ROBOTIQ *PALLETIZING SOLUTION SAFETY*

General guidelines for safe use of the Robotiq Palletizing Solution

The installer is responsible for the safe installation and commissioning of the Palletizer. Robotiq accepts no liability for damage or injury or any legal responsibility incurred directly or indirectly from the use of this product. The user (installer and operator) shall observe safe and lawful practices including but not limited to those set forth in this document.

Always comply with local and/or national laws, regulations and directives on automation safety and general machine safety.

Do not base your risk assessment solely on the information provided in this presentation.

THINKING SAFETY FIRST

1 SCOPE APPLICATION — **2** IDENTIFY & EVALUATE RISK — **3** REDUCE & ELIMINATE RISK — **4** INTEGRATE — **5** OPERATE

Design

- Determine cell functions.
- Assess, eliminate or mitigate risk.
- Adjust initial design according to safety measures.

"The safety of your people should always be a priority when installing new equipment or implementing new processes."

Étienne Samson, Robotics Application Director

Integrate

- Install robot cell in compliance with design and safety requirements.
- Program robot in collaborative mode.
- Perform test runs to avoid operating mistakes.

Operate

- Ensure safety features are functioning.
- Train operator.
- Ensure employees respect PPE requirements.

ROBOTIQ

1
SCOPE APPLICATION

Palletizing is an intrinsically unsafe application, as it involves moving multi-kilo boxes at high speed at head level.

In most use cases, if you want to operate at full speed, you must safeguard the palletizing cell.

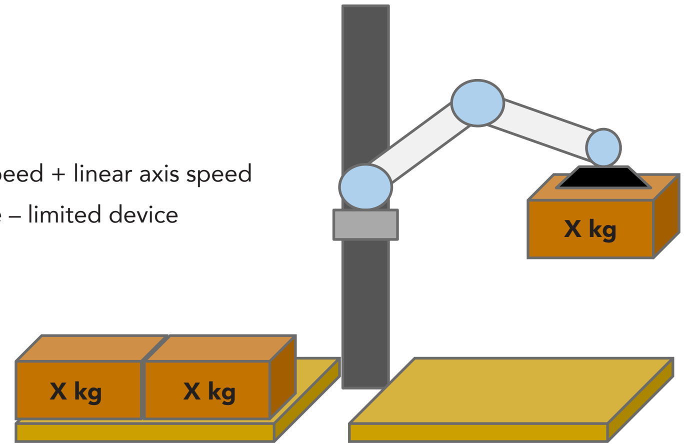
Need help scoping your application?

Consult the Lean Robotics method at leanrobotics.org.

LINEAR AXIS

Total speed = robot speed + linear axis speed

Not a power – or force – limited device



APPLICATION

Consider object:

- **Weight.** Higher weight → higher risk due to greater inertia.
- **Shape.** Sharp edges → higher risk.
- **Material.** Rigid material → higher risk.

Consider manipulation:

- Inertia from moving the object.
- Potential box drop as a result of air-pressure failure.

Consider usage:

- Who will operate the robot?
- Under what circumstances?

ROBOT

Can be safe for human-robot collaboration at all times if used with proper force, power and speed limiting

2
IDENTIFY & EVALUATE RISK

HOW TO IDENTIFY AND EVALUATE RISK

Consider all robotic cell components to determine which risk reduction method to use.
First, consider normal use of the cell, then plausible but not typical use.
Next, evaluate each risk.

IDENTIFICATION

Typically normal use:

- Operator approaches cell to get a filled pallet.
  → *Exposed to robot motion.*
- Operator approaches cell to place a new pallet.
  → *Exposed to robot motion.*

Typically plausible but not normal:

- Defective box causes vacuum gripper to fail and drop box.
  → *Exposed to falling objects.*
- Employee walks into the danger zone without noticing.
  → *Exposed to robot motion.*
- Operator accesses conveyors to remove a defective box.
  → *Exposed to robot motion and 7th axis motion.*

EVALUATION

Transient vs. quasi-static impact

- A transient impact (impact in motion) is less harmful than a quasi-static (or crushing) impact.
- Quasi-static impact should be evaluated in terms of force or pressure applied on the human body part.
- Transient impact should be evaluated in terms of energy transferred from the robot to the human body part.

$$E = \frac{F^2}{2k} = \frac{1}{2}\mu v_{rel}^2$$

Energy transfer during transient contact

(source: ISO/TS 15066)

The energy transferred from the robot in motion to the human body part can be calculated using the relative speed and mass of both objects.

When a heavy box is carried at a great speed without any physical separation between the robot payload and the human operator, chances are the potential energy transfer is way above the permissible threshold.

E Energy transferred

F Force

k Spring constant of human body region

μ Reduced mass of the two-body system

$**v_{rel}**$ Relative speed between robot and human body region

$$\mu = \left[\frac{1}{m_H} + \frac{1}{m_R}\right]^{-1}$$

Given that the maximum energy limit for the face is 0.11 J, the robot may have to run very slowly to respect the permissible energy threshold in case of impact.

If the robot carries a heavy payload and runs at high speed, you must use another risk reduction or use safeguarding.

3

REDUCE & ELIMINATE RISK

HAZARD ELIMINATION AND RISK REDUCTION (section 4.3.4, ISO/TS 15066)

After identifying hazards, use one of the following three risk reduction methods.

Elimination or reduction

Eliminate hazards via inherently safe design, or reduce them through substitutions, such as:

- Avoiding layouts featuring a rigid plane (wall), to avoid the risk that someone could be stuck between the wall and the robot.
- Reducing robot speed to prevent risks associated with dangerous kinetic energy of the robot itself and of the manipulated object.

