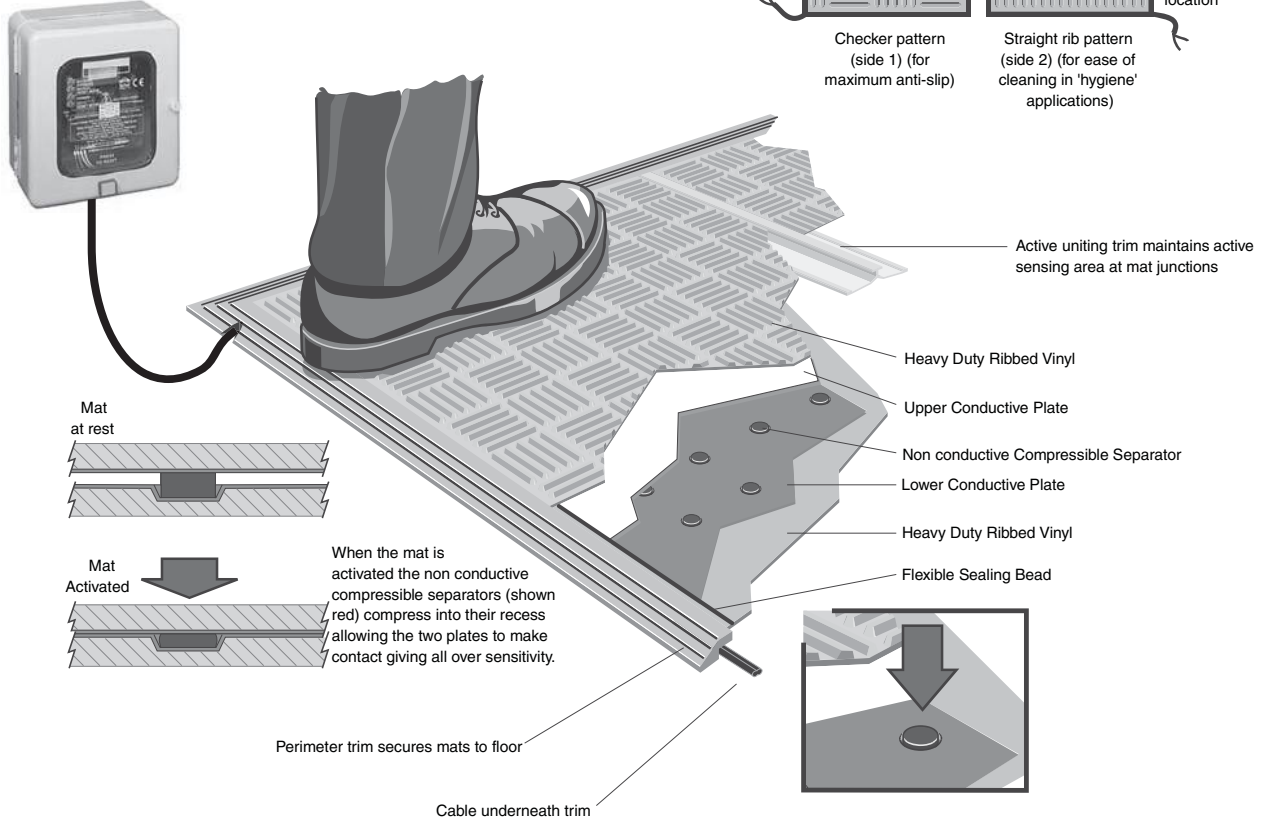


## Anatomy of a Mat System

The controller detects a presence on the mat, a short circuit, or an open circuit. Under each of these conditions, the safety output relays turn off. When interfaced properly, the machine or hazardous motion will receive a stop signal, and an auxiliary output relay turns ON.



2-Safety Mats

## Standards

The MatGuard mat system has been designed to conform with the latest European Standard EN 1760-1 "Safety of machinery—Pressure sensitive devices; mats and floors."

This standard contains requirements for all aspects of design. Some of the most important points are as follows: **(From 4.2.2)** Where an effective sensing area is built up from more than one sensor (mat) it shall have no dead zone.

The standard gives details of the size, force and positioning of test pieces for testing the mat sensitivity.

**(From 4.5.1)** A single sensor (mat) shall still perform its function after one million actuations by a mass of 75 kg.

**(From 4.7)** When the actuating force is applied the output signal switching device(s) shall change from an ON state to an OFF state. It shall remain in the OFF state for at least as long as the actuating force is applied.

**(From 4.7.1)** Device with reset – b) After the actuating force has been removed, the output signal switching device(s) shall only change to the ON state after the application of a reset signal.

**(From 4.7.2)** Device without reset—For a pressure sensitive mat without reset the output signal switching device(s) shall change to an ON state at power ON and after the actuating force has been removed.

**(From 4.15)** The pressure sensitive mats shall meet the requirements of the category for which they are specified...

**Note:** The MatGuard mat system features an "active" mat and a dual channel monitoring control unit. This means that a single electrical fault in the mat, wiring or control unit will be detected and the control unit will go to a safe (OFF) condition.

