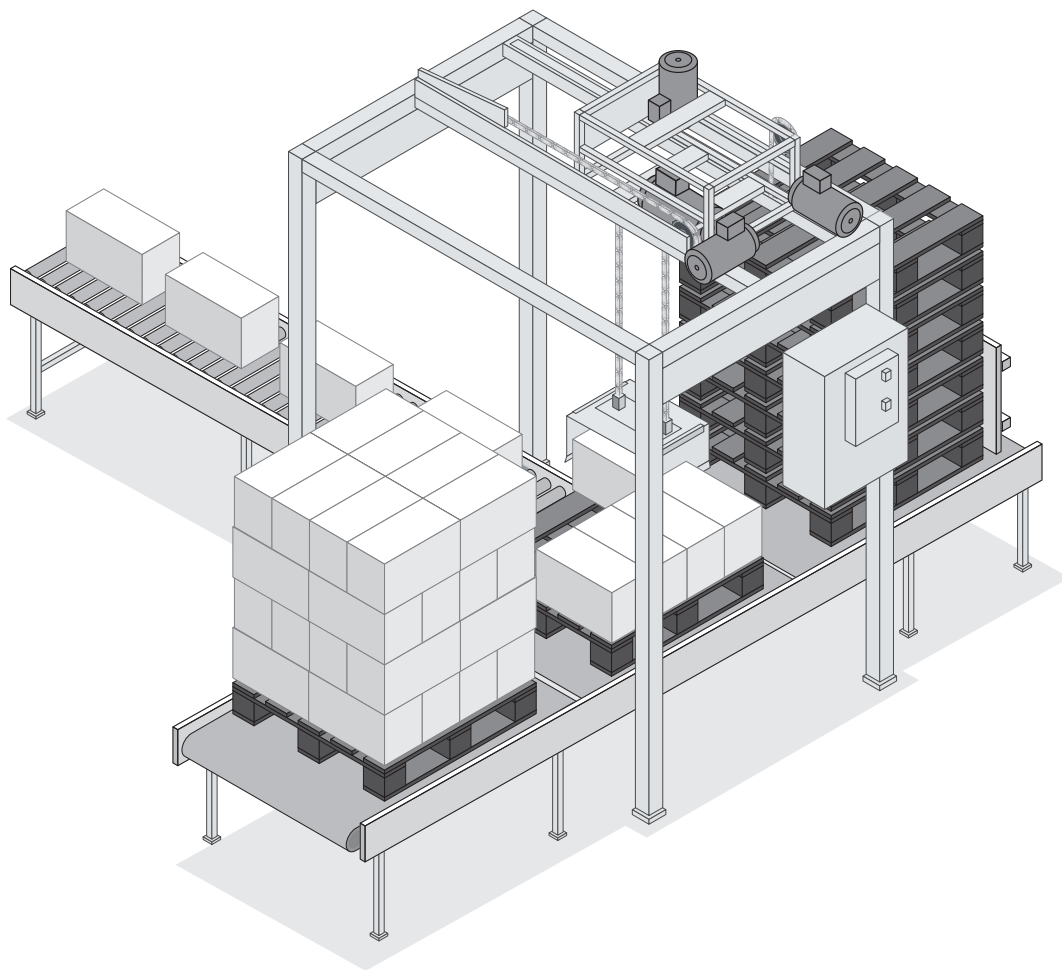


Palletizer Functional Safety with relay and configurable relay solution.



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Overview

This document has been developed for machine designers within manufacturing plants and also to assist system integrators and OEM's.

The specification covers the implementation from input devices through to final power elements giving examples utilizing a safety relay based solution and a configurable controller solution.

The diagrams in this document should be used in conjunction with the additional recommendations detailed in:

EN 60204-1: Safety of Machinery – Electrical Equipment of Machines

ANSI B155.1 - Safety requirements for packaging machinery (North America).

EN 415-4: Safety of packaging machines - Palletizers and Depalletizers (Europe).

Note: Different regions may have different guidelines.

When implemented correctly the circuits described in this whitepaper will comply with the requirements for **PL_e (Performance Level) to (EN) ISO 13849-1: 2015 and SIL3 (Safety Integrity Level) to IEC 62061: 2005.**

A detailed description of those standards is provided in Safebook 4, available from Rockwell Automation.

http://www.marketing.rockwellautomation.com/safety-solutions/en/MachineSafety/ToolsAndDownloads/safebook4_Form

For muting Rockwell Automation provides detailed description of the complete safety function:

<http://ab.rockwellautomation.com/Safety/Relays/Specialty/Muting-Light-Curtain-Monitoring#overview>

Download Safety Automation Builder

http://www.marketing.rockwellautomation.com/safety/en/Safety_Automation_Builder

Working Principle

Palletizer – Layers of packages are formed at one level usually a high level, and transferred onto the pallet which is raised and then lowered as the pallet forms.

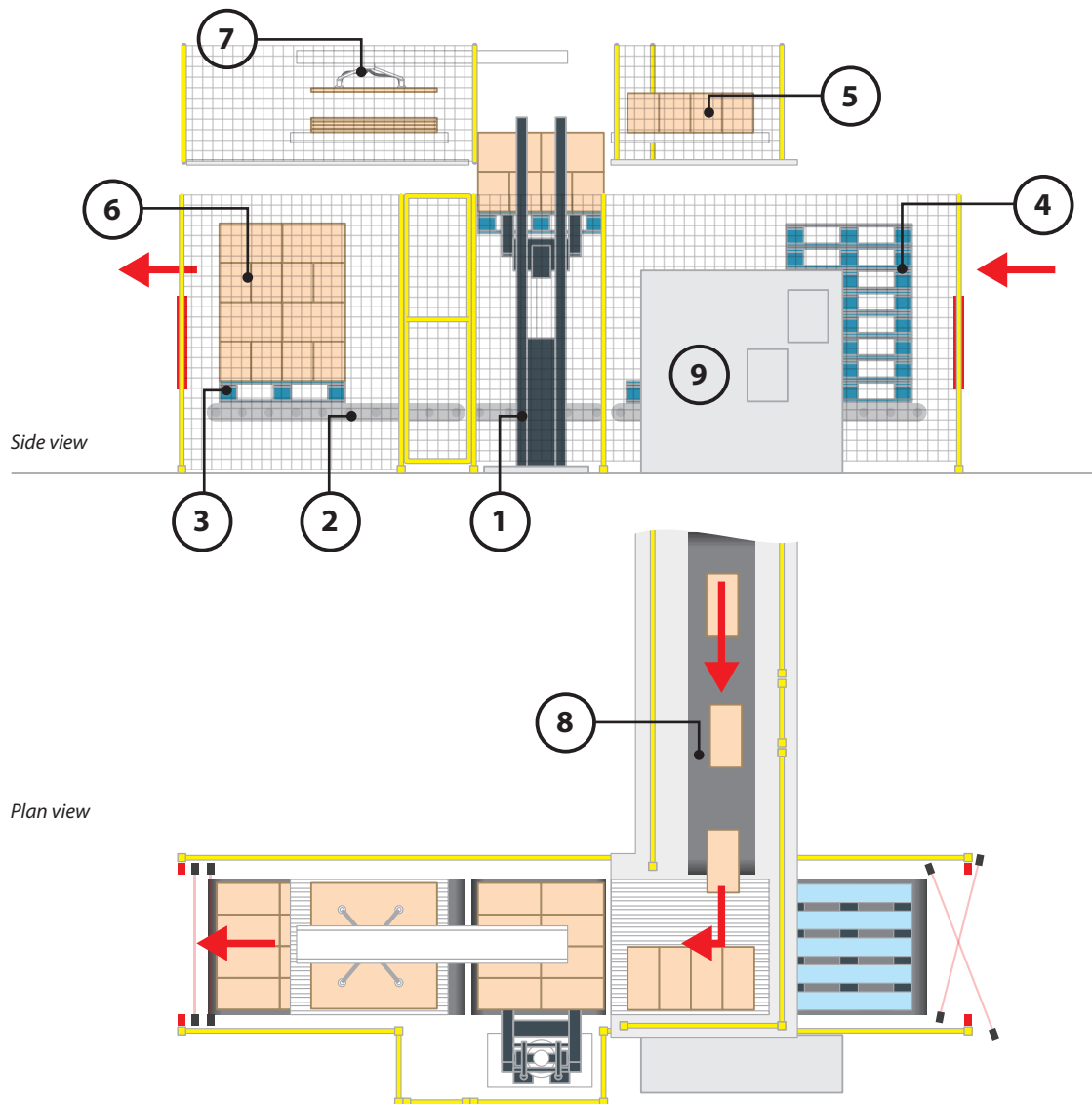
A depalletizer operates in reverse: layers of packages are gripped and moved from a pallet onto a receiving table, usually positioned at high level. The height of the pallet is raised as the pallet is dismantled.

Example of palletizer and depalletizer equipment

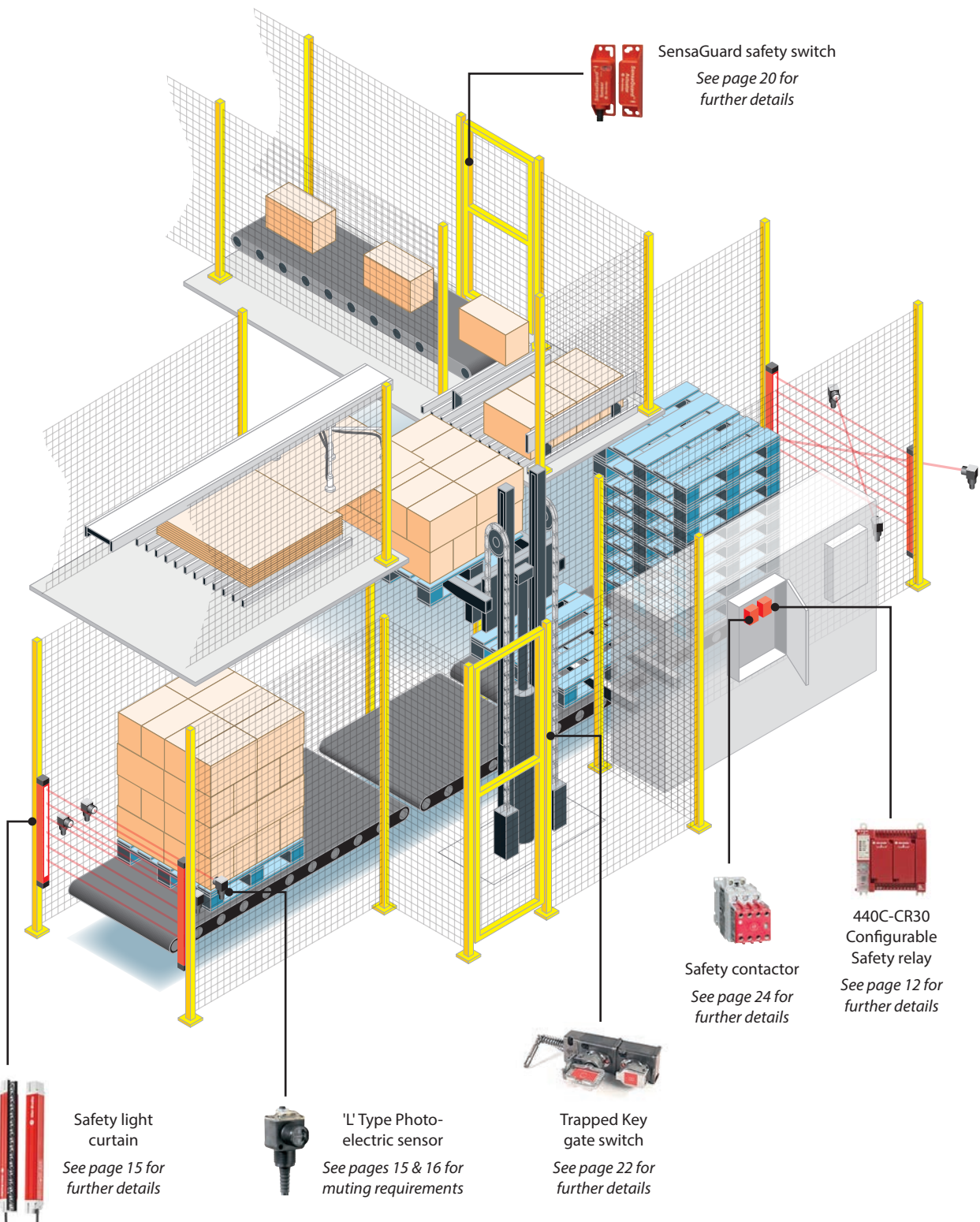
Significant Hazard cross reference list

The palletizer usually comprises the following equipment:

