



Additional Safety Requirements for New Custom-Built Assembly Machines & New Custom-Built Machines

1 SCOPE

The purpose of this is to specify TE Connectivity's additional requirements for new custom-built assembly machines as well as new custom-built machine safety systems above and beyond the minimum standards required by law and in addition to TE basic machine safety requirements in TEC-124-162115

Any supplier building and/or providing custom built equipment for use in a TE facility must also meet safety requirements of the jurisdictional authority and/or relevant normative standards while additionally adhering to this specification as well as the basic machine safety requirements in TEC-124-162115

1.1. Purpose and Content

New machines quoted after the release date of this specification must be designed and constructed in accordance with all requirements stated within this specification. Existing machines are not required to implement additional requirements resulting from a newly released revision of this specification.

The purpose of this specification is to ensure custom built machines TE purchases or builds internally are safe. The acceptance will require the builder to "show" TE that the machines we are purchasing and/or building are safe. This includes a physical demonstration of all safety functions on the machine, as well as a review of the required safety documentation.

No custom-built machines may be purchased without Qualified TE Personnel reviewing the proposed safety system design and documentation to ensure compliance with this specification. TE EHS personnel are not considered qualified to conduct this review without the assistance and oversight of a mechanical or electrical engineer with electronic controls knowledge or a TUV certification.

Qualified TE Personnel refers to either a TE employee or an authorized third-party representing TE, who possesses the technical expertise to understand and interpret this document for the purpose of verifying a machine's compliance. For example, a TUV Certified TE employee.

1.2. Application

This specification applies to all new custom-built machines and new custom-built ASSEMBLY machines that will be used inside any TE facility. This specification also applies to machines built by TE for use outside a TE facility that will be producing parts or assemblies for TE.

During **the** mechanical design of a machine mechanical solutions to reduce injury risk must be considered first. When mechanical design cannot eliminate all risks, functional safety solutions are required.

NEW CUSTOM-BUILT MACHINE

A custom-built machine is a machine which is specifically designed and assembled to meet the unique needs and specifications of TE Connectivity. These machines typically require new concepts and designs and have either never been designed or built before or are major modification of a previously designed machine.

NEW CUSTOM ASSEMBLY MACHINES

A new machine that advances components towards a final product by assembly, adhesion, marking or testing. For use and understanding in this specification assembly machines are usually designed and built (customized) by or for TE. They generally are more complex in design and function; may perform multiple and varied assembly steps. have software operated controls; and include one or more access doors that can be easily or routinely opened during production.

CATALOG or OFF-THE-SHELF MACHINES

This specification does NOT APPLY to “Off the Shelf or Catalog Machines”. These machines are typically designed for general use and can typically be purchased from a catalog or internet site with no modifications. These machines are typically mass produced, available for immediate purchase, and are available to the general public for purchase and use. Off the shelf machine are still subject to standards required by law such as UL or CE.

STAMPING, MOLDING, PLATING MACHINES

Stamping, Plating, and Molding machines are not governed by this standard.

1.3. Waivers and Deviations

If a supplier is unable to comply with the requirements an exemption (noncompliance) or waiver (alternative method of compliance) shall be submitted to site or BU EHS Lead or BU/site Ops Lead for consideration of approval.

A detailed risk assessment review and all related documents are required. In addition to a risk assessment, the following must be provided:

- *Sufficient logic for not fulfilling requirements*
- *Proof that no feasible alternative options exist for this design*

If granted, an exception only applies to the individual machine in question.

1.4. TE Connectivity Specific Requirements for New Customer Machines

TE Connectivity’s specific requirements that exceed most country-specific machine safety requirements include:

- A. Safety lights (Chapter 8)
- B. Color of pneumatic tubing (Chapter 9.4) *
- C. Two hand control and setup mode when door is open (Chapter 6.3.D)
- D. Report from Sistema software (Chapter 14.2)
- E. Manual pressure release button requirements. (Chapter 9.5) *
- F. Minimum requirements for safety control system (Chapter 5.1)
- G. Monostable valves are not allowed in safety systems (Chapter 9.2)
- H. Unique style fasteners for guarding. Reference (Chapter 12)
- I. Standard Control as well as Safety Control program must be provided in English

2 REFERENCE DOCUMENTATION AND FORMS

The following list identifies material available in support of this Standard including External Regulatory citations or directives, and TEC standards, specifications, and forms.

2.1. Regulatory

When an ANSI/ISO/IEC safety standard is referenced in this document, it refers to the most recent version.

- A. Control of Hazardous Energy Lock-Out / Tag-Out
 - U.S. OSHA § 1910.147 The control of hazardous energy (lockout/tagout)

- ANSI Z244.1 The Control of Hazardous Energy Lockout, Tagout, and Alternative Methods
 - ISO 14118 Safety of machinery — Prevention of unexpected start-up
- B. Functional Safety Design & Risk Reduction
- ISO 13849-1 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design
 - EN 62061 Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems (IEC 62061:2005)
 - ANSI B11.19 Performance Requirements for Risk Reduction Measures: Safeguarding and Other Means of Reducing Risk
 - U.S. OSHA 29CFR 1910 Subpart O, Machinery and Machine Safeguarding
- C. Industrial Robots
- ISO 10218-1 Robots and robotic devices - Safety requirements for industrial robots – Part 1: Robots
 - ISO 10218-2 Robots and robotic devices - Safety requirements for industrial robots - Part 2: Robot systems and integration
 - ISO/TS 15066 Robots and robotic devices - Collaborative robots
 - ANSI R 15.06 Industrial Robots and Robot Systems - Safety Requirements
 - RIA TR R15.406 Technical Report for Industrial Robots & Robot Systems: Safeguarding
 - ANSI/RIA 15.06 Article 10.7.7, CSA Z434-03 Article 10.7.8
 - ANSI RIA TR R15.606 Robots & Robotic Devices – Collaborative Robots
- D. Laser Safety
- IEC 60825
 - ANSI Z136
- E. Physical Guards
- Fixed:
- ISO 14120 Safety of machinery - Guards - General requirements for the design and construction of fixed and movable guards
 - ANSI B11.19 Performance Requirements for Risk Reduction Measures: Safeguarding and Other Means of Reducing Risk
 - ISO 13857 Safety of Machinery – Safety Distances to Prevent Hazard Zones Being Reached by Upper and Lower Limbs
- Movable Guard:
- ISO 14119 Safety of machinery - Interlocking devices associated with guards - Principles for design and selection
 - ISO 14120 Safety of machinery - Guards - General requirements for the design and construction of fixed and movable guards
 - ISO/TR 24119 Safety of machinery - Evaluation of fault masking serial connection of interlocking devices associated with guards with potential free contacts
 - ANSI B11.19 Performance Criteria for Safeguarding
- F. Protective Devices
- Two-Hand Control (THC); EN 574+A1
 - Emergency Stop; EN ISO 13850, EN 60204-1, ISO 13850

