MULTI-SCREEN® System
Dual Safety Light Screen System
Instruction Manual

- An optoelectronic point-of-operation guarding system for production machinery
- One control box operates two emitter/receiver sensor pairs: two pairs of MINI-SCREEN® or MACHINE-GUARD sensors, or one pair of each
- Control box automatically senses type and array length of each sensor pair connected to it; no manual settings are required
- Sensors are available with array lengths from 4.5 inches (114 mm) to 72 inches (1.8 m); accessory corner mirrors and lens shields also available
- One control box model operates from either 115 or 230V ac or 24V dc universal power input
- Features floating blanking (one- or two-beam), which is easily configured inside the lockable control box; may also be programmed for auto power-up
- Numeric diagnostic display visible through control box door
- Separate alignment indicators for each sensor pair
- Controller uses “diverse redundancy” design concept to achieve a higher level of control reliability
- FMEA (Failure Mode and Effects Analysis) tested to ensure control reliability
- Replaceable redundant output safety relays for enhanced 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 provided with sensors

Banner MULTI-SCREEN® Systems are designed and built in the U.S.A.

Printed in USA

P/N 42492L7B

Applications and Limitations of MULTI-SCREEN® Systems

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

- Hydraulic and pneumatic power presses
- Molding presses
- Automated production equipment

MULTI-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 either defined area.

MULTI-SCREEN Systems may not be used in any environment that is 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 Banner MULTI-SCREEN Systems.

Banner MULTI -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 first!

In the United States, the functions that Banner MULTI-SCREEN® Systems are intended to perform are regulated by the Occupational Safety and Health Administration (OSHA). However, whether or not any particular MULTI-SCREEN System *installation* meets all applicable OSHA requirements depends upon factors that are beyond the control of Banner Engineering Corporation. These factors include the details of how the MULTI-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 MULTI-SCREEN Systems be directed to the factory applications department at the telephone numbers or address shown at the bottom of this page.

Banner MULTI-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 MULTI-SCREEN System in full compliance with OSHA regulations.

The user of the MULTI-SCREEN System shall ensure that all machine operators, maintenance personnel, electricians, and supervisors are thoroughly familiar with and understand all instructions regarding the use and maintenance of the MULTI-SCREEN System and the machinery upon which it is installed, as well as all appropriate safety regulations. Failure to follow all instructions or warnings could result in serious bodily injury or death.

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 Institute of America (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 MULTI-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 MULTI-SCREEN System be used on full-revolution clutched machinery. Banner MULTI-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 MULTI-SCREEN® Systems

ANSI B11.1 through B11.20 .....*Safeguarding of Machine Tools*

ANSI/RIA 15.06 .....*Safety Requirements for Robot Systems*

Copies are available from:

Safety Director
National Machine Tool Builders Association
7901 Westpark Drive
McLean, VA 22101-4269

See page 57 for information on these and other applicable standards, and where to acquire copies.

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1. MULTI-SCREEN System Introduction

The Banner MULTI-SCREEN System is a microprocessor-controlled opposed mode light screen system which uses *two* pairs of sensors. The two pairs of sensors are typically used to provide point-of-operation guarding for two areas on the same machine.

This five-piece system consists of two emitters, two receivers, and one control box. The two sensor pairs may be of any length, and may be either MACHINE-GUARD, or the lower profile MINI-SCREEN sensors, or one pair of each type. The sensors connect to the control box using four 5-wire shielded cables, (purchased separately), which have quick-disconnect fittings on their sensor end. The controller automatically recognizes the size and type of the two sensor pairs wired to it - no programming is necessary. The control box may be powered by either 115 or 230V ac or 24V dc.

Banner's microprocessor-based circuit establishes a higher level of control reliability in machine guard design. The MULTI-SCREEN System uses the design concept of "diverse redundancy", in which two microprocessors of different design, running from two different instruction sets, constantly check all system components, including each other. Banner MULTI-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 certain cross section enters either guarded area of the machine (called the *defined areas*), the output relays of the MULTI-SCREEN System will open. The contacts of the output relays 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 MULTI-SCREEN System features programmable *floating blanking* which allows for the movement of multiple work-pieces through one or both light screens. The controller is easily programmed for either one- or two-beam floating blanking. There is separate programming of each of the two light screens. Use of floating blanking affects the *minimum object sensitivity.* See Section 2.1 for complete information.

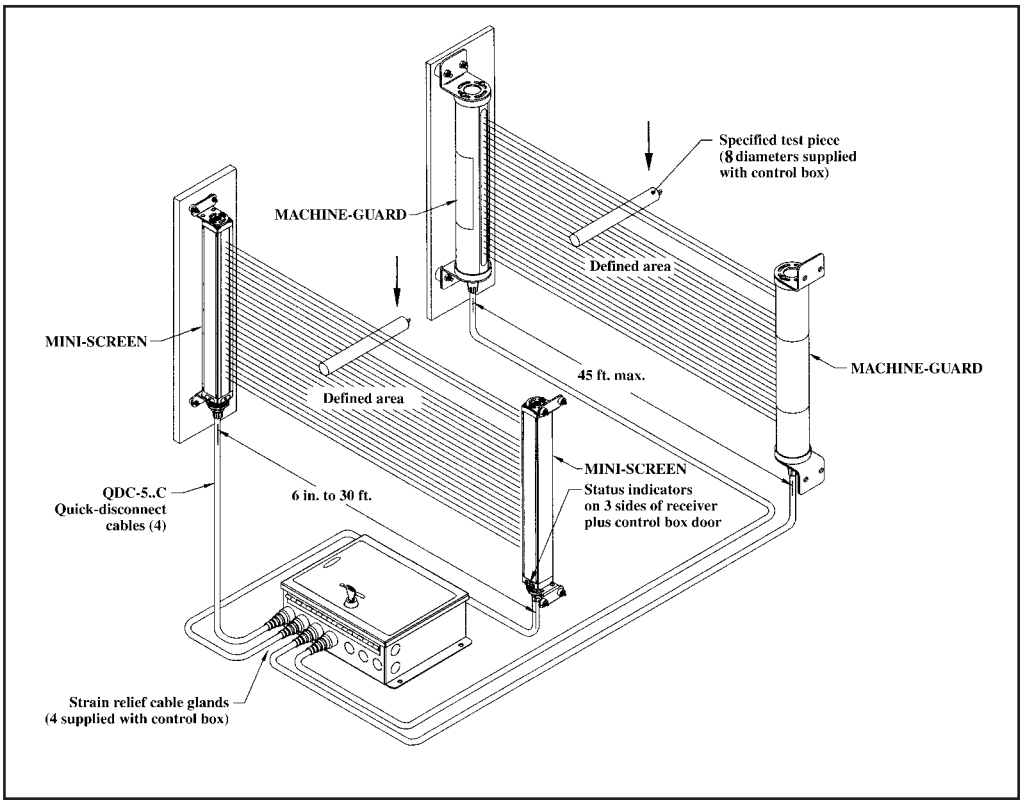


Figure 1. Banner MULTI-SCREEN System: two emitters, two receivers, control box, and four interconnecting cables.