1	Load lifting device	4	Mass of pallet in the stack	7	Interlayer placing unit
2	Pallet conveyor	5	Collating area	8	Product in-feed conveyor
3	Mass of product on the pallet	6	Mass of product	9	Electrical cabinet



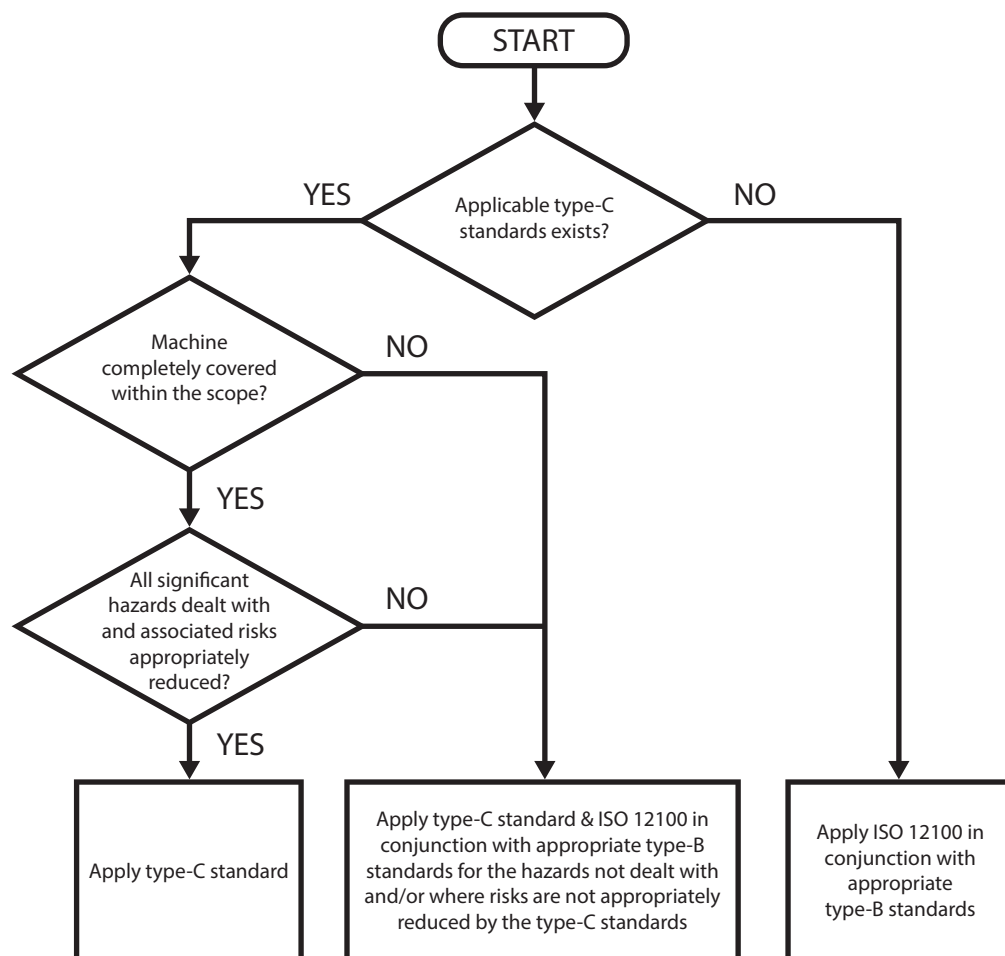
Product cross reference



Risk Assessment Requirements

Based on the figure below, application of an applicable type-C standard may be applied, in this instance EN 415-4 as the machine is being produced for a market within Europe and as such references a European standard. However it should be noted that there is still a requirement to review the standard to ensure that all significant hazards are dealt with.

Regardless of where the machine is to be installed, the information contained within ISO 12100-1 should be valuable.



Recommended steps for the practical use of ISO 12100: 2010 and existing type-B and type-C standards within this system. See Safebook 4 from Rockwell Automation.

www.machinesafety.com

Significant Hazards

The following table lists specific hazards typically associated with palletizers

The hazards listed are identified in Annex C of ANSI B115.1 as typical packaging hazards, for hazards specifically associated with palletizers the clause references relate to EN 415-10:2014

Hazard Zone	Source of hazards	Hazards	Hazardous situation / phase of life cycle	
1	Load lifting device	Mechanical hazards	Phases of life cycle <ul style="list-style-type: none"> • Operation • Changeover • Fault finding • Cleaning • Maintenance 	Situations <ul style="list-style-type: none"> • Movement of load lifting devices in all phases e.g. lowering by gravity
2	Pallet conveyors	Mechanical hazards	Phases of life cycle <ul style="list-style-type: none"> • Operation • Changeover • Fault finding • Cleaning • Maintenance 	Situations <ul style="list-style-type: none"> • Person standing on the conveyor , • Movement of conveyor
3	Mass of product on the pallet	Mechanical hazards	Phases of life cycle <ul style="list-style-type: none"> • Operation • Changeover • Fault finding • Cleaning • Maintenance 	Situations <ul style="list-style-type: none"> • Load falling
4	Mass of pallet in the stack	Mechanical hazards	Phases of life cycle <ul style="list-style-type: none"> • Operation • Changeover • Fault finding • Cleaning • Maintenance 	Situations <ul style="list-style-type: none"> • Pallet falling
5	Products (e.g. bags) flattening mechanism	All body drawing in, friction, crushing, trapping	Phases of life cycle <ul style="list-style-type: none"> • Operation • Changeover • Fault finding • Cleaning • Maintenance 	Situations <ul style="list-style-type: none"> • Person in the vicinity
6	Mass of product	Impact, crushing between fixed parts and the body of an operator	Phases of life cycle <ul style="list-style-type: none"> • Operation 	Situations <ul style="list-style-type: none"> • Manually applying or removing the means to stabilize the load or other packaging components (e.g. labels, top sheets).
7	Interlayer placing unit	Mechanical hazards	Phases of life cycle <ul style="list-style-type: none"> • Fault finding • Maintenance 	Situations <ul style="list-style-type: none"> • Person in the vicinity
8	Product in-feed conveyor	Mechanical hazards	Phases of life cycle <ul style="list-style-type: none"> • Operation • Cleaning • Maintenance 	Situations <ul style="list-style-type: none"> • Person in the vicinity
9	Electrical cabinet	Electrical hazards	Phases of life cycle <ul style="list-style-type: none"> • Fault finding • Maintenance 	Mode 3 not applied correctly - Lock Out Tag Out (LOTO) not applied whilst fault finding

General hazards

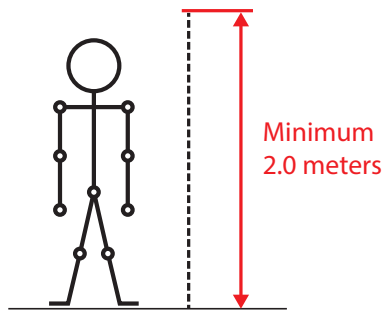
The following table lists generic hazards typically associated with palletizers

Source of hazards, hazardous elements	Hazards
Machine or parts of the machine	Mechanical hazards (according to clause 4.2 of EN 415-10:2014)
Electrical equipment	Electric shock (according to clause 4.4 of EN 415-10:2014)
Conductive parts of the machine	Electric shock (according to clause 4.4 of EN 415-10:2014)
Machine, unit load handled by the machine, equipment associated to the machines	Noise (according to clause 4.7 of EN 415-10:2014)
Pneumatic equipment and hydraulic equipment	Mechanical hazards, ejections of air, whiplash of pipes and slipping or falling, noise (according to clause 4.3 of EN 415-10:2014)
Packaging material	Slips and trips (according to clause 4.2.2 of EN 415-10:2014) cutting, impact due to broken container or material (according to 4.9 of EN 415-10:2014)
Conveyors which are part of the machines in the scope	Mechanical hazards, slips, trips and fall hazards (according to clause 4.16.4 of EN 415-10:2014)
Electric energy	Mechanical and electrical hazards (according to clause 4.4 of EN 415-10:2014)
Neglecting ergonomic principles	Fatigue, mental stress (according to clause 4.10 of EN 415-10:2014)
Moving parts	Mechanical hazards (according to clause 4.2.1 of EN 415-10:2014)
Size parts of the machine	Mechanical and ergonomic hazards (according to clause 4.16.6 of EN 415-10:2014)
Moving guards,	Crushing, shearing and impact (according to clause 4.2.4 of EN 415-10:2014)
Machine parts	Slips, trips and fall hazards (according to clause 4.2.2 of EN 415-10:2014)

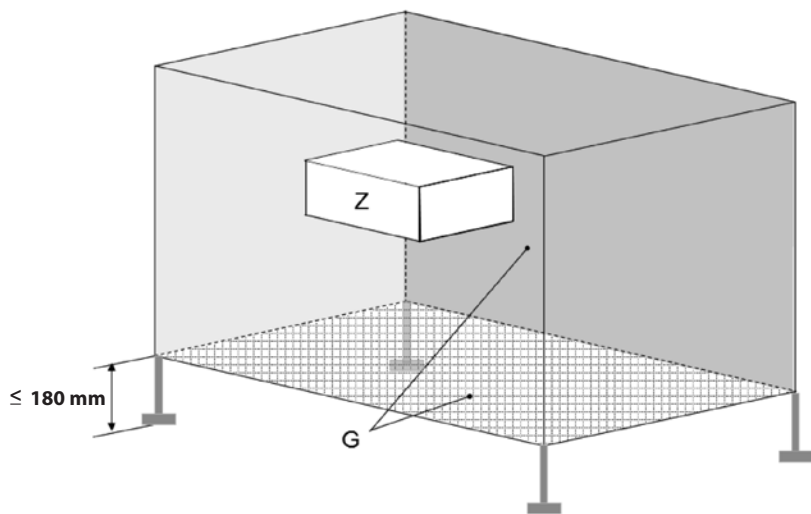
Guarding requirements

Fixed or interlocking movable guards open topped distance guards shall be at least 2000 mm high from the floor or other access platform to discourage operators climbing over. The height is measured :

- FROM the level of the permanent surface immediately outside the fence on which an operator could stand



Where there is a risk of parts or products being ejected from the machine the guards and their position shall be designed to contain these parts or products;



Key:

Z - hazard zone

G - fixed guard

Further detailed information on guarding can be found in EN 415-10:2014, ISO 14120:2015 and information on reach distances is contained within ISO 13857:2008.

Safety relay with selectable configuration

Operating principle

The following hardware solution is based on a 2 Sensor L-type muting (single direction muting) system which allows the out-feed pallet load to pass through its light curtains in one direction without shutting down the palletizer, but will issue a stop signal if anyone attempts to move through the light curtain when muting is suspended.

The system will also shut down the palletizer when an object fails to satisfy the requirements for muting.

STARTING: The MSR42 relay monitors the 100S contactors via NC contacts from each contactor connected in series to provide a Start Release function. The MSR42 relay does not respond to its Start button and energize the MSR45E safety contacts when the light curtain is interrupted, there is a fault detected, or when the 100S contactors are not in the proper off state. The MSR42 runs and monitors a muting lamp. Should the lamp burn out or be removed, the MSR42 relay does not mute the light curtain. Upon initial power-up, the start/restart button must be pressed to energize the outputs of the MSR42 and attached MSR45 extension relay. The GSR relay (1) monitors the NC contacts of the emergency stop and the OSSD (output signal switching device) outputs from the light curtain, and GSR relay (2) monitors the NC contacts of the trapped key solenoid release and the relay outputs from the MSR45, on the basis that all the input devices are healthy, the NC contacts from all the 100S contactors are present and the GSR units are reset this will allow the motor(s) to start.

MUTING: The object must block the sensor MS1 and then MS2 within the configured time limits prior to passing through the light curtain. The motor continues running during the muting operation.