**(From informative annex B.1.1)** The top (mat) surface should be of a material which will withstand the operating duty....The top surface should not present a risk through becoming slippery due to wear or the effects of liquids....

**(From informative annex B.1.7)** In some situations, heavy loads (such as fork lift trucks) can be applied to the sensor (mat).... If this is required the user should identify the need to the mat manufacturer.

**Note:** The standard MatGuard mat can be successfully used with fork lift trucks. The MatGuard Mat System should be installed in accordance with the requirements of EN 999, "The positioning of protective equipment in respect of approach speeds of parts of the human body."

**The MatGuard Safety Mat system is also designed to meet the U.S. standards ANSI/RIA R15.06-1999 Safety Requirements for Industrial Robots and Robot Systems and ANSI B11.19 Performance Criteria for Safeguarding.**

These two U.S. standards have many similar requirements and provide performance criteria for design, installation and use. Excerpts from these standards include:

**From RIA R15.06**

**(From 11.7)** Safety mat systems shall be designed, constructed, and applied such that any single component failure shall not prevent the stopping action of the robot.

**(From 5.3.4)** Safety mats shall have a minimum object sensitivity which detects 30 kg (66 lb.) weight of an 80 mm (3.125 in.) diameter circular disk anywhere on the mat sensing surface; provide a means to retain minimum object sensitivity at the area where mats joined together.

**From ANSI B11.19**

**(From 11.1.1.4)** The safety mat device shall have a maximum response time that is not affected by object sensitivity adjustments or environmental changes.

**(From 11.1.1.5)** When a component, module, device or system failure occurs, the safety related function shall prevent initiation of the hazardous machine motion, initiate an immediate stop command and prevent re-initiation of the hazardous machine motion.

**From AS 4024.5**

The MatGuard Safety Mat system is designed to meet the Australian Standard AS 4024.5, which has many similarities to the European Standard EN1760-1. Excerpts from this standard include:

**(From 3.2.2)** Where an effective sensing area is built up of more than one sensor, it shall have no dead zone.

**(From 3.7)** When the actuating force is applied the output signal switching device (s) shall change from an 'on' state to an 'off' state. It shall remain in the 'off' state for at least as long as the actuating force is applied.

**(From 3.8)** The sensor shall be provided with a means for fixed permanent location.

**(From 3.10)** Provisions shall be made on the top surface of the sensor to minimize slipping under the expected operating conditions.

**Application Details**

**Safety Distance Calculations ANSI/RIA R15.06**

The minimum distance calculated is the minimum horizontal distance from the outer edge of the MatGuard sensor mat detection zone to the nearest part of the hazard. The formula for floor mounted safety mats is:

$$Ds = [K \times (Ts + Tc + Tr)] + Dpf$$

- **Ds** is the minimum safety distance.
- **K** is a minimum speed constant based on the movement of the hand/arm only and the body being stationary.  
K=1600 mm/s (63 in./s)
- **Ts** is the worst stopping time of the machine/equipment.
- **Tc** is the worst stopping time of the control system.
- **Tr** is the response time of the safeguarding device.
- **Dpf** is the depth penetration factor which is the maximum travel towards the hazard within the safety mat area that may occur before a stop is signalled.  
Dpf=1200 mm (48 in.)

The response time of the machine and control system used in the calculation must be the worst case. Some machines have inconsistent response times that are dependent upon mode of operation, nature of the work piece and point in the operating cycle at which stopping is initiated. An allowance should be made for wear in brakes, temperature, aging of components, etc., if this can affect the response time. An allowance for further delays in the machine control system may be required in some circumstances.

*Calculation Example*

In this example, the MatGuard system is being used with a machine and control system with a worst-case response time measured at 0.485 seconds. The system is on a flat surface, it is not on a raised platform. Using the formula above.

$$T = Ts + Tc + Tr$$

$$= 0.035 + 0.485$$

$$= 0.520 \text{ s}$$

$$S = (63 \times 0.520) + 48$$

$$= 80.76 \text{ in.}$$

Sensor mats will be required from 2032 mm right up to the edge of the machine base plate.

**Safety Distance Calculations EN999**

The minimum distance calculated is the minimum horizontal distance from the outer edge of the MatGuard sensor mat detection zone to the nearest part of the hazard. The formula for floor mounted safety mats is:

$$S = [1600 \times (t1 + t2)] + (1200 - 0,4H)$$

- **S** is the minimum safety distance in mm in a horizontal plane from the danger zone to the detecting edge of the device furthest from the danger zone.
- **1600** is a minimum speed constant based on the movement of the hand/arm only and the body being stationary.  
1600 mm/s = 63 in./s
- **t<sub>1</sub>** is the maximum time between the actuation of the sensing function and the output signal switching devices being in the off state.
- **t<sub>2</sub>** is the maximum response time of the machine, i.e., the time required to stop the machine or remove the risks after receiving the output signal from the protective equipment.
- **1200** is the depth penetration factor which is the maximum travel towards the hazard within the safety mat area that may occur before a stop is signalled.  
1200 mm = 48 in.
- **H** is the distance above the reference plane, e.g., floor, in millimeters.

