



# MINI-SCREEN<sup>®</sup> Instruction Manual

For systems using control box MSCA-1L2 with Latch Output

## MINI-SCREEN Features

- A compact, modular optoelectronic point-of-operation guarding device for smaller production machinery
- Choose Standard or Long-Range emitters and receivers
- Creates a synchronized, modulated infrared light screen in 12 sizes from 100 mm to 1.2 m (4" to 4') high
- Lockable control box
- Control-reliable redundant output relays
- LEDs on control box and receiver indicate system status and emitter/receiver alignment
- Two-beam floating blanking is easily configured inside the control box
- FMEA tested to ensure control reliability
- Highly immune to EMI, RFI, ambient light, weld flash, and strobe light
- Vibration-tolerant factory burned-in emitter and receiver circuitry for toughness and dependability
- Anti-vibration mounts, swivel brackets and small, lightweight tubular sensors for quick installation and easy alignment both on new equipment and in retrofit applications



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## *Applications and Limitations of MINI-SCREEN® Systems*

**MINI-SCREEN Systems are typically used in the following applications:**

- Small assembly equipment
- Molding presses
- Automated production equipment
- Robotic work cells

**MINI-SCREEN Systems may NOT be used with the following machinery:**

- Any machine that cannot be stopped immediately after a stop signal is issued, such as single stroke (also known as “full-revolution”) clutched machinery.
- Any machine with inadequate or inconsistent machine response time and stopping performance.
- Any machine that ejects materials or component parts through the defined area.
- MINI-SCREEN Systems may not be used in any environment that is likely to adversely affect photoelectric sensing system efficiency. For example, corrosive chemicals or fluids or unusually severe levels of smoke or dust, if not controlled, may degrade the efficiency of Banner MINI-SCREEN Systems.

Banner MINI-SCREEN Systems may not be used as tripping devices to initiate machine motion (PSDI applications) on mechanical power presses, per OSHA regulation 29 CFR 1910.217.

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## **Important ... read this page before proceeding!**

In the United States, the functions that Banner MINI-SCREEN® Systems are intended to perform are regulated by the Occupational Safety and Health Administration (OSHA). However, whether or not any particular MINI-SCREEN System installation meets all applicable OSHA requirements depends upon factors that are beyond the control of Banner Engineering Corp. These factors include the details of how the MINI-SCREEN System is applied, installed, wired, operated, and maintained.

Banner Engineering Corp. has attempted to provide complete application, installation, operation, and maintenance instructions. In addition, we suggest that any questions regarding application or use of MINI-SCREEN Systems be directed to the factory applications department at the telephone numbers or address shown at the bottom of this page.

Banner MINI-SCREEN Systems can guard against accidents only when they are properly installed and integrated into the machine, properly operated, and properly maintained. See Section 3 of this manual for installation procedures, considerations, and precautions. See Sections 4 and 5 for operating and maintenance information. **It is the responsibility of the purchaser and/or user to apply this MINI-SCREEN System in full compliance with OSHA regulations.**

In addition to OSHA regulations, several other organizations provide informational material on the use of machine guard devices. The user is referred to the American National Standards Institute (ANSI), the Robotics Industries Association (RIA), the American Metal Stamping Association (AMSA), and others. Banner Engineering Corp. makes no claim regarding a specific recommendation of any organization, the accuracy or effectiveness of any information provided, or the appropriateness of the provided information for a specific application.

The user has the responsibility to ensure that all local, state, and national laws, rules, codes, and regulations relating to the use of this machine guarding system in any particular application are satisfied. Extreme care is urged to ensure that all legal requirements have been met and that all installation and maintenance instructions contained in this manual are followed.

### **Caution!!**

Banner MINI-SCREEN Systems are for use only on machinery that can be stopped immediately after a stop signal is issued. They may be used with part-revolution clutched machines that have the ability to stop at any point in their stroke. **Under no circumstances may the MINI-SCREEN System be used on full-revolution clutched machinery.** Banner MINI-SCREEN Systems may not be used as tripping devices to initiate machine motion (PSDI applications) on mechanical power presses, per OSHA regulation 29 CFR 1910.217.

#### **U.S. Standards Applicable to Use of MINI-SCREEN Systems**

ANSI B11 Standards	<i>Safeguarding of Machine Tools</i>
ANSI/RIA R15.06	<i>Safety Requirements for Robot Systems</i>
NFPA 79	<i>Electrical standard for Industrial Machinery</i>

*See page 58 for information on these and other applicable standards, and where to acquire copies.*

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# System Introduction

## 1. MINI-SCREEN System Introduction

The Banner MINI-SCREEN System is a microprocessor-controlled, opposed-mode optoelectronic light screen (or "curtain of light"). It is designed for use as a point-of-operation guarding device, and is especially suited to smaller production machinery.

Banner's microprocessor-based circuit raises the level of control reliability in machine guard design. The MINI-SCREEN System design incorporates "diverse redundancy," in which two microprocessors of different design, running from two different instruction sets, constantly check all system components, including each other. Banner MINI-SCREEN Systems are extensively FMEA (Failure Mode and Effects Analysis) tested to establish an extremely high degree of confidence that no system component will ever, even if it does fail, cause a *failure to danger*.

In typical operation, if any part of an operator's body (or any opaque object) of more than a predetermined cross section enters the guarded area of the machine, the output relays of the MINI-SCREEN System will open. The output relay contacts are connected to the guarded machine's primary control elements (MPCEs) which immediately stop the motion of the guarded machine. The output relays have forced-guided contacts for enhanced control reliability.

The *floating blanking* feature of the MINI-SCREEN System allows for the movement of multiple workpieces through the light screen at any point. Use of floating blanking affects the *minimum object sensitivity* (see section 2.1).

The Banner MINI-SCREEN System is a modular machine guard system. Each system is made up of an MSE Series emitter, an MSR Series receiver, and a control box (model MSCA-1L2), see Figure 1 and cover photo. The three MINI-SCREEN System components are interconnected using two 5-wire shielded cables with QD (Quick-Disconnect) connectors at one end, to connect to the emitter and the receiver.

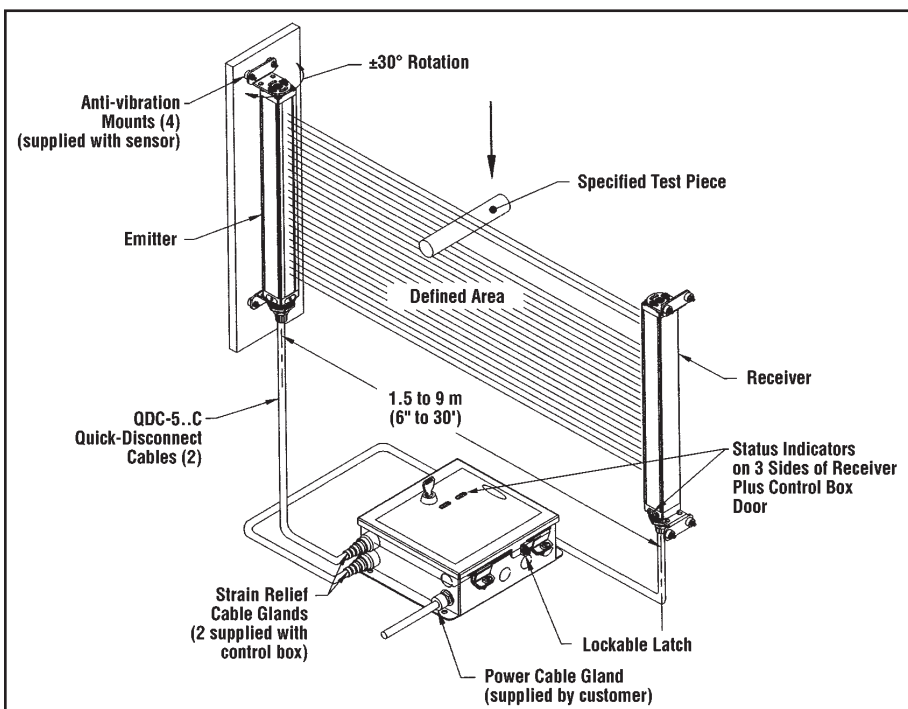


Figure 1. Banner MINI-SCREEN System: emitter, receiver, control box and two interconnecting cables.

Emitters have a row of synchronized modulated infrared (invisible) light-emitting diodes (LEDs) in a compact rectangular metal housing. Receivers have a corresponding row of synchronized phototransistors. Emitters and receivers are available in 12 lengths ranging from 102 mm to 1.2 m (4" to 4'), based on the height of the defined area (see page 6). The rectangular sensor design includes a swivel bracket at each end for quick mounting and ease of alignment. Control boxes and receivers have LED indicators for system operating status and alignment. Each receiver has three sets of status LEDs (front and both sides) for high visibility. Emitters have a POWER ON indicator.

MINI-SCREEN emitters and receivers are available with the choice of two sensing ranges (maximum emitter-to-receiver separation): 9 m (30') or 18 m (60'). With no blanking in use, the *minimum object sensitivity* of 30' range sensor pairs is 19 mm (0.75"), and 25 mm (1.0") for 60' range sensor pairs.



**WARNING . . .**  
**Do Not Connect Multiple Pairs of Sensors to One Control Box**

The MINI-SCREEN System uses *one pair of sensors* connected to *one control box*. Connection of multiple pairs of sensors to a single control box can result in serious injury or death.

NOTE: Banner MULTI-SCREEN® and Dual MINI-SCREEN® Systems are designed for connection of two sensor pairs.

The control box contains a power supply (to power the control box itself and an emitter and receiver), a microprocessor controller module to control sensing logic, and a replaceable relay board with forced-guided output relays. Diagnostic LEDs on the controller module (visible through a clear window in the control box cover) identify eight trouble causes. A Key Reset switch is mounted in the front of the control box for resetting the system at power-up or from fault (lockout) conditions. The selectable Auto Power-up feature makes a Key Reset unnecessary at system power-up.

The control box has a "latch" output which requires a manual reset after the defined area is cleared, following an interruption. The latch output is used in perimeter-guarding applications, where it is physically possible for personnel to enter into the area of hazardous motion by passing through the defined area; or where additional machine control (via the Latch Reset) is desired or required. The control box is powered by 115V ac. The control box automatically recognizes the length and style of the sensor pair wired to it – no programming is necessary.

The *minimum object sensitivity* is the minimum-diameter object that the light screen can reliably detect anywhere within the defined area. *Minimum object sensitivity* directly affects the minimum allowable distance between the defined area of the light screen and the nearest hazard point (the separation distance). See Section 3.2.

Banner MINI-SCREEN Systems are designed for convenient and dependable operation in difficult industrial environments. The microprocessor controller module has a plug-in design for easy configuring or replacement. The output relay module is easily replaceable. The control box enclosure is rated NEMA 13 (IP 64) and features a lockable cover.

Emitter and receiver circuits are designed to meet high standards for vibration resistance. Every MINI-SCREEN System emitter, receiver, and controller module is serialized and undergoes extensive burn-in testing at the factory.

Unlike some competitive systems, matched sets of MINI-SCREEN components are not required. Any MINI-SCREEN System emitter and receiver (of equal length and having the same range) may be used together with any control box.

A functional schematic diagram of the MINI-SCREEN System appears on page 11. For MINI-SCREEN System dimension drawings, see pages 21 and 22. For specifications, see page 52.

The components of a MINI-SCREEN system may be purchased separately, or they may be purchased bundled together in kit form. The components and kits are listed on the next page.

# System Introduction

## 1.1 MINI-SCREEN Components and Kits

MINI-SCREEN Systems are sold as kits which include:

- **A 115V ac control box;**
- **A compatible emitter and receiver** (of equal length and range). Emitters and receivers are available with standard (9 m/30') or long (18 m/60') operating ranges, and in two finishes: black anodized or yellow painted. They are available in lengths ranging from 114 mm (4.5") to 1219 mm (48"). The longer the sensor, the more beams it has, as shown in the chart below.
- **Hardware** for mounting the emitter and the receiver; and
- **Two quick-disconnect cables** (see page 55). Cables are interchangeable between the emitter and the receiver. Choose from three sizes (4.5 m/15', 7.6 m/25', or 15 m/50'), each with a straight Mini-style QD connector. Contact the factory Applications Department for information on cable lengths greater than 50'.

Components are also available separately (see page 54). See the Banner Machine Safety Products catalog or price list for a complete list of available kits.

MINI-SCREEN Emitters and Receivers												
Length of Defined Area	114 mm (4.5")	215 mm (8.5")	305 mm (12")	406 mm (16")	508 mm (20")	610 mm (24")	711 mm (28")	813 mm (32")	914 mm (36")	1016 mm (40")	1118 mm (44")	1219 mm (48")
Number of Beams	8	16	24	32	40	48	56	64	72	80	88	96

### Pigtail Quick-Disconnect Option

Any emitter or receiver may be ordered with a 305 mm (12") cable pigtail, terminated in the 5-pin male Mini-style quick-disconnect connector. This option accommodates requirements for right-angle exit of the cable from the base of the emitter and/or receiver, and uses the same mating quick-disconnect cables, as listed on page 54 (ordered separately). To specify a pigtail quick-disconnect cable, add suffix "P" to the model number of the emitter or receiver (for example, **MSE1624YP**).

## 2. Overview of MINI-SCREEN System Operation

In operation, a compatible emitter and receiver (of equal length and range) are mounted and aligned opposite each other. This establishes a curtain of invisible infrared light beams called the *defined area* (Figure 1). Center-to-center spacing between adjacent light beams is 12.7 mm (0.5").

Individual features of the MINI-SCREEN System are discussed in the following subsections:

- Blanking (Section 2.1)
- Auto Power-up (Section 2.2)
- Lockout Conditions and Key Resets (Section 2.3)
- Operating Status Indicator Lights (Section 2.4)
- Diagnostic Indicator LEDs (Section 2.5)
- Output Relay Operation (Section 2.6)
- Control Reliability: Redundancy and Self-checking (Section 2.7)

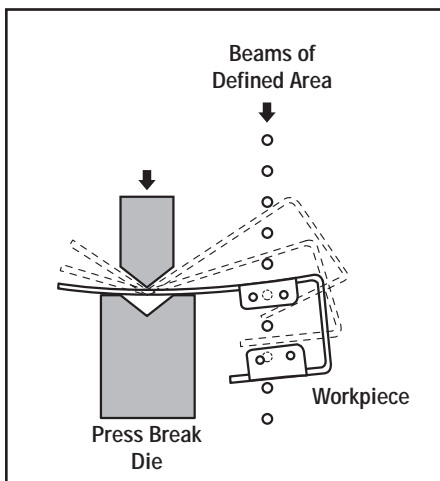


Figure 2. Two-beam floating blanking

### 2.1 Blanking

MINI-SCREEN Systems may be configured to be “blind” to the passage of multiple objects of limited size through the defined area. This is useful in press brake and other applications where multiple blanked zones (moveable or stationary) are needed. (Blanking ON is indicated by a flashing green status indicator LED on the receiver and the control box.)

*Floating blanking* is the “blinding” of one or groups of two adjacent sensing beams, which will appear to change position (“float”) in order to allow multiple objects (usually workpiece material) to move through the defined area, at any point, without tripping the final switching device relays of the MINI-SCREEN System. *With floating blanking ON, any and every one- or two-beam blockage(s) will be ignored.* See Figure 2.

Minimum Object Sensitivity			
Sensor Type	Floating Blanking	Maximum Size of Undetected Objects*	Minimum Object Sensitivity
9 m (30') Range	OFF	(Not applicable)	19.1 mm (0.75")
	ON	20.3 mm (0.80")	44.5 mm (1.75")
18 m (60') Range	OFF	(Not applicable)	25.4 mm (1.00")
	ON	16.5 mm (0.65")	50.8 mm (2.00")

\*NOTE: This assumes that the object encounters the light screen perpendicular to the plane of the light beams.

Floating blanking is turned ON or OFF via a pair of DIP switches on the controller module inside the control box (see Figure 18 and Section 3.4). The control box has a lockable cover to prevent unauthorized access to the blanking settings.

### 2.2 Auto Power-up

Normal operation of the MINI-SCREEN System requires a Key Reset each time power is applied to the system. This is usually a desired response to a power failure or interrupt, and is required by some design standards. In applications where a Key Reset is difficult to perform, the Auto Power-up feature may be selected, which puts the MINI-SCREEN System directly into RUN mode when power is applied.

Auto Power-up is enabled or disabled via a pair of DIP switches located on the controller module inside the control box. See Figure 18 and Section 3.4 for details.



**WARNING . . .**  
Use of Auto Power-up

Application of power to the MINI-SCREEN System **must NOT initiate dangerous machine motion**. Machine control circuitry must be designed so that one or more initiation devices be engaged to start the machine, after the MINI-SCREEN is placed in RUN mode.

### 2.3 Lockout Conditions and Key Resets

A *lockout condition* of the MINI-SCREEN System causes *all* of its output relays to open, sending a Stop signal to the guarded machine. A lockout condition will occur:

#### Power-up/Power Interrupt Lockouts

- Upon power-up of the MINI-SCREEN System (unless Auto Power-up is ON; see Figure 5, page 10); or
- If ac power to the MINI-SCREEN System is interrupted (unless Auto Power-up is ON; see Figure 5).

#### Internal Lockout Conditions

- If the control box Key switch is in the RESET position, at power-up (with Auto Power-up ON); or if the Key switch is switched to RESET while the System is in RUN mode;
- If an FSD (Final Switching Device, see Glossary) relay does not “drop out” within its specified time;
- If the SSD (Secondary Switching Device, see Glossary) relay has de-energized;
- If the controller module switch settings are inconsistent with each other or if they are changed while the system is in RUN mode; or
- If the self-checking circuits of the microprocessor detect a component failure within the MINI-SCREEN System itself.

A lockout condition resulting from an internal system fault is indicated by a flashing red status indicator on the control box and the receiver. The green and yellow status indicators will be OFF. See Figure 5, page 10.

**Power-up/power interrupt lockouts** (Auto Power-up OFF, conditions as described above, yellow status indicator only double-flashing) are normal and require a Key Reset for operation to continue.

**Internal lockout conditions** result from component failures or incorrect controller settings, which must be corrected before the System will allow operation to continue (Section 2.7). Diagnostic Indicator LEDs (located inside the control box on the controller module, and visible through a window in the control box cover) indicate the cause of the lockout (Section 2.5). Internal lockout conditions also require a Reset of the Key switch on the control box cover (a Key Reset) to return the System to RUN mode. To perform a Key Reset, turn the Key switch to the RESET position, hold it there for at least 1/2 second, and then return the Key switch to the RUN position.



## 2.4 Operating Status Indicator Lights

The control box front panel and the receiver have the following operating status indicator LEDs (see Figures 3 and 4): green (CLEAR), red (LATCHED), and yellow (RESET). Their indications are as follows:

**Red ON steadily and Yellow single-flashing\* (latched condition):** the MINI-SCREEN System has been reset and is in RUN mode, but either there is an obstruction in the defined area or the emitter and receiver are misaligned. FSD1, FSD2, and Alarm contacts are open (de-energized). SSD relay is closed (energized).

A flashing yellow status indicator designates sensor alignment. The faster the flash rate, the more beams are "made," and the fewer beams are blocked or "not made." This feature is helpful for emitter/receiver alignment (Section 6.1). When alignment is correct, the Green light will come ON (to join Yellow and Red light) when the obstruction is removed. If alignment is not correct, the Green light will remain OFF when the obstruction is removed.

**Red, Green\*\*, and Yellow ON steadily:** the MINI-SCREEN System has been reset and is in RUN mode, but is waiting for a latch reset (see section 3.5.1.1). The defined area is clear of obstructions, and the emitter and receiver are properly aligned. FSD1 and FSD2 contacts are open (de-energized). The SSD contact is closed (energized).

**Green\*\* and Yellow ON steadily:** the MINI-SCREEN System has been reset and is in RUN mode, the defined area is clear of obstructions, and the emitter and receiver are properly aligned. SSD, FSD1, and FSD2 contacts are closed (energized).

**Red (only) ON and flashing:** a lockout condition exists, due to an internal MINI-SCREEN System problem. SSD, FSD1 and FSD2 contacts are all open (de-energized). The Alarm contacts are closed.

**Yellow (only) ON and double-flashing:** a *double-flashing* Yellow status indicator indicates a power-up or power interrupt lockout condition. *These lockouts occur in the normal course of powering up the MINI-SCREEN System or upon an interruption of power to the System (unless Auto Power-up is ON; see Figure 5).* SSD, FSD1, FSD2, and Alarm contacts are open (de-energized).

**Yellow (only) ON steadily:** the Key switch has been switched to the RESET position at power-up. FSD1, FSD2, and Alarm contacts are open (de-energized); SSD contacts are closed (energized).

\*If the Test Input terminals are shorted and the defined area is clear, the Yellow status indicator will be ON steadily (see Section 3.5.7).

\*\* A flashing Green status indicator shows that blanking is ON.