- Interlocking Devices Associated with Guards; ISO 14119

G. Risk Assessment

- ISO 12100 Safety of machinery - General principles for design - Risk assessment and risk reduction
- ISO/TR 14121-2 Safety of machinery - Risk assessment - Part 2: Practical guidance and examples of methods
- ANSI B11.0-2020 Safety of Machinery

H. Safety Distances

- ISO 13855 Safe Distance Calculations Safety of Machinery – Position of Safeguards with Respect to the Approach speed of Parts of the Human Body
- ISO 13857 Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs
- ANSI B11.19 Performance Criteria for Safeguarding, Annex D – Safety Distance

2.2. TEC Standards

- [TEC-124-90](#) Guidance to the EU Machine Directive 2006/42/EC
- [TEC-124-118](#) Machine Guarding and Functional Safety (internal document for TE use only)
- TEC-124-162115 Machine Guarding and Functional Safety for External Suppliers
- [TEC-124-101](#) Control of Hazardous Energy (LOTO)
- [TEC-124-160024](#) Waiver exception form

2.3. TE Forms

- FORM [6260](#) – Machinery Safety Risk Assessment
- FORM 6248 – Machinery Safety Requirement Specification (SRS)
- FORM [6250](#) – Machinery Safety SISTEMA lab document
- FORM 6252 – Machinery Safety Validation form (hard guarding & safety devices)

2.4. Pneumatic Resources:

These are informational resources to be used at your discretion.

- ROSS Controls - Fluid Power Machinery Safety Guidebook
- Aventics – Application of EN ISO 13849-1 in electro-pneumatic control systems.

3 DEFINITIONS

Table 1: Definitions

Name	Definition
Alternative Methods (Measures)	A means of controlling hazardous energy (other than energy isolation) to reduce risk to an acceptable level.
Air Booster	A device that increases air pressure for certain functions.
Air Tank	A reservoir that holds a specific capacity of air with constant pressure
Actuator	The device which activates the interlock, a separate part of an interlocking device which transmit state of guard to the controller/actuating system.

Anti-Trip/Non-Repeat or Anti Tie Down	Function of operating control switches or buttons that don't allow accidental, unintended, or continuous activation of the machine.
Assembly Machine	A machine that advances components towards a final product by assembly, adhesion, marking or testing. For use and understanding in this specification assembly machines are usually designed and built (customized) by or for TE. They generally are more complex in design and function; they may perform multiple and varied assembly steps. have software operated controls; and include one or more access doors that can be easily or routinely opened during production.
Authorized Person	A person who is qualified to remove a machine safeguard component only after Lock out Tag out (LOTO) has been applied, and the Machine/Equipment is in a Zero energy state. Shall comply with the TEC-124-101 Protection against hazardous energy Lock out Tag out, shall be completed, signed/issued by the site or BU which adds the confirmation that Lock out Tag out has been applied, and that the machinery is in a Zero energy source state.
B10d	a number provided by safety hardware manufacturers which represents the testing data of the hardware when 10% of the tested components failed to a dangerous state.
Bi-Stable Pneumatic Valves	A valve with two solenoids that keep the chamber in its last activated position when electrical power is lost. It is a moving chamber that does not move to its original position as in the case of a mono-stable valve with a return spring. This category of valves would include 5-3 and 5-2 valves
Blocks	This document uses the term BLOCK as defined by SISTEMA. Safety devices that are mechanical (dry contacts) and fail based on number of operations (Nop). The manufacturer will provide B10d data for mechanical devices.
Category	Classification of safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in a fault condition. This is achieved by the structural arrangement of the parts, fault detection and/or by their reliability. Reference ISO 13849-1.
CEFS	Certified Expert in Functional Safety. This refers to a specific certification from TUV Nord.
CIP Safety	Safety over Ethernet. Safety devices are controlled over a safety rated ethernet network.
Collaborative Robot	A robot that is purposely designed to work in a collaborative workspace near a person.
CMSE	Certified Machinery Safety Expert. This refers to a specific certification from TUV Nord.
designsafe®	Risk assessment software developed and provided by Design Safety Engineering Inc.
Devices	Other safeguarding equipment other than physical guarding such as light curtains, interlocks, pressure sensitive mats, area laser curtains, etc.
Diagnostic Coverage (DC)	A measure of the effectiveness of diagnostics, which may be determined as the ratio between the failure rate of detected dangerous failures and the failure rate of total dangerous failures (None 0 to 59%; Low 60 to 89%; Medium 90 to 98%; High 99 to 100%.)
Engineering Controls	guards or devices part of a safety function used to reduce risk
Frequent Access	Access to the hazard is more often than every 15 minutes OR the accumulated exposure time to the hazard exceeds 1/20 of the daily operation time of the machine. Per ISO13849
Functional Safety	focuses on the reliability and performance of safety functions to prevent accidents and protect people. Functional Safety is achieved through the design and implementation of

	safety functions that meet specific performance criteria, such as those outlined in ISO 13849.
Functional Safety Systems	Functional safety is the part of the overall safety of a system or piece of equipment that depends on automatic protection operating correctly in response to its inputs or failure in a predictable manner (fail-safe). The automatic protection system shall be designed to properly handle likely human errors, systematic errors, hardware failures and operational/environmental stress.
Hazard Assessment	An assessment that is typically performed by 1-2 people and is not task/hazard based, but is hazard based only. Maintenance or non-routine tasks that are performed in the hazard area with power on are still analyzed at the task level. A hazard assessment is NOT a risk assessment.
Interlocking Device	Mechanical, electrical or any type of device whose primary purpose is to prevent the operation of hazardous machine functions under specific conditions such as an open door or machine guard.
Interlocking Devices Description	(According to EN ISO 14 119:2013) • Type 1: Interlocking device with mechanically actuated position switch with uncoded actuator. • Type 2: Interlocking device with mechanically actuated position switch with coded actuator. • Type 3: Interlocking device with non-contact actuated position switch with uncoded actuator. Type 4: Interlocking device with non-contact actuated position switch with coded actuator.
Interlocks	• Safety interlock devices: interlock an electrical, mechanical, or other type of device designed to prevent the operation of dangerous machinery functions.
Machine Guarding	A physical barrier that prevents entry by the operator into the point of operation, pinch or nip point, moving parts, or another machine hazard; can be fixed, interlocked, adjustable, or self-adjusting. A machine guard is part of a safeguarding system.
Machine Hazard	Sufficient energy (mechanical, electrical, light, heat, chemical, stored or potential, radiation, sharp surfaces/tooling. etc.) to cause harm to a person.
Machine Safeguarding	One or more methods including physical machine guards, devices, tools, and practices used to keep employees safe from machine hazards.
Machine Shop-Type	Machines that are typically found in a machine shop, but may also be used in other areas such as the shop floor, including but not limited to lathes, drill presses, surface grinders, milling machines, circular saws, band saws, wire EDM machines, etc.
Maintenance	Repairing, removal or changing machine components (motors, etc.), electrical work above 24 volts, work that cannot be performed with both feet on the ground (going into the machine) and work that requires going under the machine. These activities are any work on machinery not defined as normal production activities and require the use of manual lockout.
Modify	Changing the original purpose, function, or capacity of the machine by design or construction.
Non-Detachable Fixing	prevention of dismantling or re-positioning of the element of the interlocking device (e.g., welding, one-way screw, riveting) or security fixings.
Normal Production Activities	Interfacing with assembly machines at any time to perform tasks that support the production function for which the machine was intended. Normal production activities are routine, repetitive and integral to the manufacturing of product. These activities typically include

