

MODULE 10

Safety, Guarding and Code Compliance

Conveyor Solutions Engineering | Professional Training Program

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SECTION 1: INTRODUCTION

Safety is a professional discipline that a solutions engineer must carry into every project, from the first site conversation to the final commissioning walk. Engineers who treat safety as a final engineering review item are often surprised by cost additions at the end of a project, or worse, deliver a system that injures someone.

This module focuses on developing engineering judgment rather than memorizing regulatory codes. The goal is to help you recognize where hazards exist in real facilities and understand the consequences of missing them early in a project. These principles apply regardless of the manufacturer's equipment being specified or the type of facility being designed.

A solutions engineer should continuously evaluate safety considerations specific to each project and integrate them into design reviews from the beginning.

Always ask whether the customer has a defined safety specification before beginning design work.

The guidelines in this section represent general engineering practices. When these guidelines conflict with customer specifications, site policies, or local, state, or national regulations, the most stringent requirement must always be followed.

SECTION 2: LEARNING OBJECTIVES

By the end of this module you will be able to:

- 1 Identify conveyor guarding requirements based on operator proximity, conveyor elevation, and voltage class.
- 2 Apply the 96-inch rule for underside belt and roller protection on high-voltage conveyor systems.
- 3 Specify pull cord E-stop placement with proper spacing and accessibility planned during the design phase.
- 4 Determine when safety caging is required and when collaborative robot configurations change that requirement.

5	Identify bearing cover requirements on rotating shafts and understand their role in preventing entanglement injuries.
6	Scope safety elements accurately during the quoting phase to protect project margin and avoid late cost surprises.
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SECTION 3: PREREQUISITES

Required Prior Knowledge
<p>Module 3: Conveyor Fundamentals and Component Anatomy. You need a working understanding of conveyor structure, drive components, and rotating elements.</p> <p>Module 4: Conveyor Types and Technology Selection. You need familiarity with the range of conveyor technologies and their physical configurations.</p> <p>Module 5: System Design and Flow Layout. You need to understand operator flow, aisle placement, and how people move through a facility relative to the conveyor system.</p> <p>Module 9: Controls Integration and PLC Interface. awareness of E-stop circuits, PLC safety inputs, and emergency stop architecture is a plus,</p>

SECTION 4: THE THREE W'S

The three questions that must be answered at every safety-critical design point are captured here. Work through them systematically for each guarding decision.

WHY	<p>The solutions engineer is the first technical person who owns the system design. By the time final engineering begins, the layout is set, the budget is approved, and the customer has expectations locked in. Safety additions found late in that process become uncomfortable conversations at best and project failures at worst.</p> <p>Beyond cost, the stakes are real. Conveyor systems operate at speed, at elevation, and at voltage levels that can seriously injure or kill an operator who contacts a moving component. The engineer who designs the system carries professional and moral responsibility for the outcome.</p>
WHEN	<p>Safety considerations enter the design process at the first site walk. Every time you assess a project, you should be asking: where will operators be standing? How close to the conveyor? At what elevation? What are the moving parts they could contact? Are there rotating shafts within reach? Can someone reach up into a belt or roller from below?</p> <p>Safety is not a separate phase. It is a lens you apply to every design decision throughout the entire process.</p>
WHERE	<p>Safety gaps most commonly appear in three places: the underside of elevated conveyors where operators work below the system, along conveyor runs where pull cord E-stop space was never planned into the layout, and at rotating shaft locations</p>

where bearing covers were treated as optional finish items rather than required specifications.

SECTION 5: CORE CONTENT

5.1 The Five Guarding Categories

There are four primary guarding categories a solutions engineer must evaluate on every project. Each category has specific design requirements that must be addressed during the layout phase, not at final engineering.

The Five Guarding Categories

Underside belt and roller protection on conveyors where operators have access to the underside of the unit.

Pull cord E-stop placement and accessibility

Safety caging around automated cells and robotic equipment

Bearing covers and rotating shaft guards

Pinch/Nip Points

FIELD INSIGHT | MICHAEL COLLINS

The small safety items that get added late are the ones that erode your margin. Each one individually seems minor. Together they add up to real cost.