The response time of the machine and control system used in the calculation must be the worst case time. Some machines have inconsistent response times that are dependent upon mode of operation, nature of the work piece and point in the operating cycle at which stopping is initiated. An allowance should be made for wear in brakes, temperature, aging of components, etc., if this can affect the response time. An allowance for further delays in the machine control system may be required in some circumstances.

*Calculation Example*

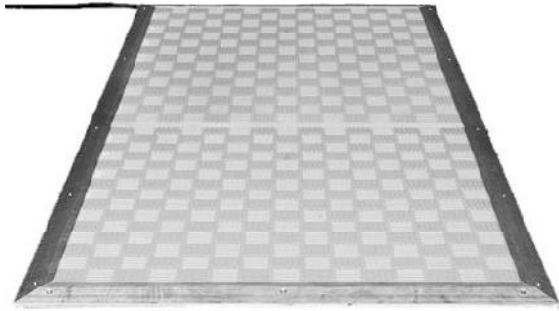
In this example, the MatGuard system is being used with a machine and control system whose worst case response time has been measured as 0.485 seconds. The system is on a flat surface, it is not on a raised platform. Using the formula above,

$$T = \frac{t_1 + t_2}{0.520 \text{ s}}$$
$$S = \frac{(1600 \times 0.520) + 1200}{832 + 1200}$$
$$2032 \text{ mm}$$

Sensor mats will be required from 2032 mm right up to the edge of the machine base plate.

## Presence Sensing Safety Devices

# MatGuard™ Mats



### Description

The MatGuard safety mat is a pressure-sensitive safeguarding product that is designed to detect the presence of people on its sensing surface.

The MatGuard safety mat has two conductive hardened steel plates that are held apart by non-conductive compressible separators. Each four-wire mat, operating on only 24V DC, is pre-wired and connected in series with other mats to form a floor level guarding system for hazardous areas. The circuit through the mat must be monitored by a safety-rated control unit, which may be a Minotaur Safety Relay, MatGuard control unit, or MatGuard Mat Manager. When the mat is clear, the control unit provides a signal to the machine control circuit.

When a mat is stepped on, the conductive plates touch and the resistance in the circuit falls to zero. This is monitored by the control unit, which sends a shutdown signal to the machine.

Since the MatGuard safety mat is completely sealed (IP67), water, liquids and coolants present no problem. In addition, the tough vinyl will resist bleaches, acids, salts and many industrial chemicals.

The unique molding process allows the long life and reliability of the mat.

### Features

- Hardened steel plate construction
- No dead spots
- 4-wire system to detect opens and shorts
- Can withstand a static pressure of 4500 psi
- IP67 rated

### Specifications

Standards	EN1760-1, EN954-1, ISO 13849-1, IEC/EN60204-1, ANSI RIA R15.06, ANSI/B11.19, AS4024.5
Category	Cat. 1 device per EN954-1, suitable for Cat. 3 systems
Certifications	CE Marked for all applicable directives, cULus Listed, CSA Z432-04, and TÜV
Power Supply	24V DC, -20% +10%, provided by the control unit
Connection Wire Length, Max.	200 m (656 ft)
Cable Length	4.5 m (15 ft) standard (see Product Selection)
Detection Weight	30 kg (66 lbs) minimum on an 80 mm (3.125 in.) diameter circular disk
Maximum Pressure Applied to Mat	31,034 kPa (4500 psi)
Zone Size	100 m <sup>2</sup> (1076 ft <sup>2</sup> ), maximum
Mechanical Life	10,000,000 operations
Operating Temperature [C (F)]	-25...55° (-14...131°)
Relative Humidity	100%
Enclosure Type Rating	IP67 (NEMA 6P)
Vibration	5 g, 10...200 Hz
Shock	11 ms 10 g/16 ms 10 g
Terminal Protection	IP 20 DIN 0470
Wire Size	0.75 mm <sup>2</sup> (18 AWG), 2 wire; 3.8 mm x 7.4 mm (0.15 in. x 0.29 in.) jacket OD
Weight	10.9 kg/m <sup>2</sup> (2.2lbs/ft <sup>2</sup> )
Material	Plastisol Vinyl
Color	Yellow or Black
Trim Material	6063 Aluminum
Mounting	Flat surface
Thickness	16 mm (0.63 in.)