	feeding of raw materials or removing of finished parts, etc. These activities may also include any of the following: set-up, inspection, adjustment, lubrication, cleaning, un-jamming, minor tool changes and other minor servicing activities that take place during normal production operations.
Operating Area of the Machine	The unprotected space inside of the machine safeguarding.
Performance Levels	are defined in detail in ISO13849-1. PL is a measure of a safety functions reliability measured in PFH (Probability of Failure per Hour). Performance Levels are a combination of Categories, MTTFd (Mean Time to Dangerous Failure), and DC (Diagnostic Coverage = monitoring). They are designated as PLa, PLb, PLc, PLd, or PLe with PLe being the hazard with the highest risk.
PFHd	Probability of Dangerous Failure per Hour. A number provided by safety hardware manufacturers which represents the testing data or non-mechanical hardware.
PLC	A programmable logic controller that is either "standard" non-safety rated or is a safety programmable logic controller.
Point-of-Operation	The part of a machine that has direct contact on the part or piece being manufactured. Actions may include stamping, molding, cutting, punching, welding, sawing, forming, riveting, transferring, etc.
Rebuilding / Reconstruction / Refurbish	Restoring the machine to its original design, purpose, capacity and function.
Reconfigure	A machine whose layout is different from the original configuration
Relocate:	To move a machine to a different location with no change to operation, process, equipment, arrangement, or risk reduction measures.
Remanufacture	Modification of a machine by replacing worn-out or failed components with new or used parts, resulting in different machine specifications
Repair	To restore a machine by replacing a part or putting together that which is broken without altering its original purpose, function, capacity, operation or risk reduction measures.
Restricted Space (robot)	Defined space established by installation of limiting devices which minimize the total distance a robot can travel.
Risk Assessment	A team-based task / hazard pair assessment of a machine whose goal is to reduce risk to an acceptable level. This considers all machine modes, as well as tasks performed by anybody who interacts with the machine – operators, maintenance, set-up, thread-up, cleaning, passer-by, etc.
Robot Maximum Space	The maximum reach of robot and end effector
Robot Safeguarded Space	The area inside perimeter guarding
Robot Operating Space	The space required by the tasks of the robot
Robot Restricted Space	The space restricted by limiting devices such as mechanical limiting devices or soft axis limiting.
(SOS) Safe Operation Stop	An integrated safety function which prevents the power drive system such as a drive or servo controller from deviating more than a defined amount from the stopped position. It represents safe standstill monitoring.
(STO) Safe Torque Off	A safety feature that ensures that no torque-generating energy can continue to act upon a motor and prevents unintentional starting. This is coast to stop.

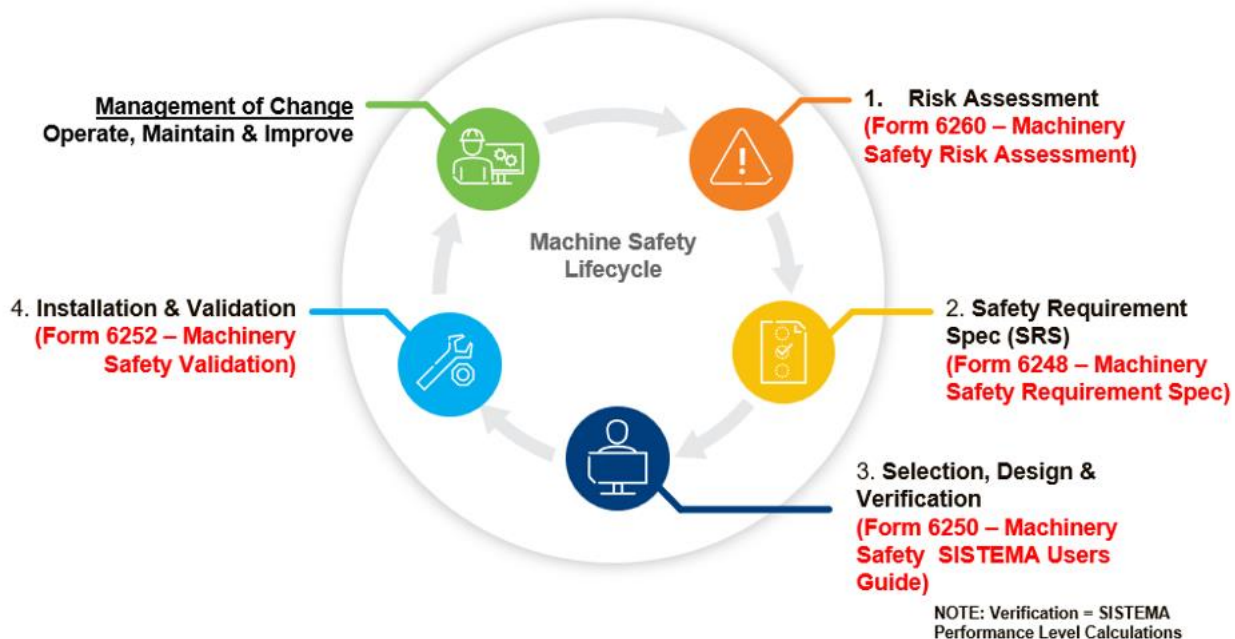
Safety Logic Device	Monitors/controls safety components and devices. Include safety relays, programmable safety relays, or safety PLC's.
Safety Function	a combination of INPUT – LOGIC – OUTPUT devices whose purpose is to protect a person.
SISTEMA	Software that calculates the performance level of safety functions. Free software published by DGUV.
Slow Speed	Slow Speed is defined according to the risk assessments, applicable international normative standards and local legislation. Slow speed is a reduction of assembly machine movement to 15% of the normal operating speed or 50 mm/sec (whichever is less).
Subsystem Device	This document uses the term SUBSYSTEM as defined by SISTEMA. Safety devices that are not mechanical and do NOT fail based on the number of operations. The manufacturer will provide PFHd or PL of this device.
T10d	a number which represents the first expected dangerous failure of a device. ISO13849 asks to design for a T10d or 20 years. T10d = B10d/Nop. Units are years. Nop = number of operations per year of a device.
Type C Standard	A standard written for a specific machine type. If the content of a type C standard differs from this document, then they type C content takes precedence. For example, robots, presses, and molding all have type C standards.

4 FUNCTIONAL SAFETY REQUIREMENTS

4.1. Machinery Safety Lifecycle & Documentation

TE prefers a machinery safety lifecycle process flow when implementing and documenting functional safety solutions at TE. These steps ensure a consistent procedure is followed when mitigating hazards to keep our employees safe. There are five main steps, and four pieces of documentation required for machinery supplied to TE. Each of the steps #1 and #4 are a piece of required documentation. Steps #2 and #3 are only required if the risk reduction method includes safety devices otherwise known as Engineering Controls – Devices. If your risk reduction method is simply hard guarding, then an SRS and SISTEMA verification are not required for that specific risk reduction method.