This should be a conversation between mechanical and controls teams, and align with any customer spec

5.2 Underside Belt and Roller Protection

The 96-Inch Rule

Belly pans are typically installed on high voltage conveyors when the conveyor is positioned at an elevation where an operator could reach up and contact a moving belt, roller, or drive component.

Belly pans are not required if the conveyor is at least 96 inches above the feet of an operator who could otherwise reach the conveyor.

This distinction is important in situations such as an inclined conveyor installed next to a staircase. The conveyor may appear to meet the 96 inch clearance when measured from the floor, but it could still be reachable from the stairs.

This guideline applies specifically to high voltage, high power conveyor systems operating on 480 volt three phase power. At this power level, contact with a moving belt or roller presents a serious risk of severe injury or fatality.

Evaluate underside cover requirements whenever a conveyor is installed above a work area, shipping dock, pick station, or any area with regular operator presence below.

Underside covers are typically formed sheet metal panels that close off the belt return side, roller nip points, and drive components from below. They are a factory option on most conveyor manufacturers' standard product lines.

Special Note: When there is a high likelihood of product falling from the conveyor, belly pans or safety netting may still be optimal.

5.3 Pull Cord E-Stop Placement

A pull cord emergency stop runs the length of a conveyor run and allows any operator along that run to stop the conveyor immediately by pulling the cord. It is one of the most important operator safety devices in a conveyor system.

Pull cord E stops must be provided anywhere a conveyor is accessible to an operator or maintenance personnel. Any conveyor that can be reached during normal operation or service requires a pull cord unless it is an MDR conveyor with no diverting, lifting, or other actuation hardware.

FIELD INSIGHT | MICHAEL COLLINS

It is important to consider E stop zones and E stop interlocks with adjacent third party equipment.

As a rule of thumb, if an operator can see the equipment or hear someone calling for help, the nearest E stop should stop that conveyor as well.

When safety interlocks are connected to third party equipment, it is important to determine which system is the master safety system. The master system should control the overall stop condition and ensure that all interconnected equipment respond appropriately to a safety event.

Design Consideration	Requirement
Cord height	Typically 30 to 48 inches above finish floor for operator reach
Cord tension	Must be maintained consistently along full run slack cable switch are required
Eyelet spacing	Typically every 10 -12 feet along the conveyor run
Reset location	Must be accessible to the operator
Clearance from obstructions	Cables and push buttons should be easily accessible
Coverage zone	Full length of any conveyor run where operator access exists, in instances where is only a small section of conveyor is accessible by the operator Pushbutton estops may be considered
PLC integration	CIP safety or Hard-wired into PLC safety circuit : must stop the full zone, not just a local section

5.4 Safety Caging and Robotic Cell Guarding

Safety caging is a physical barrier around automated equipment that operates at speeds and forces that would injure an operator on contact. It is required by code for industrial robots and is standard practice for any high-speed automated cell.

Safety caging is required when the robot or automated equipment operates at speeds and forces that would cause injury on contact, when the operational envelope of the equipment extends beyond a fixed position, and when the equipment can be triggered remotely or by sensor input.

Industrial Robot vs. Collaborative Robot

Collaborative robots, commonly called cobots, are designed to work alongside human operators without physical guarding, using force-limiting and speed-limiting technology to prevent injury on contact. An industrial robot does not have these limitations and requires full safety caging.

This is a meaningful design and cost difference. The solutions engineer needs to know which type of robot is being specified before designing the guarding package. Getting this wrong adds significant cost at the change order stage.

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Know whether you are dealing with an industrial robot or a collaborative robot before you spec the guarding. The caging requirements, access gate count, safety PLC integration, and light curtain needs are all different. It is not a minor difference.

Most times Robotic integrations companies, have standardized risk assessment documents they can provide, ask for it and see what requirements there may be

Any safety cage requires access gates for maintenance, jam clearing, and inspection. Every access gate must be interlocked. A gate without an interlock is safety violation and a liability. Design the gate locations and interlock wiring into the layout.

5.5 Bearing Covers and Rotating Shaft Guards

Exposed rotating shafts, couplings, and bearing housings are a serious entanglement hazard. An operator can catch loose clothing, a glove, or a sleeve on a rotating shaft in less than a second. Bearing covers and shaft guards eliminate that exposure.