Emitter units consist of a row of synchronized modulated infrared (invisible) light emitting diodes (LEDs). Receiver units consist of a corresponding row of synchronized phototransistors. Emitters and receivers are available in various sizes (based on the height of the defined area), ranging from 4 inches to 6 feet (see next page). The sensor design includes a swivel bracket at each end for quick mounting and ease of alignment.

The control box features two alignment indicators - one for each light screen - to simplify system setup and monitoring. In addition, MINI-SCREEN receivers each have three sets of highly-visible LED indicators for system operating status, including alignment. Alignment indicators flash to indicate the interruption of one or more beams due to blockage or misalignment.

The control box contains a power supply (to power the control box itself and the two sensor pairs), a microprocessor controller module to control sensing logic, and a replaceable relay board with forced-guided output relays. A single-digit numeric diagnostic display, which is visible through a clear window in the control box door, identifies trouble causes.

WARNING . . .
The MULTI-SCREEN System uses **two pairs** of sensors connected to **one** control box. Connection of more than two pairs of sensors to a single control box can result in serious bodily injury or death, and is prohibited.

There is a keyed panel switch for resetting the system at power-up or from fault (lock-out) conditions. The programmable auto power-up feature makes a key reset at system power-up unnessesary for those applications where a key rest is difficult to perform.

MINI-SCREEN sensor pairs have a sensing range (maximum emitter-to-receiver separation distance) of 9 m (30 ft) or 18 m (60 ft), depending on models (see page 6). MACHINE-GUARD sensors are rated for 3x excess gain at a range of 13.7 m (45 ft). Certain range reductions apply when corner mirrors are used (see Section 6). The patented modulated receiver design produces exceptionally high immunity to ambient light interference.

Banner MULTI-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 emitter, receiver, and controller module is serialized and undergoes extensive burn-in testing at the factory.

A functional schematic diagram of the MULTI-SCREEN System appears on page 12. For MULTI-SCREEN System dimension drawings, see pages 23, 25 and 26. For specifications, see pages 58-60.

The components of a MULTI-SCREEN system are purchased separately. The components are listed on the next page.

System Introduction

MULTI-SCREEN Systems consist of one control box, two sensor pairs, and four cables. All components are ordered separately. The only requirement is that the emitter and receiver of either sensor pair must be of equal length. However, the two sensor pairs may be different lengths, and MINI-SCREEN and MACHINE-GUARD sensor pairs may be used together in the same system. Cables are interchangeable between emitters and receivers. See page 63 for system accessories.

MINI-SCREEN Emitters (E) and Receivers (R)

Defined Area	Models			Number of Beams
	Black Anodized	Yellow Painted		
	Range 9 m (30 ft)	Range 9 m (30 ft)	Range 18 m (60 ft)	
114 mm (4.5 in)	**MSE424 MSR424**	**MSE424Y MSR424Y**	**MSXLE424Y MSXLR424Y**	8
215 mm (8.5 in)	**MSE824 MSR824**	**MSE824Y MSR824Y**	**MSXLE824Y MSXLR824Y**	16
305 mm (12 in)	**MSE1224 MSR1224**	**MSE1224Y MSR1224Y**	**MSXLE1224Y MSXLR1224Y**	24
406 mm (16 in)	**MSE1624 MSR1624**	**MSE1624Y MSR1624Y**	**MSXLE1624Y MSXLR1624Y**	32
508 mm (20 in)	**MSE2024 MSR2024**	**MSE2024Y MSR2024Y**	**MSXLE2024Y MSXLR2024Y**	40
610 mm (24 in)	**MSE2424 MSR2424**	**MSE2424Y MSR2424Y**	**MSXLE2424Y MSXLR2424Y**	48
711 mm (28 in)	**MSE2824 MSR2824**	**MSE2824Y MSR2824Y**	**MSXLE2824Y MSXLR2824Y**	56
813 mm (32 in)	**MSE3224 MSR3224**	**MSE3224Y MSR3224Y**	**MSXLE3224Y MSXLR3224Y**	64
914 mm (36 in)	**MSE3624 MSR3624**	**MSE3624Y MSR3624Y**	**MSXLE3624Y MSXLR3624Y**	72
1016 mm (40 in)	**MSE4024 MSR4024**	**MSE4024Y MSR4024Y**	**MSXLE4024Y MSXLR4024Y**	80
1118 mm (44 in)	**MSE4424 MSR4424**	**MSE4424Y MSR4424Y**	**MSXLE4424Y MSXLR4424Y**	88
1219 mm (48 in)	**MSE4824 MSR4824**	**MSE4824Y MSR4824Y**	**MSXLE4824Y MSXLR4824Y**	96

Machine Guard

Defined Area	Models	Number of Beams
	Black Anodized	
	Range - 13.7 m (45 ft)	
152 mm (6.0 in)	**MGE616A MGR616A**	8
305 mm (12.0 in)	**MGE1216A MGR1216A**	16
457 mm (18.0 in)	**MGE1816A MGR1816A**	24
610 mm (24.0 in)	**MGE2416A MGR2416A**	32
762 mm (30.0 in)	**MGE3016A MGR3016A**	40
914 mm (36.0 in)	**MGE3616A MGR3616A**	48
1067 mm (42.0 in)	**MGE4216A MGR4216A**	56
1219 mm (48.0 in)	**MGE4816A MGR4816A**	64
1372 mm (54.0 in)	**MGE5416A MGR5416A**	72
1524 mm (60.0 in)	**MGE6016A MGR6016A**	80
1676 mm (66.0 in)	**MGE6616A MGR6616A**	88
1829 mm (72.0 in)	**MGE7216A MGR7216A**	96

Control Boxes

MUSC-1 115V or 230V ac or 24V dc control box (One per system)

Cables (Two required per system)*

QDC-515C 4.5 m (15 ft) cable, straight QD connector. One cable per sensor.

QDC-525C 7.6 m (25 ft) cable, straight QD connector. One cable per sensor.

QDC-550C 15 m (50 ft) cable*, straight QD connector. One cable per sensor.

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

Pigtail Quick Disconnect Option

Any yellow emitter or receiver may be ordered with a 305 mm (12 in) 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 receiver. The same mating quick disconnect cables, as listed above, are used (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 MULTI-SCREEN System Operation

In operation, two sensor pairs are separately mounted and aligned. This establishes two screens of invisible infrared light beams called the *defined areas* (Figure 1, page 4).

The following features of the MULTI-SCREEN System are discussed in the listed sub-sections:

- 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 & Self-checking (Section 2.7)
- Remote Test Input (Section 2.8)

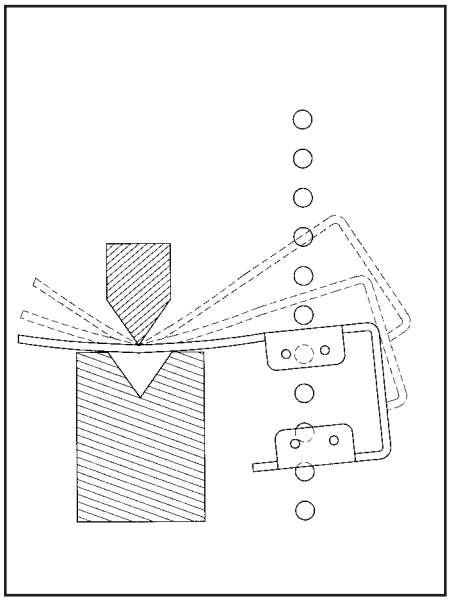


Figure 2. Floating Blanking

2.1 Blanking

MULTI-SCREEN Systems may be configured to be "blind" to the passage of multiple objects of limited size through either or (both) defined areas. This is useful in press brake and other applications where multiple blanked zones (moveable or stationary) are needed.