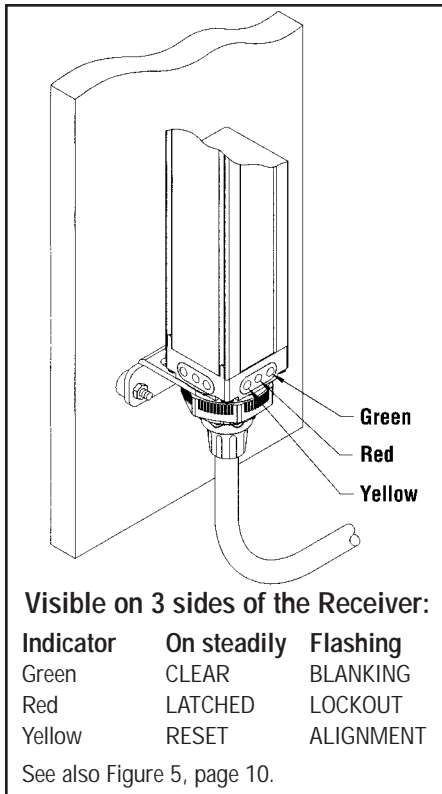


Figure 3. Receiver status indicator LEDs

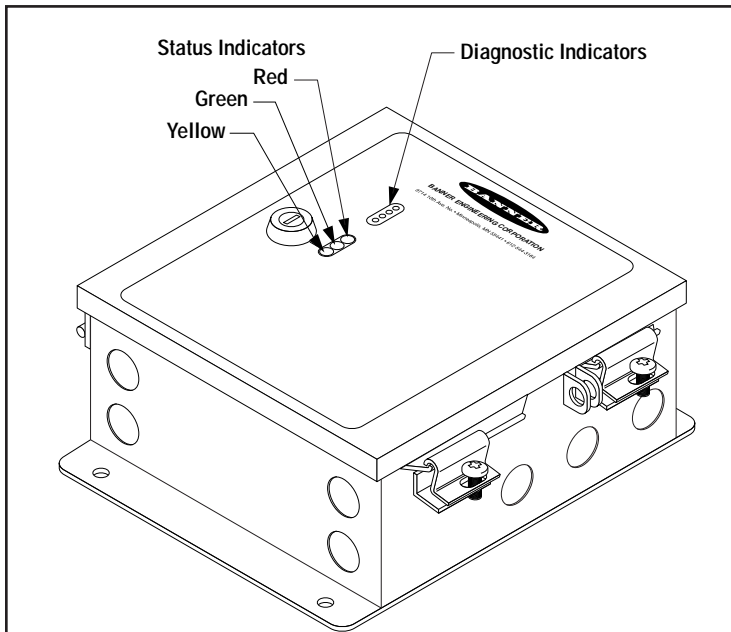


Figure 4. Control box indicator LEDs

# System Overview

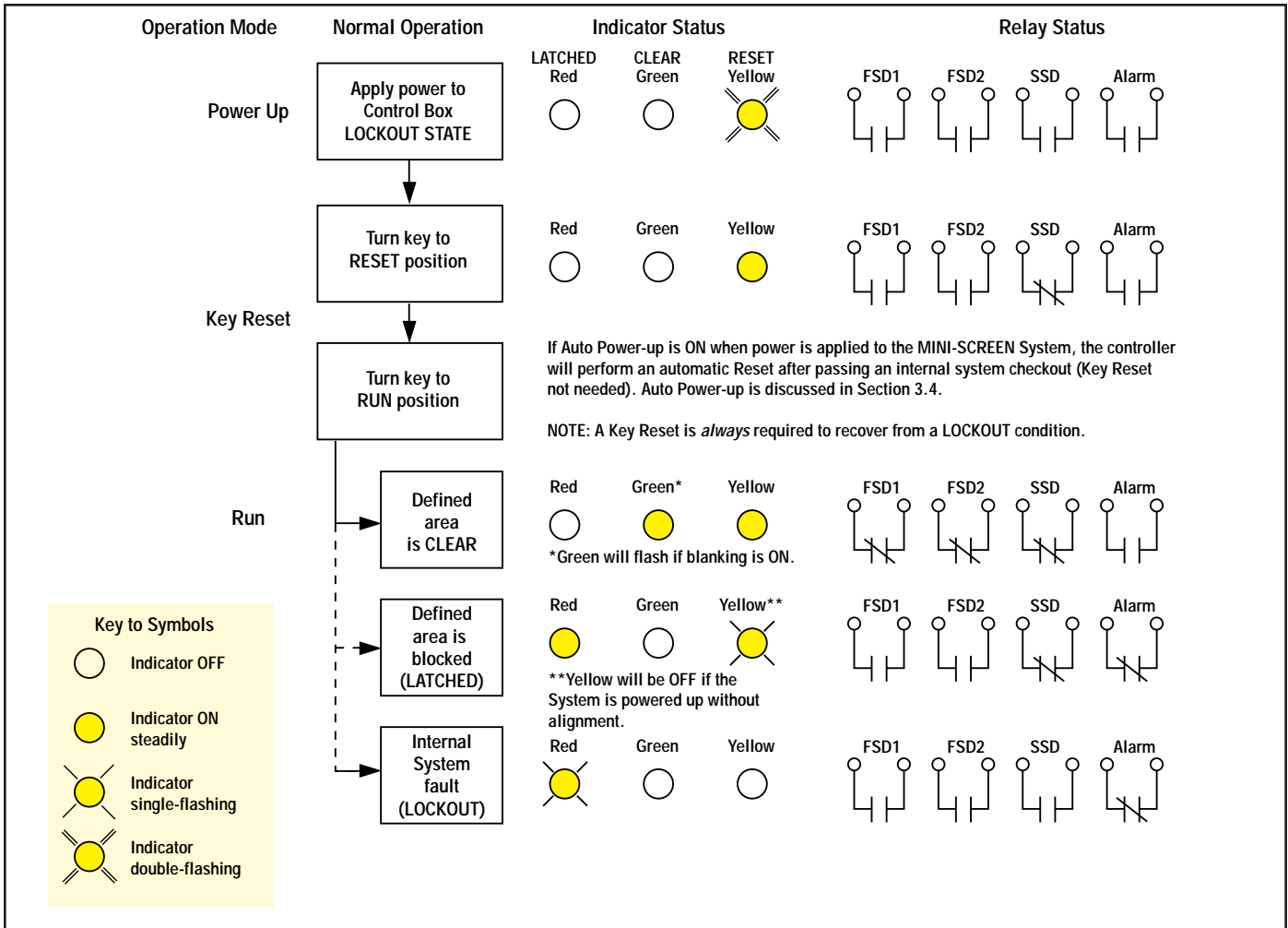


Figure 5. Operating status conditions

## 2.5 Diagnostic Indicator LEDs

Four diagnostic indicator LEDs are located on the controller module. They are visible through a transparent window in the control box cover. Refer to Figure 4 (page 9).

The purpose of the diagnostic indicator LEDs is to assist in troubleshooting by indicating the possible causes of internal MINI-SCREEN System problems (lockouts) that are discovered as a result of the controller's self-checking function.

The green diagnostic indicator LED is always ON when power is applied to the controller, unless a controller microprocessor has failed. Refer to Section 5.1 and Figure 24 for instructions on interpreting the various combinations of lit diagnostic indicator LEDs.

## 2.6 Output Relay Operation

The MINI-SCREEN System control box has three output relays labeled “FSD1,” “FSD2,” and “SSD,” plus an Alarm Relay (see Figure 6, below). The contacts of the Final Switching Device (FSD) relays (FSD1 and FSD2) are connected to the Machine Primary Control Elements (MPCEs) of the guarded machine. An MPCE is an electrically powered element of the guarded machine that directly controls the machine’s normal operating motion in such a way that it is last (in time) to operate when motion is either initiated or arrested. The Secondary Switching Device (SSD) relay contacts are connected to the guarded machine’s Machine Secondary Control Element (MSCE), an electrically powered element of the guarded machine (independent of both MPCEs) that is capable of removing power from the prime mover of the dangerous part of the machine in the event of a system fault. The two MPCEs must each (alone) be capable of stopping the motion of the guarded machine in an emergency. The opening of any FSD1, FSD2, or SSD relay contact results in the removal of power to either an MPCE or MSCE (or both), which will stop the motion in the guarded machine.

Any object that blocks one or more unblanked beams will be detected, and will cause a latch condition: output relays FSD1 and FSD2 (but not SSD) in the control box open their contacts. All three output relays (FSD1, FSD2, and SSD) will open their contacts in response to any one or more of seven lockout conditions, including component failure within the MINI-SCREEN System itself (see Control Reliability, Section 2.7). The MINI-SCREEN System requires a Key Reset of the latch to resume operation following a latch condition.

### Key Reset Procedure

To perform a Key Reset, turn the Key switch clockwise to the RESET position, hold it there *for at least 1/2 second*, and then return the Key switch to the RUN position.

Internal lockout conditions also require a Key Reset to return the System to RUN mode.

The Alarm Relay is a separate relay **intended for non-safety-related purposes**. It is typically used to signal a programmable logic controller (PLC) when a latch or lockout condition occurs. (See Section 3.5.6 for more information.)

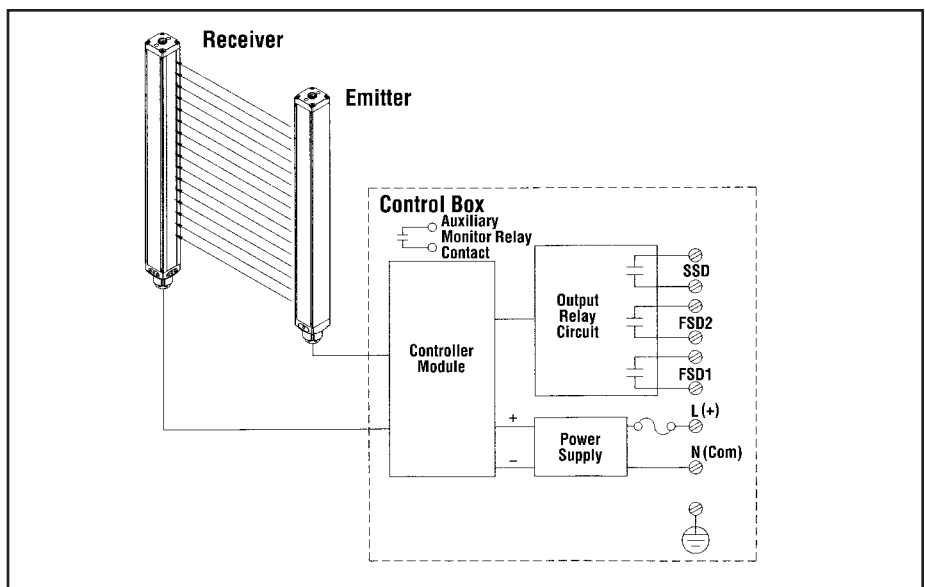


Figure 6. Banner MINI-SCREEN System functional schematic

### 2.7 Control Reliability: Redundancy and Self-checking

MINI-SCREEN Systems meet certain U.S. and international control reliability standards for safety. Banner MINI-SCREEN Systems must reliably send a Stop signal to a guarded machine as follows:

- 1) The MINI-SCREEN System must provide a Stop signal to the guarded machine whenever the defined area is interrupted, within 48, 60, or 72 milliseconds (depending upon sensor length; see Specifications, page 52).

In order for the machinery guarded by the MINI-SCREEN System to be stopped as described, *the guarded machine must be capable of stopping at any point in its machine cycle*. This means that the MINI-SCREEN System cannot be used with certain types of machinery, such as single stroke (also known as “full revolution” clutched) machinery, or any machine with inconsistent machine response time and stopping performance. If there is any doubt about whether or not your machinery is compatible, contact the Banner Factory Application Engineers.

- 2) The MINI-SCREEN System must provide a Stop signal to the guarded machine when internal component failures have occurred which compromise the integrity of the MINI-SCREEN System itself.

This type of component failure includes any internal MINI-SCREEN System failure which could prevent or delay the output relays of the MINI-SCREEN System from going to a latch condition or a lockout condition in response to a situation which, in normal operation, would cause them to do so. The ability of the MINI-SCREEN System to send a Stop signal even when such a component failure has occurred depends upon its redundant design.

*Redundancy* requires that MINI-SCREEN System circuit components be “backed up” to the extent that, if the failure of any single component will prevent effective stopping action when needed, that component must have a redundant counterpart which will perform the same function.

The microprocessor-controlled MINI-SCREEN System is designed with *diverse redundancy*. Diverse-redundant components are of different designs, and their microprocessor programs run from different instruction sets.

Redundancy must be maintained for as long as the MINI-SCREEN System is in operation. Since a redundant system is no longer redundant once a component has failed, MINI-SCREEN Systems are designed to be continuously *self-checking*. A component failure detected by or within the self-checking system causes a Stop signal to be sent to the guarded machine and puts the MINI-SCREEN System into a lockout condition.

Recovery from this type of lockout condition requires replacement of the failed component (to restore redundancy) and a Key Reset see (page 11). Possible causes of lockout conditions are listed in Section 2.3. The Diagnostic Indicator LEDs are used to diagnose internal causes of a lockout condition (Section 5.1).

## 3. System Installation and Alignment



### CAUTION . . .

#### Install System Only on Appropriate Applications

In order for the machinery guarded by the MINI-SCREEN System to be stopped as described, *that machinery must be capable of stopping at any point in its machine cycle.* This means that the MINI-SCREEN System cannot be used with certain types of machinery (see listing at right). **If there is any doubt about whether or not your machinery is compatible with the MINI-SCREEN System, contact Banner's Application Engineers at the factory.**

### 3.1 Appropriate Application

The MINI-SCREEN System may only be used to guard machinery that is *capable of stopping motion immediately* upon receiving a Stop signal and at any point in its machine cycle.

The MINI-SCREEN System may not be used with the following:

- With single stroke (also called "full revolution") clutched machinery, as this type of machinery is incapable of stopping immediately.
- On certain other types of machinery, including any machine with inadequate or inconsistent stopping response time, or any machine that ejects materials or component parts through the defined area.
- In any environment likely to adversely affect the efficiency of a photoelectric sensing system. For example, corrosive chemicals or fluids or unusually severe levels of smoke or dust, if not controlled, may degrade the efficiency of the MINI-SCREEN System.
- As a tripping device to initiate machine motion (PSDI applications) on mechanical power presses, per OSHA regulation 29 CFR 1910.217.



### WARNING . . .

#### Read this Section Carefully Before Installing the System

The Banner MINI-SCREEN System is a point-of-operation machine guarding device. **Its ability to perform this function depends upon the appropriateness of the application and upon the MINI-SCREEN System's proper mechanical and electrical installation and interfacing to the machine to be guarded.** If all mounting, installation, interfacing, and checkout procedures are not followed properly, the MINI-SCREEN System cannot provide the protection for which it was designed. The user has the responsibility to ensure that all local, state, and national laws, rules, codes, or regulations relating to the installation and use of this control system in any particular application are satisfied. Extreme care should be taken to ensure that all legal requirements have been met and that all technical installation and maintenance instructions contained in this manual are followed. ***Read Section 3 (and its subsections) of this manual carefully before installing the system. Failure to follow these instructions could result in serious bodily injury or death.***

The user has the sole responsibility to ensure that the Banner MINI-SCREEN System is installed and interfaced to the guarded machine by Qualified Persons in accordance with this manual and applicable safety regulations. A "Qualified Person" is defined as "a person or persons who, by possession of a recognized degree or certificate of professional training, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve problems relating to the subject matter and work" (ANSI/ASME B30.2-1983).

# System Installation and Alignment

## 3.2 Mechanical Installation Considerations

The two factors that most influence the layout of the MINI-SCREEN System's mechanical installation are:

- Separation distance, and
- Hard guarding.

### 3.2.1 Separation Distance

The MINI-SCREEN System must be able to react fast enough, when a hand or other object is inserted into the defined area, to send a Stop signal to the guarded machine *before the object or hand reaches the closest reachable hazard point on the machine*. The separation distance (or safety distance) is the minimum distance required between the midpoint of the defined area and the closest reachable hazard point. The actual separation distance required depends upon several factors, including the speed of the hand (or object), the total system stopping time (of which there are several response time components), and the depth penetration factor. The formula used to calculate the separation distance is:

$$D_S = K \times (T_S + T_R) + D_{pf} \quad \text{where:}$$

- $D_S$  = the separation distance;
- $K$  = the OSHA-recommended hand speed constant of 63" per second (NOTE 1, below);
- $T_S$  = the overall stop time of the machine measured from the application of the Stop signal to the final ceasing of all motion (including stop times of all relevant control elements, and measured at maximum machine velocity). See the WARNING (right), NOTE 2 (below), and the Notice Regarding MPCEs (page 29).
- $T_R$  = the response time of the MINI-SCREEN System:  
 4.5" to 16" emitter/receiver: .048 sec.  
 20" to 32" emitter/receiver: .060 sec.  
 36" to 48" emitter/receiver: .072 sec.
- $D_{pf}$  = the added distance due to depth penetration factor, as prescribed in OSHA 1910.217 and ANSI B11 standards:

9 m (30') Range		18 m (60') Range	
Floating Blanking	$D_{pf}$	Floating Blanking	$D_{pf}$
OFF	1.6"	OFF	2.5"
ON	5.0"	ON	5.9"

- 1) The OSHA-recommended hand-speed constant K has been determined by various studies, and although these studies indicate speeds of 63 in/sec to more than 100 in/sec, they are not conclusive determinations. The employer should consider all factors, including the physical ability of the operator, when determining the value of K to be used.
- 2)  $T_S$  is usually measured by a stop-time measuring device. If the specified machine stop time is used, at least 20% should be added as a safety factor to account for clutch/brake system deterioration.
- 3) Use of floating blanking will always cause the required  $D_S$  to increase.



#### WARNING . . . Position Components Carefully

The emitter and receiver must be positioned such that the hazard can not be accessed by reaching over, under, around or through the sensing field. Additional guarding may be required; see Hard Guarding, Section 3.2.2.



#### WARNING . . . Proper Separation Distance

Banner MINI-SCREEN System emitters and receivers must be mounted at a distance from moving machine parts that is determined by OSHA standards found in Section 1910.217 (c)(3)(iii)(e). **Failure to establish and maintain the required separation distance exactly as described in this manual could result in serious bodily injury or death.**



#### WARNING . . . Determine Correct Stop Time

**Be sure to include the stop time of all relevant devices and controls in your calculations.** The measurement of stop time ( $T_S$ ) must include the response time of *all* devices or controls that react to stop the machine. If all devices are not included, the calculated separation distance ( $D_S$ ) will be too short. **This can lead to serious bodily injury or death.**



#### CAUTION . . . Proper Installation When Using Floating Blanking

Floating blanking increases  $D_{pf}$  (see values at left).

- You must increase the penetration factor to calculate the separation distance whenever floating blanking is used.
- Always turn floating blanking OFF when the larger minimum object detection size is not required.

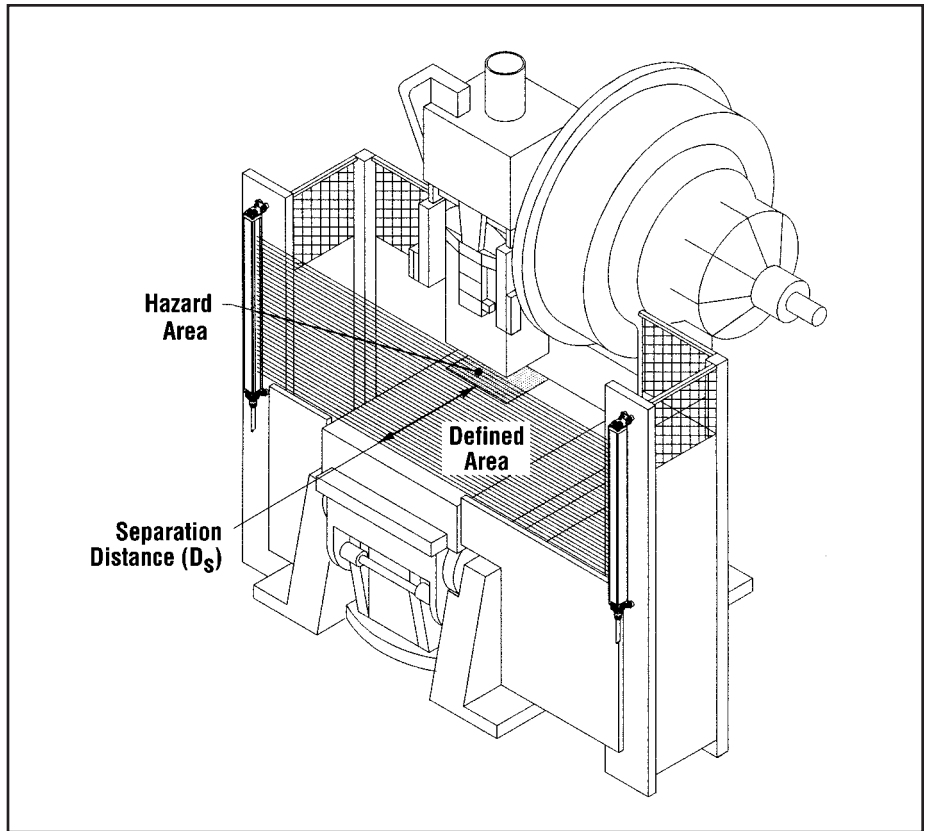


Figure 7. Separation distance

## Example: Separation Distance ( $D_S$ ) Calculation

The following example shows how to use the formula from page 14 to calculate separation (safety) distance ( $D_S$ ). We will use these numbers for the variables in the formula:

Sensors have 9 m (30') range

$K = 63$ " per second (the hand speed constant set by OSHA)

$T_S = .250$  second (the total stop time of the example machine, specified by machine manufacturer)

$T_R = .048, .060,$  or  $.072$  second (the specified response time of the MINI-SCREEN System; see Specifications, page 52 or page 14.)

Our example uses floating blanking, so we use a  $D_{pf}$  of 5" (page 14). Response time for this example is .060 second. Substitute the numbers into the formula as follows:

$$D_S = K \times (T_S + T_R) + D_{pf}$$

$$D_S = 63 \times (.250 \times 1.2^* + .060) + 5 = 28"$$

Therefore, in this example, the MINI-SCREEN emitter and receiver must be mounted so that no part of the defined area will be closer than 28" to the closest reachable hazard point on the guarded machine.

\*20% safety factor (see NOTE 2, page 14)

### 3.2.2 Hard Guarding

ANSI B11.1-1988, E6.3.2 (14) requires that “all areas of entry to the point of operation not protected by the presence-sensing device shall be otherwise safeguarded.” The hazard point must be accessible only through the defined area. This means that mechanical barriers (screens, bars, etc.), or supplemental presence-sensing devices (supplemental guarding) must be installed, wherever needed, to prevent any person from reaching around, under, or over the defined area and into the hazard area, and to prevent any person from standing between the defined area and the hazard area (see OSHA 1910.212). The use of mechanical barriers for this purpose is called “hard guarding” (see the WARNING on the right and the hard guarding example, below).

There must be no gaps between the hard guarding and the edges of the defined area. Also, OSHA specifies a relationship between the distance of the hard guard barrier from the point of operation and the maximum allowable size of openings in that barrier (see OSHA 1910.217, Table O-10). Openings in the hard guard material must meet OSHA criteria.

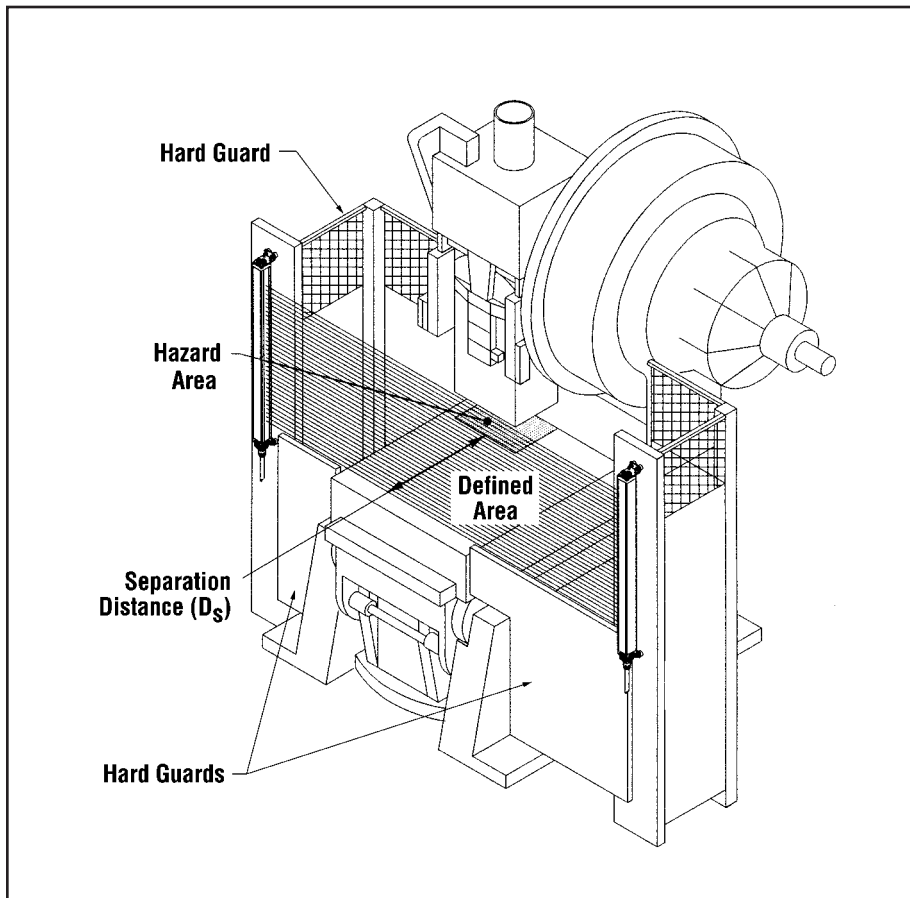


Figure 8. Example of hard guarding



**WARNING . . .**  
The Point of Operation  
Must be Accessible *Only*  
Through the Defined Area

Mechanical barriers (screens, bars, etc.), or supplemental presence sensing devices (*supplemental guarding*) must be installed, wherever needed, to prevent any person from reaching around, under, or over the defined area and into the point of operation, and also to prevent any person from entering the space between the defined area and the point of operation (see OSHA 1910.212). The use of mechanical barriers for this purpose is called “hard guarding.” There must be no gaps between the hard guarding and the edges of the defined area. Openings in the hard guard material must meet OSHA criteria (see OSHA 1910.217, Table O-10).