**Product Selection—Standard Mats**

Mat Size [mm (in.)]	Cat. No.	
	Standard Perimeter Trim Kit	Safety Mat
500 x 500 (19.7 x 19.7)	440F-T1010	<b>440F-M1010BYNN</b>
500 x 1500 (19.7 x 59.1)	440F-T1030	<b>440F-M1030BYNN</b>
500 x 750 (19.7 x 29.5)	440F-T1015	440F-M1015BYNN
750 x 750 (29.5 x 29.5)	440F-T1515	440F-M1515BYNN
750 x 1500 (29.5 x 59.1)	440F-T1530	<b>440F-M1530BYNN</b>
500 X 1000 (19.7 X 39.4)	440F-T1020	<b>440F-M1020BYNN</b>
750 X 1000 (29.5 X 39.4)	440F-T1520	440F-M1520BYNN
1000 x 1000 (39.4 x 39.4)	440F-T2020	<b>440F-M2020BYNN</b>
1000 x 1250 (39.4 x 49.2)	440F-T2025	<b>440F-M2025BYNN</b>
1000 x 1500 (39.4 x 59.1)	440F-T2030	<b>440F-M2030BYNN</b>
1000 x 1800 (39.4 x 70.9)	440F-T2036	440F-M2036BYNN
Recommended control unit. For other control units, see page 5-69.		<b>440R-C23139</b>

**Examples of Standard System Configurations**

	Bill of Materials		
	Description	Quantity	Cat. No.
	Mat	1	<b>440F-M2030BYNN</b>
	Mat	2	<b>440F-M1010BYNN</b>
	Mat	1	<b>440F-M1030BYNN</b>
	Perimeter Trim*	2	440F-T3210
	Perimeter Trim*	1	440F-T3310
	Active Uniting Trim Used to join two mats to ensure no dead spots	1	440F-T3220
	MatGuard Controllers	1	440F-C4000S
	Corner Trim	4	440F-T3012

**2-Safety Mats**

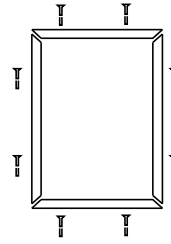
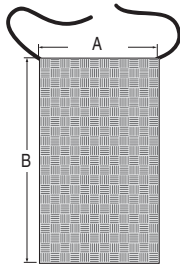
	Bill of Materials		
	Description	Quantity	Cat. No.
	MatGuard Safety Mats	1	<b>440F-M2025BYNN</b>
	MatGuard Safety Mats	1	<b>440F-M1010BYNN</b>
	MatGuard Safety Mats	1	440F-M1015BYNN
	Perimeter Trim*	1	440F-T3310
	Corner Trim	1	440F-T3012
	Uniting Trim	2	440F-T3020
	MatGuard Controllers	1	<b>440F-C4000P</b>

\* Customer must cut trim to proper length.

Presence Sensing Safety Devices  
**MatGuard™ Mats**

**Product Selection—Configurable Mats**

MatGuard safety mat and trim kit cat. nos. can be configured by selecting the appropriate codes from the tables below.



**Mats:** 440F **M** **13** **23** **A** **Y** **NN**  
*a b c d*

**Trim Kit:** 440F **T** **13** **23**  
*e a b*

2-Safety Mats

*a*

"A" Dimension [mm (in.)]	
Code	Description
2 digit number	Length of the mat in millimetres/50 Must be in 50 (1.97) increments Min. allowed 150 (03); Max. allowed 1000 (20) The length of A must be equal to or shorter than B.

*b*

"B" Dimensions [mm (in.)]	
Code	Description
2 digit number	Length of the mat in millimetres/50 Must be in 50 (1.97) increments Min. allowed 200 (04); Max. allowed 1800 (36) The length of A must be equal to or shorter than B.

*c*

Cable Exit	
Code	Description
A	Two 4.5 m (15 ft) 2-wire cables—exit out the A corners
B	Two 4.5 m (15 ft) 2-wire cables—exit out the B corners
C	One 9.1 m (30 ft) 4-wire cable with M12 male connector exits out of upper left corner
D	One 9.1 m (30 ft) 4-wire cable without connector exits out of upper left corner
F	One 0.76 m (2.5 ft) 4-wire cable with M12 male connector exits out of upper right corner
G	One 9.1 m (30 ft) 4-wire cable with M12 male connector exits out of upper left corner for use with 898D Distribution Box
H	One 9.1 m (30 ft) 5-wire cable with M12 male connector exits out of upper left corner for use with ArmorBlock Guard I/O

*d*

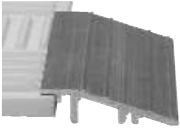





Color	
Code	Description
B	Black
Y	Yellow

*e*

Trim Options	
Code	Description
K	Cable Channel Trim
T	Standard Trim

**Note:** Order controller separately, see page 5-68 for selection details.

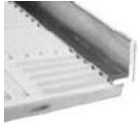
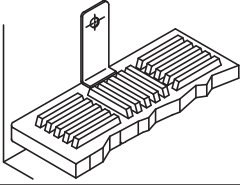
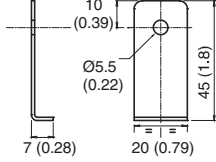
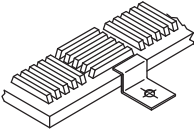
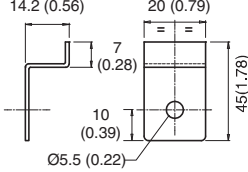
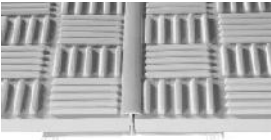