Evaluate exposed rotating components at every drive location in the system: line shaft conveyor drives, motorized roller controllers, gearbox output shafts, roller-to-roller transfers, and any location where a shaft extends beyond a bearing housing.

FIELD INSIGHT | MICHAEL COLLINS

Bearing covers often get treated as a finishing detail that can be added late in a project. In reality, they are a factory option that must be specified on the conveyor purchase order.

If they are missed at that stage, the cost can increase significantly, often 5 to 10 times more. Even if the covers arrive on time, they still have to be installed by the field installation team instead of being installed by the conveyor manufacturer during production. This adds both labor cost and schedule risk.

5.6 Lockout/Tagout Design Considerations

Lockout/Tagout is the procedure used to isolate energy sources before maintenance work is performed on conveyor equipment. The solutions engineer does not write the LOTO procedure, but the design decisions made during layout determine how practical that procedure will be.

Energy isolation points, primarily disconnect switches and lockable breaker panels, must be accessible to the maintenance technician performing the work. An isolation point located inside a panel room that requires a second person to access is a LOTO violation waiting to happen.

FIELD INSIGHT | MICHAEL COLLINS

LOTO accessibility is one of those things that customers notice immediately during commissioning and factory acceptance. If a maintenance tech cannot reach the disconnect from the floor without a ladder, or if the disconnect is behind equipment, it will get flagged. Design it right the first time.

SECTION 6: TIPS AND TRICKS

TIPS AND TRICKS | MICHAEL COLLINS

Walk the layout mentally from the operator's perspective before you finalize any design. Where will they stand? Where will they reach? Where will they be at 2 AM when something jams? That mental walk will surface safety issues that a purely technical drawing review will miss.

Do you remember in earlier modules when I said act as though you are the carton, well here, I want you to act like a person, specifically the person using the system

Nobody notices underside covers when they are there. Everybody notices when a near-miss happens on a conveyor that did not have them. Specify them during scoping on any elevated 480V system with operator access below.

Pull cord path along a conveyor run is a design decision, not an installation detail. The cord needs a clear path, accessible mounting structure, and a reset location that operators can reach. Resolve it on the layout.

Know whether you have an industrial robot or a collaborative robot before you spec the cage. That single determination drives whether you have a full safety cage installation in scope or not. The cost difference is significant and it changes the layout.

Always specify bearing covers as a factory option on the conveyor order. Field-fabricated guards are more expensive in labor, take longer, and often do not fit as cleanly as factory options.

SECTION 7: NOTES AND INSIGHTS

NOTES AND INSIGHTS

Safety items found during scoping cost the project nothing in margin. Safety items found during final engineering cost the project real money or become change order conversations the customer was not expecting. The timing of discovery is everything.

Low-voltage 24V MDR conveyor systems carry significantly lower electrical risk than 480V systems. But mechanical entanglement from an exposed underside is still a hazard regardless of voltage. Evaluate each installation on its own merits.

Belly pans are typically installed on high voltage conveyors when the conveyor is positioned at an elevation where an operator could reach up and contact a moving belt, roller, or drive component. Belly pans are not required if the conveyor is at least 96 inches above the feet of an operator who could otherwise reach the conveyor.

Safety gate interlocks must be safety-rated devices. Standard limit switches are not an equivalent. This distinction matters during specification and should not be left for the controls team to resolve without guidance from the solutions engineer.

Multi-lock hasps for LOTO allow multiple technicians to lock out the same system simultaneously. They need to be accessible, which means they need to be in scope and in the design before the panel is mounted.

SECTION 8: EXPERT CALLOUT

EXPERT CALLOUT

Placeholder for expert insight on safety and guarding from a peer reviewer with field experience. Reviewer to share a specific example where a safety requirement was missed during design, what the consequence was during commissioning or after installation, and what the correct process would have looked like.

[Reviewer Name, Title, Company]

SECTION 9: PITFALLS

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Treating safety as a final engineering item. The single most expensive safety mistake a solutions engineer makes is discovering guarding requirements after the contract is signed. Pull cord runs, underside covers, and caging scope are all items that carry real cost. Finding them during scoping means they get priced in. Finding them during final engineering means they come out of margin or become a change order conversation. Neither outcome is acceptable.