Floating blanking is the "blinding" of one or two 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 (FSD's) of the MULTI-SCREEN System. See Figure 2.

Floating blanking is separately programmed for each of the two light screens. There is the choice of either one-beam or two-beam floating blanking. The ignored object size and resultant *minimum object sensitivity* are listed in the table, below.

Sensor Type	Floating Blanking	Maximum Size of Undetected Objects	Minimum Object Sensitivity
MINI-SCREEN 9 m (30 ft) range	Off	(Not Applicable)	19.1 mm (0.75 in)
	1-Beam	7.6 mm (0.30 in)	32.0 mm (1.25 in)
	2-Beam	20 mm (0.8 in)	44.5 mm (1.75 in)
MINI-SCREEN 18 m (60 ft) range	Off	(Not Applicable)	25.4 mm (1.00 in)
	1-Beam	3.8 mm (0.15 in)	38.1 mm (1.50 in)
	2-Beam	16.5 mm (0.65 in)	50.8 mm (2.00 in)
MACHINE-GUARD	Off	(Not Applicable)	38.1 mm (1.50 in)
	1-Beam	25 mm (1.00 in)	57.1 mm (2.25 in)
	2-Beam	44 mm (1.75 in)	76.2 mm (3.00 in)

The size listed in the table for objects which move undetected through the light screen assumes that those objects move through the screen exactly perpendicular to the plane of the light beams.

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 a light screen and the nearest hazard point (i. e. - the *separation distance*). See Section 3.2.

Floating blanking preference is set via a pair of DIP switches on the controller module inside the control box (see Figure 20 and Section 3.4, both on page 27, for details). The control box is supplied with a lockable cover to prevent unauthorized access to the blanking settings. NOTE: Blanking "on" is indicated by a flashing green Status Indicator LED.

2.2 Auto Power-up

Normal operation of the MULTI-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 puts the MULTI-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 20 and Section 3.4 on page 27 details.

2.3 Lockout Conditions and Key Resets

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

1) Upon "power-up" of the MULTI-SCREEN System (unless Auto Power-up is "on"; see Figure 5, page 11),
2) If power to the MULTI-SCREEN System is interrupted (unless Auto Power-up is "on"; see Figure 5),
3) 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 the RUN mode,
4) If an FSD (Final Switching Device - see Glossary) relay does not "drop out" within it's specified time,
5) If the SSD (Secondary Switching Device - see Glossary) relay has de-energized,
6) If the controller module switch settings are inconsistent with each other or if they are changed while the system is in the RUN mode, or
7) If the self-checking circuits of the microprocessor detect a component failure within the MULTI-SCREEN System itself.

A lockout condition resulting from an internal system fault is indicated by a flashing red status indicator LED on the control box. The green and yellow LEDs will be "off". See Fig. 5, page 11.

Power-up/power interrupt lockouts (*Auto Power-up* "off", conditions #1 and 2 above, yellow LED only double-flashing) are normal and require a *key reset* for operation to continue.

Internal lockout conditions (#3 through #6 above) result from component failures or incorrect controller settings, which must be corrected before the system will allow operation to continue (Section 2.7). A numeric diagnostic indicator, visible through a window in the control box cover, indicates the cause of the lockout (Section 2.5). Internal lockout conditions also require a RESET of the keyed switch on the control box cover (a *key reset*) to return the system to the RUN mode. A valid *key reset* consists of turning the key switch to the RESET position, holding it there for at least 1/2 second, and then returning the key switch to the RUN position.

2.4 Operating Status Indicator Lights

Indicators on the front panel of the MULTI-SCREEN control box provide complete information on operating status.

2.4.1 Alignment Indicators

There are two yellow alignment indicators - one for each sensor pair. They are labeled “SCREEN 1 ALIGNMENT” and “SCREEN 2 ALIGNMENT”. When a sensor pair is properly aligned, the alignment indicator will be “on” steadily. A flashing alignment LED indicates either sensor misalignment or an object detected in the defined area. With all obstructions removed from the defined area, the alignment indicator flashes faster with better alignment, until it locks “on” solid with proper alignment.

“SCREEN 1” and “SCREEN 2” are determined by which barrier (TB2 or TB3 - inside the control box) each sensor pair is wired to. See the detail of the inside of the control box, Figure 22, page 29.

If MINI-SCREEN sensors are used, the (three) yellow LEDs on the receiver follow the action of the associated alignment LED on the control box (Figure 4). MACHINE-GUARD sensors have no status indicators. However, the flashing alignment indicators on the control box provide an easy means of accurately aligning any MACHINE-GUARD sensor pair.

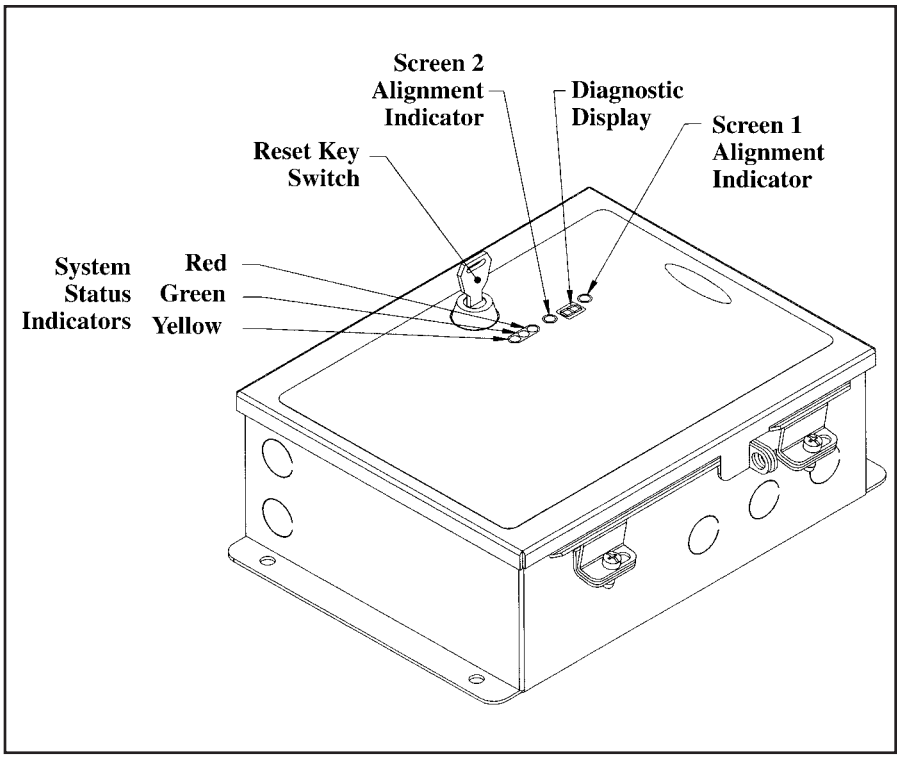


Figure 3. Control Box features

2.4.2 System Status Indicators

There are three system status indicators located on the front panel of the MULTI-SCREEN control box. The functions are as follows:

Red "on" steadily: usually means that there is an obstruction in the defined area of one or both of the light screens. If the defined area is clear, a steady red LED indicates misalignment between the emitter and receiver of one or both light screens. In either case, flashing yellow alignment LEDs will indicate which light sensor pair is either blocked or misaligned. When both light screens are properly aligned and unobstructed, the red indicator will go "off" and the green indicator will come "on", steadily.