**Product Selection, Trim Options**

Type	Description	Length	Cat. No.
	Standard perimeter trim (aluminum) for use with up to 3 cables running through channel.	2 m, square ends	440F-T3210
	Aluminum standard perimeter trim. For use with up to 3 cables running through channel.	3 m, square ends	440F-T3310
	Aluminum external corner standard perimeter trim	See page 2-99	440F-T3012
	Aluminum internal corner standard perimeter trim		440F-T3013
	Aluminum perimeter trim with cable channel. Used when up to 8 cables need to be fed through channel.	2 m, square ends	440F-T3211
		3 m, square ends	440F-T3311
		4 m, square ends	440F-T3411
	Aluminium external corner perimeter trim with cable channel	See page 2-99	440F-T3014
	Internal corner perimeter trim with cable channel		440F-T3015

**2-Safety Mats**

Presence Sensing Safety Devices  
**MatGuard™ Mats**

Accessories

Type	Description	Dimensions—mm (in)	Cat. No.
	Aluminum right angle perimeter trim	13 x 25 mm, 2 m length (½ x 1 in., 6.6 ft length)	440F-T3216
		13 x 25 mm, 3 m length (½ x 1 in., 9.8 ft length)	440F-T3316
	Stainless steel angle clip perimeter trim (5 per package)		440F-T102933
	Stainless steel z-clip perimeter trim (5 per package)		440F-T102935
	Active uniting trim (used to join two mats to ensure no dead spots)	1 m (3.28 ft) length, square ends	440F-T3120
		1.5 m (4.9 ft) length, square ends	440F-T3020
		2 m (6.5 ft) length, square ends	440F-T3220
		3 m (9.8 ft) length, square ends	440F-T3320
	Vinyl wire guide	63.5 mm (2.5 in.) width, 2 m (6.6 ft) length	440F-T3230
	Accessories kit for 440F-C4000S and 440F-C4000P. 4 butt splices, 2 500 mA fuses, 4 wire terminations	N/A	440F-A108433
	12 Philips flat head, stainless steel screws for 440FA-3211 and 440FT3411 channel trim. Secures top to the bottom.	#6 x 9.5 (3/8)	440F-A17143
	12 Philips flat head, stainless steel screws with anchors for 440F-T3210, 440F-T3310, and 440F-T3510 trim	#10 x 38 (1.5)	440F-A17141
	12 flat head, stainless steel screws with anchors for 440F-T3211 and 440F-T3411 channel trim	#10 x 32 (1.25)	440F-A17142
	DC Micro QD Cordset, 4-pin 1 Brown 2 White 3 Blue 4 Black	2 m (6.5 ft)	889D-F4AC-2
		5 m (16.4 ft)	889D-F4AC-5
		10 m (32.8 ft)	889D-F4AC-10
		15 m (49.2 ft)	889D-F4AC-15
		20 m (65.6 ft)	889D-F4AC-20
		30 m (98.4 ft)	889D-F4AC-30
Reset push button for Mat Manager controllers			800FP-FOPN3YX11

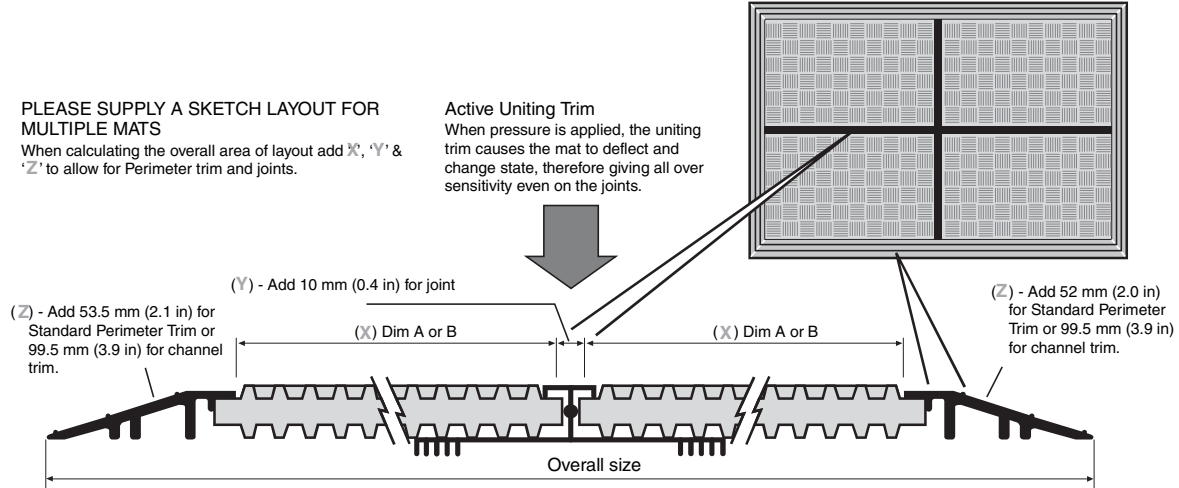


**Approximate Dimensions**

Dimensions are shown in mm (in.). Dimensions are not intended to be used for installation purposes.

**Mat System**

When more than one mat is needed to protect an area, use the dimensions below to determine how large of an area is covered.