Figure 1: Machinery Safety Life Cycle.



4.2. Methods: Lockout / Tagout and Alternative Methods

Reference [TEC-124-101](#) for TE LOTO guidelines.

4.3. Risk Assessment, SRS, SISTEMA, and Validation documents

The requirements for following the machinery safety lifecycle process and subsequent required safety documentation are outlined in TEC-124-162115 Machine Guarding and Functional Safety.

5 PERFORMANCE LEVELS

5.1. Performance Level Requirements

Machines shall be designed and built to meet the minimum legal requirements for safety in the country in which the machine will initially operate for TE. In addition, they shall meet the requirements of this specification. Risks must be eliminated, substituted, or reduced as far as possible and then reviewed as part of the mechanical design review process.

- A. Every safety function included on the machine shall have the minimum ISO performance level of Performance Level "d" Category 3 per ISO 13849
- B. PLe rated hazards do exist. If the risk assessment indicates a PLr = "e", then the safety functions protecting a person from the PLe rated hazard shall be designed to meet PLe per ISO13949-1.

6 MACHINE MODES

New custom-built assembly machines shall meet ALL the requirements of this section. New custom-built non-assembly machines are not required to include the features of this section, but if included, they shall follow the requirements included in this section.

6.1. Automatic Mode

To run in automatic mode, all safety functions must be reset and active. For example, doors are required to be closed or light curtains active (safety devices uninterrupted). Any opening of doors or break in the light curtain beam while the machine is running in automatic will lead to an emergency stop.

6.2. Set-up Mode (Door Closed)

Set-up mode shall be designed such that set-up can be performed with the machine guarding closed. In cases where human involvement is required with a door open and hazardous energy present then an engineering controls solution must be provided to protect that person from harm while performing that task.

6.3. Set-up Mode (Door Open)

- A. General requirements:
 - No hazard that can cause serious (normally irreversible) injuries are allowed movement during set-up while the door is open.
 - Set-up mode with an open door can only be selected via the keyed selector switch. This keyed switch must be positioned next to the open door.
 - The key must be removable only in its off position.
 - The key switch bypasses safety and therefore shall be a safety function and is subject to the design criteria requirements of Performance Level "d", Category 3.
 - All access points with an open-door in set-up mode require a dedicated two-hand control for any intended movement during set-up with the doors open.
 - When more than one set of access doors are open at the same time on any assembly machine, no movement is allowed.

- B. Step Function (Pneumatic movement) with a two-hand control device
- The step function will enable full speed movement of the machine, but only in one step increments (step-by-step). Requirement of 6.3.A still shall be met.
- C. Slow Function (Electrical movement also known as Safety Limited Speed) with two-hand control device
- The slow function is possible with the doors open while allowing continuous machine movement at slow speed.
 - Some machine functions cannot be performed at a slow speed. Robot clamping (moved by air) or wire bending are examples that must be done at full speed/power and therefore can only operate in the step function.
 - This safe limited speed must be monitored with a safety function. This safety function is subject to the design criteria requirements of Performance Level "d", Category 3.



Danger: *The interlocked guard shall be prevented from opening until all hazardous motion has ceased or shall be located so that the operator or others cannot reach the hazard before the machine comes to a full stop. The related calculations for the minimal safe distance (See ANSI B11.19 or ISO13855) must be calculated to determine if the safety rated door monitoring switch is required to be solenoid locking type switch.*

- D. Two-Hand Control in Set-up mode with a door open:
- Two-hand control shall be a safety function and therefore is subject to the design criteria requirements of Performance Level "d" Category 3.
 - Movement with risk of serious injury (non-reversible):
 - Hazards which could result in serious injury must be placed in a safe state when doors are open using engineering controls. This is typically the "off" state for mechanical components or utilizing the built in safety features of safety rated devices such as VFD's (variable frequency drives) or Servo Drives. These devices are typically put into a safety state using their internal safety features such as STO (safe torque off). Any hazardous potential energy must be dissipated. The only exception to this rule is the use of a Safety Operating Stop (SOS) to prevent servo axis movement. In this exception no movement is allowed but energy may still be present.
 - Movement with risk of slight (normally reversible) injury:
 - Pneumatic movement: The pneumatic power source is still present, electric power source to the valves is activated only by utilizing a two-hand safety control activation device. Only then, will the safety logic device allow the valves to move.
 - Electrical movement: Only allowed if two-hand safety controls are activated
 - While in a set-up function (step or slow) motion can only be initiated by use of a two-hand safety control activation device. Key or selector switches that allow for only one-hand operation are NOT allowed. If all the guard doors are closed one-hand operation is allowed.

6.4. Additional Requirements

- A. All hazardous energy in adjacent modules that can be accessed by an operator during set-up in another module must be deactivated or have proper guarding installed that eliminates access between zones.
- B. Hazardous functions still present during set-up mode require additional measures such as guarding.
- C. Areas presenting risk of head injury cannot be accessible
- D. Any movement with high inertia (turntable, etc.) which does not stop immediately after releasing the two-hand controls must have additional stopping measures employed.

7 SAFETY CONTROL SYSTEMS

New custom assembly machines AND new custom-built non-assembly machines are BOTH required to include the features of this section.

7.1. Safety Logic Devices

- A. Safety logic devices shall be safety rated PLC's, safety programmable relays, or safety relays.
- B. Safety programs developed in the safety logic device must be provided to TE and validated /reviewed by a competent TE engineer or TE TUV certified resource.

7.2. HMI Requirements – Safety Screens

- A. Engineering Controls – Mechanical Safety Devices: Screens shall include cycle counts for all mechanical safety devices. Both the total accumulated cycles and the estimated cycle used for PL calculations shall be displayed. The current cycle run rate can be used to extrapolate an estimated annual usage for Nop (Number of Operations per year). The annual usage cycles shall be used to calculate an actual MTTFd and T10d for that device. Once the actual T10d time has expired an HMI alarm shall be produced, and the machine shall not restart until the alarm is acknowledged. When devices are replaced, this time shall be able to be reset from this screen.
- B. Engineering Controls – Subsystem Solid State Devices: Screens shall include the elapsed time from machine installation for subsystem type devices. When devices are replaced, this time shall be able to be reset from this screen. When the accumulated time for any device exceeds 20 years an HMI alarm shall be produced, and the machine shall not restart until the alarm is acknowledged.
- C. Per ISO14119, PLd safety functions are required to be cycled a minimum of once per year while PLe safety functions are required to be cycled a minimum of once per month. The safety PLC program shall ensure safety functions are cycled within these time frames. If safety functions have not been cycled within these time frames, then an alarm shall be displayed on an HMI notifying the operator of the tasks required to exercise the safety function with visual guidance as to their location. This alarm is not required to immediately stop the machine, but once stopped, the machine shall not be able to be restarted until the safety function has been cycled.
- D. Performance Level: Screens shall include the SISTEMA calculated PL and the PLr for each safety function.
- E. Screens shall display the safety signature of the safety logic device.