Supplemental presence-sensing devices, such as safety mats, must be used if the space between the defined area and the nearest danger point is large enough to allow a person to stand undetected by the MINI-SCREEN System.





**WARNING . . .**  
**Proper Orientation of**  
**System Emitters and**  
**Receivers**

The emitters and receivers of the MINI-SCREEN System must be installed with their corresponding ends (either cabled ends or non-cabled ends) pointing in the same direction (both cabled ends "up," both cabled ends "down," etc.). Failure to do this will impair the performance of the MINI-SCREEN System and result in incomplete guarding; see Figure 10a. **Failure to observe this warning could result in serious bodily injury or death.**

### 3.2.3 Emitter and Receiver Orientation

It is absolutely necessary that the emitter and receiver are mounted perfectly parallel to each other and aligned in a common plane with both cable ends pointing in the same direction. Never mount the emitter with its cable end oriented opposite to the cable end of the receiver, or there will be voids in the light screen through which objects can pass undetected (see Figure 10a).

The emitter and receiver may be oriented in a horizontal plane, or at any angle between horizontal and vertical. However, the cable ends must always point in the same direction. Always be certain that the light screen completely covers all access to the hazard point not protected by hardguarding or other supplemental guarding.

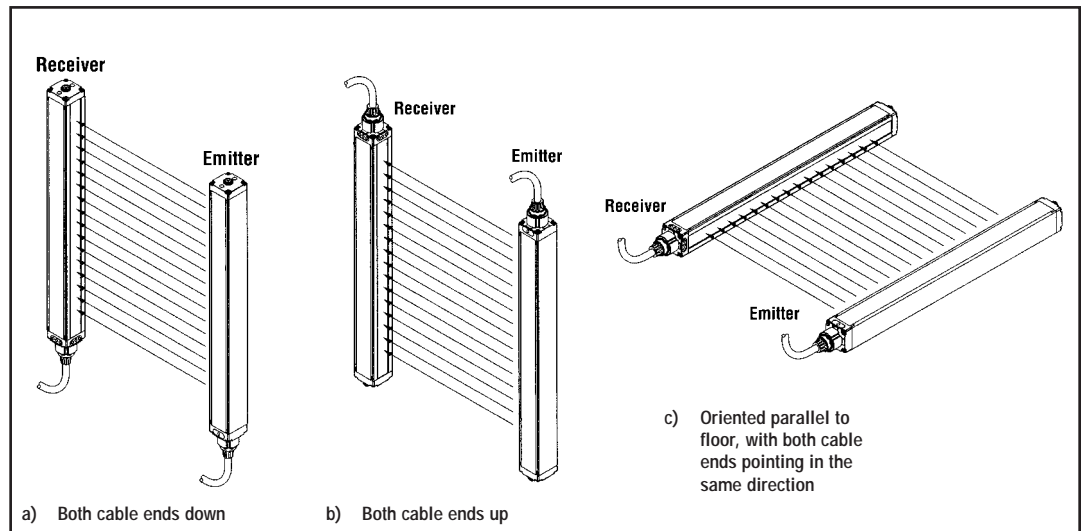


Figure 9. Correct emitter and receiver orientation

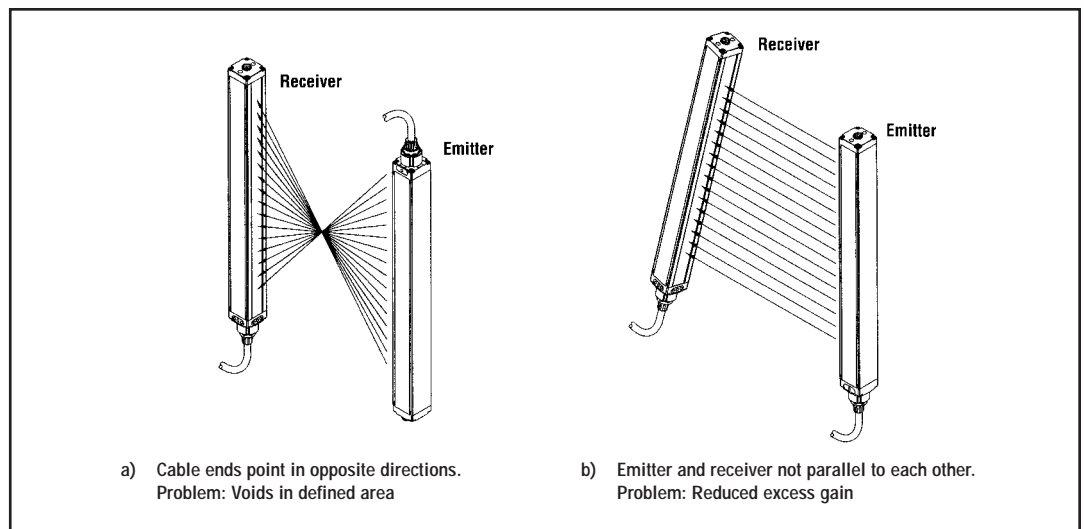


Figure 10. Incorrect emitter and receiver orientation

### 3.2.4 Adjacent Reflective Surfaces

A reflective surface located adjacent to the defined area may deflect one or more beams of the light screen around an object which is in the defined area. In the worst case, an object may pass through the defined area undetected.

A reflective surface may be a part of the machine or the workpiece and may include shiny metal or plastic or surfaces with glossy paint. Where possible, reflective surfaces adjacent to the defined area should be roughened or covered with a dull material. Where this is not possible (as with a reflective workpiece), the sensor mounting should include a means of restricting the field of view of the receiver or the spread of the light from the emitter (see Figure 8).

Beams deflected by reflective surfaces are discovered during the initial checkout procedure (Section 3.5.3), the final alignment and checkout procedure (Section 6.1), and also by the periodic checkout procedures (Sections 6.2, 6.3, and 6.4).

### 3.2.5 Use of Corner Mirrors

MINI-SCREEN sensors may be used with one or more corner mirrors. The use of corner mirrors somewhat reduces the maximum specified emitter/receiver separation (see page 41). Corner mirrors and stands are available from Banner; contact the factory Applications Engineering Department for information.

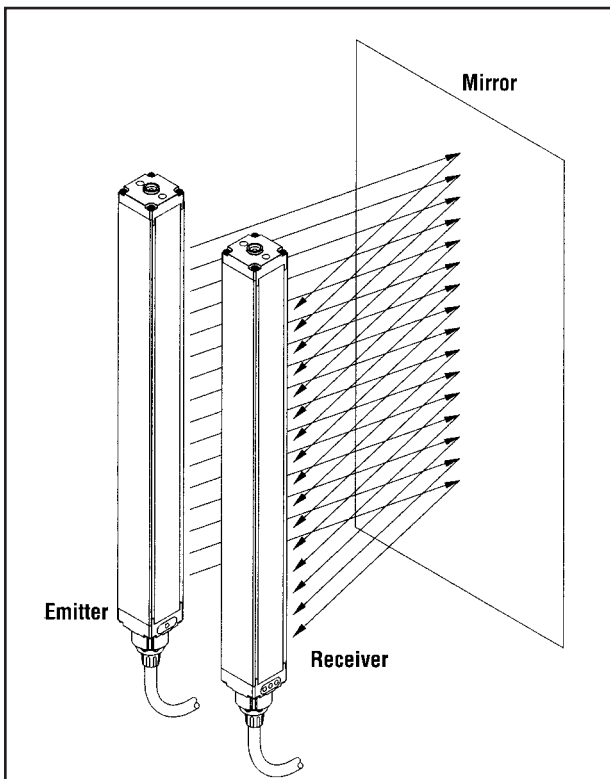


Figure 11. Never use MINI-SCREEN sensors in retroreflective mode.



#### **WARNING . . .** Installation Near Reflective Surfaces

A highly reflective surface (such as a shiny machine surface or a shiny workpiece) may reflect sensing light around an object in the defined area, preventing that object from being detected. This potentially dangerous condition is discovered using the "trip test" as described in the Initial Checkout Procedure (Section 3.5.5), the Alignment Procedure (Section 6.1), and the periodic checkout procedures (Sections 6.2, 6.3, and 6.4).

**When this condition is discovered, eliminate the problem reflection(s):**

- **If possible, relocate the sensors** to move the light screen beams away from the reflective surface(s), being careful to retain at least the required separation distance (Section 3.2.1).
- **Otherwise, paint, mask, or roughen the interfering shiny surface** to reduce its reflectivity.

Repeat the trip test to verify that these changes have eliminated the problem reflection(s). (NOTE: If the workpiece is especially reflective and comes close to the light screen, perform the trip test with the shiny workpiece in place.)



#### **WARNING . . .** Avoid Retroreflective Installation

**Never use MINI-SCREEN sensors in retroreflective mode, as illustrated in Figure 11.**

The MINI-SCREEN System is not designed for use in retroreflective mode (where the sensors are mounted adjacent to each other and the light from the emitter is bounced back directly to the receiver by a mirror or other reflective surface). **Sensing is unreliable in this mode and could result in serious injury or death.**

## 3.2.6 Installation of Multiple MINI-SCREEN Systems

Whenever the emitter and receiver pairs of two or more MINI-SCREEN Systems are adjacent to one another, there is potential for optical crosstalk to take place between systems (the receiver of one sensor pair senses light from the emitter of another sensor pair). To minimize optical crosstalk, it is recommended to alternate emitters and receivers, as shown in Figure 12.

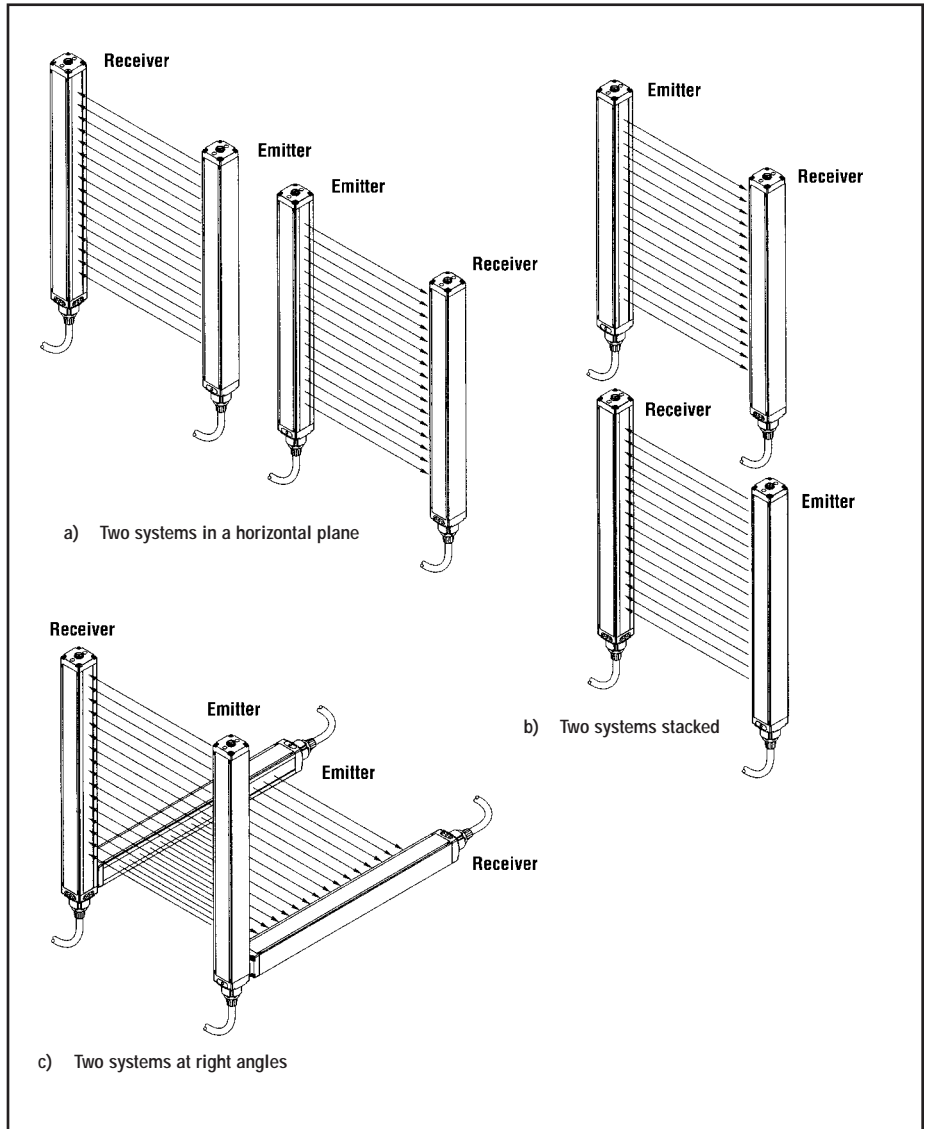


Figure 12. Alternate emitters and receivers to avoid optical crosstalk in multiple-system installations.

When three or more systems are installed in a horizontal plane, (as shown for two pairs in Figure 12a), optical crosstalk may occur between those sensor pairs whose emitter and receiver lenses are oriented in the same direction. In this situation, optical crosstalk may be controlled by mounting the sensor pairs exactly in line with each other within the same plane, or by adding a mechanical light barrier between the pairs.

## 3.3 Mounting Procedure

### Sensor Mounting

Banner MINI-SCREEN System emitters and receivers are small, lightweight, and easy to handle during mounting. The mounting brackets (supplied) allow  $\pm 30^\circ$  rotation.

From a common point of reference, make measurements to locate the emitter and receiver in the same plane with their midpoints directly opposite each other.

**Important: The connector ends of both sensors must point in the same direction (see drawings and WARNING, page 17).** Mount the emitter and receiver brackets using the vibration isolators and M4 Keps nuts (all supplied); see Figure 13. Standard #8-32 bolts may be substituted (and the vibration isolators eliminated) in situations where the emitter and receiver are not subjected to shock or vibration forces. While the internal circuits of the emitter and receiver can withstand heavy impulse forces, the vibration isolators dampen impulse forces and prevent possible damage due to resonant vibration of the emitter or receiver assembly.

Mount the emitter and receiver in their brackets and position their windows directly facing each other. Measure from one or more reference planes (e.g., the building floor) to the same point(s) on the emitter and receiver to verify their mechanical alignment. If the units are positioned exactly vertical or horizontal to the floor, a carpenter's level is useful for checking alignment. A straightedge or a string extended between the sensors also helps with positioning. Also check "by eye" for line-of-sight alignment. Make any necessary final mechanical adjustments, and hand-tighten the bracket hardware. A detailed alignment procedure is given in Section 6.1.

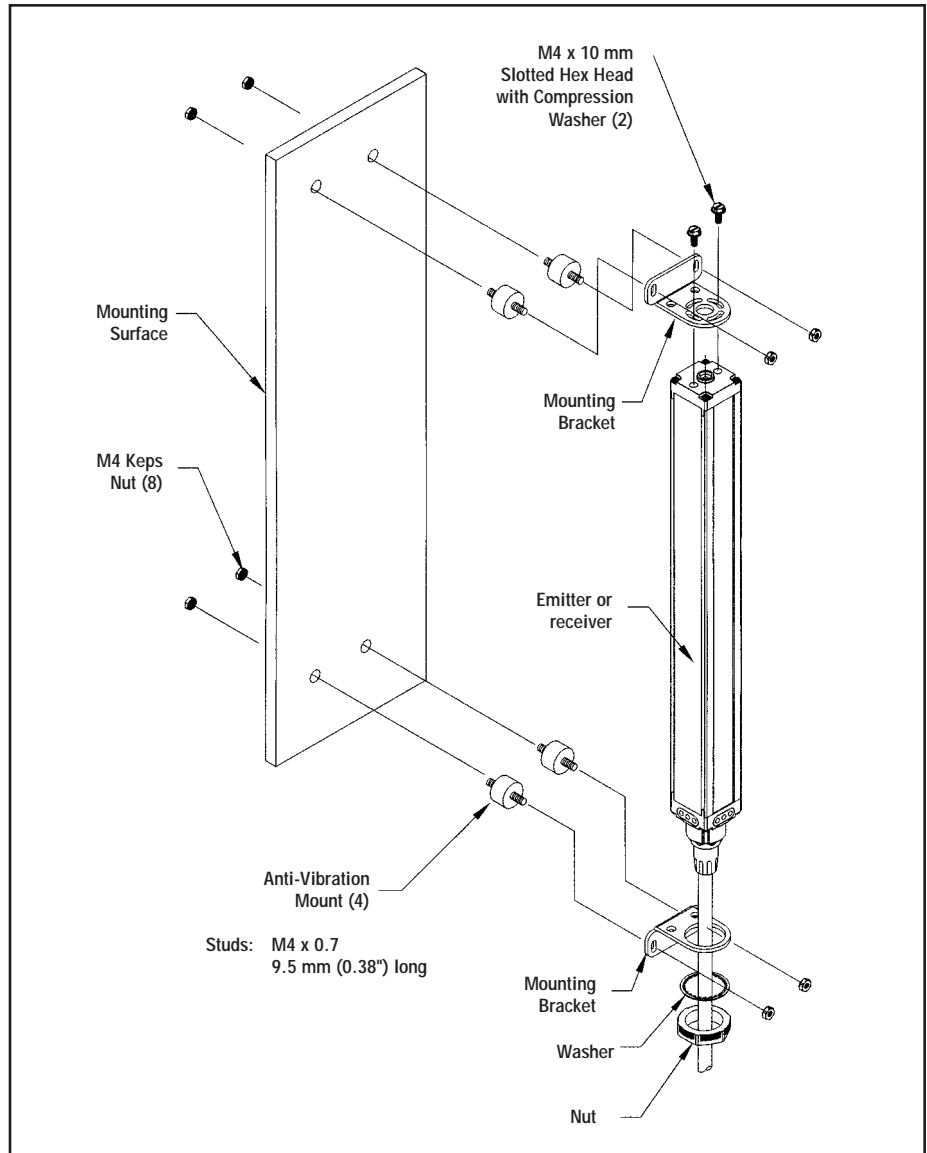


Figure 13. Emitter and receiver mounting hardware

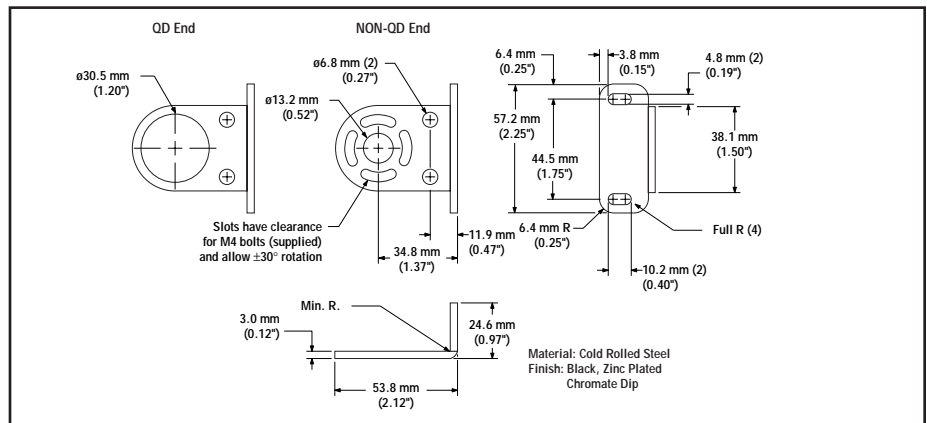


Figure 14. Emitter and receiver mounting bracket dimensions

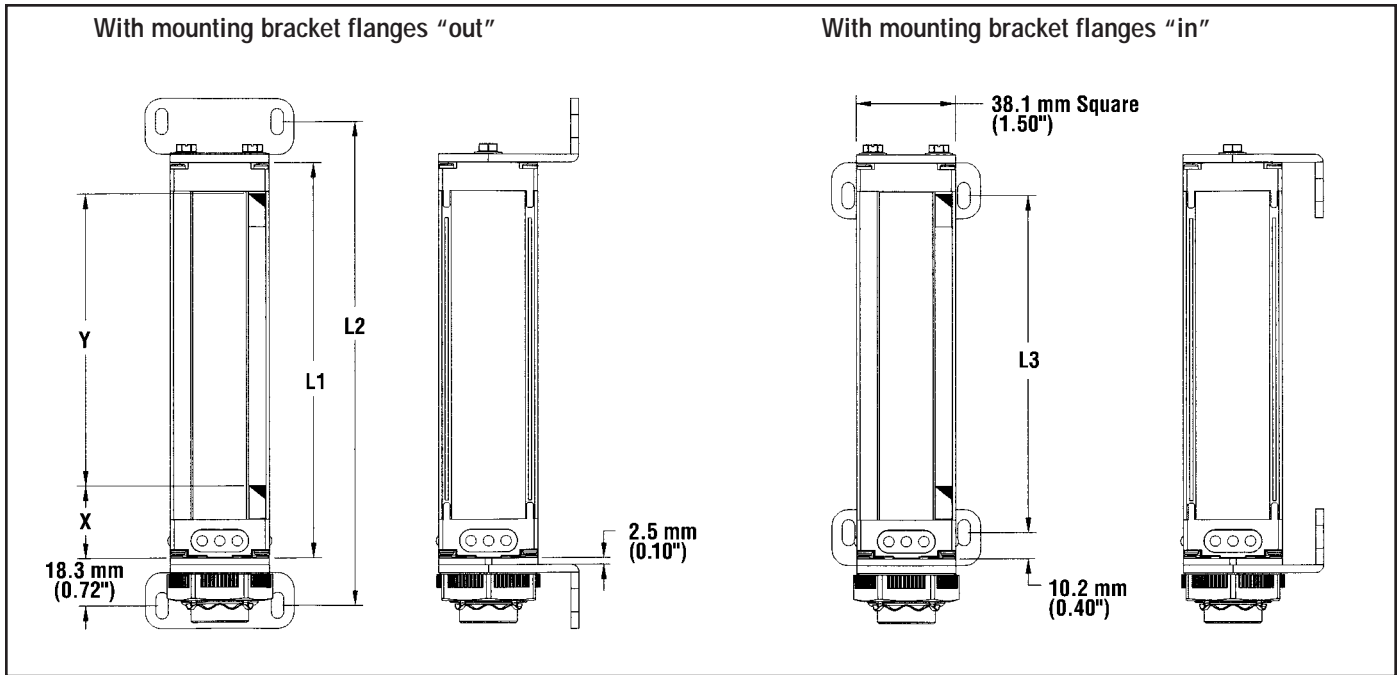


Figure 15. Emitter and receiver mounting dimensions and location of defined area

Models	Housing Length L1	Distance Between Bracket Holes		Defined Area	
		L2	L3	X	Y
MSE424 emitter MSR424 receiver	153 mm (6.0")	188 mm (7.4")	130 mm (5.1")	28 mm (1.1")	114 mm (4.5")
MSE824 emitter MSR824 receiver	254 mm (10.0")	287 mm (11.3")	231 mm (9.1")	28 mm (1.1")	215 mm (8.5")
MSE1224 emitter MSR1224 receiver	356 mm (14.0")	389 mm (15.3")	333 mm (13.1")	30 mm (1.2")	305 mm (12")
MSE1624 emitter MSR1624 receiver	457 mm (18.0")	490 mm (19.3")	434 mm (17.1")	30 mm (1.2")	406 mm (16")
MSE2024 emitter MSR2024 receiver	558 mm (22.0")	592 mm (23.3")	536 mm (21.1")	30 mm (1.2")	508 mm (20")
MSE2424 emitter MSR2424 receiver	659 mm (26.0")	693 mm (27.3")	637 mm (25.1")	30 mm (1.2")	610 mm (24")
MSE2824 emitter MSR2824 receiver	761 mm (30.0")	795 mm (31.3")	739 mm (29.1")	33 mm (1.3")	711 mm (28")
MSE3224 emitter MSR3224 receiver	862 mm (33.9")	896 mm (35.3")	838 mm (33.0")	33 mm (1.3")	813 mm (32")
MSE3624 emitter MSR3624 receiver	963 mm (37.9")	998 mm (39.3")	940 mm (37.0")	33 mm (1.3")	914 mm (36")
MSE4024 emitter MSR4024 receiver	1064 mm (41.9")	1100 mm (43.3")	1041 mm (41.0")	33 mm (1.3")	1016 mm (40")
MSE4424 emitter MSR4424 receiver	1166 mm (45.9")	1201 mm (47.3")	1143 mm (45.0")	33 mm (1.3")	1118 mm (44")
MSE4824 emitter MSR4824 receiver	1267 mm (49.9")	1300 mm (51.2")	1245 mm (49.0")	33 mm (1.3")	1219 mm (48")