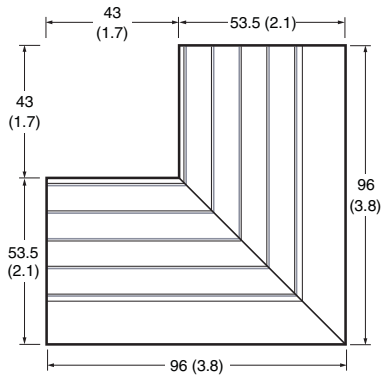


**IMPORTANT** Use the Distance Calculation on page 2-92 to ensure adequate coverage around the hazard.

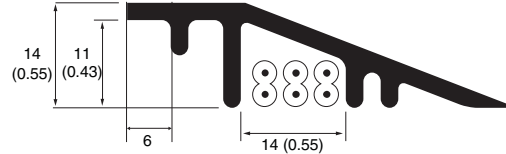
2-Safety Mats

**Standard Perimeter Trim**

Internal and External Corners



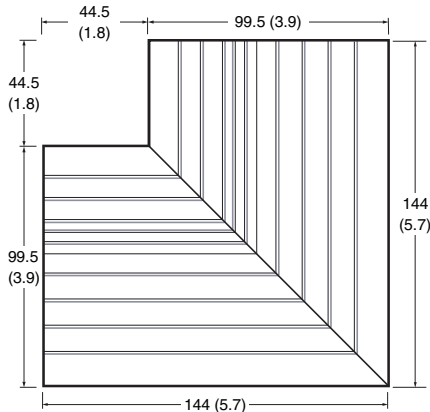
Channel Dimensions



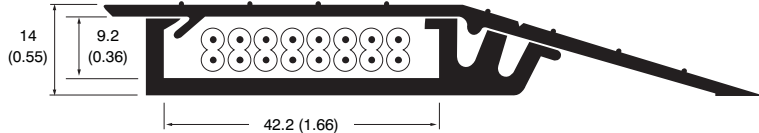
Standard perimeter trim holds three standard 2-wire mat cables or 2 4-wire cables. The equivalent of two cables are needed when connecting two mats in series.

**Perimeter Trim with Cable Channel**

Internal and External Corners



Channel Dimensions



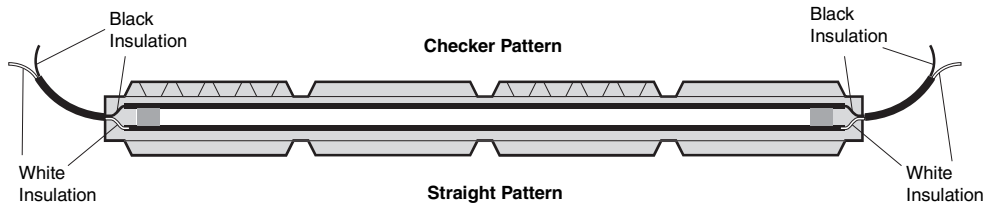
Cable channel trim holds up to 8 standard 2-wire mats cables or 7 4-wire cables even when going around corners.

# Presence Sensing Safety Devices

## MatGuard™ Mats

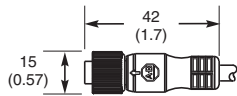
### Connectivity

#### Two-Wire Cable Option



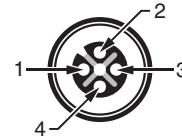
Note: Flat cable O.D. 6.5 mm x 3.5 mm

#### 4-Pin Micro M12 Connector Option [mm (in.)]



Straight Male

Checked Rib Side of Mat



Straight Rib Side of Mat

#### Connection Cables

Cable Exit Configuration Code	Description	Compatibility	Connector	Wire Color	Circuit
A	Two 4.5 m (15 ft) 2-wire cables—exit out the A corners	Safety Relays		Black Black	N.C.
B	Two 4.5 m (15 ft) 2-wire cables—exit out the B corners	Safety Relays		White White	N.C.
C	One 9.1 m (30 ft) 4-wire cable with M12 male connector exits out of upper left corner	Mat Managers		1 Brown 2 White	N.C.
D	One 9.1 m (30 ft) 4-wire cable without connector exits out of upper left corner	Safety Relays		3 Blue 4 Black	N.C.
				1 Brown 2 White 3 Blue 4 Black	N.C.
F	One 0.76 m (2.5 ft) 4-wire cable with M12 male connector exits out of upper left corner	Mat Managers		1 Brown 2 White 3 Blue 4 Black	N.C.
G	One 9.1 m (30 ft) 4-wire cable with M12 male connector exits out of upper left corner	Distribution Block (2 N.C.) 898D-4*LT-DM4	1 Brown 3 Blue	N.C.	
			2 White 4 Black	N.C.	
H	One 9.1 m (30 ft) 5-wire cable with M12 male connector exits out of upper left corner	ArmorBlock Guard I/O	5 2 1 3 4	1 Brown 2 White	N.C.
			4 Black 5 Grey	N.C.	