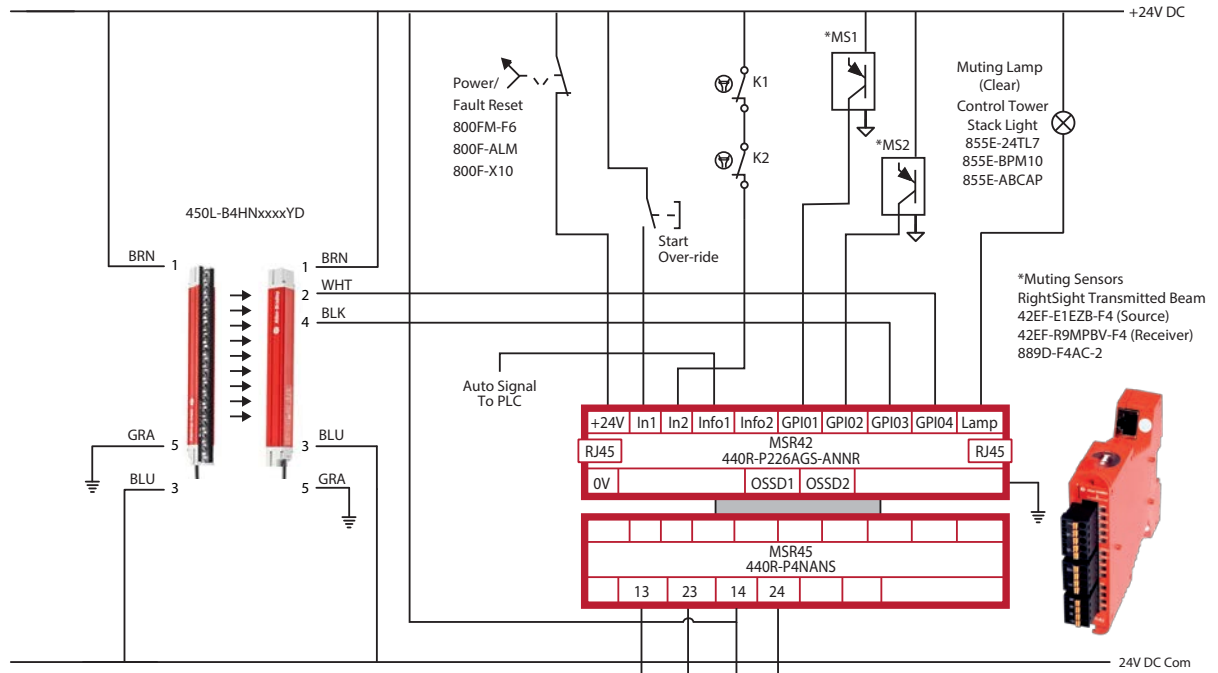
STOPPING: Obstructing the light curtain without blocking sensors MS1 and MS2 de-energizes the MSR42/ MSR45 outputs. After clearing the light curtain, press the start/ restart button to re-energize the safety outputs of the MSR42/MSR45. Clearing the light curtain can also be managed by activating the override function (pressing the spring-loaded key). Operating the emergency stop, energizing the solenoid release and operating the isolator, activating the pallet in-feed light curtain or the MSR45 outputs switching off de-energizes the 100S contactors.

Fault Detection

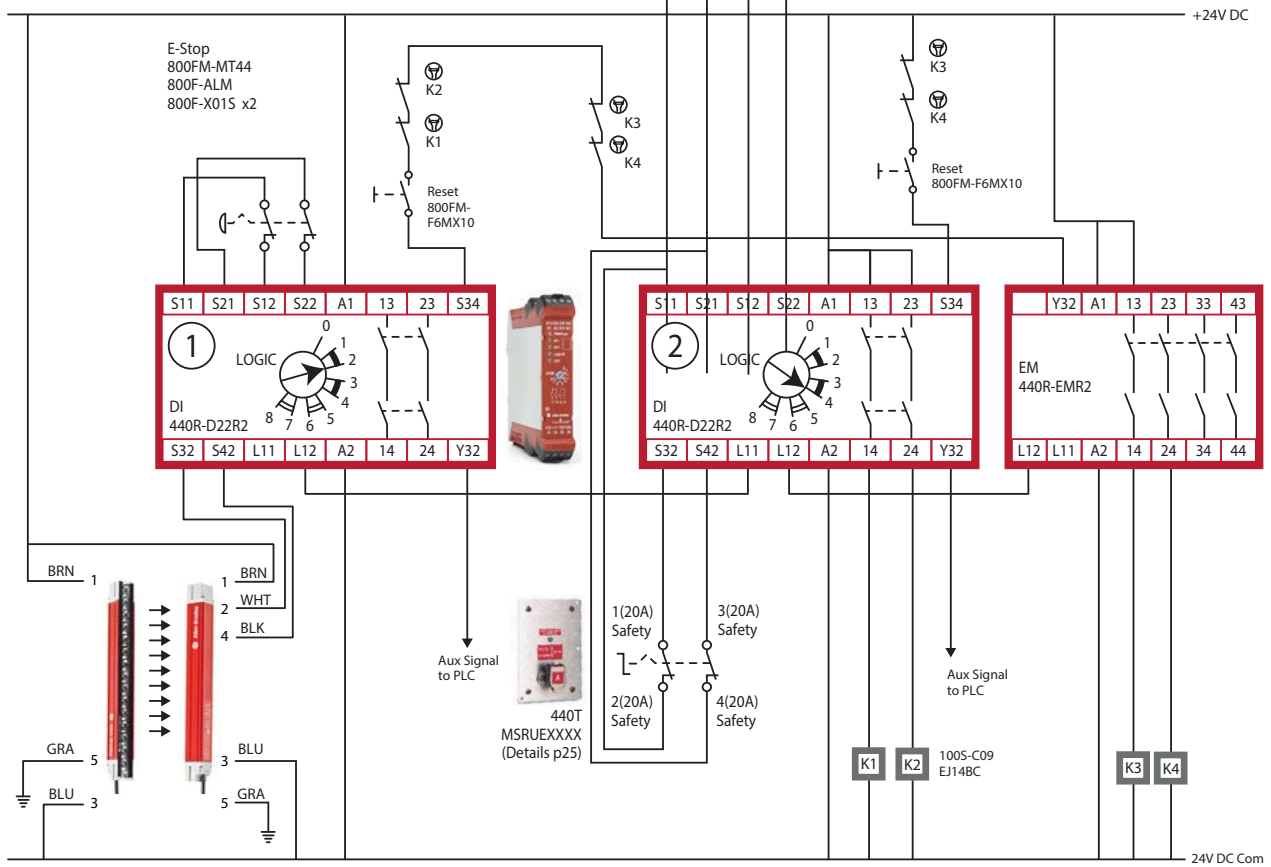
Upon power-up, the connected GuardShield light curtains, as well as the MSR42, and GSR relays perform internal checks. The GSR relays check for faults in the emergency stop circuit and solenoid monitoring circuit by connecting its pulse test outputs through the respective volt free contacts and monitoring the associated inputs. If OK and the protection fields of the connected GuardShield light curtains are clear, the outputs will turn on after the start signal. For power up, the muting sensor can be blocked, allowing the outputs to be turned on, however the muting process cannot be activated because the muting sequence is not adhered to. The blocking material must be transported backwards, clearing the sensors first, or must be transported forwards through the protection field using the override functionality.

While running, an incorrect sequence of the complete muting sequence (MS1->MS2->LC) or excessive time to move the object through the muting zone will de-energize the safety outputs of the MSR42/MSR45. The muting lamp blinks to indicate a fault has occurred. The exact fault can be read out using the USB-configuration tool.

Muted Light Curtain (generally out-feed conveyor)



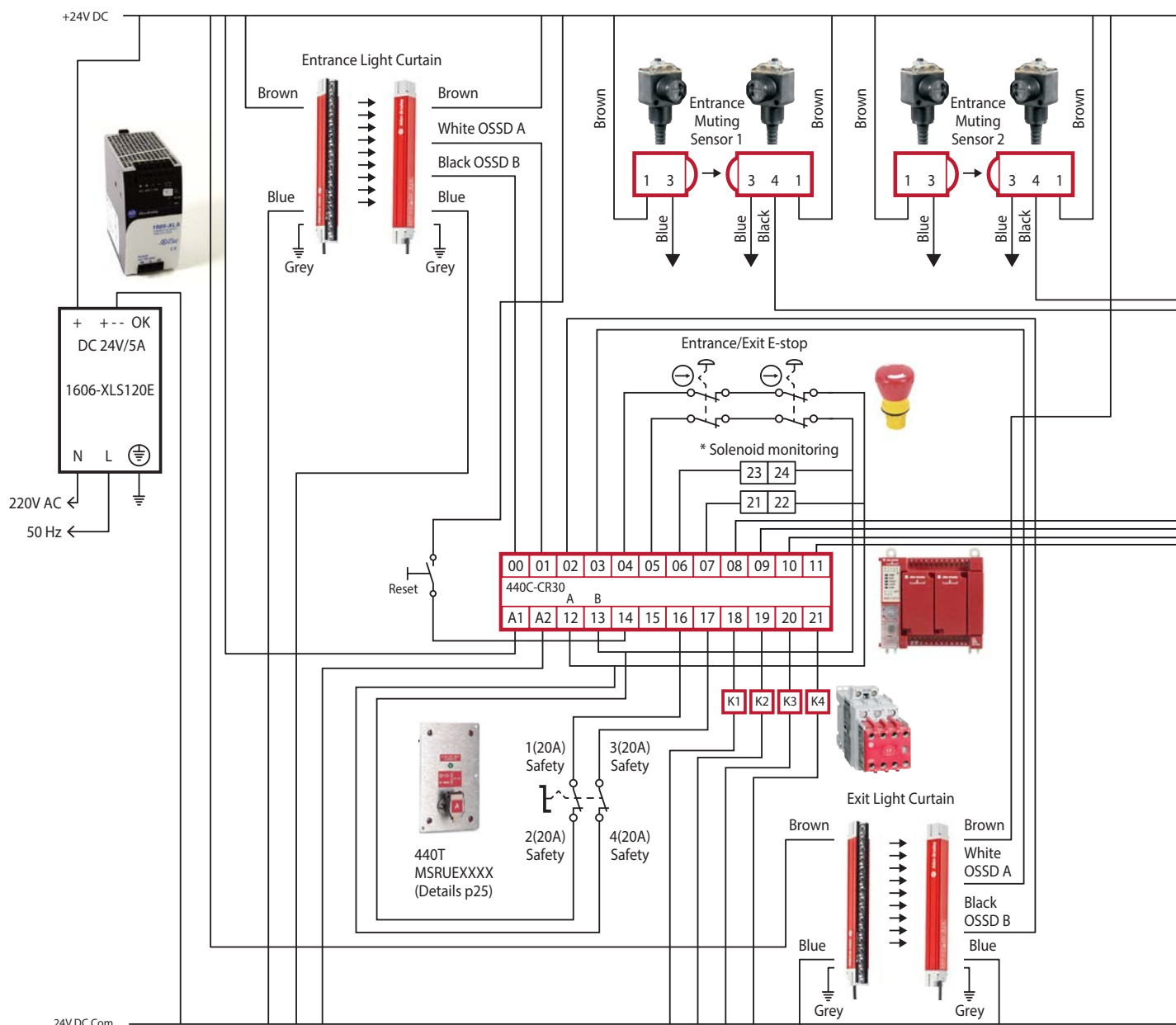
General Access Functional Safety Description



Safety relay with software configuration

The following solution utilises the 440C-CR30 configurable safety relay, as this is a software configurable solution it offers more scope in its flexibility to cater for numerous applications, in this example both sets of safety light curtains may be muted (similar to a pallet wrapping application) the operating principle is similar to that explained earlier where each safety light curtain turns its two OSSD outputs OFF. These signals are connected to