## System Installation and Alignment

Connect the shielded cables to the emitter and receiver and route them (per local wiring code for low-voltage dc control cables) to the control box mounting location. (NOTE: Emitter and receiver cables must be routed to the control box knockouts closest to terminal barrier TB3; see Figures 19 and 20.) The same cable type is used for both emitter and receiver (two cables required per system); emitter and receiver cable lengths may not exceed 50' (each). Cables may be cut to length during installation, after all cables are routed properly and re-checked (see Figures 19 and 20). The cable braid at the control box connection points may be either removed or twisted together with the drain wire for attachment to the wiring block.

### Control Box Mounting

Mount the MINI-SCREEN System control box in a convenient location that is free from heavy impulse force and high-amplitude vibration. **The control box must be mounted at a location which provides an unobstructed view of the defined area.** Mounting hole information is given in Figure 17 (below).

The MINI-SCREEN controller module must be configured *before* initial checkout and use. Controller configuration is done at the row of DIP switches along the edge of the controller module (Figure 18). The controller will automatically sense the length of the emitter and receiver, and set its response time accordingly.

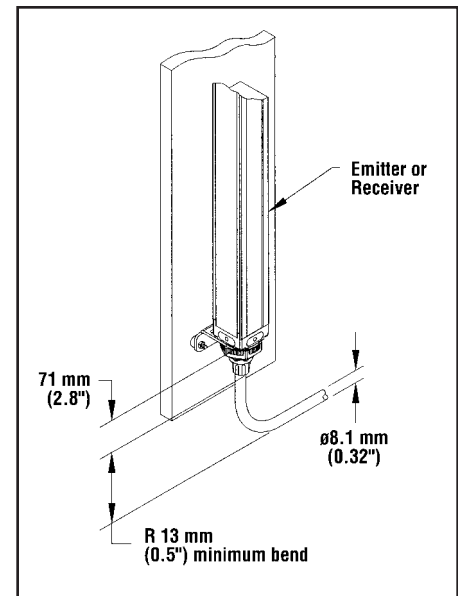


Figure 16. Quick-disconnect cable clearance dimensions

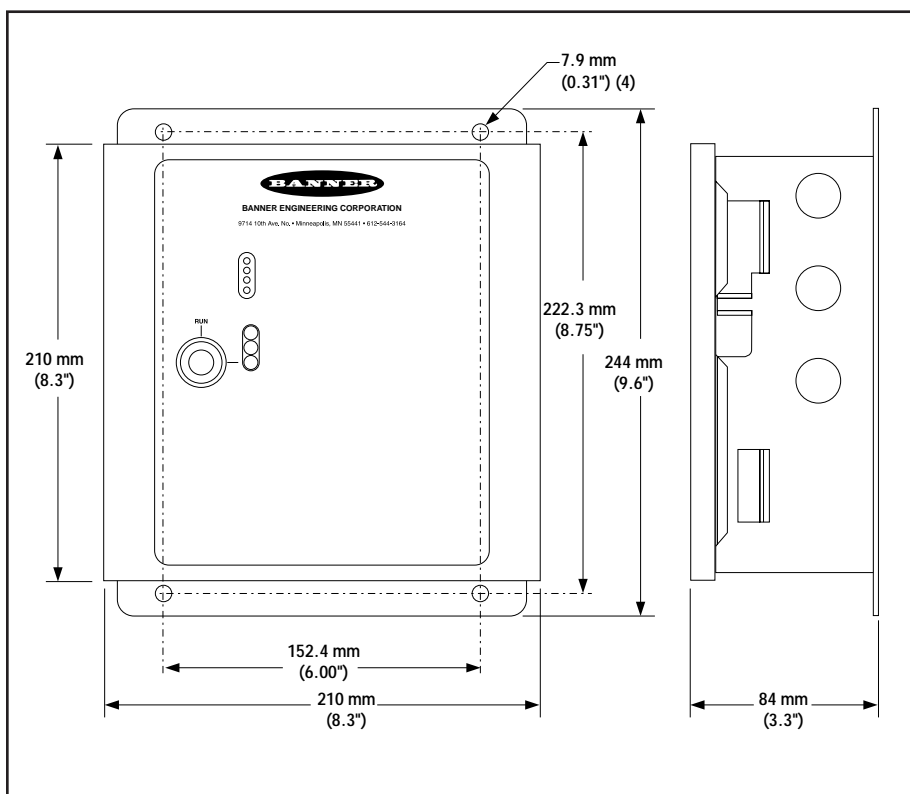



Figure 17. Control box dimensions and mounting hole locations

**WARNING . . .**  
**Control Box Location**

 The control box must be located outside the area of dangerous motion, and must be located where the entire area of dangerous motion may be observed by the operator during a Key Reset.

Failure to observe this warning could result in serious bodily injury or death.

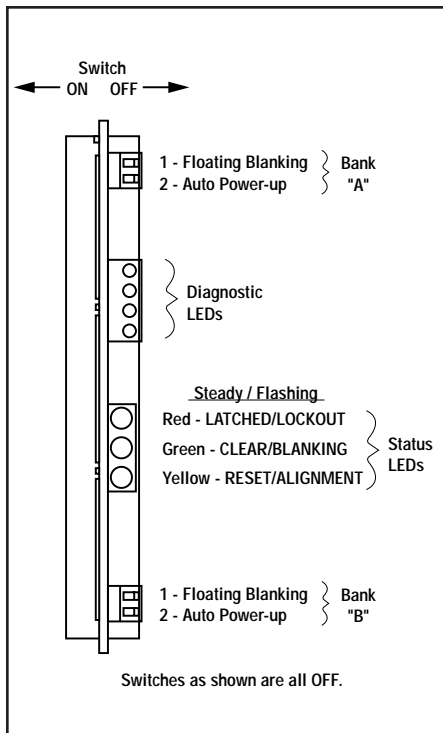


Figure 18. Controller module configuration DIP switches and indicators

## 3.4 Controller Module Configuration

The parameters to be manually configured are:

- Floating blanking ON or OFF.
- Auto Power-up ON or OFF.

NOTE: The factory setting for both parameters is OFF.

Because it has redundant microprocessors, the controller module has two identical DIP switch banks (bank A and bank B) which must be set identically. Failure to set both banks identically will cause a lockout condition when power is applied to the control box.

**Power to the MINI-SCREEN System must always be OFF when changing DIP switch settings.** Changing DIP switch settings with power ON will cause a lockout condition. A switch pushed to the left (with controller module oriented as shown in Figure 18) is ON; a switch pushed to the right is OFF. Set the configuration switches as follows:

### To Set Floating Blanking ON or OFF

Locate the floating blanking (FB) configuration switch in bank A (switch #1). Set the corresponding switch at bank B identically. Be aware of the difference in minimum object sensitivity, penetration factor, and required light screen separation distance between the ON and OFF settings (refer to Sections 2.1 and 3.2.1).

### Maximum Size of Undetected Objects Using Floating Blanking

9 m (30') range sensors: 20.3 mm (0.80")

18 m (60') range sensors: 16.5 mm (0.65")

NOTE: Assumes that the object encounters the light screen perpendicular to the plane of light.

### To Set Auto Power-up Feature ON or OFF

Locate the Auto Power-up (AP) configuration switch (switch #2) in bank A. If Auto Power-up is ON (see Figure 18) when power is applied to the MINI-SCREEN System, the controller will automatically reset after conducting and passing an internal system checkout. If the switch is OFF, this initial reset is manual (via the Key Reset switch on the front panel). Regardless of the setting of this switch, a Key Reset is always necessary to recover from an internal lockout condition. To select Auto Power-up, remove the protective coating on switch #2 and push the switch to the ON position. The corresponding switches at banks A and B must be set identically.

## 3.5 Electrical Hookup and Checkouts

Make the electrical connections in the order that they are presented in Sections 3.5.1 through 3.5.7. **Exercise care when removing control box knockouts, so as to not damage the contents of the control box.**

The following wiring connections are located inside the control box:

- Emitter and receiver cables,
- System power,
- Output relay connections (FSD1, FSD2, and SSD),
- Alarm Relay, and
- Remote devices (Key switch and Test input).

Several conduit knockouts are provided on the sides of the control box. Select knockout locations that are closest to the internal control box connection points that you want to access; refer to Figures 19 and 20. **NOTE:** Except for emitter and receiver cable entries (for which cable glands are supplied), it is the user's responsibility to maintain NEMA 13 sealing at all cable entries into the control box.

**NOTE:** The wiring barriers inside the control box can accept conductors no larger than #14 AWG. Also, the wires used should have an insulation temperature rating of at least 90°C (194°F).



**WARNING . . .**  
Proper Electrical Hookup  
Is Imperative

- **Electrical hookup must be made by Qualified Personnel** and must comply with NEC (National Electrical Code) and local standards.
- **Make no more connections to the MINI-SCREEN System than are described in Sections 3.5.1 through 3.5.8 of this manual.**

**Connection of other wiring or equipment to the MINI-SCREEN System could result in serious bodily injury or death.**

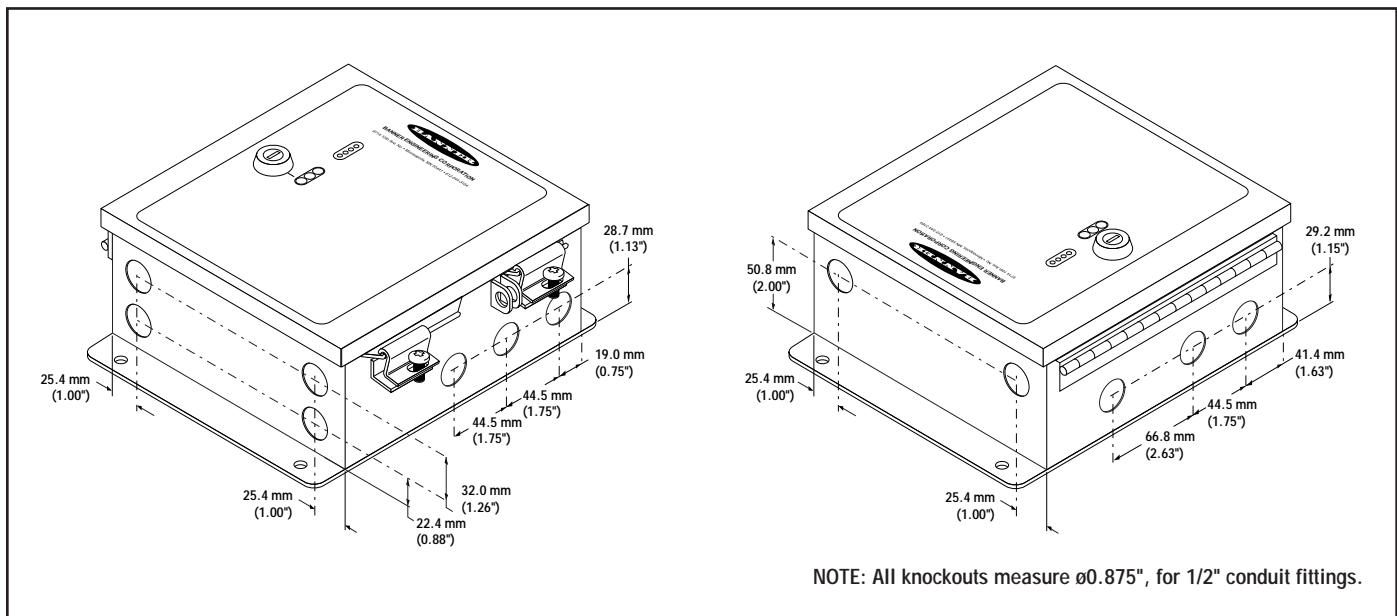


Figure 19. MINI-SCREEN control box knockout locations



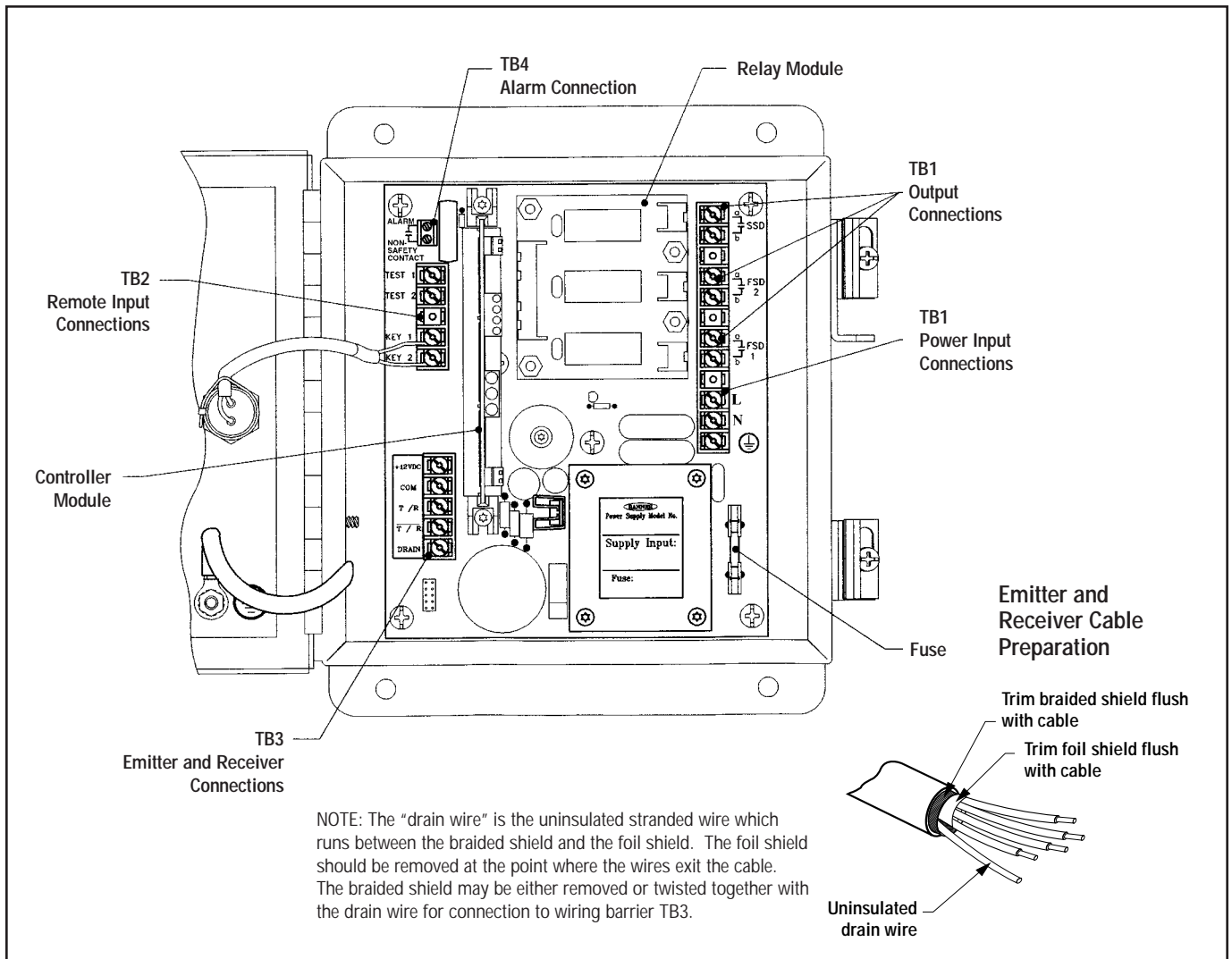


Figure 20. MINI-SCREEN system electrical connections

## 3.5.1 Emitter and Receiver Hookup

The emitter and receiver cables require two control box knockouts. Two cable gland strain relief fittings are supplied with each control box for the entrance of emitter and receiver cables into the control box. Emitter and receiver cables both connect to wiring barrier TB3 (Figure 20, above); route the cables through the knockouts nearest to barrier TB3. *Use only Banner QDC Series cables (see page 54) to ensure reliable communication of data between the controller and the sensors.* Match the color-coded terminals of wiring barrier TB3 to colored wires in each 5-conductor cable. **Double-check your wiring; incorrect wiring can lead to component damage.**

There are no user adjustments or connections inside the MINI-SCREEN emitter or receiver.

## 3.5.2 System Power (Temporary Connection)

As shown in Figure 23 (page 30), the ac lines to the control box will connect through the MPCE monitor contacts of the guarded machine. **However, do not wire to the MPCEs at this time.** Instead, temporarily connect power directly at the L and N terminals of control box wiring barrier TB1. Connect earth ground at the terminal provided. This will allow the MINI-SCREEN System to be checked out, by itself, before permanent power connections are made through the guarded machine's monitor contacts. Permanent power connection will be made after MINI-SCREEN System initial checkout, and is covered in Section 3.5.5.

## 3.5.3 MINI-SCREEN System Initial Checkout

This initial checkout procedure must be performed by a Qualified Person (see WARNING, page 13). It must be done after connecting the emitter and receiver (Section 3.5.1) and temporary power (Section 3.5.2) to the MINI-SCREEN control box, but before the MINI-SCREEN System is connected to the machine to be guarded.

Initial checkout of the MINI-SCREEN System must always be performed by a Qualified Person (see Section 3.1). The procedure is performed on two occasions:

- To ensure proper installation when the System is first installed, and
- To ensure proper System function whenever any maintenance or modification is performed on the System or on the machinery being guarded. (See Section 4.2 for a schedule of required checkouts.)



**CAUTION . . .**  
Shock Hazard

Electrical shock hazard exists when the MINI-SCREEN System has power applied to it and the control box door is open. **Close the hinged control box cover and secure the latches before running this checkout procedure.**

**Failure to observe this warning could result in serious bodily injury or death.**

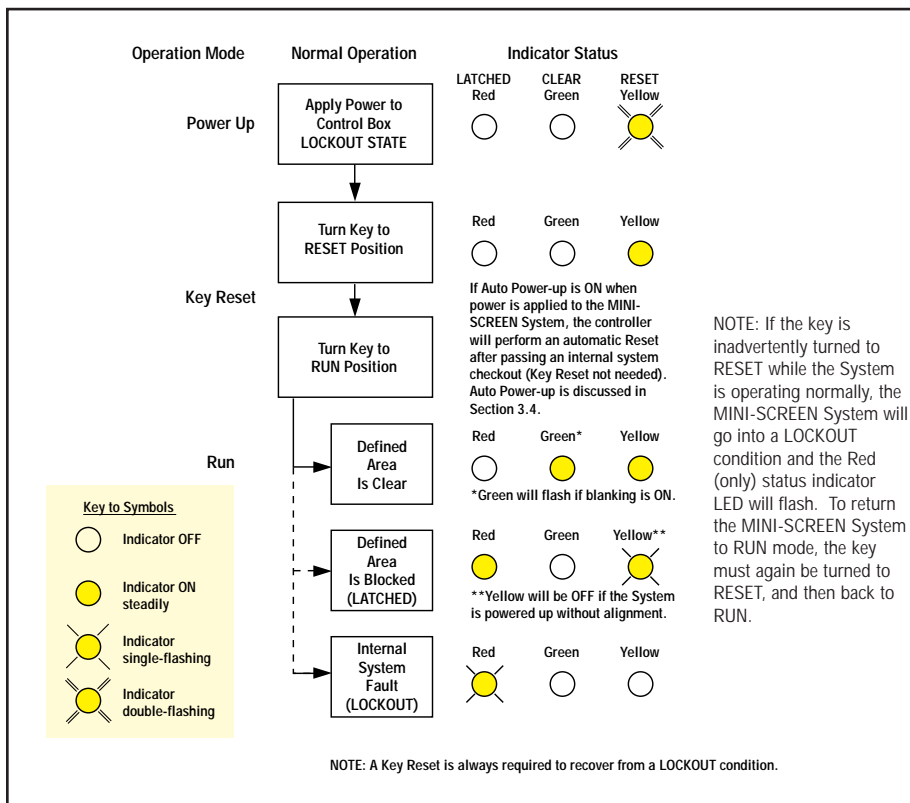


Figure 21. Operating status LED conditions

### INITIAL CHECKOUT PROCEDURE:

The MINI-SCREEN System has three operating modes: POWER UP, LATCH, and RUN. Monitor the three status LEDs (red, yellow, and green, on the control box front panel or the receiver) and refer to Figure 21.