### Connection to Logic Interfaces

Description	Safety Outputs	Auxiliary Outputs	Terminals	Reset Type	Power Supply	Cat. Page No.	Cat. No.
<b>Single-Function Safety Relays</b>							
MSR131RTP	3 N.O.	2 N.C., 2 PNP Solid State	Removable (Screw)	Auto./Manual or Monitored Manual	24V AC/DC	5-28	440R-C23139
MSR30RT	2 N.O. Solid State	1 N.O. Solid State	Removable	Auto./Manual or Monitored Manual	24V DC	5-16	440R-N23198
<b>Specialty Safety Relays</b>							
MSR23M	2 N.O.	1 N.C.	Fixed	Automatic/Manual Monitored Manual	24V AC/DC	5-66	<b>440R-P23073</b>
Mat Controller	2 N.O.	1 N.C.	Fixed	Automatic/Manual Monitored Manual	24V AC/DC or 115/230V AC	5-68	<b>440F-C4000S</b>
Mat Manager	2 N.O.	1 N.C.	Fixed	Auto./Manual Monitored Manual	24V DC	5-70	<b>440F-C28011</b>
<b>Modular Safety Relays</b>							
MSR210P Base (2 N.C.)	2 N.O.	1 N.C. and 2 PNP Solid State and 2 PNP Solid State	Removable	Auto./Manual or Monitored Manual	24V DC from the base unit	5-82	440R-H23176
MSR220P Input Module (all)	—	—	Removable	—	24V DC	5-86	440R-H23178
MSR320P Input Module (all)	—	2 PNP Solid State	Removable	—	24V DC from the base unit	5-106	440R-W23218

**Note:** For additional Safety Relays connectivity, see the Logic section of this catalog.  
 For additional Safety I/O connectivity, see the Safety I/O section of this catalog.  
 For Application and wiring diagrams, see the Applications section of this catalog.

### Connection Systems

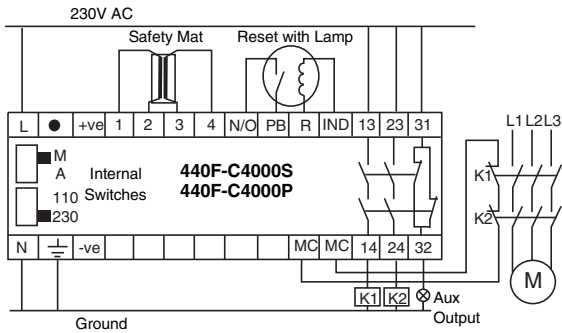
Connection	4-Pin	5-Pin
Cordset	889D-F4AC-*	889D-F5AC-*
Patchcord	889D-F4ACDM-*	889D-F5ACDM-*
Distribution Box	898D-4†LT-DM4	NA
Shorting Plug	898D-41LU-DM	NA
T-Port	898D-43LY-D4	NA

- \* Replace symbol with 2 (2 m), 5 (5 m), or 10 (10 m) for standard cable lengths.
- \* Replace symbol with 1 (1 m), 2 (2 m), 3 (3 m), 5 (5 m), or 10 (10 m) for standard cable lengths.
- † Replace symbol with 4 or 8 for number of ports.