7.3. Safety Reset

- A. When a safety function is activated, such as walking through a light curtain or opening a gate or moveable guard, then a safety reset shall be pressed prior to allowing a restart to occur. The reset shall be a physical blue button and reset ALL machine safety functions. Resets are not allowed to be performed through an HMI.
- B. The safety reset button shall reset the safety function on a high-to-low transition.
- C. Light Curtains safety functions with auto reset. If automatic reset is required due to high frequency operator part loading / unloading, then the light curtains shall continuously detect the body parts in the hazard area. Automatic reset does not require human intervention to initiate the reset function. Automatic reset shall not be used for whole body access applications.

7.4. Restart Condition

Automatic restarts are not allowed. A physical reset shall occur prior to a machine restart. For example, an interlocked guard door safety system shall be designed and installed so that the action of re-closing the door will not in itself cause any motion in the machine

7.5. Servo Drives (Electronic Motor Drives)

If a motor drive such as a VFD or a servo drive's integral safety features are used as part of a safety function to protect a person, then that drive shall have a minimum Performance Level of "d".

8 SAFETY INDICATOR LIGHTS

New custom assembly machines shall meet ALL the requirements of this section. New custom-built non-assembly machines are not required to include the features of this section, but if included, they shall follow the requirements included in this section.

To confirm the proper functioning of ALL safety functions, a visual indication must be provided such as a light emitting diode (LED) light.

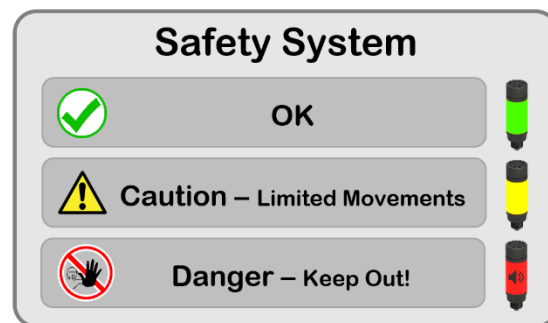
- A. The LED light shall turn from off to green when the door is opened indicating that the operator is protected by a properly operating safety function. The light shall illuminate yellow when in set-up mode. The LED shall flash red with an audible alarm if the safety system is not operating as intended (see Table 2 for more information). Yellow illumination is not required if no set-up mode is required.
- B. If the LED cannot be seen from all entry points, additional lights must be installed. This light is required to be mounted inside the machine and must be accompanied by signage indicating what the three colors represent. An example can be seen in Figure 2.
- C. These safety system indicator lights shall be chosen and designed in a way that the lights cannot be easily confused with the indicator lights used for non-safety purposes.

Table 1: Conditions & Indicator Lights

Condition	Color	Meaning
All guard doors closed.	Blank (off)	Machine is running normally with all doors closed
Guard opened during automatic mode.	Green	All hazardous energy is either dropped or in safe state and no movement can occur. All safety functions are operating as intended.

By turning the setup key the set-up mode becomes active. Slow or step functions are selected.	Yellow	All safety functions are operational, but at a slow speed or in the step-by-step function. Partial energy remains in the machine.
By turning the setup-key the set-up mode becomes active. Slow or step functions are selected.	Yellow Flashing	If more than one door is opened, while in set-up mode, the yellow light will flash and use of any two-hand is inhibited. Partial energy remains in the machine.
Safety fault with a door open (light flashing) with audible alarm.	Red	Something has gone wrong with a safety function. A safety function is NOT operating as intended. Door interlock may prevent door from opening if the feature is available.

Figure 2: Safety Light Labeling.



9 COMPRESSED AIR SYSTEMS

New custom assembly machines shall meet ALL the requirements of this section. New custom-built non-assembly machines are not required to include the features of this section, but if included, they shall follow the requirements included in this section.

If it is required to stop a pneumatic device to protect a person, then that pneumatic device is part of a safety function and shall be designed to meet the minimum performance level requirements of chapter 5.

9.1. Valves

The safe state of a pneumatic hazard shall be determined by the risk assessment. Exhausting or dumping all air on a machine may not always produce a safe state for all pneumatic hazards. Individual fluid power hazards may require different safe states. Air release, or return to home and hold, or a hold in position are all possible safe states. If it is required to stop a pneumatic device to protect a person or release trapped air causing a potential energy hazard, then that pneumatic device is part of a safety function and shall be designed meet the minimum performance level requirements of chapter 5.

9.2. Mono-Stable Valves

Monostable valves are not allowed in control reliable safety systems. Exemptions to this requirement are:

- Air nozzles
- When a valve is controlling only the release of air

- Where the hazardous function is not accessible (covered)
- When the mono-stable valve adds additional safety to the function

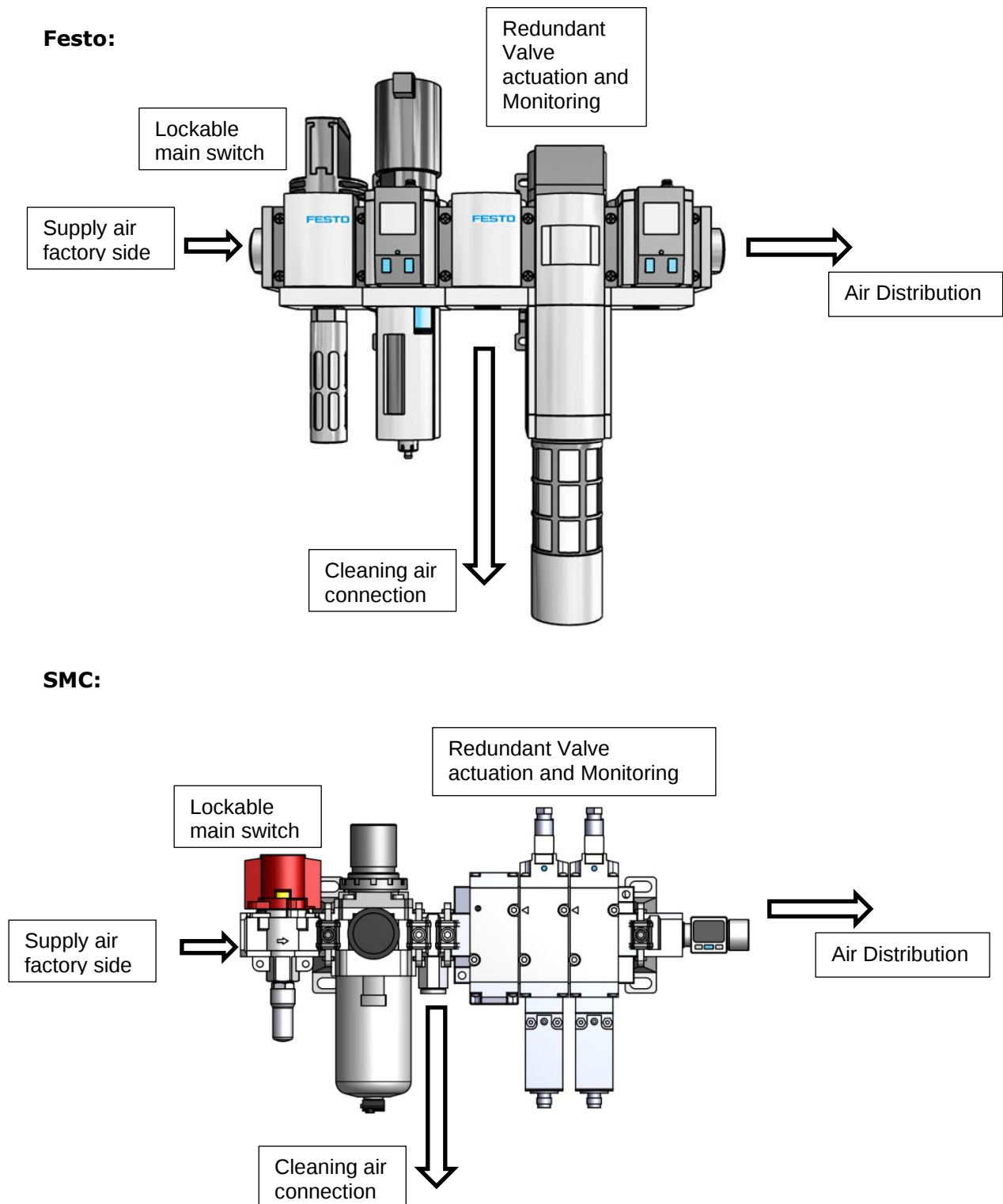
9.3. Dual and Monitored Valves for Isolation of Air