Red flashing: indicates a lockout condition due to an internal MULTI-SCREEN System problem. All outputs are open (de-energized) for a lock-out condition.

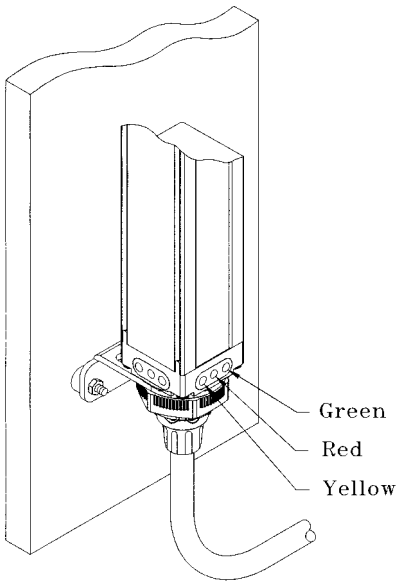
Green "on" steadily: indicates proper alignment of both light screens and no obstruction in either one. The two yellow alignment indicators will also be "on" steadily. This is the normal "RUN" mode condition, when all outputs will be closed (energized).

Green flashing: means the same as green "on" steadily, and also indicates that floating blanking is in use for one or both light screens.

Yellow "on" steadily: occurs during a key reset of a lockout condition, when the key is in the "RESET" position. The yellow indicator remains "on" steadily during the RUN mode.

NOTE: the yellow LEDs on a MINI-SCREEN receiver serve also as alignment indicators. As a result, the yellow indicators on a MINI-SCREEN receiver will flash to indicate an obstrution in the defined area or sensor misalignment (see discussion on "Alignment Indicators", page 9). Yellow double-flashing: indicates a lockout due to a power interrupt*. This is the normal indication whenever the MULTI-SCREEN System is powered-up. A key reset is required to restore the RUN mode.

*NOTE: the MULTI-SCREEN System enters the RUN mode directly upon power-up when the Auto Power-up feature is "on" (i.e. no key reset is required). As a result, the yellow LED will not double-flash when Auto Power-up is engaged.



Indicator	On steadily	Flashing
GREEN	Clear	Blanking
RED	Blocked	Lockout
YELLOW	Reset	Alignment

(Three sides of receiver)
See also Figure 5, page 11.

Figure 4. Status Indicator LEDs (MINI-SCREEN receiver)

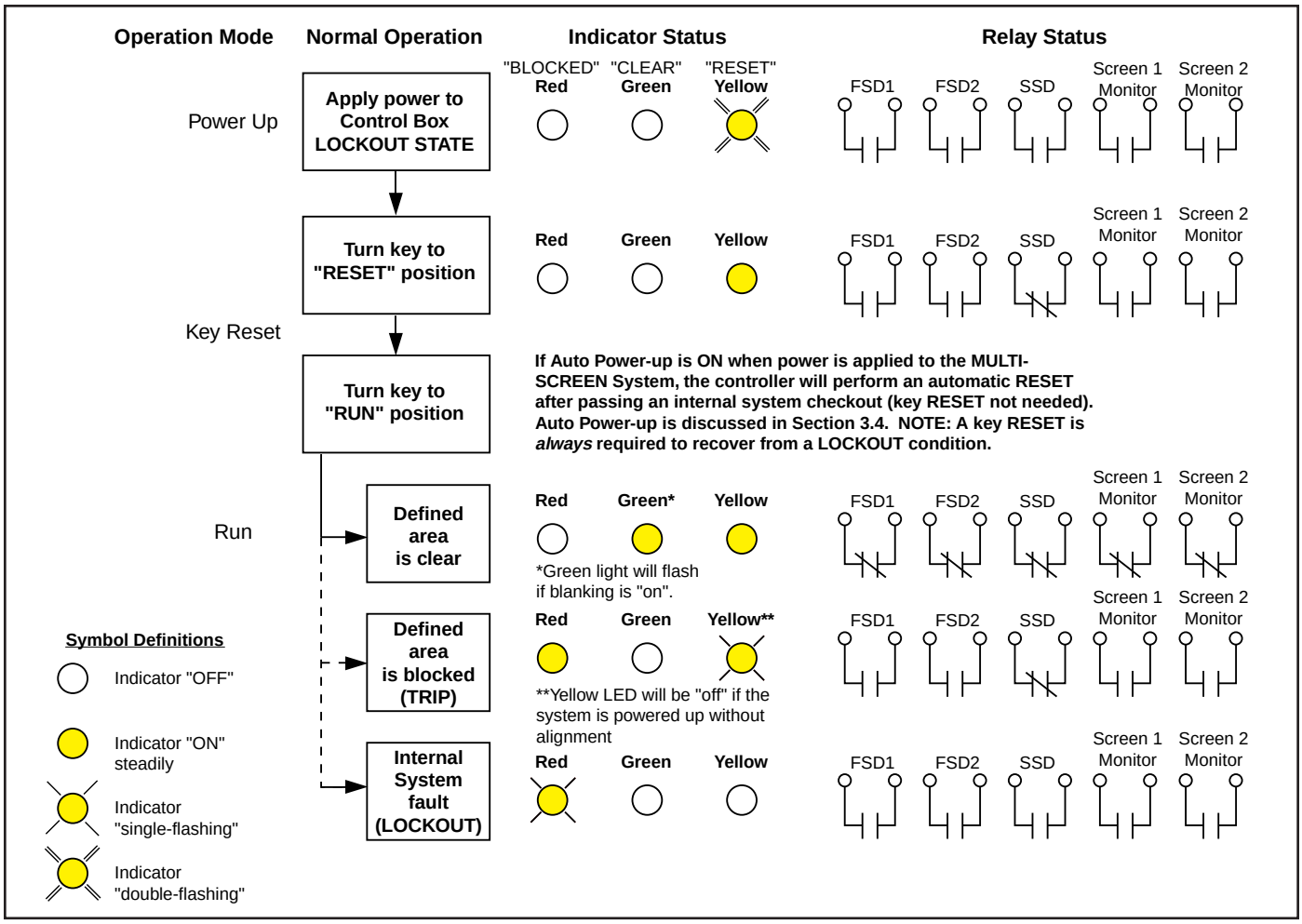


Figure 5. MULTI-SCREEN System status indicators and associated output conditions

2.5 Diagnostic Display

There is a single-digit numeric display located on the front panel of the MULTI-SCREEN control box which indicates an error code corresponding to the cause of a fault (lockout) condition. Error codes are listed and interpreted in Figure 27 on page 41.