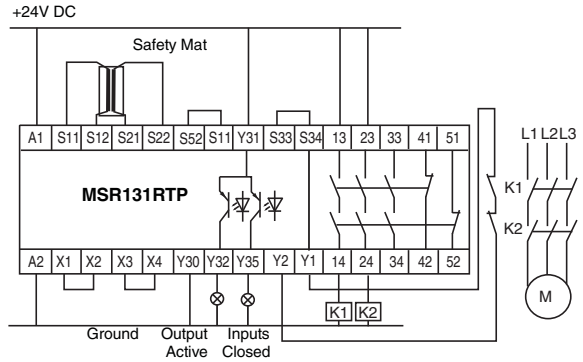
# Presence Sensing Safety Devices

## MatGuard™ Mats

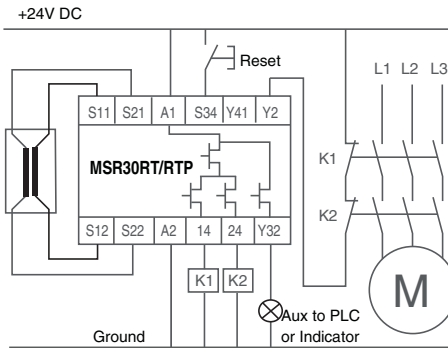
### Typical Wiring Diagrams



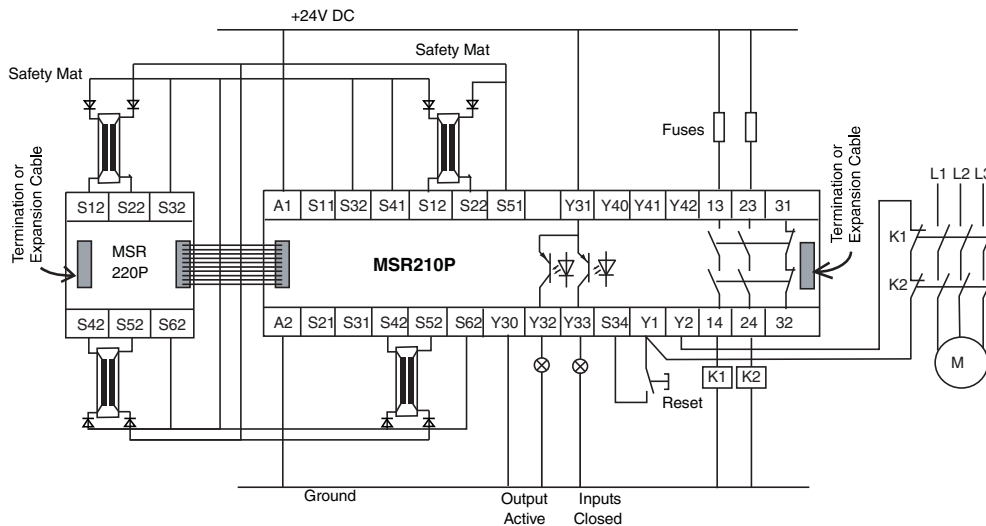
**Safety Mat, Monitored Manual Reset, Dual Channel Output, Monitored Output**



**Safety Mat, Automatic Reset, No Output Monitoring**

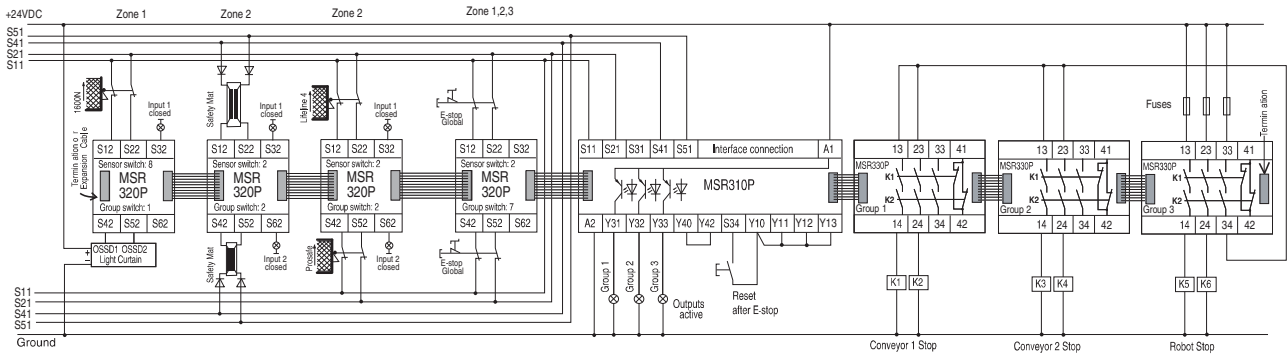


**Safety Mat, Dual Channel Output Monitored, Manual Reset, Output Monitoring**

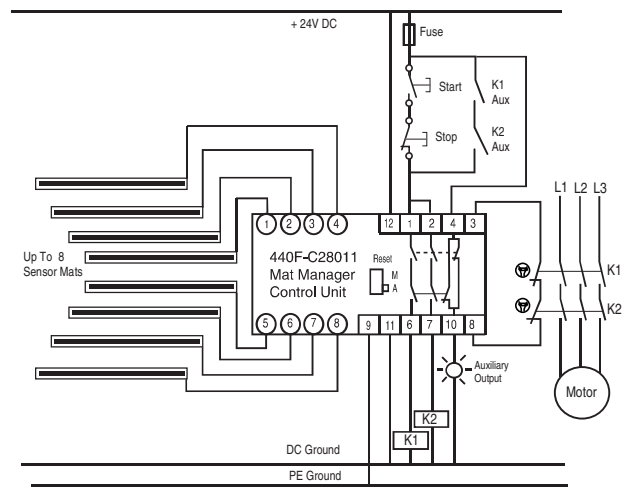
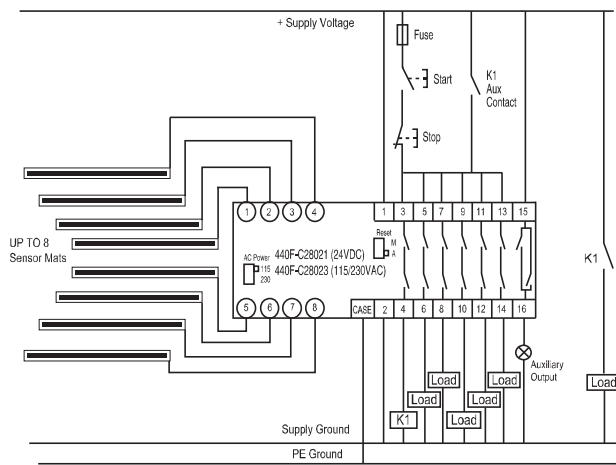


**Four Individually Monitored Safety Mats, Monitored Manual Reset, Dual Output, Output Monitoring**

**Note:** The diodes shown can be terminal blocks with built-in diodes (1492-JD3DF or 1492-JD3DR).



**Note:** The diodes shown can be terminal blocks with built-in diodes (1492-JD3DF or 1492-JD3DR).



**2-Safety Mats**