If it is determined from a risk assessment the safe state of the entire machine is to release or dump all compressed air, then a safety rated main dump valve shall be used.

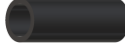
If all air on a machine needs to be exhausted or dumped to protect a person from a pneumatic hazard, then the dump valve is part of a safety function and therefore shall meet the minimum performance level requirements of chapter 5.

To switch-off the pneumatic power for serious risks, it is possible to use dual and monitored safety valves (e.g. VOFA valves) located near the pneumatic function instead of the second monitored safety air valve in air main units.

Figure 3: Dual Valve Examples.



9.4. Colors for pneumatic air tubing

Slight (normally reversible) Injuries		Serious (normally irreversible) Injuries	
From Air Preparation Unit to Valve(s)			
Blue		Yellow	
From Valves to pneumatic function(s)			
Extend	Retract	Extend	Retract
Blue	Blue or Black	Yellow	Yellow
	 		

9.5. Trapped Air (Residual Pressure)

- A. Valves with a 5/2 configuration are preferred. Can be used with a check valve (if required) positioned very close to the point needing to maintain pressure when doors are opened.
- B. Any situation that creates trapped air must be labeled with precautionary label about residual air pressure and must include a way to release the air pressure (manual relief). This additional hazard must be indicated in the machine's documentation (in a list) and accounted for in the risk assessment.
- C. Air pressure release valves must include the ability to be actuated without tools and labeled as such.
- D. Vertical machine functions that have the potential to fall or slide down when the doors are opened (causing unacceptable operational problems or potential injury) require two 3/2 valves to ensure ~~it~~ they cannot drop when a door is opened. This pair of valves must also have a back-flow prevention valve and a release valve installed.
- E. Valves with a 5/3 configuration (closed middle position) are not to be used unless necessary.
- F. Recommended type of label from ISO 7000 Ref. No. 1320

Figure 4: ISO 7000 Label.



This symbol alerts operators that pieces of the assembly machine are still under pressure.

9.6. Air Reservoirs

- A. Air tanks used to store additional volume of air (Boosters) must have a manual air release and must be labeled with precautionary statements.
- B. Air tanks may be used when it is determined pneumatic hazard movement is required for the purpose of escaped or trapped persons under an E-stop condition. This pneumatic circuit would be part a safety function and therefore is subject to the minimum performance level requirements of chapter 5.
- C. Boosters must also have redundant and monitored valves to block downstream pressure when the tank does not bleed off pressure while the doors are opened.
- D. Downstream pressure must be bled off.
- E. Components used for booster systems must be designed to meet the extra pressure needs.

10 COMPONENTS

10.1. Safety Components

Non detachable fixing of safety device actuators (security fixings or one-way screw, riveting, security-torx) are mandatory for new equipment. For interlocking devices, follow ISO 14119 table 5 mounting requirements.

Order of preference for safety component hardware:

- FIRST: Solid-state, smart devices with time-stamping capabilities
- SECOND: Non-mechanical solid state (Subsystem) type devices: devices classified as subsystems in SISTEMA. RFID switches for example.
- THIRD: Mechanical devices with dry contacts. (Block) type devices: devices classified as Blocks in SISTEMA.

Mechanical safety devices shall be Well-Tried per ISO13849 which includes features such as:

- Mechanically Linked Contacts
- Positive Mode Actuation

10.2. Mechanical Relays

Any mechanical relay used in a safety function must have mechanically linked contacts and be monitored by a safety logic device.

10.3. Solenoid Locking Safety Gate Switches

- A. If a hazardous condition would still be present when a door is opened (i.e. momentum, latent heat, pressurized air, etc.), the door must remain locked until the hazardous energy has dissipated, and the machine has achieved a non-hazardous energy state. Hazardous motion stopping time may need to be measured for use with safe distance calculations to determine if a gate or moveable guard needs to be locked. If the safety gate switch is being locked to protect a person, then the gate locking solenoid would be part a safety function and therefore is subject to the minimum performance level requirements of chapter 5.

10.4. Safety Interlocking Devices

- A. The design of electro-mechanical safety interlocks used as part of the safety system must be per ISO 14119 and must have the following features:
 - Forced guided contacts to guarantee a positive break.

- Output configurations that offer redundant normally closed contacts or mechanically linked normally closed / normally open contacts are required
 - Designed in a way that is not easily defeatable.
- B. Mechanical door interlock switches may be wired in series per ISO14119-2024 Appendix J as long as Performance Levels per Chapter 5 are still met. Solid state door interlocks can be wired in series as long as Performance Levels per Chapter 5 are still met. For solid state safety switches, the number of switches wired in series is typically defined by the manufacturer. Series wiring may affect response times.
- C. Safety interlock installation shall be applied in accordance with the manufacturer's recommendations
- D. The safety interlocking device shall be interfaced to a safety rated monitored relay, safety controller or safety PLC.

10.5. Interlocked Doors (Logic)

- A. If more than one door (double opening doors are considered one door) is opened per module in set-up mode, the safety system will disable any movement in the machine. Two-hand controls will become disabled, and the machine safety indicator light will flash yellow. The safety system will de-energize the machine as if a door had been opened during operation.
- B. Closing interlocked doors cannot initiate the machine's operation.
- C. Home position cannot be initiated when the door is opened. If the operator is required to reset the machine to home position, they must do it in manual mode only after the doors are re-closed.
- D. If a guard door could be closed behind a person and the machine configuration could allow a person to be inside the hazard area and out of site of the gate, reset, or ALL start buttons on the machine, then either , a door blocking device or presence sensing device must be installed to ensure inadvertent start-up cannot occur, or a device must be provided as part of the gate switch which allows the person to maintain control of the gate switch (such as a key).
- E. Transport systems between two adjacent modules must stop when any adjacent door is opened.