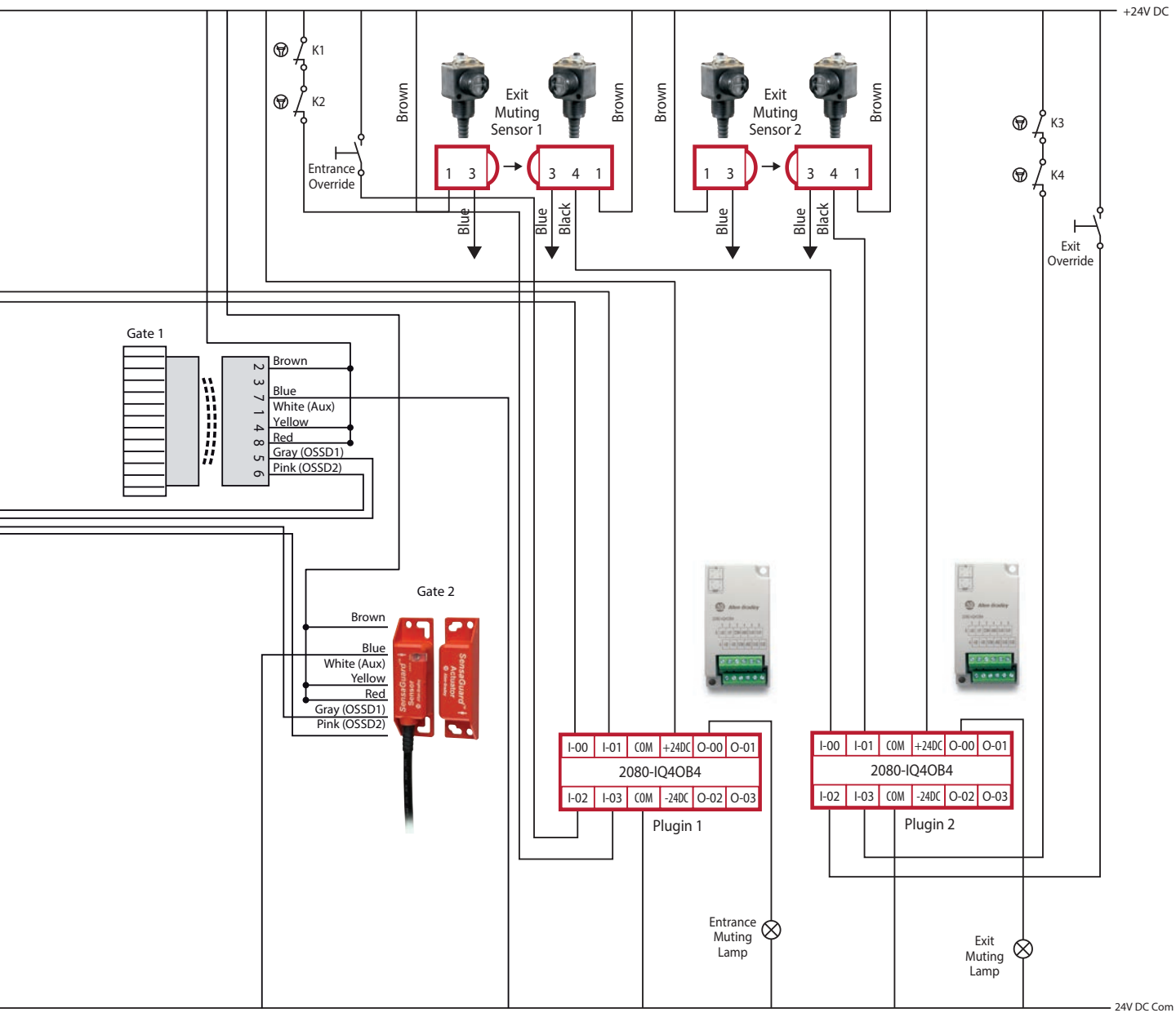
the safety input terminals of the 440C-CR30 safety relay. When the light curtain's OSSD outputs turn OFF, the safety relay responds by turning OFF its own redundant safety outputs. This action removes the 24V signal from the coils of the two safety contactors whose main motor contacts then open, thus removing power from the motor. This action causes the motor to coast to a stop (Stop Category 0). Stopped is the safe state.



The 100S-C safety contactors are the final control devices. A 24V signal is passed through mechanically-linked, normally closed (N.C.) auxiliary contacts of the 100S-C contactors to inputs on the 440C-CR30 safety relay, enabling the relay to monitor the status of the main contacts. This 24V feedback (monitoring) signal is only present at the safety relay's inputs if the main contacts are open, meaning that the contactors are in a safe state. If one of the main motor contacts is welded shut, the auxiliary N.C. contacts are held open by the mechanical linkage and the 24V feedback signal does not reach the inputs of the safety relay.

The safety relay does NOT reset under this condition. The failed contactor would have to be replaced.

After the pallet load clears the light curtain, the light curtain's OSSD outputs turn ON. When the safety relay detects these signals and the feedback monitoring signal, when no faults are detected, and the reset push button is pressed (for 0.25 to 3.0 seconds) and released, the 440C-CR30 relay turns its safety outputs ON, providing power to the contactor coils.



Position the reset button where it is possible for the operator to view the entire hazardous area. If a person is in the hazardous area, the reset button should not be pressed. If it is not possible to view the entire accessible hazardous area when operating the reset button, use supplemental safeguarding, such as the ProSafe trapped key system described later.

The reset button and contactor feedback-monitoring circuits connect to the 2080 plug-in I/O module. This module is not safety rated. It is acceptable to use standard inputs for the reset and feedback because they are not safety-rated signals. They are simple 24V signals. The 440C-CR30 safety relay limits the use of standard I/O to functionality that does not require safety rated signals. By comparison, the E-Stop and light curtain signals must not be connected to the standard I/O plug-in module. These signals must be connected to safety-rated inputs. Both the configuration software and the firmware prevent you from using standard inputs for signals that must be safety rated. Reset and feedback monitoring signals can be connected to safety rated inputs if so desired. This example uses the 2080 plug-in I/O module to show the capability of the 440C-CR30 safety relay.

The light curtain monitors its internal circuitry and its OSSD outputs for faults. When the light curtain detects a fault in the internal circuitry, the light curtain responds by turning its OSSD outputs OFF. A fault on the OSSD outputs is detected either immediately, or upon the next safety demand. The light curtain turns its OSSD outputs OFF when it detects an output fault, such as a short-circuit to another signal, or between the two OSSD channels. Most internal and wiring faults of the light curtain require you to cycle power after removing the cause of the fault to internally clear the fault and enable the light curtain to turn its outputs ON.

The 440C-CR30 safety relay sends test pulse signals from multi-purpose terminals 12 and 13 through the contacts of the E-Stop, which are connected back to the safety inputs on the safety relay. Pressing the E-Stop interrupts this circuit. The safety relay responds by turning its safety outputs OFF, which

de-energize the coils of the 100S-C contactors. This causes the main motor contacts to open, removing power from the motor and causing it to coast to a stop (Stop Category 0).

The 440C-CR30 safety relay monitors the E-Stop circuit for faults. Loose wires, shorts to 24V, shorts to ground, contacts failed closed, and cross faults are detected. When a fault is detected, the safety relay responds by turning its safety outputs OFF, taking the system to a safe state.

The 440C-CR30 safety relay checks itself for internal faults and turns its outputs off, if any are detected.

No single fault results in the safety system failing to perform its safety function. A single fault is detected before or upon the next demand on the safety system. The system cannot be reset until the fault is cleared.

Safety Light Curtain operation

Circuit Status

The light curtain is clear. The muting sensors are clear. The outputs of the safety relay are de-energized, and the motor is off.

Operating Principle

The 440C-CR30 can be configured for automated conveyor applications, where an object moves through a light curtain out of a hazardous area. With L-type two sensor muting, the object can move only in one direction.

STARTING: Upon initial power-up, the start/restart button must be pressed to energize the outputs of the 440C-CR30. On the basis that all other conditions are clear this will start the motor.

MUTING: The object must block the sensor MS1 and then MS2 within the configured time limits prior to passing through the light curtain. The motor continues running during the muting operation.

STOPPING: Obstructing the light curtain without blocking sensors MS1 and MS2 de-energizes the 440C-CR30 outputs. After clearing the light curtain, press the start/restart button to re-energize the safety outputs of the 440C-CR30. Clearing the light curtain can also be managed by activating the override function (pressing the spring-loaded key).

Fault Detection

Upon power-up, the connected GuardShield light curtain, as well as the 440C-CR30, performs internal checks. If OK and the protection field of the connected GuardShield light curtain is clear, the outputs will turn on after the start signal. For power up, the muting sensor can be blocked. If so the outputs can be turned on, but the muting process cannot be activated because the muting sequence is not adhered to. The blocking material must be transported backwards, clearing the sensors first, or must be transported forwards through the protection field using the override functionality.

While running, an incorrect sequence of the complete muting sequence (MS1->MS2->LC) or excessive time to move the object through the muting zone will de-energize the safety outputs of the 440C-CR30. The muting lamp indicates if muting is activated and blinks to indicate a fault.

If the override functionality is activated in the 440C-CR30, a simple re-activation of the start button may be used to manually move material through the conveyor. The outputs of the 440C-CR30 will then stay activated for the configured override time. If the protection field is cleared during that time the motor continues running. If the light curtain is still blocked after that time the 440C-CR30 will deactivate the safety outputs.

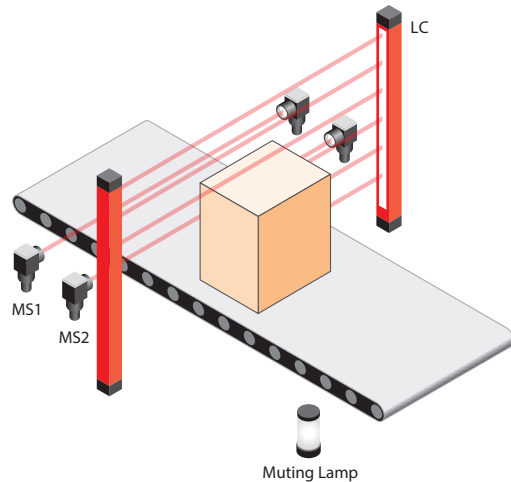
Under circumstances where openings in the muted material lead to a failure in the muting sequence, a muting sensor delay function can be activated in the 440C-CR30 to accommodate the variability in the material.

Ratings

This circuit meets the safety performance requirements of PL e of (EN) ISO 13849-1: 2015 or SILcl 3 of IEC 62061: 2005

This circuit executes a Category 0 stop.

'L' - Type, 2 Sensor Uni-directional muting

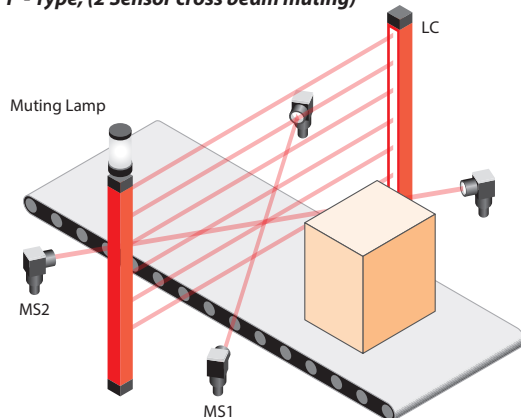


'L' - Type, 2 Sensor Uni-directional muting

Muting requires the material to break the beams and light curtain in a certain sequence: sensor MS1 first then MS2 and then the light curtain.

Only if the beams are broken in sequence and then clear in sequence will the light curtain allow material through without initiating a machine stop.

'T' - Type, (2 Sensor cross beam muting)



Bi-directional Muting

Bidirectional, two and four-sensor, T-type muting system lets valid loads or objects pass through its light curtains in either direction without shutting down the machine or process, but will stop the machine or process if anything or anyone attempts to move past the light curtain in any other manner.

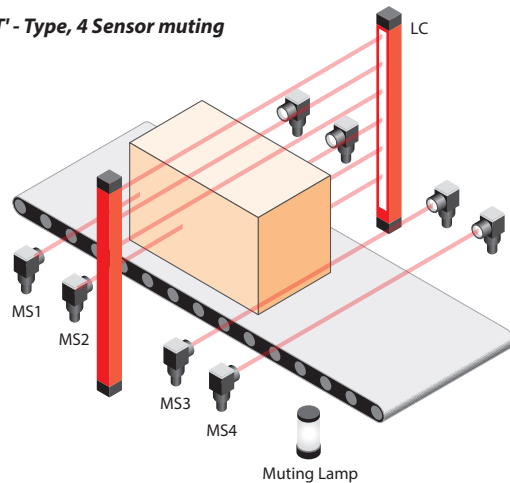
This type of system is often used to guard the access point at a hazardous portion of a machine or process where material must pass either into or out of the guarded area, such as an automatic palletizing system or automatic assembly machine.

'T' - Type, 4 Sensor muting

In this four sensor example a load can enter from the left or right but has to pass in sequence through the first two muting sensors and the LC (light curtain). After passing the light curtain, the load passes, in sequence, the last two sensors. An object passing the sensors in the proper sequence and within the configured time constraints is permitted to pass through the light curtains without triggering a safe stop. The light curtains are ignored by the safety system until the object passes completely through, clearing the light curtain sensing field and passing the third sensor, ending the muting period.