Safeguarding

Provide measures that will prevent people from being exposed to danger, such as:

- Fences to prevent the operator from entering a dangerous area.
- An area scanner that will monitor for the presence of humans and slow or stop the cobot cell if someone approaches.

Protective measures

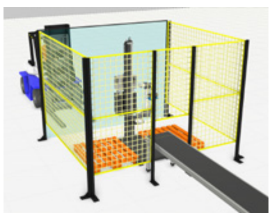
Provide supplementary protective measures, such as usage information, training, signs, and personal protective equipment.

You have to go through these three steps for hazard elimination and risk reduction, whether for an industrial or collaborative robot.

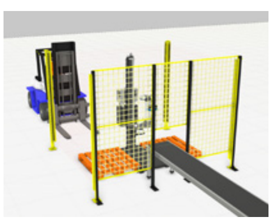
With **industrial** robots, risk reduction is typically achieved through safeguards that separate the operator from the robot system. Why? The weight, force, payload, and speed at which they are operating can never be reduced to an acceptable threshold. Therefore, physical safeguards are required.

With **collaborative** robots, risk reduction is primarily addressed through the design of the robot system and collaborative workspace. However, even cobots sometimes need safeguarding, because of the nature of the application or other moving cell components.

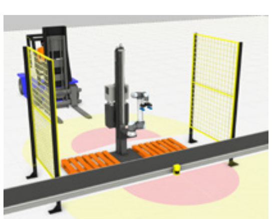
SAFEGUARDING METHODS FOR COBOT CELLS

<table>
<tr><th>Safeguarding</th><th>Application fit</th><th>State</th><th>Relevant technical info</th></tr>
<tr><td>No safeguarding (safe by design)</td><td>Good for slow-paced applications.
Operator should have training and PPE.</td><td>No difference between collaboration mode and operation mode.</td><td>N/A</td></tr>
<tr><td>Fencing
$
</td><td>Good for dedicated cells that don't need to be moved often.
Good for fast-paced/high-payload applications.
Cheap and simple.
Operator cannot interfere with cell operation by mistake.</td><td>Barrier open → collaboration mode.
Barrier closed → operation mode.
Palletizing cell will stop when the safeguard is opened.</td><td>Use ISO 13857 to determine the safety distance (the distance to be maintained between equipment and fences, to prevent barriers from being breached).

Complete table can be found in ISO 13857.

<table>
<tr><th rowspan="2">Opening (e) (mm)</th><th colspan="3">Safety distance (mm)</th></tr>
<tr><th>Slot</th><th>Square</th><th>Round</th></tr>
<tr><td>30 < e ≤ 40</td><td>≥ 850</td><td>≥200</td><td>≥120</td></tr>
<tr><td>40 < e ≤ 120</td><td>≥ 850</td><td>≥ 850</td><td>≥ 850</td></tr>
</table></td></tr>
<tr><td>Light curtain
$$
</td><td>Simple.
Good for fast-paced / high-payload applications.
Might have smaller footprint than fencing.
Operator saves time getting into cell area.</td><td>Light curtain triggered → collaboration mode.
Light curtain not triggered with reset → operation mode.
Palletizing cell will stop when the safeguard is opened.
Requires a reset button to be placed outside the curtain.</td><td>Use EN/ISO 13855 to determine safe light curtain positioning.

S = k (t1 + t2) + C

K: Constant (mm/s) calculated from approach speed of a human moving toward a dangerous area (typically 1600 mm/s)
t1: Global response time of the light curtain (s)
t2: Machine global stopping time (s)
C: Supplementary distance (mm)</td></tr>
<tr><td>Area scanner
$$$
</td><td>Minimal footprint.
Can be part of a mobile solution.
Allows for multiple different zones to be set at reduced speed or complete stop.</td><td>Cell slows down when a human approaches the robot, according to sensor settings.
Auto-resets when operator exits the danger zone.</td><td>Use EN/ISO 13855 to determine safe area scanner positioning
(for a beam placed 300 mm from the ground).

S = 1600 (t1 + t2) + 1200

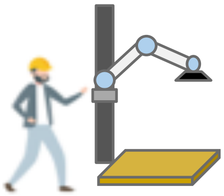
t1: Global response time of the light curtain (s)
t2: Machine global stopping time (s)</td></tr>
</table>

4

INTEGRATE

TIPS FOR SAFE INTEGRATION

- Install the robot cell in compliance with design and safety requirements.
- Remember that safety requirements also apply to the installation and programming part of the process; make sure to design a safe cell before starting to unpack your robot.
- Program the robot in collaborative mode.
- Perform test runs to avoid operating mistakes:
  - Run your program block by block.
  - Run tests at a safe distance and/or very low speed.
  - Gradually increase speed until you reach operational speed.



5

OPERATE

BEFORE OPERATING

- Complete your risk assessment before entering production.
- Follow certification procedures, as required by law (region-dependent).
- Train employees to be aware of possible dangers.
- Review safety measures every time you make any change to cell operation.

WHILE OPERATING

Treat cobot cell safety as something that evolves over time, and commit to a continuous improvement plan.

SAFETY DISCLAIMER

The intent of this document is to provide general guidelines for safe use of the Robotiq Palletizing Solution. The installer is responsible for the safe installation and commissioning of the Palletizer. Robotiq accepts no liability for damage or injury or any legal responsibility incurred directly or indirectly from the use of this product. The user (installer and operator) shall observe safe and lawful practices including but not limited to those set forth in this document. **Always comply with local and/or national laws, regulations and directives on automation safety and general machine safety.** Do not base your risk assessment solely on the information provided in this presentation.