10.6. Emergency Stops

- A. All emergency stop safety functions must be designed to a minimum performance level "d". The use of E-STOP's cannot be part of the normal machine stop procedure.
- B. Emergency Stop buttons shall:
- Be self-latching and keep the button in the compressed position after being pressed until manually released
 - Use Normally Closed self monitoring contact blocks.
 - Be mounted on every control panel
 - Have an opening operation that physically separates the circuit.
 - Be a red mushroom head button and the area immediately around the E-STOP device must be colored yellow.
 - Be placed in locations easily accessible to the operators (and additionally in door locations).

- Must not be mounted flush to the surface it is mounted to. Collars or button guards or other protective devices are not allowed
- C. If more than one E-STOP zone is required, these zones must be indicated at the button of each E-STOP with grouped labels to differentiate them such as "Zone A" and "Zone B".
- D. Care must be taken to ensure that the shutting down of systems does not cause a more severe hazard, i.e., the release of chemicals, etc. (air pressure is often dumped depending on the situation).
- E. Control power cannot automatically reset after the E-STOP is pushed or after the release of the E-STOP.
- F. Using a keyed E-STOP or using an E-STOP as a lockout point (or any other function) is not permitted.

10.7. Two-Hand Control Devices

- A. The minimum safe distance formula shall be used to determine the location of the activation devices in relation to the hazardous motions of the assembly machine. Both reaching distances and safe distance calculation must be considered.
- B. Two-hand controls must be redundant, monitored, and installed for all modules and/or stations if movement needs to be initiated with an open door. If there is no need to initiate movement with an opened door, then there is no need for two hand controls. Hold to run function is no longer permitted.
- C. Each activation button of the two-hand controls must be separated by the appropriate distances. Reference ISO13855 or ANSIB11.19.
- D. Two-hand controls must be linked to the other doors used for access to the affected area and ensure that it has no function if a second door is opened.
- E. Dis-attached 3 position activation switches with unbound cable are not allowed, unless the design cable does not allow hands to reach the hazard area.

10.8. Pendants

- A. Pendants may be used as an activation device to facilitate work on long lines or modules.
- B. Pendants are required to be two-hand controlled.

10.9. Light Curtains

Because of the safe distance required from the point of operation while using light curtains, the use of drawers/doors is encouraged. These solutions can be less expensive and allow the operator to be positioned closer to the machine.

- A. Light Curtains must be Type 4.
- B. Light Curtains safety functions with manual reset. Manual reset is the preferred method of control. Manual resets buttons shall not be used to initiate machine motion. Manual reset light curtain safety functions must have a start cycle that requires manual reset first, and then a separate start button to activate machine movement after the light curtain is cleared.
- C. Light Curtains safety functions with auto reset. If automatic reset is required due to high frequency operator part loading / unloading, then the light curtains shall continuously detect the body parts in the hazard area. Automatic reset does not require human intervention to initiate the reset function. Automatic reset shall not be used for whole body access applications.

- D. If it is feasible that parts, or particles could be ejected from the machine and cause injury to personnel, then light curtains shall not be used
- E. Light curtains used for perimeter guarding whole body access must be mounted no more than 180mm from the surface.

10.10. Safety Mats (Only allowed when no other method is possible)

- A. Safety mats must be made of material that senses a change in density as a person steps on the solid material and be without moving parts.
- B. Safety mats shall be interfaced to a safety relay, safety controller or safety PLC.
- C. Indication that the safety mat device is functioning shall be included as part of the safety indicator LED requirement.

11 LOCKOUT DESIGN

11.1. Manual Lockout

- A. Each machine must be able to be locked out. This means that the design of the machinery must provide isolation of hazardous energy and must allow for the use of and application of locks for lockout.
- B. There shall be one main disconnect for each energy source (electric, pressurized air, hydraulic, etc.). This means that the main disconnect completely separates the machine from that energy source.
- C. In addition to the main disconnect, any number of secondary or isolation disconnects may be provided to allow for isolation of focused lockout zones.
- D. A means shall also be provided to release any trapped or residual energy from the system automatically. The discharge shall bleed down without risk to personnel.

11.2. Access to Energy Isolation Devices (valves, disconnects, etc.)

Any disconnecting means to be used by the operator for lockout shall be readily accessible from the operator station. These energy isolation devices must be:

- A. Fully accessible between 60 and 170 centimeters from the floor
- B. Outside the guarded area and easily accessible
- C. Capable of being locked (receiving a lock's shank when turned off)

11.3. Energy Isolation Device Labeling

Each energy isolation device to be used as the primary point of lockout must be clearly identified with the name of the machine, a unique number and the related magnitude of the energy it controls. All valves in the machine do not need to be labeled; only the ones that it would be expected that a maintenance person or operator would need to manually turn off power and place a lock to perform maintenance activities.

11.4. Through-the-Door Disconnects

Through-the-door energy isolation devices are not allowed. This type of disconnect consist of a shaft extending from a rotating handle to a breaker in an electrical cabinet. These types of disconnects that are mounted on a door are not permitted but can be substituted for a similar device that brings the entire unit to the door (or side of the electrical cabinet) without the need for a linkage rod.

12 GUARDING

- A. All moving parts of the machine shall be guarded preventing the operator from reaching the hazardous zone in any way, including over, under, around or through.
- B. Guarding shall be securely anchored to the machine or floor. (employees shall not be able to easily remove or tamper with the safeguard). If the guards are fixed, they shall be affixed such that unique tools are required for removal. Fixed guard fasteners shall be captive to the guard. Guards made of perforated material like mesh guards shall be painted black to ensure line of sight to hazards.
- C. Machine guarding doors, panels, frames, and Safety devices (Interlocks, Light curtains, etc.) shall be constructed and set in place with fasteners that require a unique tool to remove. Unique means needing a unique tool to undertake removal. Flat / Phillips / Cross / Hex / Allen-Heads are NOT classified as being unique.
- D. Security heads, one-way screws, riveting, or security-torx are considered unique.
- E. Fixed guards shall not be easily removable and are required to be constructed with fasteners that prevent operators from removing them for easy access (e.g. Security Torx style fasteners)
- F. Moveable guards must stay affixed to the machine when opened. The use of thumb screws or screw slots to allow the operator to lift guards up and off are NOT allowed. Door hinges should be installed in such a way to prevent the doors from being lifted off.
- G. All guarding that can be opened or removed without the aid of tools shall be electrically interlocked with an applicable safe stop rated circuit. Guards which only purpose is noise reduction do not have to be safety interlocked.
- H. Guards shall be sturdy enough to withstand operational forces while being free of sharp edges and projections that would create a hazard. Doors shall not flex or bend enough to allow gaps that a hand can reach through.
- I. Guarding must allow for maintenance, lubrication, machine adjustments and parts loading, etc. without removal. This can be accomplished by extending grease fittings, etc.
- J. Provisions must be made to prevent operators from standing undetected in hazardous areas of the machine. This can be accomplished by mechanisms that prevent door closure or presence sensing devices, etc.
- K. Lasers can employ either movable or fixed guarding. Guarding that moves to enclose a part and prevent the laser beam from escaping when the beam is active is considered a moveable laser guard. In this case, the open/close shutter shall be activated with two channels by the safety controller. Fixed guarding prevents escape of the laser beam when the shutter is open or closed. Entering and exiting this fixed guard will not allow the laser beam to escape. Fixed mechanical guards do not need monitoring or special shutter controls.
- L. Guards and doors shall not open (swing) into any hazardous area of the machine.