- 1) **Power Up the System** by applying power to the control box with the key in the RUN position (see CAUTION, page 26). With Auto Power-up OFF, the System will power up into a lockout condition (yellow LED only will double-flash). With Auto Power-up ON, the System will automatically enter RUN mode (if the defined area is clear); go to step 3.
- 2) **Perform a Key Reset** by turning the key clockwise to RESET. The yellow indicator will glow steadily.

NOTE: *Hold the key in RESET position for at least one-half second.* This allows time for the microprocessors to run a startup diagnostic check routine.

- 3) **Enter RUN mode** by turning the key from RESET to RUN position.

**If the red status indicator (only) lights and flashes** when the system is placed in RUN mode, an internal lockout condition exists. Refer to Section 5.1 to determine the cause of the lockout.

**If the red and yellow status indicators come ON**, the defined area is not clear (one or more light beams are obstructed) or the system may be out of alignment. The system is in LATCH mode. If this occurs, check the defined area for obstruction(s). The red indicator will be ON steadily. The yellow indicator will be flashing to indicate the relative number of made (cleared) light beams; the faster the flash rate, the more beams are made. If all beams are blocked, the red indicator will be ON steadily, with yellow and green indicators both OFF.

If the MINI-SCREEN System is properly aligned, blanking is properly set, and all obstructing objects are removed from the defined area, the green and yellow indicators should come ON after step #3 has been performed (the green indicator will flash if blanking is ON, but the yellow indicator should be ON steadily).

The green indicator LED comes ON as soon as all beams are clear. After step #3, the FSD relays are energized, the alarm contact opens and the Red indicator LED goes OFF. The System is now in RUN mode. **If you are setting up the MINI-SCREEN System for the first time, or if the green and yellow indicators do not come ON during step #3, perform the alignment procedure in Section 6.1.** When you are certain that the emitter and receiver are aligned properly, tighten the emitter and receiver mounting hardware in position and repeat steps #1-3 above.

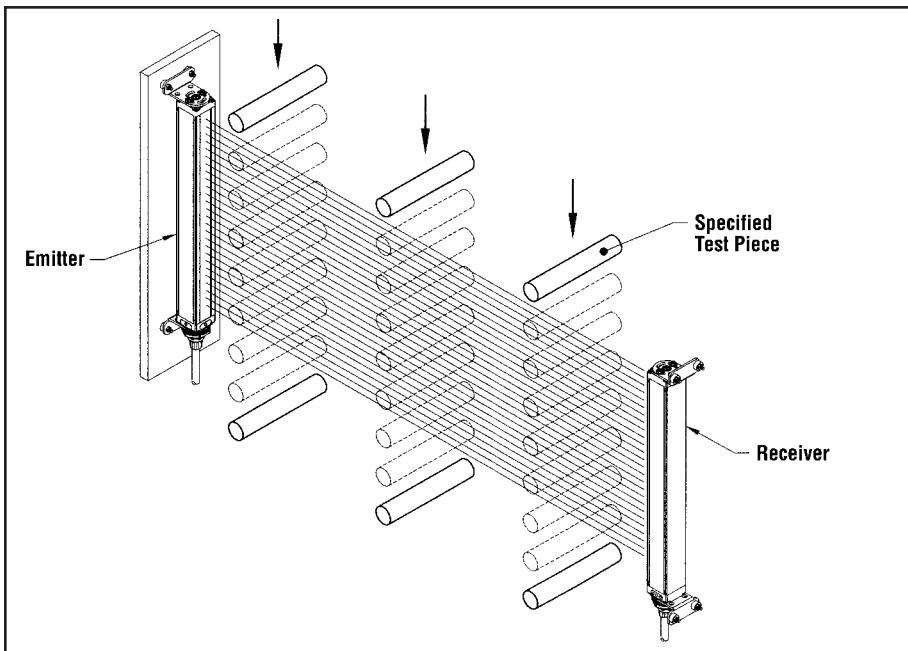


Figure 22. MINI-SCREEN System trip test

- 4) Next, trip test the MINI-SCREEN System for object detection capability using the specified test pieces supplied with the control box. To perform the trip test, the Key switch must be in RUN position, the yellow status indicator must be ON steadily, and the green status indicator must either be ON steadily (to indicate blanking OFF) or flashing (to indicate blanking ON).

Use the following test pieces:

Appropriate Test Pieces for Trip Test		
Sensing Range	Floating Blanking OFF (Green Status Indicator ON Steadily)	Floating Blanking ON (Green Status Indicator Flashing)
9 m (30')	19.1 mm (0.75") diameter Model STP-2	44.5 mm (1.75") diameter Model STP-3
18 m (60')	25.4 mm (1.00") diameter Model STP-7	50.8 mm (2.00") diameter Model STP-8

Pass the specified test piece, very slowly, down the length of the defined area in three paths: close to the emitter, close to the receiver, and midway between the emitter and receiver (see Figure 22). In each case, the red indicator must come ON and the green indicator must go OFF and remain OFF for as long as the test piece is within the defined area. When the test piece is removed from the defined area, the green status indicator must come ON (if floating blanking is ON, it will be flashing). If the green indicator comes ON at any time when the test piece is within the defined area, check for reflective surfaces; do not continue until the cause is discovered and the situation is resolved.

NOTE: The red status indicator will remain ON following each pass. Turn it OFF between passes by resetting the Latch (with a Key Reset).

If the MINI-SCREEN System passes all of the checks in Section 3.5.3, go on to Section 3.5.4.

If the MINI-SCREEN System fails any of these checks, do not attempt to use the System or the guarded machine until the reason for the failure(s) is identified and all failures are corrected.



**CAUTION . . .**  
Shock Hazard

Electrical shock hazard exists when the MINI-SCREEN System has power applied to it and the control box door is open. Use extreme caution to avoid electrical shock at all times when the control box door is open. **Always disconnect all power from the MINI-SCREEN System and the guarded machine before making any connections or replacing any component.**



**WARNING . . .**  
Final Switching Device

The output relays of the MINI-SCREEN System must be the *final switching devices* for the machinery being guarded.

**Connection of the output relays to the guarded machine must be direct and must produce immediate stopping action. Never wire an intermediate device (e.g., a programmable logic controller - PLC), other than a safety relay, between either FSD and the machine primary control elements (Reference ANSI B11.1-1988, Appendix B4). To do so could result in serious bodily injury or death.**

## Notice Regarding MPCEs

Each of the two Machine Primary Control Elements (MPCE 1 and MPCE 2) must be capable of immediately stopping the dangerous machine motion, irrespective of the state of the other. These two channels of machine control need not be identical, but the stop time performance of the machine ( $T_s$ , used to calculate the separation distance) must take into account the *slower* of the two channels.

Some machines offer only one primary control element. For such machines, it is necessary to duplicate the circuit of the single MPCE to add a second machine primary control element. Refer to Figure 23 (page 30) or consult the machine manufacturer for additional information.

## 3.5.4 Output Relay Connections

Output relay connections are made at the FSD1 (Final Switching Device 1), FSD2 (Final Switching Device 2), and SSD (Secondary Switching Device) terminals on wiring barrier TB1. These relays are energized (contacts closed) in normal operation with no obstructions in the defined area. All relays become de-energized (their contacts open) in a lockout condition. Relays FSD1 and FSD2 (only) de-energize in a trip condition. Before continuing, read NOTICE regarding MPCEs, below, left.

**The FSD1 output relay** connects to Machine Primary Control Element #1 (MPCE 1) on the guarded machine. MPCE 1 is an electrically powered element of the guarded machine that directly controls the normal operating motion of the machine; it must be last (in time) to operate when motion is either initiated or arrested. The output contact of relay FSD1 must be connected, as shown in Figure 23, to control power to Machine Primary Control Element #1. The switching capacity of relay FSD1 is 250V ac max., 4 amps max. (resistive load).

**The FSD2 output relay** connects to Machine Primary Control Element #2 (MPCE 2) on the guarded machine. MPCE 2 is an electrically powered element of the guarded machine (in a different control path than MPCE 1) that directly controls the normal operating motion of the guarded machine; it must be last (in time) to operate when machine motion is either initiated or arrested. The output contact of relay FSD2 must be connected, as shown in Figure 23, to control power to Machine Primary Control Element #2. The switching capacity of relay FSD2 is 250V ac max., 4 amps max. (resistive load).

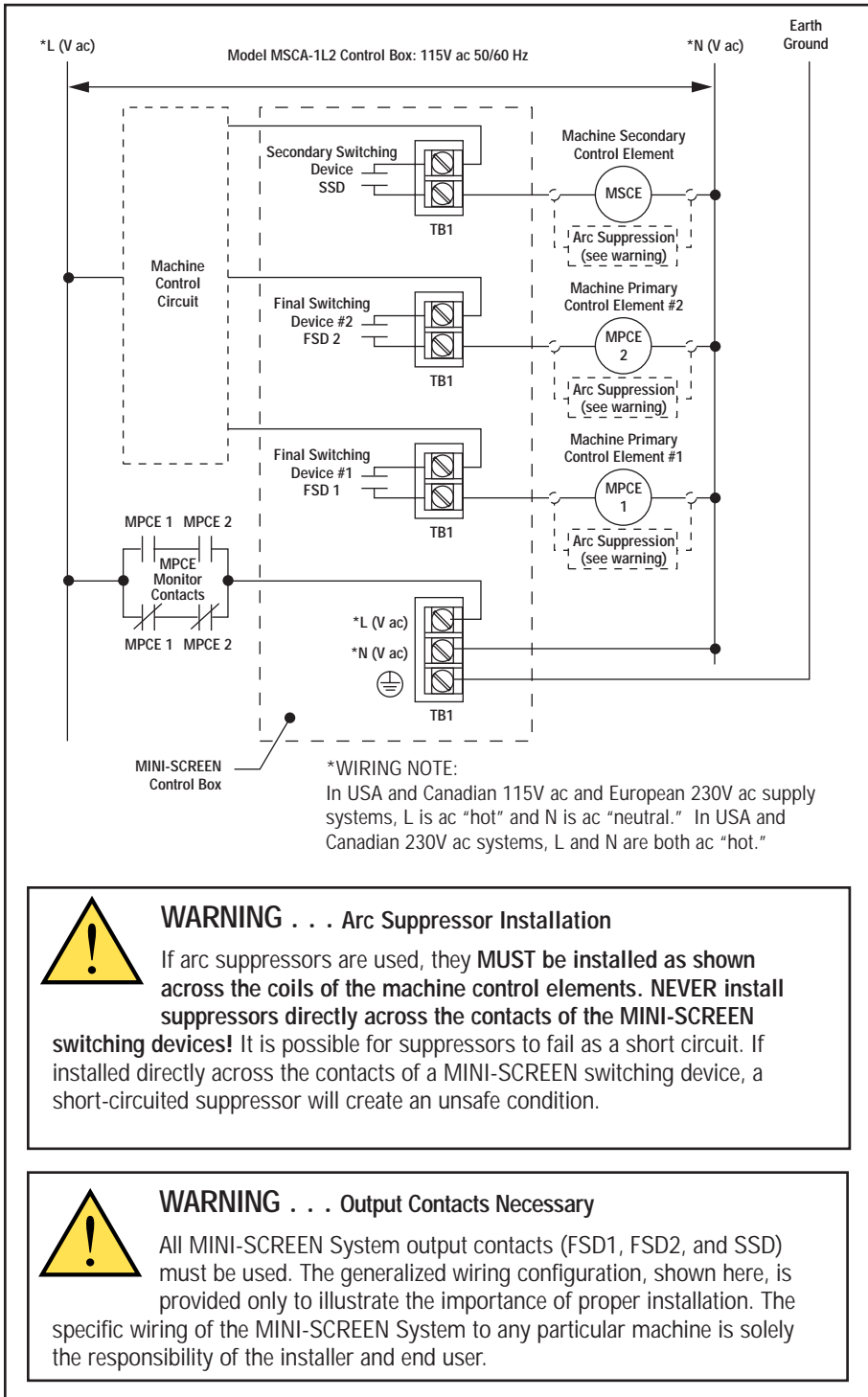
Many different types of mechanisms are used to arrest dangerous machine motion. Examples include mechanical braking systems, clutch mechanisms, and combinations of brakes and clutches. Additionally, control of the arresting scheme may be hydraulic or pneumatic.

As a result, MPCEs may be of several control types, including a wide variety of contactors and electromechanical valves. **If your machine documentation leaves any doubt about the proper connection points for the MINI-SCREEN System output relay contacts, do not make any connections.** Contact the machine builder for clarification regarding connections to the MPCEs and MSCE.

**The SSD output relay** connects to the Machine Secondary Control Element (MSCE) on the guarded machine. The MSCE is an electrically powered element of the guarded machine (independent of the MPCEs) that is capable of removing power from the prime mover of the dangerous part of the machine in the event of an emergency. The output contacts of the SSD relay must be connected, as shown in Figure 23, to the Machine Secondary Control Element such that, if a lockout condition occurs, the motive power will be removed from the machine. The switching capacity of the SSD relay is 250V ac max., 4 amps max. (resistive load).

## System Installation and Alignment

Figure 23 (below) shows output relay connections in a generic interfacing situation. The connections between the MINI-SCREEN System outputs and the machine primary and secondary control elements must be direct, and arranged so that any single line fault or earth fault will not result in a circuit failure to a potentially dangerous state.



### WARNING . . . Arc Suppressor Installation

If arc suppressors are used, they **MUST** be installed as shown across the coils of the machine control elements. **NEVER** install suppressors directly across the contacts of the MINI-SCREEN switching devices! It is possible for suppressors to fail as a short circuit. If installed directly across the contacts of a MINI-SCREEN switching device, a short-circuited suppressor will create an unsafe condition.



### WARNING . . . Output Contacts Necessary

All MINI-SCREEN System output contacts (FSD1, FSD2, and SSD) must be used. The generalized wiring configuration, shown here, is provided only to illustrate the importance of proper installation. The specific wiring of the MINI-SCREEN System to any particular machine is solely the responsibility of the installer and end user.

Figure 23. MINI-SCREEN System generic machine interface

## Notice Regarding MPCE Monitoring Hookup

It is strongly recommended that one normally open and one normally closed auxiliary contact of each MPCE be wired (as shown in Figure 23, page 30) as MPCE monitor contacts. If this is done, any inconsistency of action between the two MPCEs will remove power from the MINI-SCREEN System, causing a lockout condition<sup>†</sup>. **MPCE auxiliary contacts must be used as MPCE monitor contacts in order to maintain redundancy and control reliability.** MPCE auxiliary contacts used for this purpose must be rated at 55 VA minimum.

**In order to maintain control reliability, the MPCE monitor contacts must be wired as described in section 3.5.5 and Figure 23, page 30.**

<sup>†</sup> NOTE: Assumes Auto Power-up feature is not in use.

### 3.5.5 System Power (Permanent Connection)

After the initial checkout of Section 3.5.3 has been successfully completed, the power lines to the MINI-SCREEN System must be re-routed to their permanent hookup through the MPCE monitor contacts of the guarded machine. This is important: it ensures that any inconsistency in action between the two MPCEs will remove power from the system. (See **Notice regarding MPCE Monitoring Hookup**, left).

Connection of system power is at the L and N (or + and -) terminals of control box wiring barrier TB1. The MINI-SCREEN System requires 115V ac, 50/60Hz; three-wire connection (ac "hot," ac "neutral," and earth ground) to ac power mains must be done according to NEC and local wiring codes. *Do not operate the MINI-SCREEN System without an earth ground connection.*

After power has been connected to the MINI-SCREEN System and the output relay contacts have been connected to the machine to be guarded, the operation of the MINI-SCREEN System with the guarded machine must be verified before the combined system may be put into service. **To do this, a Qualified Person must perform the Commissioning Checkout Procedure (Section 6.2, page 42).**

### 3.5.6 Alarm Relay

The action of the Alarm Relay contact is closed for a latch or lockout condition. The Alarm Relay contact is a light-duty contact used for *control functions that are not safety-related*. A typical use is to communicate with a programmable logic controller (PLC). The switching capacity of the Alarm Relay is 125V ac or dc max., 500mA max. Connection to the Alarm Relay contact is made at wiring barrier TB4.

### 3.5.7 Accessory Connections

Terminal Barrier TB2 at the upper left corner of the control box allows connection of remote inputs including the following:

*Optional (see page 55) MGA-KSO-1 Remote Key Switch* connects across the Key 1 and Key 2 terminals of TB2. It is functionally equivalent to the control box Key switch. ***The MGA-KSO-1 must be positioned at a location that provides the switch operator with an unobstructed view of the entire defined area.*** Use shielded cable or separate wiring in a grounded conduit; see Section 5.2.

*Remote Test Input* connects to the Test 1 and Test 2 terminals of TB2 (see Figure 20, page 25). When connected together (shorted) for a minimum of 50 milliseconds, these terminals provide the MINI-SCREEN System with the equivalent of a BLOCKED beam condition, for testing purposes. The switch or switching device used to short the Test contacts must be capable of switching 15 to 50V dc at 20 to 100 mA dc.

## 4. Operating Instructions

### 4.1 Security Protocol

The MINI-SCREEN control box has a lockable cover and a key-operated front-panel Reset switch.

In order to prevent access by unauthorized personnel, and to ensure that all lockout conditions come to the attention of a person qualified to deal with them, a lock must be inserted in the lockable cover and the key (or combination) to this lock must be kept in the possession of a Qualified Person as defined in ANSI/ASME B30.2-1983 (see Glossary). Only Qualified Persons should have access to the interior of the MINI-SCREEN System control box.

The key to the front-panel Reset switch should be available to a Designated Person or Persons. A Designated Person is one who is identified and designated in writing, by the employer, as being appropriately trained and qualified to perform a specified checkout procedure. If the machine operator meets these requirements, he/she may be a Designated Person.

### 4.2 Periodic Checkout Requirements

In addition to the checkouts that are performed by a Qualified Person or persons at the time that the MINI-SCREEN System is installed and put into service, **the functioning of the MINI-SCREEN System and the machine it guards must be verified on a regular periodic basis to ensure proper operation. This is absolutely vital and necessary. Failure to ensure proper operation can lead to serious injury or death.**

Checkouts must be performed according to checkout procedure 6.3, page 44 as follows:

- 1) By a Designated Person at every power-up of the MINI-SCREEN System;
- 2) By a Qualified Person following the correction of every lockout condition; and
- 3) By a Designated Person at every shift change or machine setup change.

Checkouts must be performed according to checkout procedure 6.4, page 49 as follows:

- 1) By a Qualified Person semi-annually (every 6 months) following installation of the MINI-SCREEN System.



#### **WARNING . . .** For Proper Operation

The Banner MINI-SCREEN System can do the job for which it was designed only if it and the machine it guards are operating properly, both separately and together. **It is the user's responsibility to verify proper operation, on a regular basis, as instructed in Section 4.2 and Section 6 of this manual.**

**If the MINI-SCREEN System and the guarded machine do not perform exactly as outlined in the checkout procedures, do not use the System or the guarded machine until the cause of the problem is found and corrected. Failure to do so can result in serious bodily injury or death.**



### 4.3 Normal Operation

#### Power-up

If the Auto Power-up feature is ON when ac power is applied to the System, the controller performs a system checkout and resets itself, without the need for a Key Reset. If Auto Power-up is OFF when ac power is applied to the MINI-SCREEN System, it is normal for it to power up into a lockout condition. To prepare the MINI-SCREEN System for operation after a power-up lockout, the Designated Person must perform a Key Reset:

- 1) Turn the key clockwise to the RESET position (yellow indicator goes ON steadily).

Wait at least one-half second, then

- 2) Turn the key counterclockwise to the RUN position.

**If the defined area is clear**, the green and yellow indicators will go ON (red indicator goes OFF). *(If floating blanking is ON, the green indicator will be flashing.)*

**If the emitter and receiver are misaligned**, the red indicator will come ON. The yellow indicator will single-flash at a rate that indicates the relative number of light beams established.

**If the defined area is blocked and the emitter and receiver are aligned**, the red indicator will come ON, and the yellow indicator will single-flash at a rate that indicates the relative number of light beams established.

When the defined area is clear, perform checkout procedure 6.4 on page 44.

#### Floating Blanking Operation

When floating blanking is ON, objects of up to a specified size may enter the defined area at any point without causing a Latch condition (see Section 2.1). Floating blanking causes the minimum object sensitivity to be increased.

The use of floating blanking also increases the Penetration Depth Factor (Dpf) and, consequently, the separation distance required between the defined area and the closest machine danger point. If the separation distance was for no floating blanking and you later begin to use floating blanking, OSHA regulations require the separation distance to be increased accordingly. See Section 3.2.1.

### 5. Troubleshooting and Maintenance

#### 5.1 Troubleshooting Lockout Conditions

A lockout condition of the MINI-SCREEN System causes all of its relays to open, sending a Stop signal to the guarded machine. A lockout condition will occur:

##### Power-up/Power Interrupt Lockouts

- Routinely upon power-up of the MINI-SCREEN System (unless Auto Power-up is ON; see Section 4.3); or
- If power to the MINI-SCREEN System is interrupted (unless Auto Power-up is ON).

##### Internal Lockout Conditions

- If the control box Key switch is in the Reset position, at power-up (with Auto Power-up ON); or if the Key switch is switched to Reset while the System is in RUN mode;
- If an FSD (Final Switching Device) relay does not “drop out” within its specified time;
- If the SSD (Secondary Switching Device) relay has de-energized;
- If the controller module switch settings are inconsistent with each other or if they are changed while the System is in RUN mode; or
- If the self-checking circuits of the microprocessor detect a component failure within the MINI-SCREEN System itself.

A lockout condition causes output relays FSD1, FSD2, and SSD to open, shutting down the MPCEs and MSCE of the guarded machine. A lockout condition resulting from an internal system fault is indicated by the red status indicator (only) flashing.

Power-up/power interrupt lockouts (Auto Power-up OFF, conditions as described above, yellow indicator only double-flashing) are normal and require a Key Reset for operation to continue.

##### Key Reset

Use the following procedure to resume operation after a power interruption:

- 1) Turn the key clockwise to the RESET position (yellow status indicator should light) and wait at least one-half second, then
- 2) Turn the key counterclockwise to the RUN position.  
If the defined area is clear and the emitter and receiver are properly aligned, the green and yellow indicators will light.