As soon as the third sensor is cleared, the safety system will again trigger a safe stop if anything breaks the sensing field without first passing MS1 and MS2 in the proper order and within the configured time constraints.

'T' - Type, 4 Sensor muting



The international standard IEC TS 62046: 2008 describes two- and four-sensor T- and L-type muting. The sensor positions recommended below are taken from IEC TS 62046: 2008 and IEC 61496-1: 2012 (A.7). The light curtain should detect the material, not the carrier (pallet).

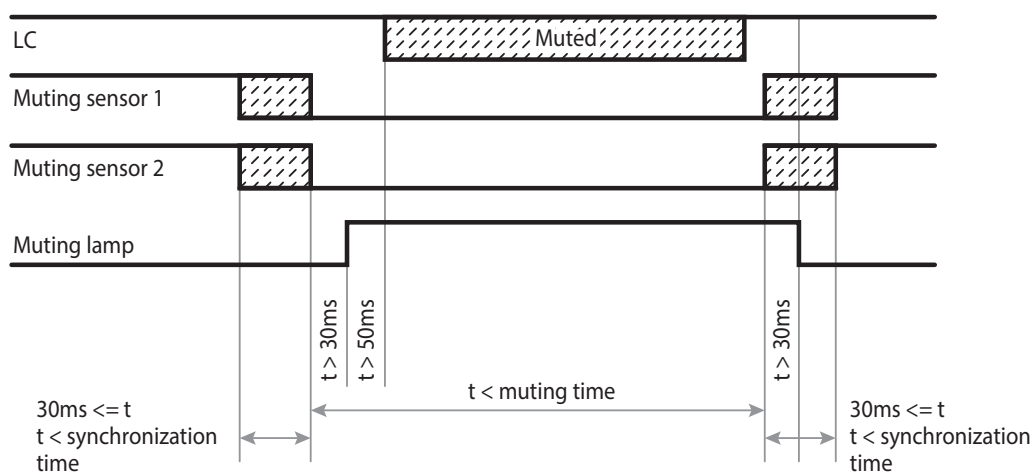
Muting types

Light Curtain Entrance

A 2 sensor T-type muting arrangement is used for the material entering the hazard area. The material can move in either the forward or reverse direction. The sensors are transmitted beam-receiver pairs. The Override momentary pushbutton activates the override function, which allows movement of material that may get stuck in the light curtain. The override duration is set in the muting function block in 5 second increments.

The muting lamp is on solid when muting takes place and flashes when the override function is active.

The timing diagram for 2-sensor "T" type muting is shown below. Muting begins after the second sensor is blocked. Muting ends after material moves through light curtain and moves past a first sensor. The sequence in which muting sensors 1 and 2 are blocked is critical.



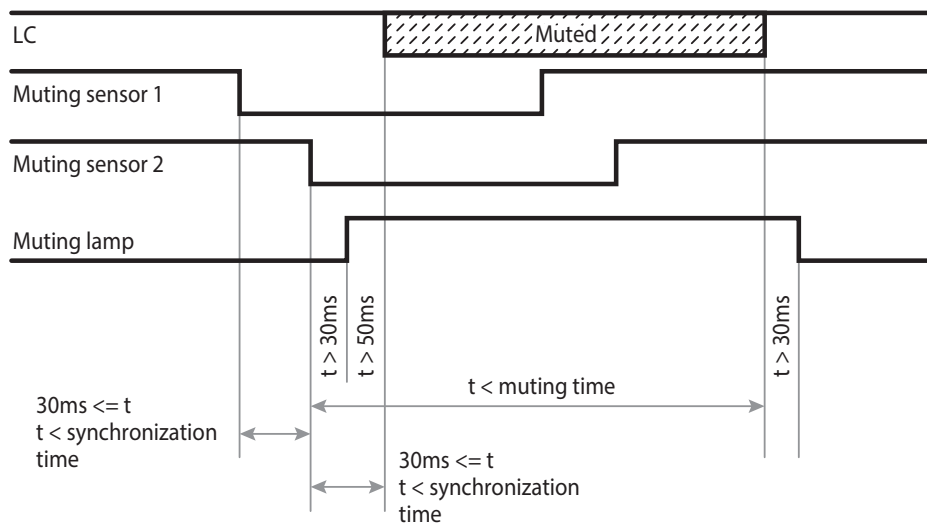
Light Curtain Exit

A 2-sensor "L" muting arrangement is used for the material exiting the hazard area. The material can only be moved in the outgoing direction. If movement is required in both directions, a 2-sensor "T" arrangement can be used in place of the 2 sensor "L" arrangement.

The Override momentary pushbutton activates the override function, which allows movement of material that may get stuck in the light curtain.

The muting lamp is on solid when muting takes place and flashes when the override function is active.

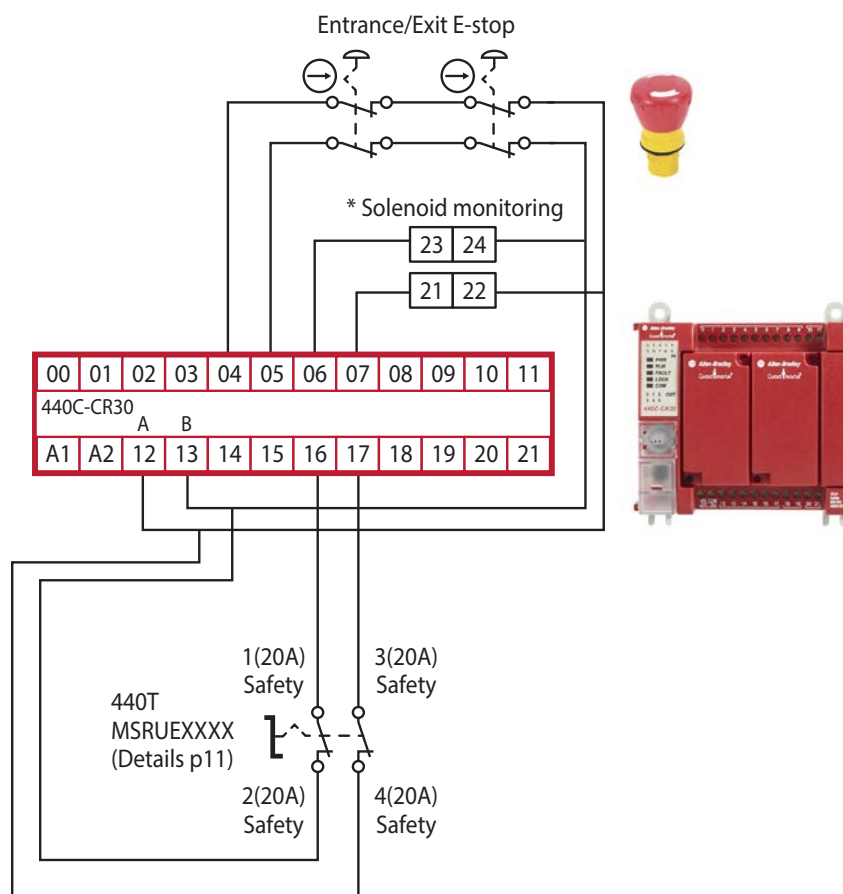
The timing diagram for 2 sensor "L" type muting is shown below. Muting begins after the second sensor is blocked. Muting ends after material moves through light curtain.



E-Stops

Two e-stop buttons, each with two normally closed mechanical contacts, are located at each of the light curtains. The e-stops use pulse testing outputs from terminals 12 and 13 of the 440C-CR30 to check for potential short circuit conditions.

Pressing either E-stop stops both conveyors.

