the protective separation distance (PSD). When the operator is not near the robot, it can move at much faster speeds than a cobot safeguarded using PFL.

Suitable for:

- Intermittent and "Co-existence" collaborative work

Not suitable for:

- Transient applications (this refers to contact force transients shorter than 0.5 s duration)
- Quasi-static applications (this designates sustained contact events of longer than 0.5 s duration)

FIND OUT MORE ABOUT PROTECTIVE SEPARATION DISTANCE

Also in this section take a look at:

Power and force limiting (PFL)
>> Read more

Speed and separation monitoring (SSM)
>> Read more

Combining PFL and SSM
>> Read more

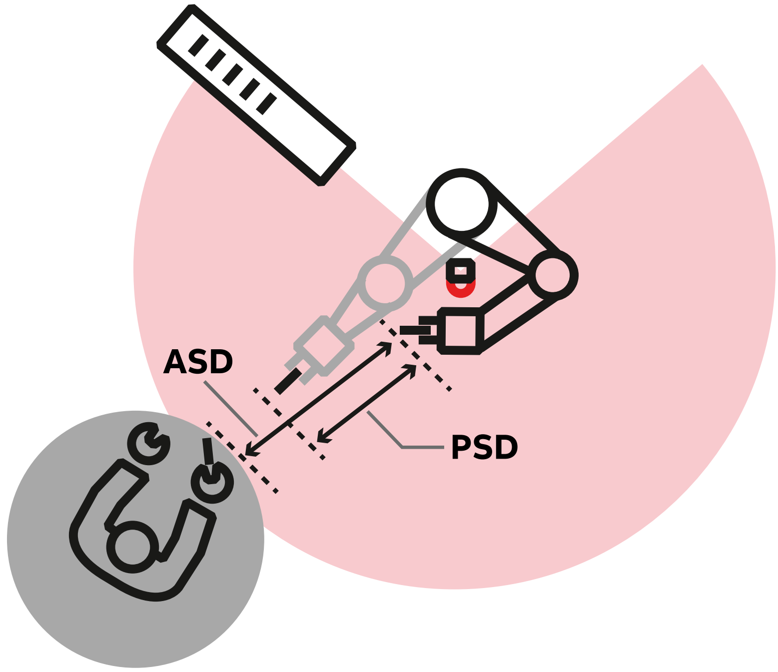
Speed and separation monitoring

Protective separation distance (PSD)

Refers to the separation distance between the human operator and moving parts of the cobot system so that the operator cannot reach it before it has come to a stop. Central to SSM is the continuous comparison of the PSD to the measured actual separation distance (ASD) between the human operator and the cobot system. The protection objective is fulfilled whenever the ASD is large enough.

Protective criterion for SSM risk reduction

Dotted outline indicates where the robot would come to rest if a stop were triggered. The light red shading indicates the detection field of a safety sensor, located at the base of the robot in this example. The protective separation distance PSD and the actual separation distance ASD are indicated.



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Combining PFL and SSM
>> Read more

Reduce the risk

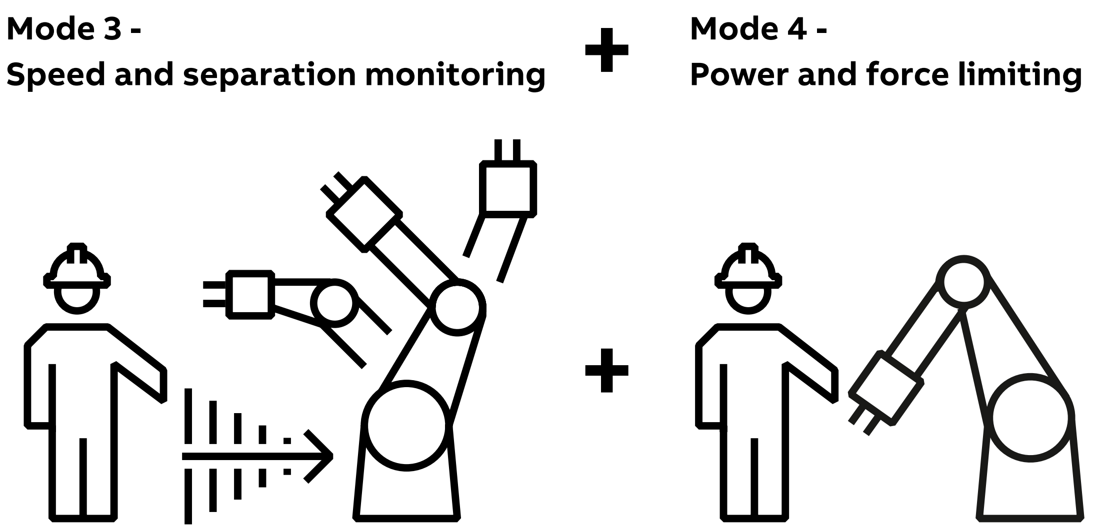
1 2 3 4 5

Combining PFL and SSM

Combining PFL and SSM as risk reduction means can be a good approach to protect cobot applications in which phases of close co-operation alternate with phases of intermittent short interventions.

The shortcoming of PFL – operating with limited speed even without an operator in immediate vicinity of the cobot – is remedied by SSM that allows higher cobot speeds in these cases.

The weakness of SSM – needing to come to a complete stop when the operator approaches the system close enough to touch it – is complemented by PFL that allows for a non-zero cobot speed in this situation. The higher complexity compared to pure PFL or pure SSM enables further productivity gains as well as flexibility with respect to varying operating conditions.



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Combining PFL and SSM
>> Read more

Determine the residual risk

1 2 3 4 5

To verify any risk reduction measure achieved, measurements of possible contact forces and pressures can be conducted by the system integrator or by a qualified safety consultant who will provide a document.

It is legally binding to conduct a risk assessment of the completed application and to implement risk reduction measures as appropriate. It's important to confirm that the cobot always maintains at least the protective separation distance to any persons in its workspace. The tests, the results and the suitability of the risk reduction achieved must be documented and filed for reference.

When changes are made to a cobot application or when the existing safety configuration is no longer valid, a renewed risk assessment and risk reduction, as well as verification and validation are required.

Cobot safety checklist

Proper risk assessment and risk reduction are a key requirement for a safe cobot installation if all the standards are followed. Following the steps listed below will set you on the path to both safety and productivity; helping you create the best cobot application for your needs.

- Good practice starts with a description of your cobot application and its intended use, followed by identification of all the hazards that it may present during programming, commissioning and operation.

- The risks must be reduced sufficiently using the safety functionalities of the robot, e.g., limiting positions, speeds and contact forces, or using external safety sensors.

- The system integrator must document the safety-related aspects of the cobot system, the procedures followed for their correct configuration, the intended manner of working with the system as well as any limitations on use or requirements on regular adjustments or maintenance. Please note, if the application is made directly by the end customer, the responsibility is on them.

For more information on our cobots visit:
new.abb.com/products/robotics/robots/collaborative-robots