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Omitting underside covers when needed.

- ! Not planning pull cord space during layout. Pull cord space seems like an installation detail until the system is going in and there is a column in the way, pull cord placement is a layout decision. It belongs in the flow diagram, not in the field installation notes.
- ! Specifying safety caging without knowing the robot type. Scoping a full safety cage for a cell that ends up using a collaborative robot means overpricing the project. Scoping no caging for a cell that ends up with an industrial robot means a change order and a schedule impact. Ask the robot question before the scope is written. The answer changes the design.
- ! Leaving bearing covers for installation. Field installed shaft guards cost more labor and take more time. The result is either a cost overrun, a schedule delay, or a guard that gets skipped.. Own the spec from the beginning.
- ! Using standard limit switches for safety gate interlocks. A standard limit switch on a safety gate is not a safety device. Safety-rated switches are required for interlock applications. The distinction matters for compliance and it matters during incident investigation. If a gate interlock fails and someone is injured, the first question will be whether the switch was safety-rated. Specify correctly from the start.

SECTION 10: FOREST THROUGH THE TREES

How Safety Integration Connects to Everything That Follows

Safety decisions made during the scoping phase are design decisions. Safety decisions deferred to final engineering are cost problems. That is the forest.

Every system you design will have operators near it. Some will work below it. Some will walk the full length of it during every shift. Some will need to lock it out at 2 AM to clear a jam. The solutions engineer who has thought through all of those scenarios during the layout phase delivers a system that works safely for the life of the project. The solutions engineer who has not will be fielding calls and writing change orders.

Safety is part of engineering. When safety is not accounted for at every stage, the risk of injury increases.

Safety thinking should be integrated into every step of the design process, from the first site walk to the final layout review. When it is built into the design rather than treated as an add on, it becomes part of a well engineered system. The goal is not for safety to stand out because something went wrong. The goal is for it to be there from the start, preventing the near misses and recordables that make people notice in the first place.

SECTION 11: KEY TAKEAWAYS

KEY TAKEAWAYS | MODULE 10

Any 480V conveyor may require underside belt and roller protection. Where accessible Specify it during scoping, not during final engineering.

Pull cord E-stop path and locations are layout decisions. Resolve them on the drawing before the design is finalized.

Industrial robots require safety caging with interlocked access gates and safety-rated switches. Collaborative robots typically do not. Know which type is in scope before any guarding decisions are made.

Bearing covers and shaft guards belong on the conveyor order as factory options. Adding them in the field costs more.

LOTO accessibility is a design decision. Disconnect switches and panel doors need clear access. Plan it into the layout.

Safety items found during scoping cost nothing. Safety items found during final engineering cost margin or customer relationships.

A solutions engineer always scans for safety considerations specific to each project. It is a professional habit, not a compliance exercise.

SECTION 12: MODULE ASSESSMENT

Answer the following questions to test your understanding and applied judgment from Module 10.

Knowledge Check

Q1

A distribution center is installing a 480V belt conveyor system. The underside of the conveyor will be 200 inches above the warehouse floor, which is an active work area. What should the solutions engineer specify and why?

Q2

A solutions engineer is laying out a 300-foot conveyor run in a fulfillment center. Operators will be stationed at multiple points along the run for exception handling and jam clearing. What safety device is required, and what design decisions need to be made during the layout phase?

Forest Through the Trees Exercise

Forest Reflection

A coworker on your team tells you they plan to address safety requirements during final engineering once the system design is locked in. How do you respond, and what would you tell them about how safety decisions connect to project cost, customer trust, and professional responsibility?

END OF MODULE 10

Next: Module 11 | Quoting, Scope, and Project Handoff

Before continuing, complete a guarding audit on your most recent project layout. Identify every location where operator proximity, elevation, rotating components, or automated cells exist. For each one, note the guarding solution you would specify and confirm it was scoped at bid time.

The safety design work from this module feeds directly into Module 11. Every guarding element, every pull cord location, every cage interlock, and every LOTO isolation point is a scope item. If it is not in the quote, it is a change order. Module 11 covers how to make sure that does not happen.