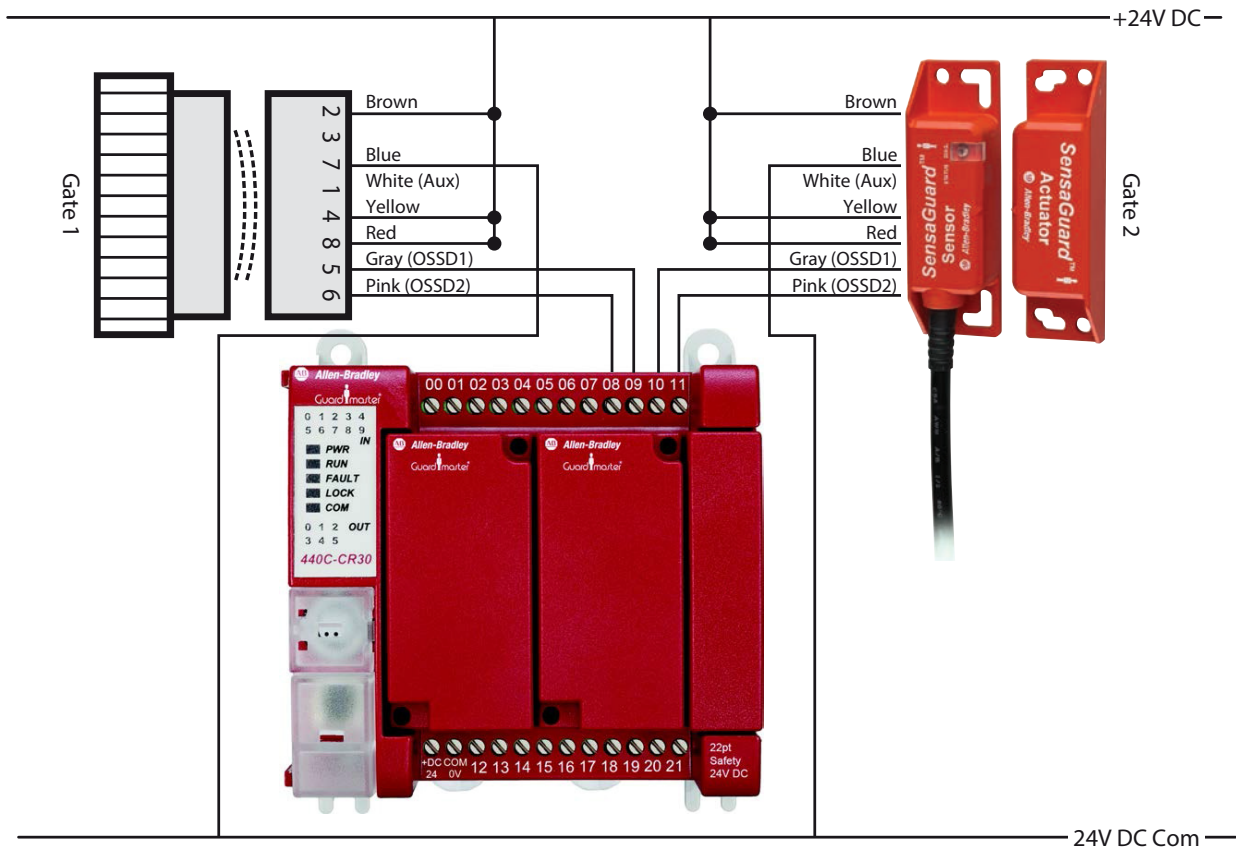


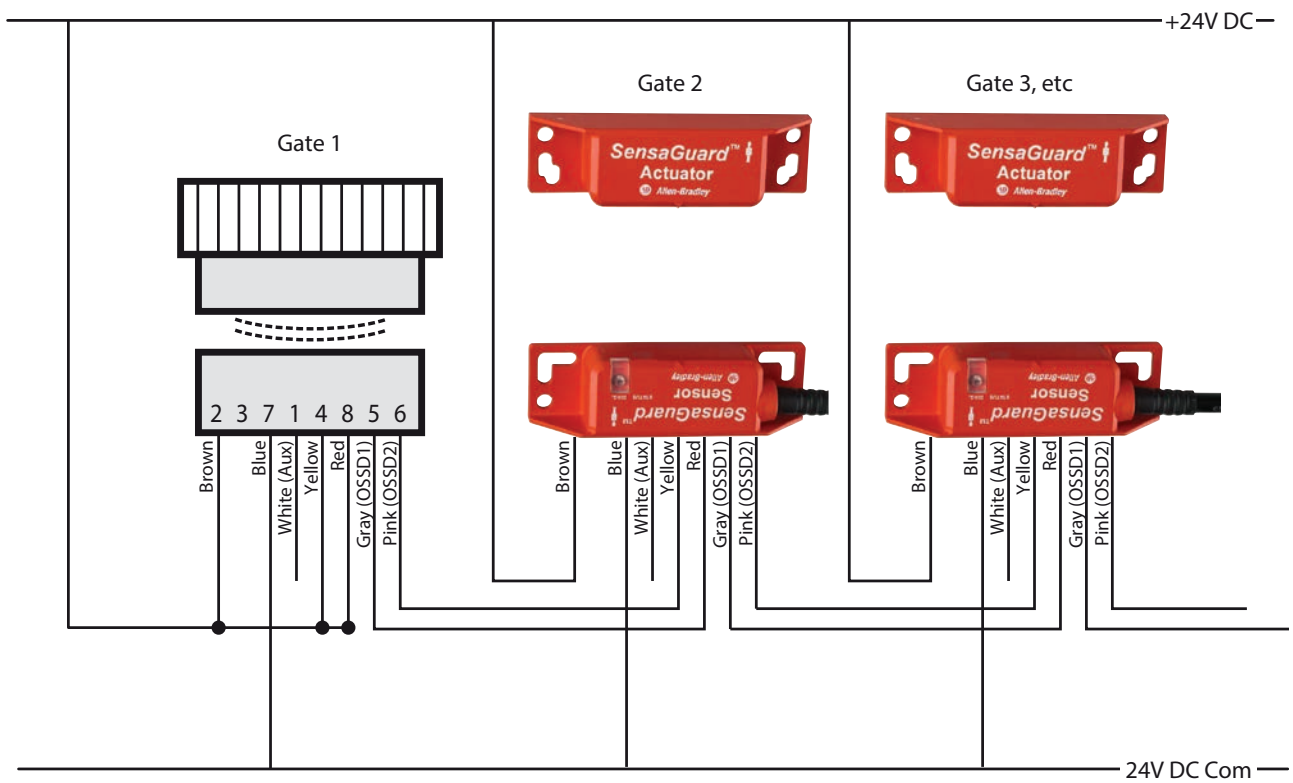
Gate Switches

Two non-contact SensaGuard Interlocks, each with dual OSSD outputs monitor the two safety gates.

Since the SensaGuard interlocks have self-checking OSSD outputs, pulse testing is disabled in the SMF9 and SMF10 blocks.

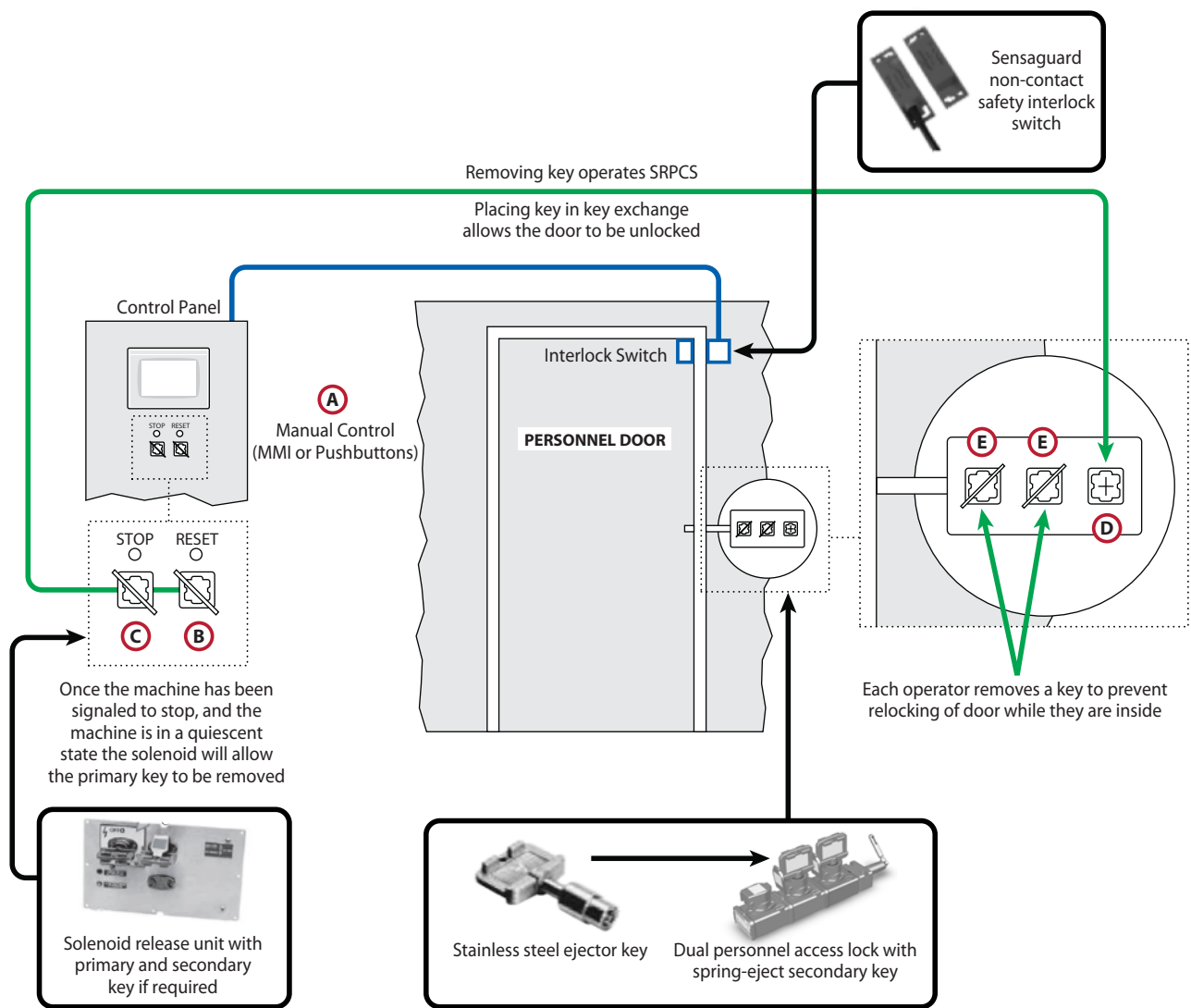
Opening either gate stops both conveyors.





Personnel Access

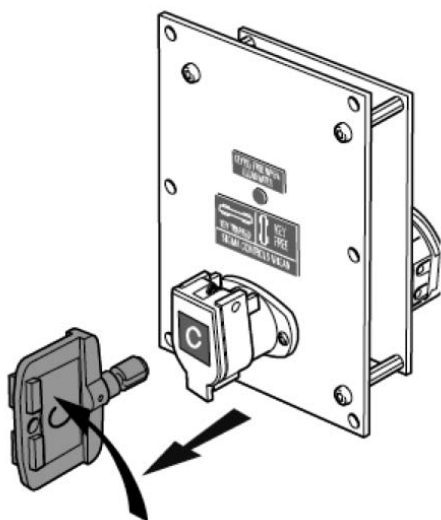
Functional Safety Description



At least one interlocked moveable guard (personnel door) shall be provided to allow operators and maintenance staff to enter the danger zone. The design of the personnel door or its interlocking device shall minimise the risk of the door closing accidentally i.e. closing the door shall require a deliberate action.

The SRPCS for access shall be in accordance with the diagram left, and shall operate as follows:

- A** A manual control shall be supplied on the control panel which controls the machinery in the danger zone (this control can be by means of a pushbutton operator or HMI (Human Machine Interface). When this is operated the machinery in that danger zone shall assume a quiescent state.
- B** Once in this state and provided that all energy sources are isolated the control system shall allow the release of a key on the front of the control panel.



- C** If more than one access gate is required, an additional key can be incorporated if required. There shall be a unique key for each personnel gate. Removing the key initiates the SRPCS and puts the machinery in that danger zone into a safe state for entry.
- D** The control panel key can then be taken to the personnel gate and placed into a key exchange. This action unlocks the gate and releases a spring ejector key which the operator takes into the danger zone with him. This second key (personnel protection key) shall prevent the personnel door from being closed and locked behind him. It shall also prevent the re-insertion of the key required to allow the resetting and restarting the machinery in the danger zone.
- E** Two keys shall be available at the gate allowing two operators to enter the danger zone.

Resetting and restarting shall be at the control panel but shall only be possible after the correct reversal of the sequence described above has been followed, and provided the feedback loop containing the solenoid monitoring on the solenoid locking switch is correct.

Using this technique allows a maximum Performance Level of d (PLd) in accordance with (EN) ISO 13849-1: 2015 If a PLe is required then an interlocking gate switch shall be used in accordance with drawing shown and the general access safety description. Generally, PLd is sufficient.

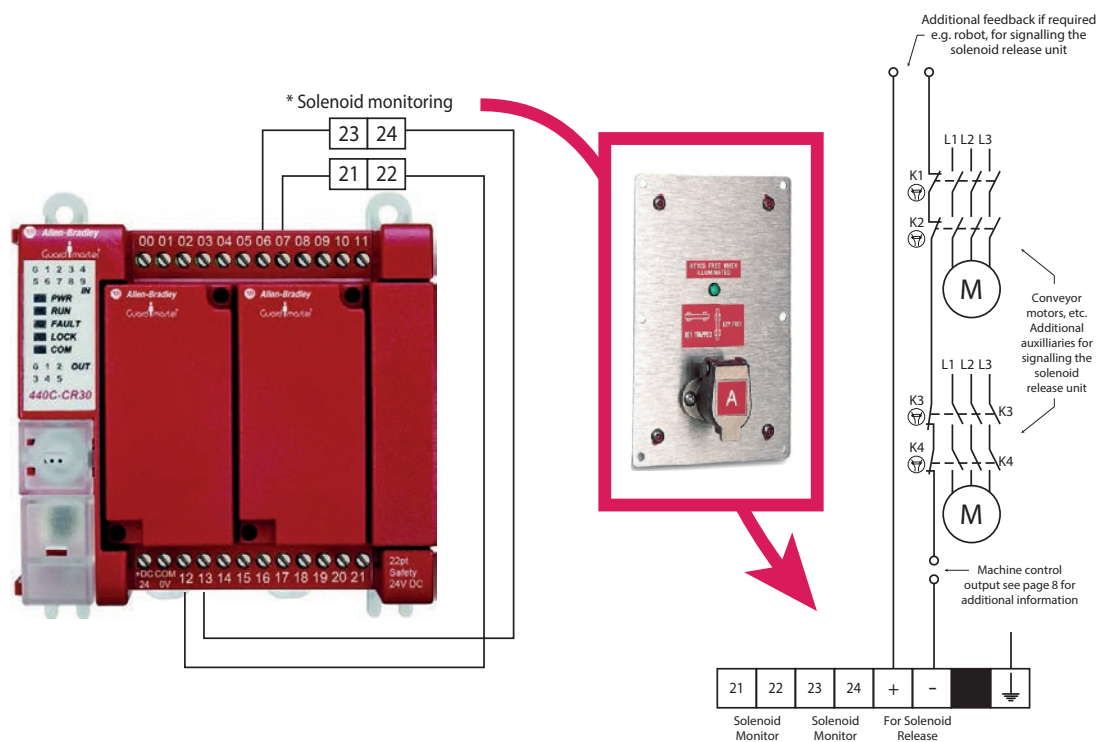
In the Health and Safety section of the Instruction Manual the following information shall be given:

- i) It shall stress the importance of the operator taking the key with him into the machine (this is particularly important when more than one operator are within the palletizer) and not attaching the key to the guards e.g. with a piece of string.
- ii) It shall state that in the event that more than two persons require access at any one time, then a specific risk assessment and method statement shall be drawn up to ensure that all those who have entered the danger zone have left it before the machinery is set in motion.

Solenoid release units - product selection			
Solenoid Voltage	Contacts	Nominal Current	Catalogue Number
24V DC	2 N.O. & 2 N.C.	20A	440T-MSRUE11 ①
	4 N.O.		440T-MSRUE10 ①
110 VAC	2 N.O. & 2 N.C.		440T-MSRUE22 ①
	4 N.O.		440T-MSRUE20 ①
230V AC	2 N.O. & 2 N.C.		440T-MSRUE33 ①
	4 N.O.		440T-MSRUE30 ①
110V DC	2 N.O. & 2 N.C.		440T-MSRUE44 ①
	4 N.O.		440T-MSRUE40 ①
	3 N.O. & 3 N.C.		440T-MSRUE46 ①

① Substitute the desired primary code for this symbol i.e. AA, AB, etc

Connection details for solenoid release key



Access is only permitted if all the output devices (K1, K2, etc) have de-energised.