In addition, the decimal point of the display flashes to indicate a high level of electrical or optical interference in the area of MULTI-SCREEN System. This diagnostic feature makes system troubleshooting an easy task.

Under normal RUN conditions, the diagnostic indicator will display a horizontal bar (i.e. the center segment of the display will be lit).

2.6 Output Relay Operation

The MULTI-SCREEN System control box has three output relays plus two Auxiliary Monitor Relays. Refer to Figure 6, below. The three output relays are labeled "FSD1", "FSD2", and "SSD". 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 in either light screen will be detected, and will cause a trip 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 several *lockout conditions,* including component failure within the MULTI-SCREEN System itself (see *Control Reliability*, Section 2.7). The MULTI-SCREEN System automatically resets itself from a *trip condition* when the object that caused the trip is removed, but recovery from a *lockout condition* requires a *key reset* (Section 2.3). NOTE: See warning regarding use of the MULTI-SCREEN for perimeter guarding on page 14.

There are two Auxiliary Monitor Relays. One relay is assigned to each of the two light screens. The relay contacts are closed when the MULTI-SCREEN System is in the RUN mode, and both light screens are properly aligned and are clear of obstructions. When an obstruction is sensed in one of the light screens, the associated monitor contact will open. In addition, both monitor contacts will open for a lockout condition. These monitor contacts are rated only for 10VA, maximum, and are typically used to signal light screen activity to a process controller. The contacts of these relays are not for safety-related use.

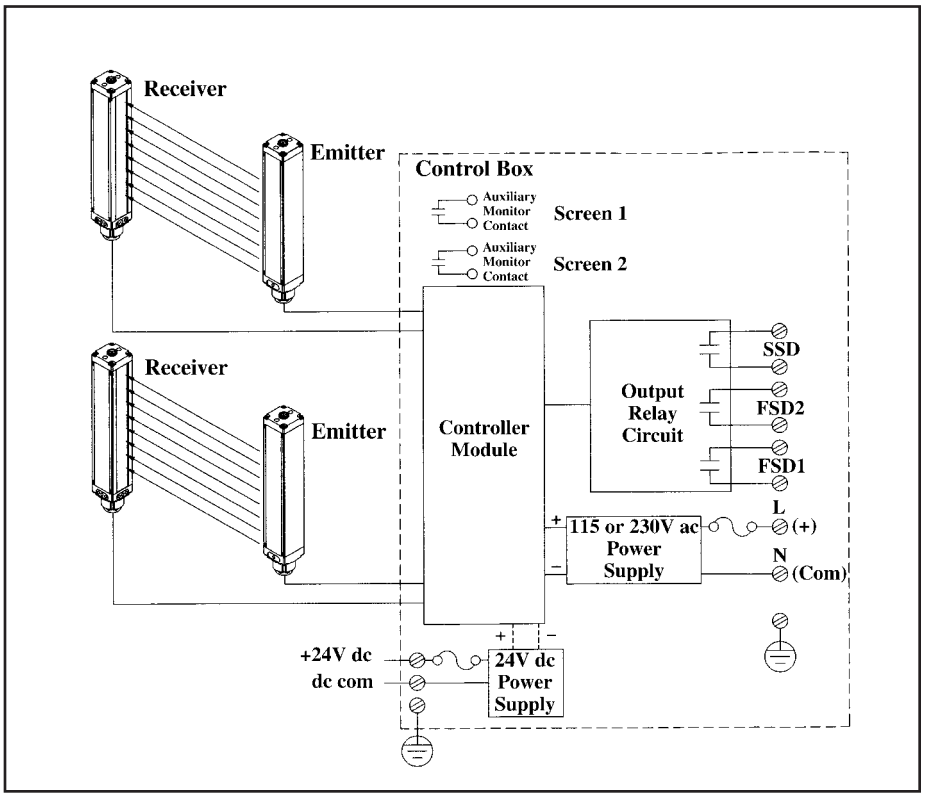


Figure 6. Banner MULTI-SCREEN System functional schematic

2.7 Control Reliability: Redundancy & Self-Checking

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

*Depending upon sensor length: see Specifications, pages 58-60.

1) The MULTI-SCREEN System must provide a "stop" signal to the guarded machine, within 48, 60, or 72 milliseconds*, whenever the defined area is interrupted, and

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

Regarding the first situation: In order for the machinery guarded by the MULTI-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 MULTI-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.

Regarding the second situation: This type of component failure includes any internal MULTI-SCREEN System failure which could prevent or delay the output relays of the MULTI-SCREEN System from going to a *trip condition* or a *lockout condition* in response to a situation which, in normal operation, would cause them to do so. The ability of the MULTI-SCREEN System to send a "stop" signal even when such a component failure has occurred depends upon the design principle of *redundancy.*

Redundancy requires that MULTI-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 MULTI-SCREEN System is designed with *diverse redundancy*. Diverse redundant components are of different designs, and microprocessor programs used by them run from different instruction sets written by different programmers.

Redundancy must be maintained for as long as the MULTI-SCREEN System is in operation. Since a redundant system is no longer redundant once a component has failed, MULTI-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 MULTI-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*. Possible causes of lockout conditions are listed in Section 2.3. The Diagnostic display is used to diagnose internal causes of a lockout condition (Section 5.1).

2.8 Remote Test Input

A pair of terminals is provided on barrier TB4 (see Figure 22, page 29) for an external normally-open switch. These terminals are labeled “TEST a” and “TEST b”. Closing a switch connected between these two terminals simulates an interruption of one of the light screens. The device used must be capable of switching 15 to 50V dc at 20 to 100 mA. The switch must be held closed for a minimum of 0.05 seconds to guarantee system response. This remote test input is sometimes useful for system setup and checkout procedures.

3. System Installation and Alignment

3.1 Appropriate Application

The MULTI-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 MULTI-SCREEN System may not be used with single stroke (also called "full revolution") clutched machinery, as this type of machinery is incapable of stopping immediately.

MULTI-SCREEN Systems also may not be used on certain other types of machinery. This includes any machine with inadequate or inconsistent stopping response time, and any machine that ejects materials or component parts through either defined area.

MULTI-SCREEN Systems may not be used in any environment that is 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 MULTI-SCREEN System.

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

CAUTION . . .

In order for the machinery guarded by the MULTI-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 MULTI-SCREEN System cannot be used with certain types of machinery (see listing, at left). **If there is any doubt about whether or not your machinery is compatible with the MULTI-SCREEN System, contact Banner's Application Engineers.**

WARNING . . .

The Banner MULTI-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 MULTI-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 MULTI-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 of this manual carefully before installing the system. Failure to follow the instructions in Section 3 (and its subsections) could result in serious bodily injury or death.***

The user has the sole responsibility to ensure that the Banner MULTI-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).

WARNING . . .

Use of MULTI-SCREEN Systems for Perimeter Guarding

If a MULTI-SCREEN System is installed for use as a perimeter guarding system, the Machine Primary Control Elements (MPCEs) of the guarded machine must be wired such that any interruption of the defined area will cause immediate arrest of the dangerous motion of the guarded machine. Following any interruption, the dangerous machine motion must be able to be initiated *only* after actuation of a reset switch. This reset switch must be located outside of the area of dangerous motion, and must be positioned so that the area of dangerous motion may be observed by the switch operator during the reset operation. Failure to observe this warning could result in serious bodily injury or death.