**If the lockout condition was due to a momentary power interruption** that has been corrected, the MINI-SCREEN System will now operate normally. **Upon recovery from a power interruption, checkout procedure 6.3 on page 44 must be performed.**

**If the Status Indicator LEDs will not operate,** the lockout condition is due to another



##### WARNING . . . Power Failures

Power failures or other MINI-SCREEN System lockout conditions should always be investigated immediately by a Qualified Person. *With the exception of Power-up/power interrupt lockouts (left), a lockout is a positive indication of a problem and should be investigated at once. Attempts to continue to operate machinery by bypassing the MINI-SCREEN System are dangerous and could result in serious bodily injury or death.*



##### WARNING . . . High Voltage

Dangerous voltages are present inside the MINI-SCREEN System control box whenever ac power to the System and/or machine control elements is ON. **Exercise extreme caution whenever the control box cover is open and ac voltage is or may be present!**

cause (internal lockout conditions). In this case, the Qualified Person must note the state of the Diagnostic Indicator LEDs (refer to Figure 24, below). If one or more of the red Diagnostic Indicator LEDs is ON, the cause of the lockout condition is *within* the MINI-SCREEN System. The MINI-SCREEN System will not operate if its self-checking circuits have detected an internal problem. Take the corrective measure(s) shown in Figure 24 for the listed error number and related problem. If further assistance is required, contact your Banner field service engineer or the factory Applications Engineering Department.

If no Diagnostic Indicator LEDs are ON, power to the system may have been lost. The green LED on the power supply board (see Figure 20, page 25) indicates the presence (ON) or absence (OFF) of dc power at the power supply board. **NOTE: It is possible for power to be present at the input of the power supply even if the dc power LED is OFF. Exercise care; a shock hazard may exist under these conditions.**

**Very carefully check for voltage across the L and N (or + and -) terminals of wiring barrier TB1.** If voltage is not present at L and N, power to the MINI-SCREEN System has been lost, and the cause is outside the System. Check for 12V dc at connector block TB3. If 12V dc is not present there, turn off the power to the control box and check the fuse. If the fuse is bad, replace it (Section 5.3.1). If the fuse is good, and 12V dc is still not present at TB3, a power supply failure has occurred.

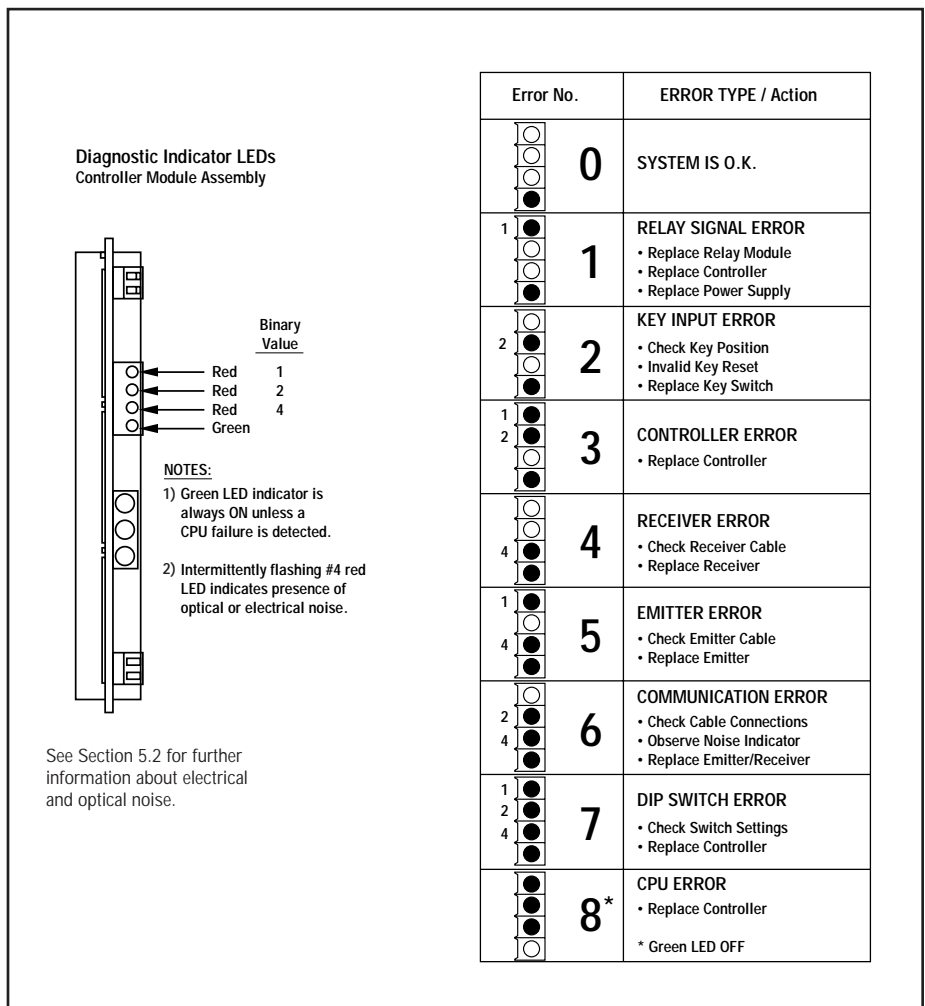


Figure 24. Interpretation of Diagnostic Indicator LEDs

## Troubleshooting and Maintenance

### 5.2 Effects of Electrical and Optical Noise

The MINI-SCREEN System is designed and manufactured to be highly resistant to electrical and/or optical “noise” and to operate reliably in industrial settings. However, serious electrical and/or optical “noise” may cause a random latch condition. In very extreme cases, a lockout is possible. In order to minimize the effects of transitory noise, the MINI-SCREEN System will respond to noise only if the noise is detected on multiple consecutive scans. Red diagnostic indicator LED #4 will flash to indicate the presence of electrical or optical noise. This indicator can be used to track down particularly offensive noise sources (see sidebar); simply observe the indicator while shutting down or isolating the suspected sources.

Whenever a remote accessory (such as the MGA-KSO-1 Remote Key Switch) is used with the MINI-SCREEN System, use shielded cable or a separate grounded conduit to prevent undue noise.

### 5.3 Servicing and Maintenance

#### 5.3.1 Fuse Test and Replacement

**Turn off ac power to the control box before proceeding.**

The MINI-SCREEN System control box fuse is located in a fuseholder on the power supply board (see Figure 20, page 25). Remove the fuse from the holder. Visually inspect the fuse and/or test its conductivity using an ohm meter or a continuity tester. The fuse is a 3AG or 5x20 mm slow-blow type (see specifications, page 53).

#### 5.3.2 Controller Module and Relay Replacement

MINI-SCREEN Systems are designed for reliability. While replacement of the controller module and relays is not normally required, these components have been designed to be easily replaceable as a convenience to the customer. **To maintain control reliability, use only Banner-supplied replacement relays with forced-guided contacts.**

The controller module may be removed from the control box by gently “rocking” the board to loosen it and then sliding the board out of the box. To re-install the controller module, slide the board into place until snug, then push it into place.

### Electrical and Optical Noise

Check the following if red Diagnostic Indicator #4 is flashing:

- Poor connection between control module and earth ground
- Drain wire of emitter and/or receiver not connected to TB3 (see Figure 20)
- Sensor wires or output wires routed too close to “noisy” wiring
- Optical interference from adjacent light screens or other photoelectrics



#### **WARNING . . .** **Shut Down Machinery Before Servicing**

You may be working close to a hazardous area of your machinery while servicing the MINI-SCREEN System. **The machinery that the MINI-SCREEN System is connected to must not be operating at any time during this procedure.**

**Servicing the MINI-SCREEN System while the hazardous machinery is operational could result in serious bodily injury or death.**



#### **CAUTION . . .** **Dangerous Voltages**

Electrical shock hazard exists when the control box door is open and the MINI-SCREEN System has power applied to it and/or the machine control elements. Use extreme caution to avoid electrical shock during installation or servicing or when the control box door is open to change programming or observe the diagnostic indicators. **Always disconnect all power from the MINI-SCREEN System and the guarded machine before making any wire connections or before replacing any component.**

**The control box should be opened and/or serviced only by a Qualified Person (see Section 4.1).**



### **WARNING . . .** **Use Only Genuine Banner Replacement Parts**

If replacement parts are ever required, **always use only genuine Banner-supplied replacement parts** (see page 55). Do not attempt to substitute parts from another manufacturer. **To do so could impair the operation of the MINI-SCREEN System and could result in serious bodily injury or death.**

The output relays are configured on one module (see Figure 20, page 25). To remove the module, remove the 3/8" nylon hex nuts and gently slide the module out of the control box to disconnect it from the mother board. To reinstall, press the module firmly and evenly onto its connector pins and replace the hex nuts. Use care to avoid overtightening.

**NOTE: Do not open the emitter or receiver housing. The emitter and receiver contain no field-replaceable components.** If repair is necessary, return the unit to the factory. Do not attempt to repair an emitter or receiver yourself.

**If it ever becomes necessary to return a MINI-SCREEN component to the factory, please do the following:**

- 1) Contact the Banner Factory Application Engineering group at the address or numbers listed below.

**Banner Engineering Corp.  
9714 - 10th Avenue No.  
Minneapolis, MN 55441  
Phone: 612.544.3164  
Fax: 612.544.3213**

They will attempt to troubleshoot the system from your description of the problem. If they conclude that a component is defective, they will issue an RMA (Return Merchandise Authorization) number for your paperwork, and give you the proper shipping address.

- 2) Pack the component(s) carefully. Damage which occurs during return shipping is not covered by warranty.

### 5.3.3 Cleaning

The **MINI-SCREEN System control box** is constructed of welded steel with a black polyester paint finish, and is rated NEMA 13 (IP 64). It may be cleaned using mild detergent or window cleaner and a soft cloth.

The **MINI-SCREEN System emitter and receiver units** are constructed of aluminum with a black anodized or yellow painted finish and are rated NEMA 4, 13 (IP 65). Lens covers are acrylic. Emitters and receivers are best cleaned using mild detergent or window cleaner and a soft cloth. Avoid cleaners containing alcohol, as they may damage the acrylic lens covers.

## 6. Alignment and Checkout

Study each procedure from beginning to end to make sure that you understand each step before you start. Refer all questions to the Banner Applications Engineering Department (see page 2 for address, telephone, and fax information).

Section 6.1 is a procedure for optically aligning a MINI-SCREEN System. Sections 6.2, 6.3, and 6.4 are periodic performance checkout procedures for the MINI-SCREEN System, and are performed according to the schedule given in Section 4.2.


### 6.1 MINI-SCREEN System Alignment

This alignment procedure begins with the assumption that the MINI-SCREEN System has been mechanically aligned as described in Section 3.3.

Follow the measures outlined below to maximize MINI-SCREEN System excess gain. If there are reflective surfaces near the defined area, read alignment step #5 (page 39) before proceeding further, to prevent possible reflection problems.

Only a **Qualified Person** may align the MINI-SCREEN System, as follows:

- 1) Turn OFF power to the MINI-SCREEN System and to the guarded machine. Leave power to the guarded machine OFF, and power-up the MINI-SCREEN System only, with the key in the RUN position.
- 2) The MINI-SCREEN will power up into a power-up lockout condition (unless Auto Power-up is ON). Remove all obstructions from the defined area and reset the MINI-SCREEN System as follows:
  - a. Turn the control box front-panel Key Reset switch to the RESET position,
  - b. Wait at least 1/2 second to allow time for internal system checks, and
  - c. Turn the Key Reset switch to the RUN position.



**WARNING . . .**  
Turn Machinery OFF Before Proceeding

The machinery that the MINI-SCREEN System is connected to must not be operating at any time during the alignment procedure of Section 6.1. You may be working close to hazardous areas of your machinery while aligning the MINI-SCREEN System. Doing so while the hazardous machinery is operational could result in serious bodily injury. Aligning the MINI-SCREEN System while the hazardous machinery is operational could result in serious bodily injury.

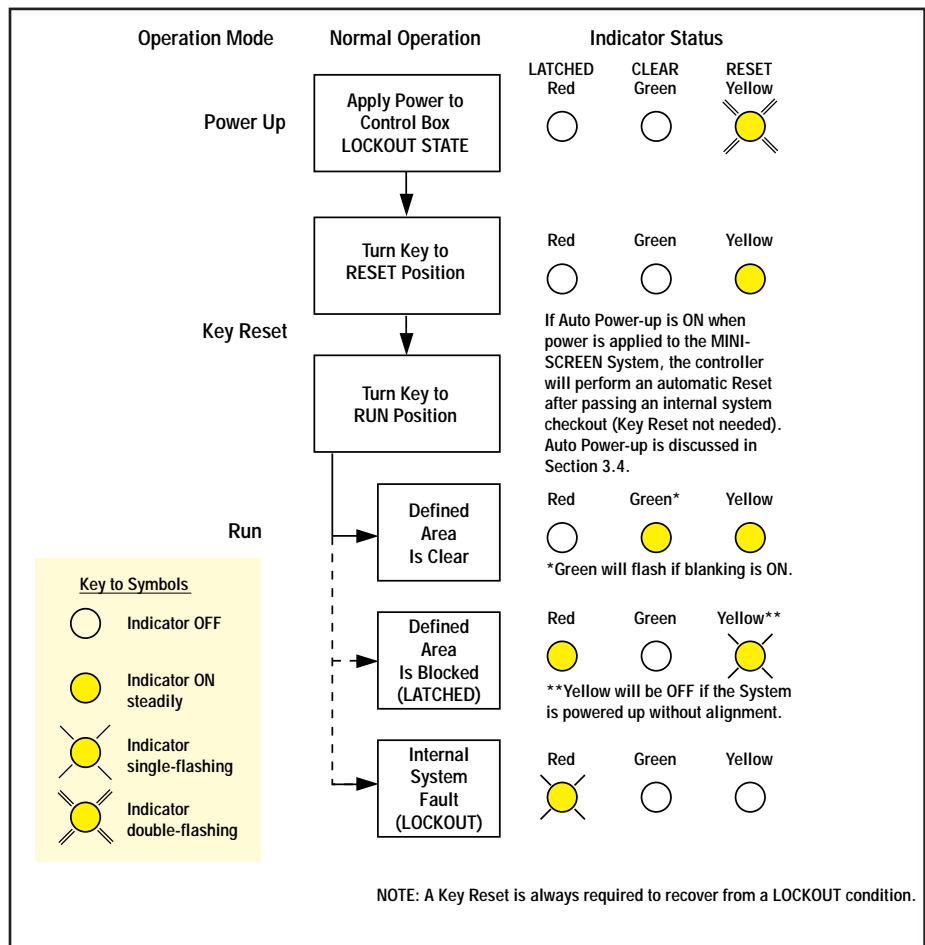


Figure 25. Operating status LED conditions

- 3) Upon completion of the Key Reset (step #2), the MINI-SCREEN will indicate either a LATCHED or a CLEAR condition:
  - a) A LATCHED condition is indicated by the red indicator ON steadily and the yellow indicator flashing at a rate proportional to the number of beams which are aligned and unblocked. Go to step #4.
  - b) A CLEAR condition is indicated by the red indicator OFF, and the green and yellow indicators ON steadily. Further alignment is not necessary.
- 4) A LATCHED condition after Reset indicates that one or more of the beams is misaligned or interrupted. When this occurs:
  - a) Check carefully for any obstructions in the path of the beams within the defined area (the limits of which are indicated by yellow arrows on the front face of the emitter and receiver; see Figure 15).
  - b) If the defined area is completely clear of obstructions, loosen the two slotted hex head M4 bolts and the M30 nut on the cable end which fasten the receiver to its mounting brackets. Slowly rotate the receiver first to the right and then to the left while watching the LED indicators at the base of the receiver.
  - c) If the green indicator does not come ON, regardless of the angle of the receiver, then loosen the emitter and rotate both sensors relative to each other until the green indicator comes ON. Secure the emitter and receiver in the center of the area of rotation where the yellow and green indicators are ON steadily. (NOTE: The green status indicator will flash if floating blanking is ON.)
  - d) If the green indicator still fails to come ON, then re-check the sensor mounting per the procedure in Section 3.3, and then re-align as described above.
- 5) "Trip test" the MINI-SCREEN System for object detection capability using the test piece(s) supplied with the control box. To perform this test, the Key Reset switch must be in the RUN position and the green and yellow indicators (only) must be ON steadily. Reset the system (Key Reset) to attain this condition, after each pass.

Appropriate Test Pieces for Trip Test		
Sensing Range	Floating Blanking OFF (Green Status Indicator ON Steadily)	Floating Blanking ON (Green Status Indicator Flashing)
9 m (30')	19.1 mm (0.75") diameter Model STP-2	44.5 mm (1.75") diameter Model STP-3
18 m (60')	25.4 mm (1.00" ) diameter Model STP-7	50.8 mm (2.00") diameter Model STP-8

## Alignment and Checkout

Pass the appropriate specified test piece downward through the defined area at three points (see Figure 26):

- close to the receiver,
- close to the emitter, and
- midway between the emitter and receiver.

In each case, the red indicator must come ON and the green indicator must go OFF and remain OFF for as long as the test piece is within the defined area.

If the green indicator comes ON at any time when the test piece is within the defined area, check for light reflected from the emitter to the receiver by a nearby reflective surface (see Caution on page 18). If a reflective surface can be identified, move either the defined area (move the sensors) or the reflective surface. Be sure to maintain at least the minimum required separation distance (see Section 3.2.1). Alternately, take measures to reduce the reflectivity of the interfering surface, for example by angling, painting or masking.

**Do not continue until the situation is corrected.**

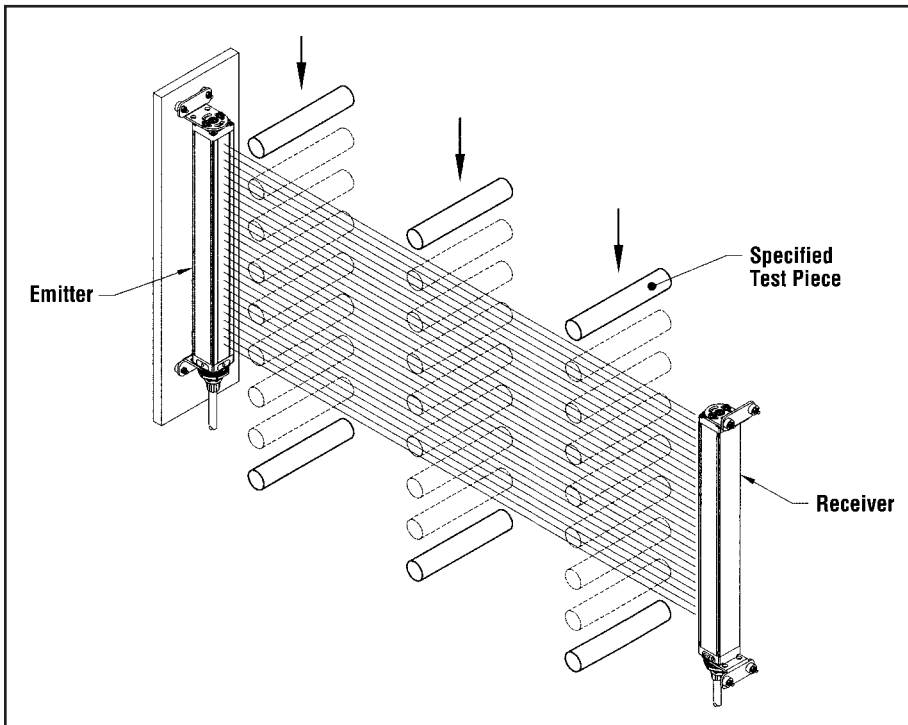


Figure 26. MINI-SCREEN trip test



### WARNING . . .

If Trip Test Indicates a Problem

If the MINI-SCREEN System does not respond properly to the trip test, do not attempt to use the System. If this occurs, the System cannot be relied upon to stop dangerous machine motion when a person or object enters the defined area. **Serious bodily injury or death could result.**



## Use of Corner Mirrors

MINI-SCREEN sensors may be used with one or more MSM Series corner mirrors for guarding along more than one side of an area.

The Accessories section lists the 12 available lengths of corner mirrors (see page 56). These are rear-surface glass mirrors which are rated at 85% efficiency; sensing range (and therefore excess gain) is reduced when using mirrors. The following table lists the resultant range when using from one to four MSM Series corner mirrors in either sensing path.

Maximum Emitter and Receiver Separation				
Number of Corner Mirrors	1	2	3	4
9 m (30') range sensors	8.5 m (28')	7.8 m (25.5')	7.2 m (23.5')	6.7 m (22')
18 m (60') range sensors	16.8 m (55')	15.5 m (51')	14.3 m (47')	13.1 m (43')

Mirrors should be securely mounted to a solid, vibration-free surface. Using a level, mount the mirror(s) exactly parallel to (in the same plane as) the sensors, with the midpoint of the mirror(s) directly in line with the midpoint of the sensors' defined area. The upper and lower limits of the defined area of MINI-SCREEN sensors is marked by arrows along the edge of each sensor window, and is dimensioned in the chart on page 21.

Adjust the corner mirror(s) so that the angle of incidence of light to the mirror equals the angle of reflection from the mirror. Referring to Figure 27 below, sight from behind one of the sensors directly towards the mirror (or the first mirror in line). When alignment is correct, you will see the straight and centered reflection of the lens of the other sensor in the mirror. Accessory laser tool, model LAT-1 is available to assist in alignment (see page 57).

Use the yellow alignment indicator corresponding to the screen being aligned for final alignment. Refer to the data sheet (P/N 43658) packed with each MSM Series corner mirror for complete information on the use of corner mirrors.



**WARNING . . .**  
Use with Supplemental Sensing Devices if Necessary

Supplemental presence-sensing devices, such as safety mats, must be used if any space between either defined area and any danger point is large enough to allow a person to stand undetected by the MINI-SCREEN System. Failure to observe this warning could result in serious injury or death.

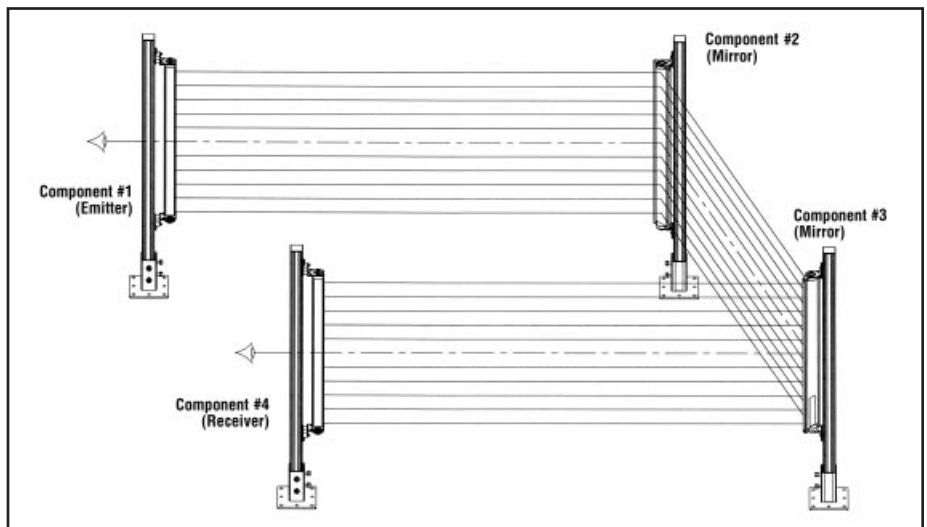



Figure 27. Corner mirror alignment

## 6.2 Commissioning Checkout (To Be Performed at Installation)


This commissioning checkout must be done by a Qualified Person who possesses all of the manufacturer-provided information on the MINI-SCREEN® System and guarded machine and who, by possession of a recognized degree or certificate of professional training or who, by extensive knowledge, training, or experience, has successfully demonstrated the ability to solve problems relating to the installation, operation, and maintenance of optoelectronic machine guards.