Provided that all the output devices have de-energised, the solenoid is energised allowing the control panel key to be removed (and any additional keys if multiple gates are present/required).

Once the solenoid is energised the key can be rotated to the off position. This disconnects contacts 1&2 and 3&4 on

the isolator and switches the inputs on the 440C-CR30 to "off" (effectively performing an emergency stop command).

The machine can only be energised provided all the control panel keys are inserted and rotated to the on position. On the basis that the solenoid monitoring contacts and any feedback connections are correct, the machine can then be restarted.

le {A}	Contactor Selection		
AC-3	AC-1	30kW (50 Hz)	Catalogue Number
9	32	4	100S-C09**22BC
12	32	5.5	100S-C12**22BC
16	32	7.5	100S-C16**22BC
23	32	11	100S-C23**22BC
30	65	15	100S-C30**22BC
37	65	18.5/20	100S-C37**22BC
43	85	22	100S-C43**22BC
60	100	32	100S-C60**22BC
72	100	40	100S-C72**22BC
85	100	45	100S-C85**22BC

** The catalog number as listed is incomplete. Select a coil voltage code from the tables below

AC Control, 100S-C	
Code	Description
KJ	24V, 50/60 Hz
D	110V, 50Hz
KF	230V, 50/60 Hz
KA	240V, 50/60 Hz

DC Control, 100S-C	
Code	Description
DJ	24V, Integrated diode (60...97 A only)
EJ	24V, Electronic coils (9...55 A only)

Safety Rating

The safety functions initiated by the gates, e-stops and light curtains meet the requirements of Cat 4 PLe according to (EN) ISO 13849-1: 2015 and SIL 3 to IEC 62061: 2005.

List of materials

Safety relay with selectable (Hardware) configuration			
Item	Product	Description	Qty
1	440R-D22R2	Guardmaster Dual Input Safety Relay (DI), 2 Dual Channel Universal Inputs, 1 N.C. Solid State Auxiliary Outputs	2
2	440R-EM4R2	Guardmaster Expansion Module Safety Relay (EM), Expansion Module (Single Wire Safe is only input), 1 N.C. Solid State Auxiliary Outputs	1
3	440R-P226AGS-NNR	MSR42 Multi function Controller for GuardShield Light Curtains	1
4	440R-P4NANS	MSR45E 2NO relay extension module	1
4.1	440R-ACABL1	Description - MSR45E Ribbon cable	1
5	42EF-P2MPB-F4	PHOTOELECTRIC SENSOR	2
5.1	889D-F4AC-5	22 AWG, 300V, 3 A, MOLDED OIL-RESISTANT POLYURETHANE BODY, 5 M	2
5.2	92-109	ACCESSORIES PHOTOELECTRIC SENSORS, REFLECTORS, REFLECTIVE TAPE, REFLECTOR, 51 X 51 MM WITH FIXING HOLES	2

Safety relay with Software configuration			
Item	Product	Description	Qty
6	440C-CR30-22BBB	Guardmaster 440C-CR30 Software configured safety relay, PLe SIL 3, 22 Safety I/O, embedded serial port, USB programming port, 2 Plug-in Slots, 24.0V DC	1
6.1	2080-IQ4OB4	4-ch Digital Input/Output combination module	2
7	440N-Z21SS2H	PLASTIC RECTNGLR FLATPAK	2
7.1	889D-F8AB-10	CORDSET, DC MICRO	2

List of common materials

Equipment common to both Hardware and Software solutions			
Item	Product	Description	Qty
8	450L-B4HN0900YD	450L Safety light curtain Transceiver, Height 900mm, Res: 30mm	4
8.1	450L-APT-PW-5	Transmitter plug-in M12-5Pin	2
8.2	450L-APR-ON-5	Receiver plug-in M12-5Pin	2
8.3	889D-F5EC-10	CONNECTION SYSTEM, CORDSET, DC MICRO, 5-PIN, STRAIGHT FEMALE YELLOW PVC, BRAIDED, 18AWG, 10 M	4
9	440T-MSRUE110A	SOLENOID KEY RELEASE	1
9.1	440T-AKEYE100A	KEY, STANDARD PROSAFE	1
9.2	440T-MDALJ100A0B	Access Interlock - Dual Key with Eject Key, Standard Key Code Labeling, Lever Actuator. Primary key trapped, Secondary spring eject key.	1
9.3	440T-MSRUE110A	SOLENOID KEY RELEASE	1
9.4	440T-AKEYE100A	KEY, STANDARD PROSAFE	1
9.5	440T-MDALJ100A0B	Access Interlock - Dual Key with Eject Key, Standard Key Code Labelling, Lever Actuator. Primary key trapped, Secondary spring eject key.	1
10	42EF-P2MPB-F4	PHOTOELECTRIC SENSOR	4
10.1	889D-F4AC-5	22 AWG, 300V, 3 A, MOLDED OIL-RESISTANT POLYURETHANE BODY, 5 M	4
10.2	92-109	ACCESSORIES PHOTOELECTRIC SENSORS, REFLECTORS, REFLECTIVE TAPE, REFLECTOR, 51 X 51 MM WITH FIXING HOLES	4
11	855E-BVMC	CONTROL TOWER STACK LIGHT MOUNTING BASE	2
11.1	855E-24TL7	CONTROL TOWER STACK LIGHT, 24V AC/DC FULL VOLTAGE	2
12	800FP-MT44	800F MUSHROOM - PLASTIC, 40MM, TWIST	2
12.1	800F-ALM	800F LATCH	2
12.2	800F-X10	800F CONTACT BLOCK	2
12.3	800F-X01S	800F CONTACT BLOCK	4
Pushbutton stations if preference is to have local reset, emergency stop and start			
13	800F-3PM	800F 3 HOLE ENCLOSURE, GRAY PLASTIC	2
13.1	800FP-F3	800F PUSH BUTTON - PLASTIC, FLUSH, GR	2
13.2	800F-BX10	800F CONTACT BLOCK	2
13.3	800FP-F6	800F PUSH BUTTON - PLASTIC, FLUSH	2
13.4	800F-BX10	800F CONTACT BLOCK	2
13.5	800FP-MT44	800F MUSHROOM - PLASTIC, 40MM, TWIST	2
13.6	800F-BX01	800F CONTACT BLOCK	4

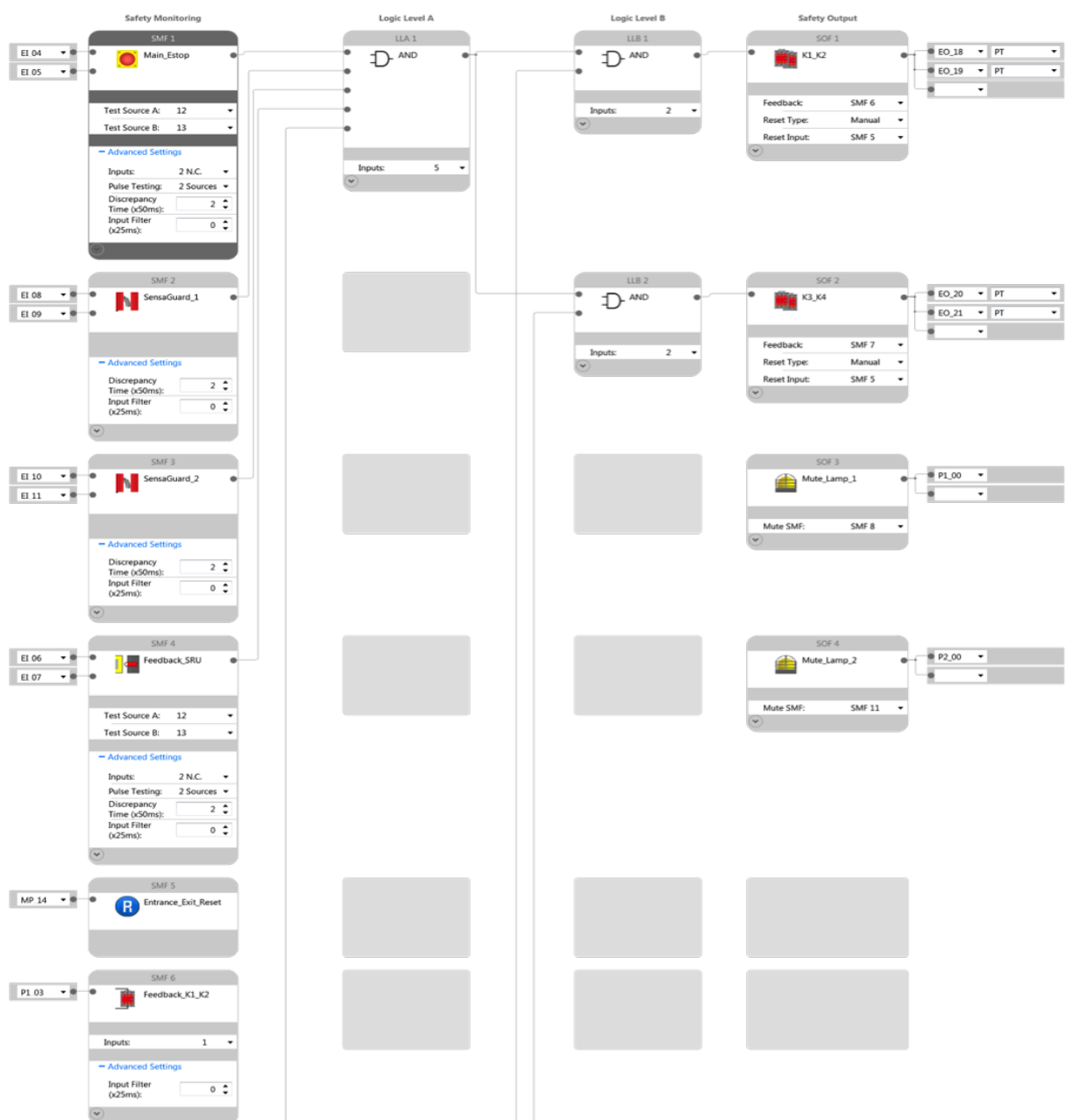
Annex: Function blocks

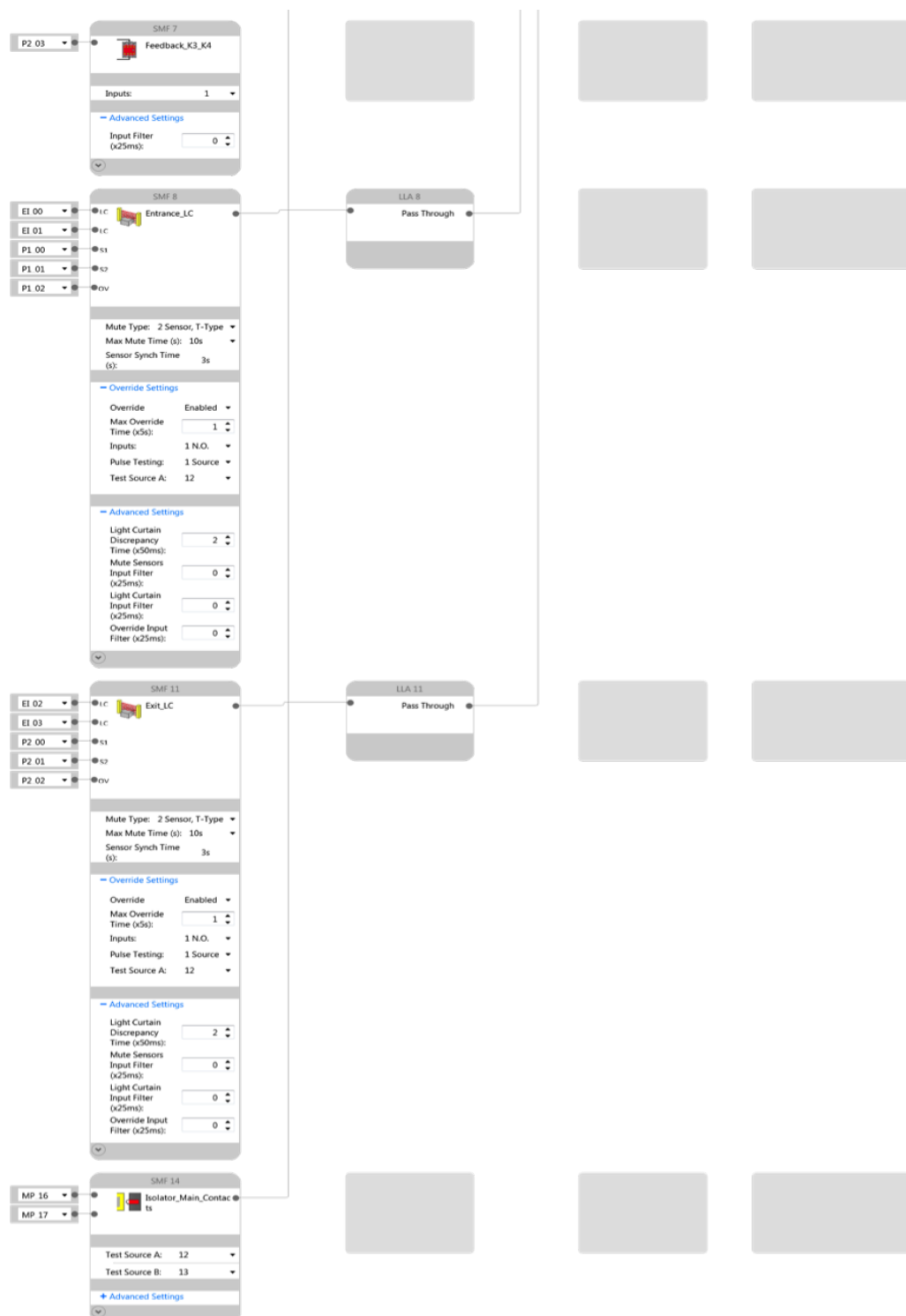
Connected Components WorkBench Overview

This condensed version of the Connected Components Workbench programming software shows the basic logic of the light curtains, e-stops and gate interlock switches. Each light curtain controls a conveyor. The e-stops and gate interlock switches are ANDed together and then ANDed again with the light curtains.