3.2 Mechanical Installation Considerations

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

- *separation distance*, and
- *hard guarding*.

3.2.1 Separation Distance

The MULTI-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 which must stop the dangerous motion before the object or hand reaches the closest reachable hazard point on the machine. The *separation distance* is the minimum distance that is 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:

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

where:

D_S = the separation distance;

K = the OSHA-recommended hand speed constant of 63 inches 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 WARNINGs (page 16), NOTE 2 (below), and the NOTICE regarding MPCEs (page 34).

T_r = the response time of the MULTI-SCREEN System. Response time varies with sensor length. See Sidebar A at upper left. Always use the longest response time for the two sensor pairs in use.

D_{pf} = the added distance due to depth penetration factor,as prescribed in OSHA 1910.217 and ANSI B11 standards: See sidebar at left. *Note: The value for D_{pf} may be different for each of the two sensor pairs.*

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) Ts 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 will always cause the required D_{pf} to increase.

Sidebar A:
MULTI-SCREEN System Response Time - T_r

Using MINI-SCREEN sensors:

T_r = .048 sec. for 4.5 in. to 16 in. sensors
T_r = .060 sec. for 20 in. to 32 in. sensors
T_r = .072 sec. for 36 in. to 48 in. sensors

Using MACHINE-GUARD sensors:

T_r = .048 sec. for 6 in. to 24 in. sensors
T_r = .060 sec. for 30 in. to 48 in. sensors
T_r = .072 sec. for 54 in. to 72 in. sensors

Sidebar B:
Depth Penetration Factor - D_{pf}

Using MINI-SCREEN sensors with 9 m (18 ft) range:

D_{pf} = 1.6 inches with floating blanking “off”
D_{pf} = 3.3 inches with one-beam floating blanking “on”
D_{pf} = 5 inches with two-beam floating blanking “on”

Using MINI-SCREEN sensors with 18 m (60 ft) range:

D_{pf} = 2.5 inches with floating blanking off
D_{pf} = 4.2 inches with 1-beam floating blanking “on”
D_{pf} = 5.9 inches with 2-beam floating blanking “on”

Using MACHINE-GUARD sensors:

D_{pf} = 4 inches with floating blanking “off”
D_{pf} = 7 inches with one-beam floating blanking “on”
D_{pf} = 31.5 inches with two-beam floating blanking “on”

Reference OSHA 1910.217, Table O-10, Graph h-1.

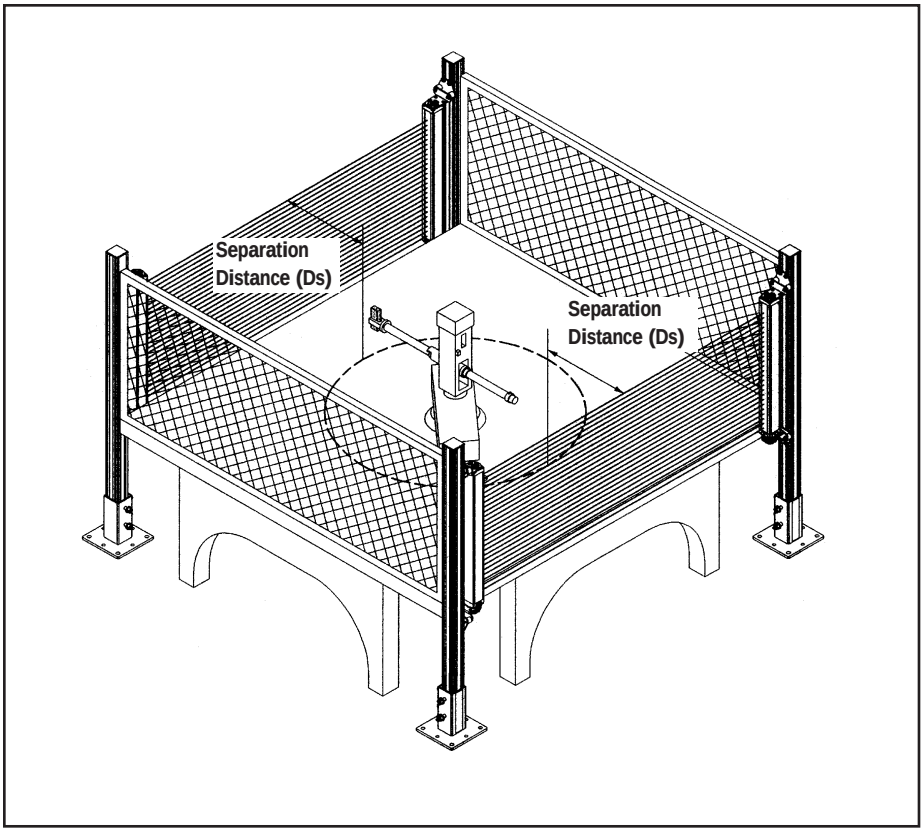


Figure 7. Separation distance

Example: Separation Distance (Ds) Calculation

The following is an example showing how to use the formula from page 15 to calculate the safety distance (D_S). We will use these numbers for the variables in the formula:

K = 63 inches 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 MULTI-SCREEN System; see Specifications, page 15 or pages 58-60.)

This example will assume use of one 24-inch and one 48-inch MINI-SCREEN emitter and receiver pair. Both pairs have a 9 meter (30 ft) sensing range. From Sidebar A on page 15, the value for MULTI-SCREEN System response is T_r = .060 seconds for the 24-inch sensors and T_r = .072 seconds for the 48-inch sensors. The longest of the two times, .072 seconds, is used in the formula.

This example will also assume the use of 2-beam floating blanking on both light screens, which requires the depth penetration factor D_{pf} = 5 for both light screens, as indicated in Sidebar B on page 15. Substitute these numbers into the safety distance formula, as follows:

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

$D_S = 63 \times (.250 \times 1.2^* + .072) + 5 = 28$ inches

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

*20% safety factor (see NOTE 2, on page 15)

WARNING . . .

Banner MULTI-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 Section 3.2 of the MULTI-SCREEN manual could result in serious bodily injury or death.

WARNING . . .

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 safety distance (D_S) will be too short. This can lead to serious bodily injury or death. *Be sure to include the stop time of all relevant devices and controls in your calculations.*

CAUTION . . .

Floating blanking increases D_{pf}. 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.

WARNING. . .
The point of operation must be accessible *only* through the defined areas. 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 either defined area and into the point of operation, and also to prevent any person from entering the space between either 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 areas. 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 either defined area and the nearest danger point is large enough to allow a person to stand undetected by the MULTI-SCREEN System.

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 areas. 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 either defined area and into the hazard point, and to prevent any person from standing between either defined area and the hazard point (see OSHA 1910.212). The use of mechanical barriers for this purpose is called "hard guarding" (see the WARNING on the left and the hard guarding example, below).

There must be no gaps between the hard guarding and the edges of the defined areas. 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.