13 ROBOTS

- A. All robots are subject to compliance to the ANSI/RIA 15.06:2012 or EN ISO 10218:2025 standards.
- B. Robot movement is only allowed to be activated by two-hand controls when in set-up mode.
- C. All robotic systems that can perform program verification (teach mode operation at intended/normal application speed) can only be programmed from outside the guarding in the

safeguarded space. Protection around the outside of the “restricted space” shall be provided by perimeter guarding which establishes the safeguarded space.

- D. The teach-pendant of the robot shall have a 3-position activation switch. The switch shall require the teach-pendant operator to maintain the switch in the center position for the robot to be active. Squeezing or releasing the switch shall disable the robot. The teach-pendant shall have sole control of the robot when active (i.e., the robot shall not be able to be started from any other station if the teach-pendant is active). However, all system E-STOP’s shall remain active; allowing any station to issue an E-STOP command.
- E. If personnel are allowed to enter inside the guarded space to perform the slow speed teach function, they must be provided a minimum clearance of 20 inches (0.5m) between the robot’s operating space and the nearest building, structure, utility, other machine(s) and equipment (not specifically supporting the robot function) that may create a trapping or pinch point. Where the minimum clearance is not provided, the person shall be prevented from entering the area with additional guarding.



NOTE: *This clearance requirement includes those areas that can be accessed by climbing over, around or under some object, creating an entrapment situation for the technician doing the teach function.*

- F. Robot movement shall be limited to a slow speed of 250 mm/sec or less during teach mode.

14 DOCUMENTATION

14.1. Safety Documentation Required

- A. Risk assessment using TE template Form 6260 or equivalent. Equivalent means initial task/hazard-based risks rating including the PLr. Also identifying risk reduction and final ratings.
- B. Safety Requirement Specification (SRS) using TE template Form 6248 or equivalent. This is a preferred document, not a required document for new machines from external suppliers. It is required for TE built machines for use by TE and for existing machine upgrades or modifications.
- C. Verification - SISTEMA or equivalent Performance Level calculations for each safety function (SISTEMA native electronic file format in English and Native language)
- D. Validation documents using TE template Form 6252 or equivalent. Equivalent means the validation covers at a minimum: hard guarding, safety devices, SRS, and software validation results.

If third party or integrators do not have their own forms, the TE template forms can be supplied by TE Connectivity.

CE marked machines are still subject to document review as stated above. If a custom-built machine is CE marked, this does not automatically imply the machine is safe. Documentation review is still required and shall include at a minimum:

1. Risk Assessment showing reduced risk as well as PLr
2. Performance Level Calculations from SISTEMA report or equivalent
3. Validation testing results

14.2. Machine Documentation and Programming Languages

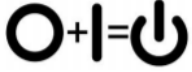
- A. Written documentation and user interface must be supplied in both the language of the receiving location and English
- B. All safety written coding must be in English (TE Requirement).
- C. All labels must be provided in the local language of the country where the machine is to be used.



NOTE: *It is acceptable for pictograms to be used exclusively if explanations are given in the machine's documentation*

- D. Two universal symbols can be used to represent "ON", "OFF" or in combination, as follows:

Figure 5: Universal On/Off Symbols.

 A circle representing "OFF"	 A vertical line representing "ON"
 Combining circle and vertical line	 Button for both ON and OFF

14.3. Content of Technical Documentation

The following documentation must be provided in a design review before machine build:

- A. A general description of the machine
- B. An overall drawing of the machinery (3D PDF)
- C. Connection diagrams for all energy sources used in the machine.
- D. Bill of Material with manufacturer's part numbers
- E. A risk assessment package shall be provided that includes:
 - A list of every task/hazard pair in the machine
 - A list of every applicable hazards resulting from the machine movement.
 - Determination of possibility, frequency and severity for each hazard (at the time of the design review)
 - A description of the risk reduction method used to reduce the risk to an acceptable level (at the time of the design review)
 - The performance levels of every safety function (at the time of the design review)
 - The SISTEMA project and report (when the electrical design is complete)
 - Validation testing results for hardguarding and all safety devices.
 - Manufacturers safety certifications for all safety components in use



NOTE: *Issues that may require deviation must be reviewed before the machinery is ordered or manufactured. Any changes to the machinery after it has been installed and approved must be re-approved by the facility EHS Manager to provide an additional level of review.*

14.4. Responsibility to Issue a CE Conformity (European Economic Area Only)

- A. The responsibility to issue the CE conformity for the whole process is with the party that is considered the "integrator". It is preferable that a third party be the integrator. The integrator can be a TE representative if an outside firm is not assigned this task. Although the integrator may not have made any of the components, it is the integrator's responsibility to issue the CE conformity for the whole process. The party that is the integrator must be defined before any work begins. As a result, all manufacturers of components are required to provide all necessary information to the integrator in order to assess risks and determine safety requirements for the whole process. This agreement is included as part of the purchase contract and any deviations need a written agreement. All parties have not completed their requirements until official approvals have been issued from TE Connectivity Engineering, the manufacturer and TE EHS. Any deviation must be documented and signed by the following TE personnel; Facility Manager, Regional Operations Leader, and Business Unit EHS Leader.
- B. A technical file that includes the CE declaration of conformity (to include the declaration of incorporation) of machinery and/or other products incorporated into the machinery is required.
- C. The safety documentation shall be included in the technical file and shall be reviewed by a Qualified TE Personnel prior to a new machine being placed into production in any TE facility. The minimum documents shall include risk assessment, SISTEMA native program or equivalent, and validation testing results.
- D. If TE is considered the integrator, the CE conformity certificate needs to be issued on behalf of the TE legal entity and signed by the general manager according to legal requirements. A TE engineer, assigned as a project manager, needs to assure that all steps needed to certify a machine (risk assessment, verification, etc.) are taken and documentation is provided (technical file) according to the EU machinery directive.



Appendix A Revision History

Revision	Date	Incorporated By	Summary of Change
A	N/A	Corp EHS	Initial issue
B	N/A	Corp EHS	Update
C	N/A	Corp EHS	Update
D	January 2020	Corp EHS	Major re-write
E	June 2025	Corp EHS	Rewritten to align with the 2025 update to TEC-124-118



Revision D to Revision E Changes

Rewritten to align with the 2025 update to TEC-124-118.