A copy of checkout results should be kept in the employer's files; see OSHA 1910.217(e)(1). The qualified person must:

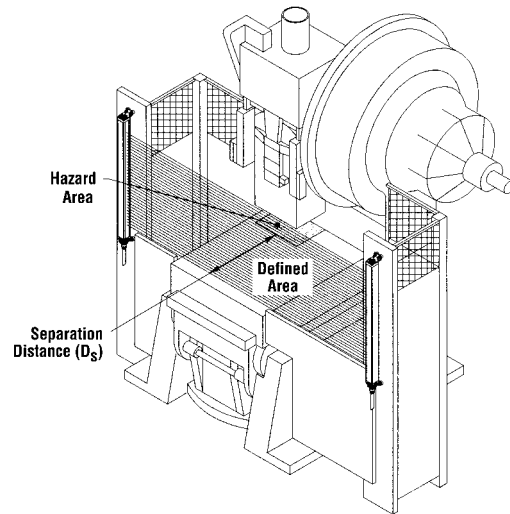
- 1) Examine the guarded machine to verify that it is of a type and design that is compatible with the MINI-SCREEN System. See page 2 for a list of misapplications.
- 2) Verify that the minimum separation distance from the closest danger point of the guarded machine to the defined area is not less than the calculated distance (see Figure 28).
- 3) Verify that access to the dangerous parts of the guarded machine is not possible from any direction not protected by the MINI-SCREEN System, hard guarding, or supplemental guarding, and verify that all supplemental guarding devices and hard guarding are in place and operating properly.
- 4) Verify that it is not possible for a person to stand between the defined area and the dangerous parts of the guarded machine. Or, verify that supplemental presence-sensing devices, such as safety mats, are in place and functioning properly in any space between the defined area and any danger point which is large enough to allow a person to stand undetected by the MINI-SCREEN System.
- 5) Examine the electrical wiring connections between the MINI-SCREEN output relays and the guarded machine's control elements to verify the requirements stated in Section 3.5.4.



**WARNING . . . Shock Hazard**  
A shock hazard exists while the lockable enclosure is open. **Before continuing, verify that the enclosure is closed and latched.**



**WARNING . . . Calculate the Safety Distance Carefully**  
Failure to maintain appropriate separation distance can result in serious bodily injury or death.



The formula used to calculate the separation distance is:

$$D_s = K \times (T_s + T_r) + D_{pf}$$

where:

$D_s$  = the separation distance;

$K$  = the OSHA-recommended hand speed constant of 63" per second (NOTE 1, below);

$T_s$  = the overall stop time of the machine measured from the application of the Stop signal to the final ceasing of all motion (including stop times of all relevant control elements, measured at maximum machine velocity). See NOTE 2, below.

$T_r$  = the response time of the MINI-SCREEN System:  
4.5" to 16" emitter/receiver: .048 sec.  
20" to 32" emitter/receiver: .060 sec.  
36" to 48" emitter/receiver: .072 sec.

$D_{pf}$  = the added distance due to depth penetration factor, as prescribed in OSHA 1910.217 and ANSI B11 standards:

9 m (30') Range		18 m (60') Range	
Floating Blanking	$D_{pf}$	Floating Blanking	$D_{pf}$
OFF	1.6"	OFF	2.5"
ON	5.0"	ON	5.9"

NOTES:

- 1) The OSHA-recommended hand-speed constant  $K$  has been determined by various studies, and although these studies indicate speeds of 63 in/sec to over 100 in/sec, they are not conclusive determinations. The employer should consider all factors, including the physical ability of the operator, when determining the value of  $K$  to be used.
- 2)  $T_s$  is usually measured by a stop-time measuring device. If the specified machine stop time is used, we recommend that at least 20% be added as a safety factor to account for clutch/brake system deterioration.
- 3) Use of floating blanking always causes the required  $D_s$  to increase.

Figure 28. Calculation of  $D_s$

- 6) Test the effectiveness of the MINI-SCREEN System with power ON, as described in steps (a) through (d), below.

The controller includes two or four specified test pieces. Select the proper test piece based on the sensors used and the system configuration, per the following chart:

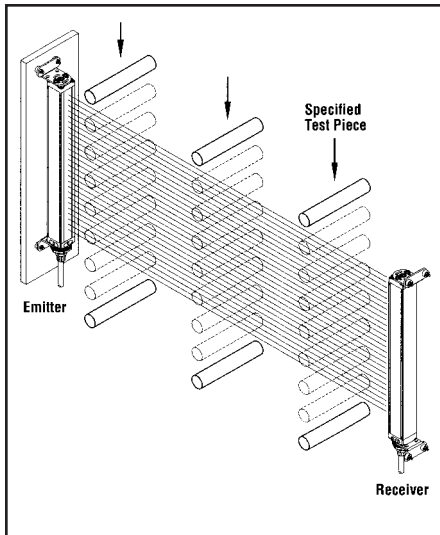


Figure 29. Use of test piece in trip test

Appropriate Test Pieces for Trip Test		
Sensing Range	Floating Blanking OFF (Green Status Indicator ON Steadily)	Floating Blanking ON (Green Status Indicator Flashing)
9 m (30')	19.1 mm (0.75") diameter Model STP-2	44.5 mm (1.75") diameter Model STP-3
18 m (60')	25.4 mm (1.00") diameter Model STP-7	50.8 mm (2.00") diameter Model STP-8

- a) Verify that the MINI-SCREEN System is in RUN mode (green and yellow status indicators ON).
- b) With the guarded machine at rest, pass the specified test piece (supplied with the control box) downward through the defined area at three points: close to the receiver column, close to the emitter column, and midway between the emitter and receiver columns (Figure 29). In each case, the red indicator must come ON and the green indicator must go OFF and remain OFF for as long as the test piece is within the defined area. If the green indicator comes ON at any time when the test piece is within the defined area, check for reflective surfaces, and do not continue until the cause is discovered and the situation is resolved.

NOTE: Latching output models require a Key Reset after each pass of the test piece.

- c) Initiate machine motion of the guarded machine and, during motion, insert the specified test piece into the defined area (at right angles to the defined area). **Do not attempt to insert the test piece into the dangerous parts of the machine.** Upon insertion of the test piece into the defined area at any time during machine motion, the dangerous parts of the machine should come to a stop with no apparent delay. Upon removal of the test piece from the defined area, verify that the machine does **not** automatically restart, and that the initiation devices must be engaged to restart the machine.

NOTE: Latching output models require a Key Reset before the initiation devices are engaged to restart the machine.

- d) With the guarded machine at rest, insert the specified test piece into the defined area and verify that it is not possible for the guarded machine to be put into motion while the specified test piece is within the defined area.
- 7) Remove electrical power to the MINI-SCREEN System. All output relays should immediately de-energize, and should not be capable of being reactivated until power is re-applied and a Key Reset is performed (unless Auto Power-up is ON).
- 8) Test the machine stopping response time using an instrument designed for that purpose to verify that it is the same or less than the overall system response time specified by the machine manufacturer. (NOTE: Banner's Applications Engineering Department can recommend a suitable instrument.)



**WARNING . . . Do Not Use Machine Until System Is Working Properly**


If all of the described checks cannot be verified, **DO NOT USE** the MINI-SCREEN System/guarded machine until the defect or problem has been corrected (see Section 5). Doing so could result in serious bodily injury or death.

## 6.3 Shift Change, Power-up and Machine Setup Change Checkout

Daily checkout and checkouts after tooling and machine changes must be performed by a *Designated Person* appointed and identified in writing by the employer. During continuous machine run periods, this checkout must be performed at intervals not to exceed 24 hours. A copy of checkout results should be kept on or near the machine; see OSHA 1910.217(e)(1).

The Designated Person must:

- 1) Verify that access to the dangerous parts of the guarded machine is not possible from any direction not protected by the MINI-SCREEN System, hard guarding, or supplemental guarding, and verify that all supplemental guarding devices and hard guarding are in place and operating properly.
- 2) Verify that the minimum separation distance from the closest danger point of the guarded machine to the defined area is not less than the calculated distance. (See Section 3.2.1.)
- 3) Ensure that it is not possible for a person to stand between the defined area and the dangerous parts of the guarded machine. Or, verify that supplemental presence sensing devices, such as safety mats, are in place and functioning properly in any space between the defined area and any danger point which is large enough to allow a person to stand undetected by the MINI-SCREEN System.
- 4) Verify that the enclosure for the MINI-SCREEN control module is latched and locked. The key (or combination or tool) to the locking mechanism should be in the possession of a qualified person.
- 5) Test the effectiveness of the MINI-SCREEN with power ON, as described in steps (a) through (d), below.



**WARNING . . .**  
**Shock Hazard**  
 A shock hazard exists while the lockable enclosure is open. **Before continuing, verify that the enclosure is closed and latched.**

**Appropriate Test Pieces for Trip Test**

Sensing Range	Floating Blanking OFF (Green Status Indicator ON Steadily)	Floating Blanking ON (Green Status Indicator Flashing)
9 m (30')	19.1 mm (0.75") diameter Model STP-2	44.5 mm (1.75") diameter Model STP-3
18 m (60')	25.4 mm (1.00" ) diameter Model STP-7	50.8 mm (2.00") diameter Model STP-8

- a) Verify that the MINI-SCREEN System is in RUN mode (green and yellow status indicators ON). See Section 4.3 for Reset procedure; refer to Figure 29.
- b) With the guarded machine at rest, pass the correct specified test piece downward through the defined area at three points: close to the receiver column, close to the emitter column, and midway between the emitter and receiver columns. In each case, the red indicator must come ON and the green indicator must go OFF and remain OFF for as long as the test piece is within the defined area. If the green indicator comes ON at any time when the test piece is within the defined area, check for reflective surfaces (see Warning, page 45).

NOTE: Latching output models require a Key Reset after each pass of the test piece.

- c) Initiate machine motion of the guarded machine and, during motion, insert the specified test piece into the defined area (at right angles to the defined area). **Do not attempt to insert the test piece into the dangerous parts of the machine.** Upon insertion of the test piece into the defined area at any time during machine motion, the dangerous parts of the machine should come to a stop with no apparent delay. Upon removal of the test piece from the defined area, verify that the machine does not automatically restart, and that the initiation devices must be engaged to restart the machine. NOTE: Latching output models require a Key Reset before the initiation devices are engaged to restart the machine.
- d) With the guarded machine at rest, insert the specified test piece into the defined area and verify that it is not possible for the guarded machine to be put into motion while the specified test piece is within the defined area.
- 6) Check carefully for external signs of damage to the MINI-SCREEN System, the guarded machine, and their electrical wiring. Any damage found should be immediately reported to management.

### 6.4 Semi-Annual Checkout (To Be Performed at Six-Month Intervals)



#### WARNING . . .

##### Shock Hazard

A shock hazard exists while the lockable enclosure is open. **Before continuing, verify that the enclosure is closed and latched.**

This semi-annual checkout must be done by a Qualified Person. A copy of test results should be kept on or near the machine.

The Qualified Person must:

- 1) Perform the Commissioning Checkout Procedure (Section 6.2). If any decrease in machine braking ability has occurred, make the necessary clutch/brake repairs, readjust  $D_s$  appropriately, and re-perform the checkout sequence of Section 6.2.
- 2) Examine and test the machine primary control elements (MPCEs) to ensure that they are functioning correctly and are not in need of maintenance or replacement.
- 3) Inspect the guarded machine to ensure that there are no other mechanical or structural problems that would prevent the machine from stopping or assuming an otherwise safe condition when signalled to do so by the MINI-SCREEN System.
- 4) Examine and inspect the machine controls and connections to the MINI-SCREEN System to ensure that no modifications have been made which adversely affect the System.



#### WARNING . . .

##### Do Not Use Machine Until System Is Working Properly

If all of the described checks cannot be verified, **DO NOT USE** the MINI-SCREEN System/guarded machine until the defect or problem has been corrected (see Section 5). Doing so could result in serious bodily injury or death.



#### WARNING . . . Reflective Surfaces

It may be possible for a highly reflective surface (a shiny machine surface or a shiny workpiece) to reflect sensing light around an object in the defined area, preventing that object from being detected. This potentially dangerous condition is discovered using the trip test as described in the Initial Checkout Procedure (Section 3.5.3), the Alignment Procedure (Section 6.1), and the periodic checkout procedures (Sections 6.2, 6.3, and 6.4).

**When this condition is discovered, eliminate the problem reflection(s):**

- 1) **If possible, relocate the sensors** to move the light screen beams away from the reflective surface(s), being careful to retain at least the required separation distance (Section 3.2.1).
- 2) **Paint, mask, or roughen the interfering shiny surface** to reduce its reflectivity.

**Use the trip test to verify that these changes have eliminated the problem reflection(s).**

**NOTE:** If the workpiece is especially reflective and comes close to the light screen, perform the trip test with the shiny workpiece in place.

## Glossary of Terms

Terms shown in *italics* in the definitions below are themselves defined elsewhere in the glossary.

**ANSI (American National Standards Institute):** the American National Standards Institute, is an association of industry representatives which develops technical standards which include safety standards. These standards comprise a consensus from a variety of industries on good practice and design. ANSI standards relevant to application of the MINI-SCREEN System include ANSI B11.1 (mechanical power presses), ANSI B11.2 (hydraulic power presses), and ANSI/RIA R15.06 (industrial robots and robot systems). See page 56

**Auxiliary monitor or Alarm contact:** a low load capacity, non safety-related relay contact within the MINI-SCREEN System whose primary purpose is to communicate system status to a PLC.

**Auto Power-up:** a feature of the MINI-SCREEN control box which, when switched ON, enables the MINI-SCREEN to be powered up (and recover from a power interruption) without the necessity of a *key reset*. When Auto Power-up is ON, the MINI-SCREEN control box automatically begins internal diagnostics upon power-up, and automatically resets the system if it passes the diagnostic check. With Auto Power-up OFF, a manual reset is required.

**Control reliability:** A method of ensuring the integrity of performance of a control system. Control circuits are designed and constructed so that a single failure or fault within the system does not prevent the normal stopping action from being applied to the machine when required, or does not create unintended machine action, but does prevent initiation of successive machine action until the failure is corrected.

**Control box:** contains the circuitry (internal to the MINI-SCREEN System) that provides the proper voltages to the system, controls the sensing units, receives and processes information from the sensing units and the safety monitoring means, and provides outputs to the *Final Switching Devices (FSD1 and FSD2)*, the *Secondary Switching Device (SSD)*, and the *Auxiliary Monitor Relay*.

**Control module:** a removeable printed circuit board, located within the MINI-SCREEN System control box, which contains the microprocessors and related electronic circuits.

**Defined area:** the "curtain of light" generated by the MINI-SCREEN System. When the defined area is interrupted by an opaque object of a specified cross section, a *latch condition* results (see Figure 1).

**Designated person:** a person or persons identified and designated in writing, by the employer, as being appropriately trained and qualified to perform a specified checkout procedure.

**Diverse redundancy:** in diverse redundancy, the redundant components are of different design, and any microprocessor programs used must run from different instruction sets written by different programmers.

**Emitter:** the light-emitting component of the MINI-SCREEN System, consisting of a row of synchronized modulated infrared LEDs. The emitter, together with the *receiver* (placed opposite), creates a “curtain of light” called the *defined area*.

**Final switching device (FSD):** the two output relays (FSD1 and FSD2) of the MINI-SCREEN System which respond to an interruption of the defined area by interrupting the circuit connecting them to the *Machine Primary Control Elements (MPCEs)* of the *guarded machine*.

**Floating blanking:** a feature that allows the MINI-SCREEN System to be programmed to produce an intentionally disabled light beam, within the “curtain of light”, which appears to move up and down (“float”) in order to allow the feeding of an object through the curtain (the *defined area*) at any point along the length of the curtain without causing a *trip condition*.

The MINI-SCREEN System offers two-beam floating blanking which allows **multiple** objects (usually workpiece material) up to 0.8 inch in cross section to move through the *defined area* without tripping the *final switching devices*.

**FMEA (Failure Mode and Effects Analysis):** a testing procedure by which potential failure modes in a system are analyzed to determine their results or effects on the system. Component failure modes that produce either no effect or a *lockout condition* are permitted; failures which cause an unsafe condition (a *failure to danger*) are not. Banner MINI-SCREEN Systems are extensively FMEA tested.

**Forced-guided contacts:** relay contacts that are mechanically linked together, so that when the relay coil is energized or de-energized, all of the linked contacts move together. If one set of contacts in the relay becomes immobilized, no other contact of the same relay will be able to move. The function of forced-guided contacts is to enable the safety circuit to check the status of the relay. Forced-guided contacts are also known as “positive-guided contacts”, “captive contacts”, “locked contacts”, or “safety relays”. MINI-SCREEN Systems use output relays with forced-guided contacts.

**Full-revolution devices:** a method of machine drive arranged such that, once started, the machine can only be stopped when the full cycle is complete. Examples include positive key clutches and similar mechanisms. Banner MINI-SCREEN Systems may **not** be used with full-revolution devices.

**Guarded machine:** the machine whose point of operation is guarded by a MINI-SCREEN System, and whose *MPCEs* and *MSCE* are connected to relays *FSD1*, *FSD2*, and *SSD* of the MINI-SCREEN System.

**Hard guarding:** screens, bars, or other mechanical barriers that prevent a person from reaching over, under, or around the *defined area* of an installed MINI-SCREEN System and into the *point of operation* of the *guarded machine*.

**Internal lockout:** a *lockout condition* that is due to an internal MINI-SCREEN System problem. Indicated by the red Status Indicator LED (only) flashing. Requires the attention of a *qualified person*.

**Key Reset:** a key-operated switch that is used to restore the *Final Switching Devices (FSDs)* and *Secondary Switching Device (SSD)* to the *ON state* from a *lockout condition*. Also refers to the act of using the switch to reset the MINI-SCREEN System.

**Latch condition:** In latching output models, the response of the *Final Switching devices (FSD)* relays when an object equal to or greater than the diameter of the *specified test piece* enters the *defined area*. In a Latch condition, *FSD1* and *FSD2* simultaneously de-energize and open their contacts. The latch must be reset after the *defined area* is cleared by momentarily closing the normally open contact of the Key Reset switch. (See *Trip condition*.)

**Lockout condition:** a condition of the MINI-SCREEN System that is automatically attained both: (1) when its ac supply mains are interrupted and restored, and (2) in response to certain failure signals. When a lockout condition occurs, the MINI-SCREEN System's *FSD*, *SSD*, and *Auxiliary Monitor Relay* contacts open, and a *key reset* is required to return the system to the RUN condition.

**Machine primary control element (MPCE):** an electrically powered element, external to the MINI-SCREEN System, which directly controls the machine's normal operating motion in such a way that it is last (in time) to operate when motion is either initiated or arrested.

**Machine response time:** the time between the interruption by the *Final Switching Devices (FSDs)* of the electrical supply to the *Machine Primary Control Element(s) (MPCEs)* and the instant when the dangerous parts of the machine reach a safe state by being brought to rest.

**Machine secondary control element (MSCE):** a machine control element independent of the *Machine Primary Control Element(s) (MPCEs)*, capable of removing the source of power from the prime mover of the relevant dangerous machine parts.



**Minimum object sensitivity:** the minimum-diameter object that a light curtain system can reliably detect. Objects of this diameter or greater will be detected anywhere in the sensing field. A smaller object can pass undetected through the curtain of light if it passes exactly midway between two adjacent light beams. See also *specified test piece*.

**MPCE monitor contacts:** the normally open and normally closed contacts of a *guarded machine's* MPCEs which are connected in series with the ac power supply to the MINI-SCREEN System. Any inconsistency of action between the two sets of monitor contacts will remove power from the MINI-SCREEN System and cause a *lockout condition*. See Figure 23.

**OFF state (of Final and Secondary Switching Devices):** in the OFF state, the output circuit is broken and interrupts the flow of current.

**ON state (of Final and Secondary Switching Devices):** in the ON state, the output circuit is complete and permits the flow of current.

**OSHA (Occupational Safety and Health Administration); OSHA CFR 1910.217:** Occupational Safety and Health Administration (a US Federal agency), Division of the US Department of Labor, that is responsible for the regulation of workplace safety. OSHA regulations often follow ANSI standards, including mechanical power press requirements (OSHA CFR 1910.217). These regulations become law when adopted by OSHA, and must be followed. See page 56.

**Output relays:** the devices (within the MINI-SCREEN System) that are used to initiate an emergency stop signal. The MINI-SCREEN System's output relays (FSD1, FSD2, and SSD) use *forced-guided contacts*.

**Point of operation:** the area of the guarded machine where a workpiece is positioned and a machine function (i.e. shearing, forming, punching, assembling, welding, etc.) is performed upon it.

**Power supply board:** a removable printed circuit board which contains the power supply circuit and output relays and is located inside the MINI-SCREEN System *control module*. A green LED on the power supply board lights whenever dc power is present on the board.

**Power-up/power interrupt lockout:** a *lockout condition* of the MINI-SCREEN System that, if *Auto Power-up* is OFF, occurs when the system is powered up (including upon power-up after a loss of power). Indicated by the yellow status indicator LED (only) flashing. Requires a *Key Reset* by a *Designated Person*.

**PSDI (Presence Sensing Device Initiation):** an application in which a presence sensing device is used to actually start the cycle of a machine. In a typical situation, an operator manually positions a part in the machine for the operation. When the operator moves out of the danger area, the presence sensing device starts the machine (i.e. no start switch is used). The machine cycle runs to completion, and the operator can then insert a new part and start another cycle. The presence sensing device continually guards the machine. Single break mode is used when the part is automatically ejected after the machine operation. Double break mode is used when the part is both inserted (to begin the operation) and removed (after the operation) by the operator. PSDI is defined in OSHA CFR 1910.217. *Banner MINI-SCREEN Systems may not be used as PSDI devices on mechanical power presses, per OSHA regulation 29 CFR 1910.217.*

**Qualified Person:** a person or persons who, by possession of a recognized degree or certificate of professional training, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve problems relating to the subject matter and work (ANSI B30.2-1983).

**Receiver:** the light-receiving component of the MINI-SCREEN System, consisting of a row of synchronized phototransistors. The receiver, together with the *emitter* (placed opposite), creates a "curtain of light" called the *defined area*.

**Secondary switching device (SSD):** the output relay of the MINI-SCREEN System which, in a *lock-out condition*, interrupts the circuit connecting it to the *Machine Secondary Control Element (MSCE)*.