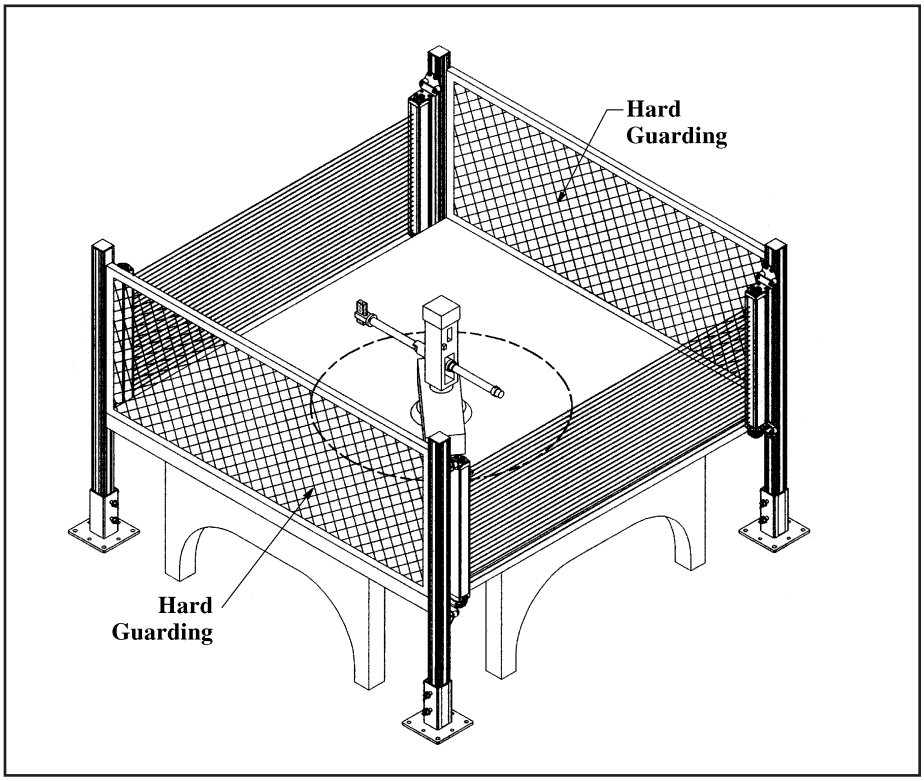


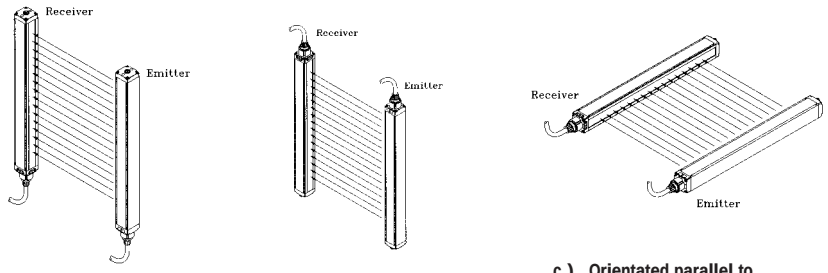
Figure 8. Example of "Hard Guarding"

3.2.3 Emitter and Receiver Orientation

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

An emitter and receiver pair 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 each light screen completely covers all access to the hazard point which is not already protected by hardguarding or another means of supplemental guarding.

WARNING. . .
Each emitter and receiver pair of the MULTI-SCREEN System must be installed with their corresponding ends (either cabled ends or non-cabled ends) pointing in the same direction (i.e. both cabled ends "up", both cabled ends "down", etc.). Failure to do this will impair the performance of the MULTI-SCREEN System and result in incomplete guarding. See Figure 10a. Failure to observe this warning could result in serious bodily injury or death.



a.) Both cable ends down

b.) Both cable ends up

c.) Orientated parallel to floor with both cable ends pointing in the same direction

Figure 9. Examples of *Correct* Emitter and Receiver Orientation

a.) Cable ends pointing in opposite directions.
Problem: Voids in defined area.

b.) Emitter and receiver not parallel to each other.
Problem: Reduced excess gain

Figure 10. Examples of *Incorrect* Emitter and Receiver Orientation

3.2.4 Adjacent Reflective Surfaces

WARNING. . .
It may be possible for a highly reflective surface (such as a shiny machine surface or a shiny workpiece) to reflect sensing light around an object in the defined area, thus 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). If possible, relocate the sensors to move the curtain of light beams away from the reflective surface(s). If relocating the sensors, be 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. 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 curtain, perform the trip test with the shiny workpiece in place.

A reflective surface located adjacent to a 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 which are 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.

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 and MACHINE-GUARD sensors may be used with one or more corner mirrors. The use of corner mirrors somewhat reduces the maximum specified emitter/receiver separation. Corner mirrors and stands are available from Banner. See page 47 for more information.

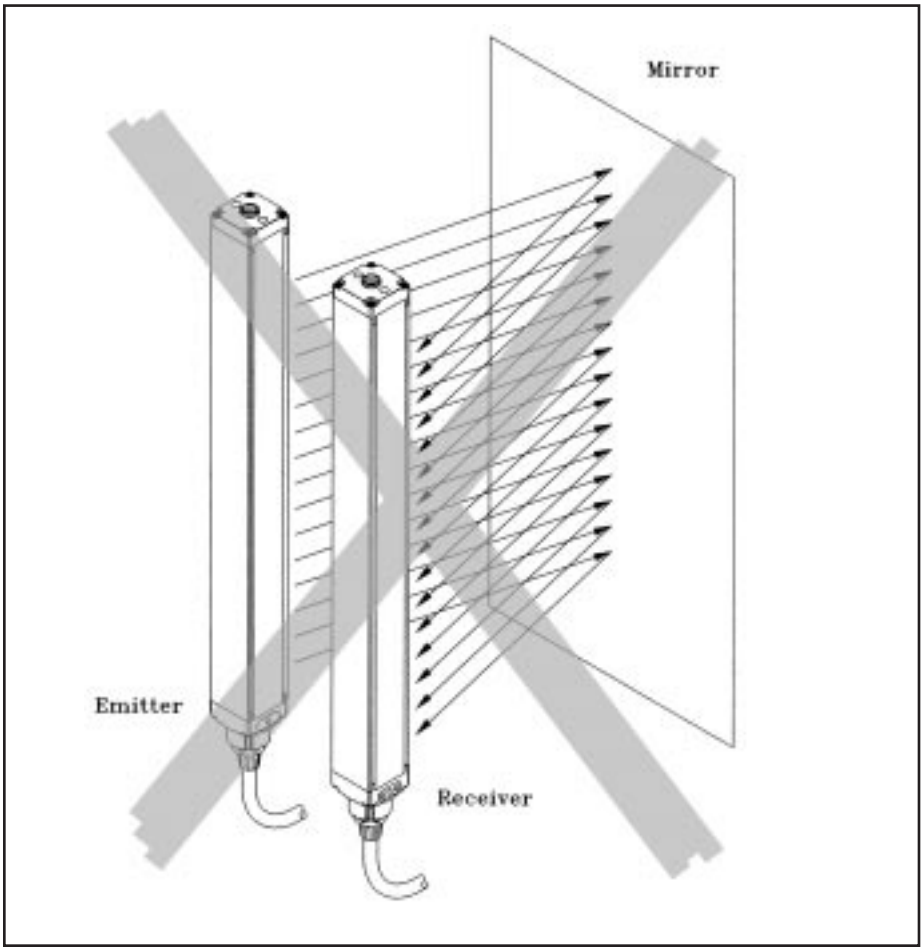


Figure 11. Never use the MINI-SCREEN or MACHINE-GUARD Sensors in a retroreflective mode.