A short video how to configure a 440C-CR30 is provided here:

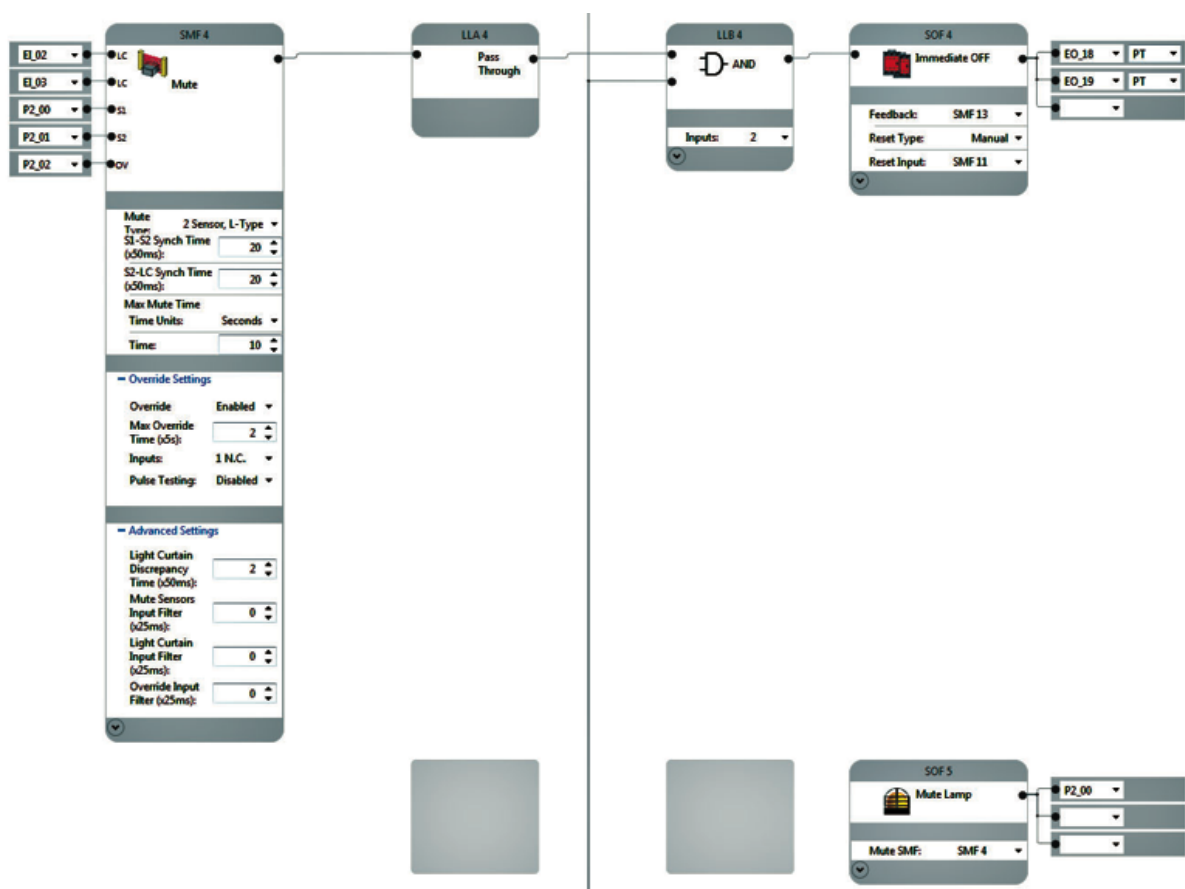
<http://ab.rockwellautomation.com/relays-and-timers/safety-relays/guardmaster-440c-cr30>





Light Curtain

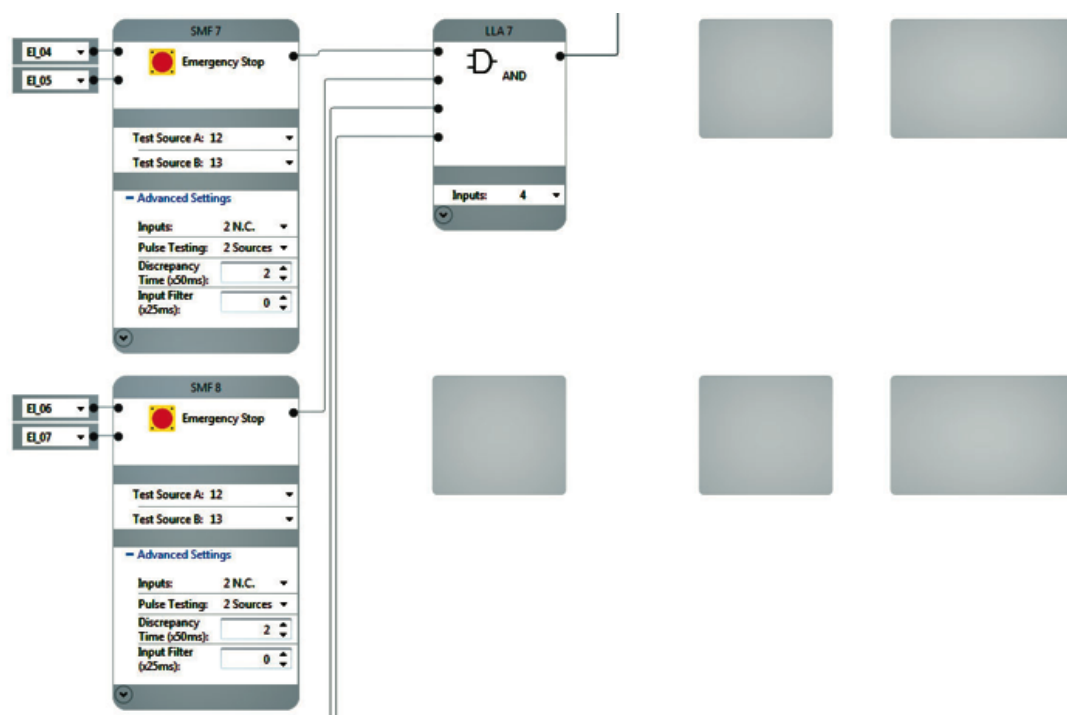
The light curtain used at the entrance and exit is shown in the Safety Monitoring Function blocks (SMF8 and SMF 11). This block includes the muting inputs and the override input. The output of SMF8 is ANDed with the signals from the e-stops and gate switches (SMF1, 2, 3 and 4). The Safety Output Function block (SOF1) enables the motion of the entrance conveyor.



E-Stops

Two e-stop buttons, each with two normally closed mechanical contacts, are located at each of the light curtains. The e-stops use pulse testing outputs from terminals 12 and 13 of the 440C-CR30 to check for potential short circuit conditions.

Pressing either E-stop stops both conveyors.

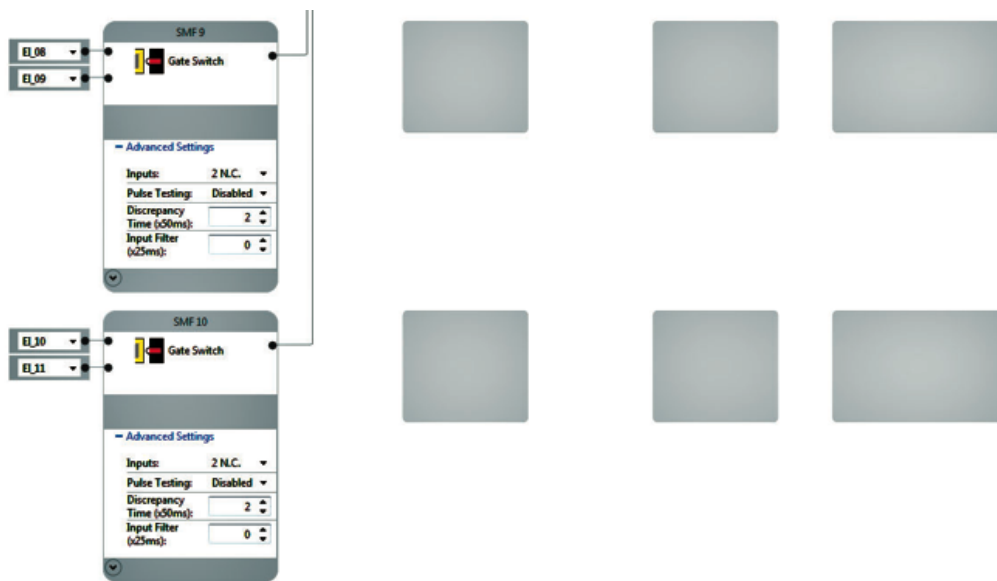


Gate Switches

Two non-contact SensaGuard Interlocks, each with dual OSSD outputs monitor the two safety gates.

Since the SensaGuard interlocks have self-checking OSSD outputs, pulse testing is disabled in the SMF9 and SMF10 blocks.

Opening either gate stops both conveyors.



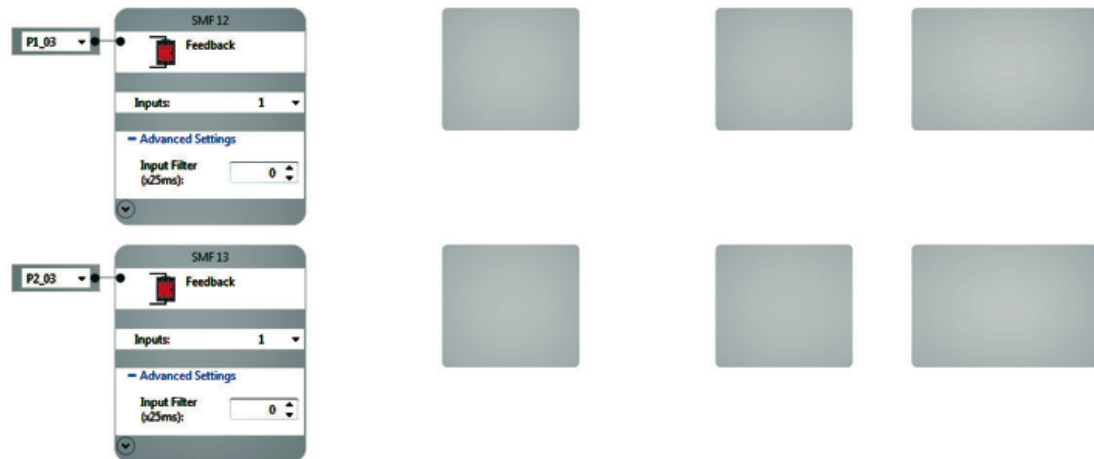
Reset

The safety output function blocks are set for manual reset. The reset input signal resets both safety output blocks.



Feedback Blocks

The two contactors for the entrance conveyor are monitored by SMF6. The two contactors for the exit conveyor are monitored by SMF7. The Input Filters are set to 0.



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