**Self-checking (circuitry):** a circuit with the capability to electronically verify that all of its own critical circuit components, along with their redundant backups, are operating properly. Banner MINI-SCREEN Systems are self-checking.

**Separation distance:** that distance, along the direction of approach, between the outermost position at which the appropriate test piece will just be detected and the nearest dangerous machine parts.

**Single-stroke press:** see *full-revolution devices*.

**Specified test piece:** an opaque object of the minimum cross section required to place the MINI-SCREEN System into a *trip condition* or a *latch condition* when inserted into any part of the *defined area*. See also *minimum object sensitivity*.

**Supplemental guarding:** additional electrosensitive safety device(s), possibly employed along with *hard guarding* measures, used for the purpose of preventing a person from reaching over, under, or around the *defined area* of an installed MINI-SCREEN System and into the *point of operation* of the *guarded machine*.

**Trip condition:** In trip output models, the response of the *Final Switching Device (FSD)* relays when an object equal to or greater than the diameter of the *specified test piece* enters the *defined area*. In a trip condition, FSD1 and FSD2 simultaneously de-energize and open their contacts. A Trip condition clears automatically when the object is removed from the *defined area*. (See *Latch condition*.)

**UL (Underwriters Laboratory):** a third-party organization which tests a manufacturer's products for compliance with appropriate Standards, electrical and/or safety codes. Compliance is indicated by their listing mark on the product.

## Specifications

MINI-SCREEN Specifications					
Models	Defined Area	Number of Beams	Models	Defined Area	Number of Beams
MSE424 emitter MSR424 receiver	114 mm (4.5")	8	MSE2824 emitter MSR2824 receiver	711 mm (28")	56
MSE824 emitter MSR824 receiver	215 mm (8.5")	16	MSE3224 emitter MSR3224 receiver	813 mm (32")	64
MSE1224 emitter MSR1224 receiver	305 mm (12")	24	MSE3624 emitter MSR3624 receiver	914 mm (36")	72
MSE1624 emitter MSR1624 receiver	406 mm (16")	32	MSE4024 emitter MSR4024 receiver	1016 mm (40")	80
MSE2024 emitter MSR2024 receiver	508 mm (20")	40	MSE4424 emitter MSR4424 receiver	1118 mm (44")	88
MSE2424 emitter MSR2424 receiver	610 mm (24")	48	MSE4824 emitter MSR4824 receiver	1219 mm (48")	96
<b>Emitter/receiver separation:</b>	15 cm (6") to 9 m (30') for standard sensors 15 cm (6") to 18 m (60') for optional long-range sensors				
<b>Minimum object sensitivity:</b>	19.1 mm (0.75") with 9 m (30') range sensors and floating blanking OFF 44.5 mm (1.75") with 9 m (30') range sensors and floating blanking ON 25.4 mm (1.00") with 18 m (60') range sensors and floating blanking OFF 50.8 mm (2.00") with 18 m (60') range sensors and floating blanking ON				
<b>Response time:</b>	Less than 48 milliseconds using emitter/receiver with 4.5" to 16" defined area Less than 60 milliseconds using emitter/receiver with 20" to 32" defined area Less than 72 milliseconds using emitter/receiver with 36" to 48" defined area				
<b>Self-checking interval:</b>	20 milliseconds				
<b>Ambient light immunity:</b>	>10,000 lux at 5° angle of incidence				
<b>Strobe light immunity:</b>	Totally immune to one Federal Signal Corp. "Fireball" model FB2PST strobe.				
<b>Emitter elements:</b>	Infrared LEDs; 880nm peak emission				
<b>Enclosures: Emitter and receiver:</b>	<b>Size:</b> see Figure 15, page 21 <b>Material:</b> Aluminum, with black anodized or yellow painted finish; acrylic lens cover <b>Rating:</b> NEMA 4, 13 (IP 65)				
<b>Control box:</b>	<b>Size:</b> see Figure 17, page 22 <b>Material:</b> Welded steel box with black polyester powder paint finish <b>Rating:</b> NEMA 13 (IP 64)				
<b>Mounting hardware:</b>	Emitter and receiver are each supplied with a pair of mounting brackets. Mounting brackets are 11-gauge cold-rolled black zinc-chromate finished steel. A set of four vibration-dampening mounts is also supplied.				
<b>Certifications:</b>	Approvals in process. Consult factory.				

MINI-SCREEN Control Module Specifications	
System power requirements	115V ac $\pm$ 15% (50/60Hz), 55 VA
Fuse rating	1/2 amp, 250V (3AG or 5x20 mm slow blow)
Status indicators	<p><b>Control Box and Receiver:</b></p> <p><b>Red</b> = LATCHED      <b>Flashing red</b> = LOCKOUT  <b>Green</b> = CLEAR      <b>Flashing green</b> = BLANKING ON  <b>Yellow</b> = RESET      <b>Double-flashing yellow</b> = waiting for power-up manual Key Reset  <b>Single-flashing yellow</b> = ALIGNMENT indicator. Flash rate increases with the number of sensing beams "made"; solid yellow when aligned and defined area is clear.</p> <p><b>Emitter:</b> Emitter has green LED to indicate power ON.</p>
Diagnostic indicator	Four LEDs indicate 8 system status conditions (see Figure 24, page 35). Diagnostic LEDs are visible through a window in the control box cover.
Controls and adjustments	Keyed Reset of system lockout conditions Blanking selection switches Auto Power-Up ON/OFF switches
Test input	Terminals must be closed for a minimum of 0.05 seconds in order to guarantee a test input signal. The switching device used must be capable of switching 15-50V dc at 20 to 100 mA.
Auxiliary monitor relay	Reed relay; 125V ac or dc max., 500 mA. max. (10VA maximum, resistive load)
Output configuration (FSD1, FSD2, and SSD)	Forced-guided contact relays, 250V ac max., 4 amps max. (resistive load). <i>Mechanical life</i> 10,000,000 operations (minimum). <i>Electrical life</i> (at full rated load) 100,000 operations (typical). <i>Arc suppression is recommended when switching inductive loads. See Figure 23, page 30.</i>
Operating temperature	0° to +50°C (+32° to 122°F)
Relative humidity	95% maximum (non-condensing)
FMEA tested (Failure Mode and Effects Analysis)	Per requirements of proposed first edition of UL 491 Standard and BS6491.
Cables	<i>NOTE: Use only Banner cables, which incorporate a "twisted pair" for noise immunity on RS485 data communication lines. Use of other cables can result in "nuisance" lockouts.</i> Emitter and receiver cables are ordered separately. Banner 5-conductor shielded cables have a straight QD (quick-disconnect) connector molded onto the sensor end. Cables measure 8.1 mm (0.32") diameter, and are shielded and PVC-jacketed. Conductors are 20-gauge. Two liquid-tight cable gland/strain relief fittings are supplied with each control box to admit the emitter and receiver cables through the selected knockouts on the control box wall. Emitter and receiver cable lengths may not exceed 50' (each). See Cables, page 55. See cable and sensor drawing, page 22.

## Models and Accessories

### Ordering Information

MINI-SCREEN Systems are sold as kits which include a control box, an emitter and receiver of equal length, emitter and receiver mounting hardware, and two quick-disconnect cables. Cables are interchangeable between the emitter and the receiver. Components are also available separately (below).

Defined Area	Black Anodized				Yellow Painted				Beams
	9 m (30') Range		18 m (60') Range		9 m (30') Range		18 m (60') Range		
	Model	Part Number	Model	Part Number	Model	Part Number	Model	Part Number	
114 mm (4.5")	MSE424 MSR424	37444 37445	MSXLE424 MSXLR424	52625 52626	MSE424Y MSR424Y	47650 47651	MSXLE424Y MSXLR424Y	48125 48126	8
215 mm (8.5")	MSE824 MSR824	37446 37447	MSXLE824 MSXLR824	52627 52628	MSE824Y MSR824Y	47652 47653	MSXLE824Y MSXLR824Y	48127 48128	16
305 mm (12")	MSE1224 MSR1224	37448 37449	MSXLE1224 MSXLR1224	52629 52630	MSE1224Y MSR1224Y	47654 47655	MSXLE1224Y MSXLR1224Y	48129 48130	24
406 mm (16")	MSE1624 MSR1624	37450 37451	MSXLE1624 MSXLR1624	52631 52632	MSE1624Y MSR1624Y	47656 47657	MSXLE1624Y MSXLR1624Y	48131 48132	32
508 mm (20")	MSE2024 MSR2024	37452 37453	MSXLE2024 MSXLR2024	52633 52634	MSE2024Y MSR2024Y	47658 47659	MSXLE2024Y MSXLR2024Y	48133 48134	40
610 mm (24")	MSE2424 MSR2424	37454 37455	MSXLE2424 MSXLR2424	52635 52636	MSE2424Y MSR2424Y	47660 47661	MSXLE2424Y MSXLR2424Y	48135 48136	48
711 mm (28")	MSE2824 MSR2824	37456 37457	MSXLE2824 MSXLR2824	52637 52638	MSE2824Y MSR2824Y	47662 47663	MSXLE2824Y MSXLR2824Y	48137 48138	56
813 mm (32")	MSE3224 MSR3224	37458 37459	MSXLE3224 MSXLR3224	52639 52640	MSE3224Y MSR3224Y	47664 47665	MSXLE3224Y MSXLR3224Y	48139 48140	64
914 mm (36")	MSE3624 MSR3624	37460 37461	MSXLE3624 MSXLR3624	52641 52642	MSE3624Y MSR3624Y	47666 47667	MSXLE3624Y MSXLR3624Y	48141 48142	72
1016 mm (40")	MSE4024 MSR4024	37462 37463	MSXLE4024 MSXLR4024	52643 52644	MSE4024Y MSR4024Y	47668 47669	MSXLE4024Y MSXLR4024Y	48143 48144	80
1118 mm (44")	MSE4424 MSR4424	37464 37465	MSXLE4424 MSXLR4424	52645 52646	MSE4424Y MSR4424Y	47670 47671	MSXLE4424Y MSXLR4424Y	48145 48146	88
1219 mm (48")	MSE4824 MSR4824	37466 37467	MSXLE4824 MSXLR4824	52647 52648	MSE4824Y MSR4824Y	47672 47673	MSXLE4824Y MSXLR4824Y	48147 48148	96

#### Pigtail Quick-Disconnect Option

Any emitter or receiver may be ordered with a 305 mm (12") cable pigtail terminated in the 5-pin male Mini-style quick-disconnect connector. This option accommodates requirements for right-angle exit of the cable from the base of the emitter and/or receiver. They use the same mating quick-disconnect cables as listed above (ordered separately). To specify a pigtail quick-disconnect cable, add suffix "P" to the model number of the emitter or receiver, for example: **MSE1624YP**.

### Control Boxes (One required per system)

Description	Model Number	Part Number
115 V ac control box	MSCA-1L2	55692

### Cables (Two required per system, one per sensor)

Description	Model Number	Part Number
4.5 m (15') cable, straight QD connector	QDC-515C	37442
7.6 m (25') cable, straight QD connector	QDC-525C	37443
15 m (50') cable**, straight QD connector	QDC-550C	37498

Contact factory Applications Department for information on cable lengths greater than 50 feet.

### Documentation

The following documentation is supplied with each MINI-SCREEN System Control Box. Additional copies are available at no charge.

Description	Part Number
Instruction Manual for MINI-SCREEN Systems	55702
Checkout Procedure Card (Daily)	39020
Checkout Procedure Card (Semi-annual)	39021

### Replacement Parts, MINI-SCREEN Systems

Description	Model Number	Part Number
Mounting Hardware Kit for one emitter or receiver	BA2MB	40091
Ground strap, control box door	MGA-GSA-1	27850
Replacement key	MGA-K-1	28513
Key switch, only (no wires)	MGA-KSO-1	30140
Microprocessor control module	MSAL-1	55695
Key switch, pre-wired	MSA-KS-1	39023
Replacement power supply board (115V ac)	MSA-PSA-2	55694
Control box mounting hardware	MSA-MH-1	39024
Relay module	MSA-RM-1	39025
Specified test piece (.75" dia.)	STP-2	39026
Specified test piece (1.75" dia.)	STP-3	39911
Specified test piece (1.00" dia.)	STP-7	48981
Specified test piece (2.00" dia.)	STP-8	49162

## Models and Accessories

### MINI-SCREEN Lens Shields

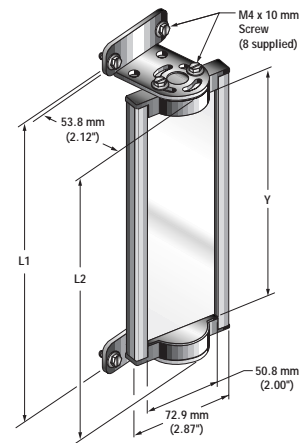
Model MSSxx is a replaceable protective cover for the lens of a MINI-SCREEN sensor. The shield is made of 1.5 mm (0.06") clear polycarbonate. Shield models are available for every sensor length from 4" to 48" (see chart, below). The shields attach to the sensor using two adhesive-backed Neoprene foam strips.

Application Note: When shields are installed on both the emitter and receiver, excess gain is reduced by 36% (and maximum operating range is reduced by 20%).

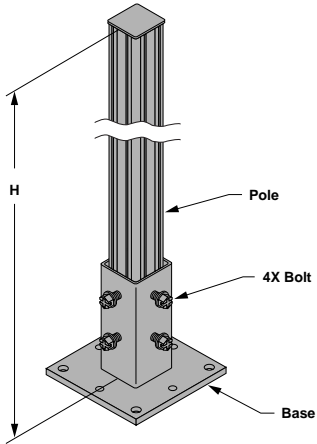
Protective Shield Size	Model Number	Overall Sensor Length	Assembly Number
4"	MSS4	5.4"	44308
8"	MSS8	9.4"	44309
12"	MSS12	13.4"	44310
16"	MSS16	17.4"	44311
20"	MSS20	21.4"	44312
24"	MSS24	25.3"	44313
28"	MSS28	29.3"	44314
32"	MSS32	33.3"	44315
36"	MSS36	37.3"	44316
40"	MSS40	41.3"	44317
44"	MSS44	45.3"	44318
48"	MSS48	49.3"	44319

### MSM Series Corner Mirrors

Mirror Size	Reflective Area Y	Mounting L1	Height L2	Mirror Model Number	Part Number
4"	16.5 cm (6.5")	22.1 cm (8.7")	19.1 cm (7.5")	MSM4A	43162
8"	26.7 cm (10.5")	32.3 cm (12.7")	29.2 cm (11.5")	MSM8A	43163
12"	35.6 cm (14")	41.1 cm (16.2")	38.1 cm (15")	MSM12A	43164
16"	45.7 cm (18")	51.3 cm (20.2")	48.3 cm (19")	MSM16A	43165
20"	55.9 cm (22")	61.5 cm (24.2")	58.4 cm (23")	MSM20A	43166
24"	66.0 cm (26")	71.6 cm (28.2")	68.6 cm (27")	MSM24A	43167
28"	76.2 cm (30")	81.8 cm (32.2")	78.7 cm (31")	MSM28A	43168
32"	86.4 cm (34")	91.9 cm (36.2")	88.9 cm (35")	MSM32A	43169
36"	96.5 cm (38")	102.1 cm (40.2")	99.1 cm (39")	MSM36A	43170
40"	106.7 cm (42")	112.3 cm (44.2")	109.2 cm (43")	MSM40A	43171
44"	116.8 cm (46")	122.4 cm (48.2")	119.4 cm (47")	MSM44A	43172
48"	127.0 cm (50")	132.6 cm (52.2")	129.5 cm (51")	MSM48A	43173







**MSA Series Stands**

Stand Height	Mirror Length (Brackets Outward)	Mirror Length (Brackets Inward)	Sensor Length (Brackets Outward)	Sensor Length (Brackets Inward)	Stand Model	Part Number
24"	4" to 8"	4" to 12"	4" to 12"	4" to 16"	MSA-S24-1	43174
42"	4" to 24"	4" to 28"	4" to 32"	4" to 36"	MSA-S42-1	43175
66"	4" to 48"	4" to 48"	4" to 48"	4" to 48"	MSA-S66-1	43176
84"	4" to 48"	4" to 48"	4" to 72"	4" to 72"	MSA-S84-1	52397



**LAT-1 Laser Alignment Tool**

Description	Model Number	Part Number
Self-contained visible-beam laser tool for alignment of any MINI-SCREEN emitter/receiver pair. Includes retroreflective target material and two mounting clips	LAT-1	52150

### U.S. Application Standards

**ANSI B11.1**

Machine Tools – Mechanical Power Presses – Safety Requirements for Construction, Care, and Use of

**ANSI B11.2**

Hydraulic Power Presses – Safety Requirements for Construction, Care, and Use of

**ANSI B11.3**

Power Press Brakes – Safety Requirements for Construction, Care, and Use of

**ANSI B11.4**

Shears – Safety Requirements for Construction, Care, and Use of

**ANSI B11.5**

Machine Tools – Iron Workers – Safety Requirements for Construction, Care, and Use of

**ANSI B11.6**

Lathes – Safety Requirements for Construction, Care, and Use of

**ANSI B11.7**

Cold Headers and Cold Formers – Safety Requirements for Construction, Care, and Use of

**ANSI B11.8**

Drilling, Milling, and Boring Machines – Safety Requirements for Construction, Care, and Use of

**ANSI B11.9)**

Grinding Machines – Safety Requirements for Construction, Care, and Use of

**ANSI B11.10**

Metal Sawing Machines – Safety Requirements for Construction, Care, and Use of

**ANSI B11.11**

Gear Cutting Machines – Safety Requirements for Construction, Care, and Use of

**ANSI B11.12**

Roll Forming and Roll Bending Machines – Safety Requirements for Construction, Care, and Use of

**ANSI B11.13**

Machine Tools – Single – and Multiple-Spindle Automatic Bar and Chucking Machines – Safety Requirements for Construction, Care, and Use of

**ANSI B11.14**

Coil Slitting Machines/Systems – Safety Requirements for Construction, Care, and Use of

**ANSI B11.15**

Pipe, Tube, and Shape Bending Machines – Safety Requirements for Construction, Care, and Use of

**ANSI B11.16**

Metal Powder Compacting Presses – Safety Requirements for Construction, Care, and Use of

**ANSI B11.17**

Horizontal Extrusion Presses – Safety Requirements for Construction, Care, and Use of

**ANSI B11.18**

Machinery and Machine Systems for the Processing of Coiled Strip, Sheet, and Plate – Safety Requirements for Construction, Care, and Use of

**ANSI B11.19**

Performance Criteria for the Design, Construction, Care, and Operation of Safeguarding when Referenced by the Other B11 Machine Tool Safety Standards

**ANSI B11.20**

Machine Tools – Manufacturing Systems/Cells – Safety Requirements for Construction, Care, and Use of

**ANSI/RIA R15.06**

Safety Requirements for Industrial Robots and Robot Systems

**NFPA 79**

Electrical Standard for Industrial Machinery 1994 Edition

**SOURCES****ANSI B11 Documents**

American National Standards Institute

11 West 42nd Street  
New York, NY 10036  
Telephone: 212.642.4900

-or-

Safety Director

AMT – The Association for Manufacturing Technology  
7901 Westpark Drive  
McLean, VA 22102-4269  
Telephone: 703.827.5266

**ANSI/RIA Documents**

Obtain from ANSI (above) or:

Robotics Industries Association  
900 Victors Way, P.O. Box 3724  
Ann Arbor, MI 48106  
Telephone: 734.994.6088

**NFPA Documents**

National Fire Protection Association  
1 Batterymarch Park  
P.O. Box 9101  
Quincy, MA 02269-9101  
Telephone: 800.344.3555

**SOURCE**

Underwriters Laboratories Inc.  
333 Pfingsten Road  
Northbrook, IL 60062-2096  
Telephone: 847.272.8800

**U.S. Design Standards**

**UL 491**

The Standard for Power-operated Machine Controls and Systems

**UL 1998**

Standard for Safety Related Software

**UL 991**

Tests for Safety-related Controls Employing Solid-state Devices

**SOURCE**

Part of:  
Code of Federal Regulations  
Title 29, Parts 1900 to 1910  
Superintendent of Documents  
Government Printing Office  
P.O. Box 371954  
Pittsburgh, PA 15250-7954  
Telephone: 202.512.1800

**OSHA Regulations**

**OSHA 29 CFR 1910.212**

General Requirements for (Guarding of) All Machines

**OSHA 29 CFR 1910.217**

(Guarding of) Mechanical Power Presses

**SOURCES**

***EN and IEC Standards***

Available from:

Global Engineering Documents  
15 Inverness Way East  
Englewood, CO 80112-5704  
Phone: 1.800.854.7179  
Fax: 303.397.2740

***BS Documents***

British Standards Association  
2 Park Street  
London W1A 2BS  
England  
Telephone: 011-44-908-1166

**European Standards**

**EN 292-1**

Safety of Machinery – Basic Concepts, General Principles for Design Part 1: Basic Terminology, Methodology

**EN 292-2**

Safety of Machinery – Basic Concepts, General Principles for Design Part 2: Technical Principles and Specifications

**EN 294**

Safety of Machinery – Safety Distances to Prevent Danger Zones Being Reached by the Upper Limbs

**EN 418**

Safety of Machinery – Emergency Stop Devices, Functional Aspects – Principles for Design

**prEN 574**

Safety of Machinery – Two-hand control devices – Functional Aspects – Principles for Design

**prEN 811**

Safety of Machinery – Safety Distances to Prevent Danger Zones Being Reached by the Lower Limbs

**EN 954-1**

Safety of Machinery – Safety Related Parts of Control Systems

**prEN 999**

Safety of Machinery – The Positioning of Protective Equipment in Respect to Approach Speeds of Parts of the Human Body

**EN 1050**

Safety of Machinery – Principles of Risk Assessment

**ISO 14119**

Safety of Machinery – Interlocking Devices Associated with Guards – Principles for Design and Selection

**IEC 60204-1**

Electrical Equipment of Machines Part 1: General Requirements

**IEC 61496**

Safety of Machinery – Electro-sensitive Protection Equipment

**IEC 60529**

Degrees of Protection Provided by Enclosures

**IEC 60947-5-1**

Low Voltage Switchgear – Electromechanical Control Circuit Devices

**IEC 60947-1**

Low Voltage Switchgear – General Rules



**Warranty:** Banner Engineering Corporation warrants its products to be free from defects for a period of one year. Banner Engineering Corporation will repair or replace, free of charge, any product of its manufacture found to be defective at the time it is returned to the factory during the warranty period. This warranty is necessarily limited to the quality of materials and workmanship in MINI-SCREEN Systems as they are supplied to the original purchaser. Proper installation, operation, and maintenance of the MINI-SCREEN System becomes the responsibility of the user upon receipt of the system. This warranty does not cover damage or liability for the improper application of the MINI-SCREEN System. This warranty is in lieu of any other warranty, either expressed or implied.

See also warranty-related return shipping information, page 37.