WARNING. . .
The MULTI-SCREEN System is not designed for use in a 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. Never use MINI-SCREEN or MACHINE-GUARD sensors in a retro reflective mode, as illustrated in Figure 11. Sensing is unreliable in this mode and could result in serious injury or death.

3.2.6 Installation of Adjacent Sensor Pairs

Whenever two or more sensor pairs are adjacent to one another, there is potential for optical crosstalk to take place between pairs. This potential for crosstalk exists for adjacent sensor pairs connected to different light screen systems or to the same MULTI-SCREEN System. To minimize optical crosstalk, it is recommended to alternate emitters and receivers, as shown in Figure 12.

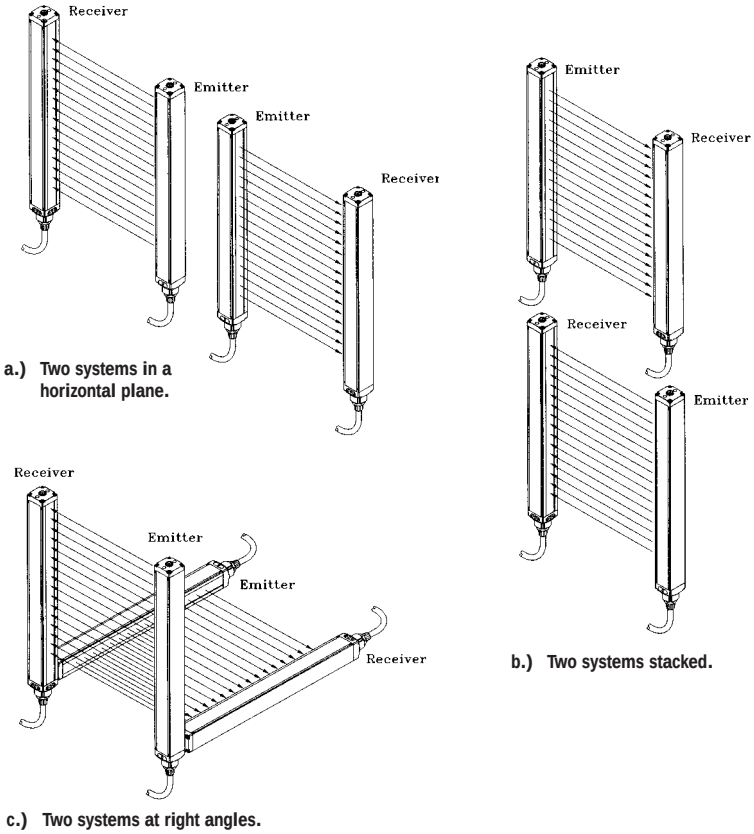


Figure 12. Installation of adjacent sensor pairs. Alternate emitters and receivers to avoid optical crosstalk.

When three or more sensor pairs (e.g. from multiple systems) are installed in a horizontal plane, (as shown for two pairs in Figure 12a.), optical crosstalk may occur between those sensor pairs which have their emitter and receiver lenses orientated in the same direction. In this situation, optical crosstalk may be controlled by mounting these 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

3.3.1 MINI-SCREEN Mounting

Banner MINI-SCREEN emitters and receivers are small, lightweight, and easy to handle during mounting. The mounting brackets (supplied) allow ±30 degrees 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. 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 are able to 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 the red lenses of the two units directly facing each other. **Important: The connector ends of both sensors must point in the same direction (see drawings and WARNING, page 18).** 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 sensors 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.

The defined area of a MINI-SCREEN sensor is marked by two arrows on its lens side. The defined area is also specified by dimensions "X" and "Y" in Figure 15 on the next page. If corner mirrors are used the center of the length of the defined area must be aligned with the center of the length of the mirror's reflective area (see Figure 30, page 47).

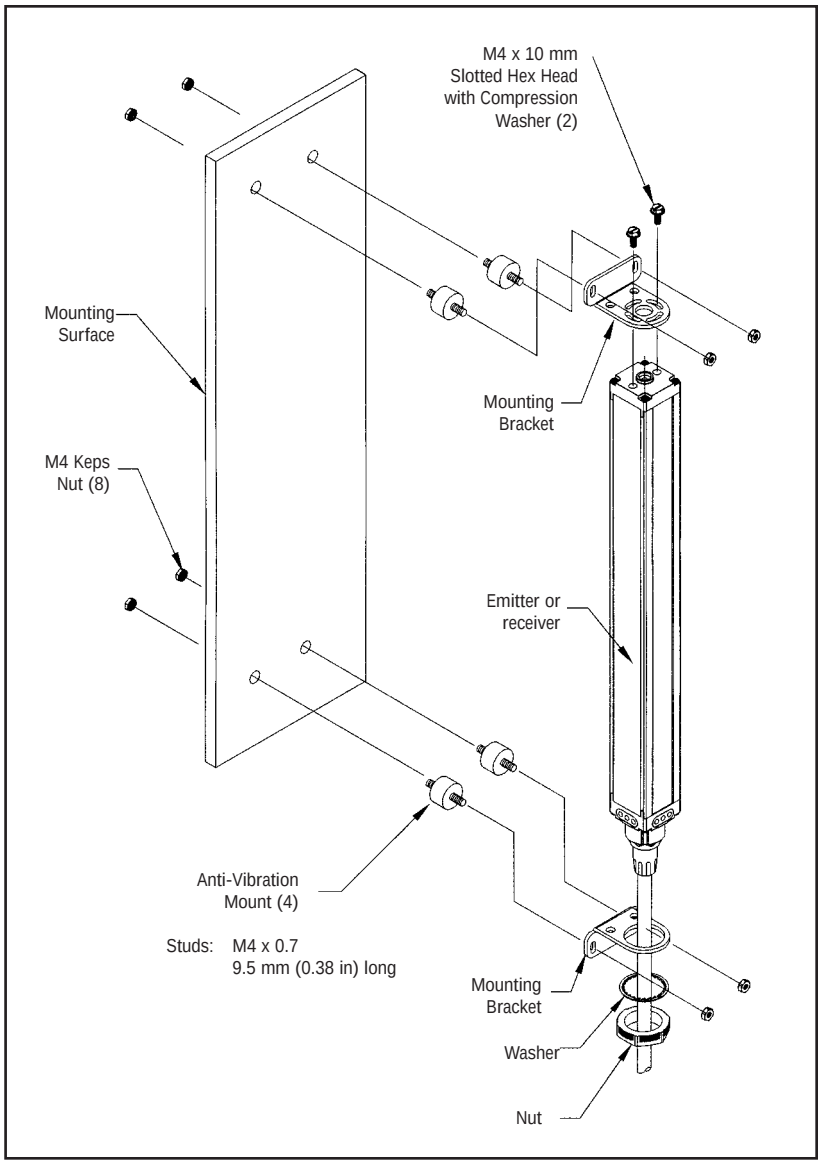


Figure 13. MINI-SCREEN Emitter and Receiver Mounting Hardware

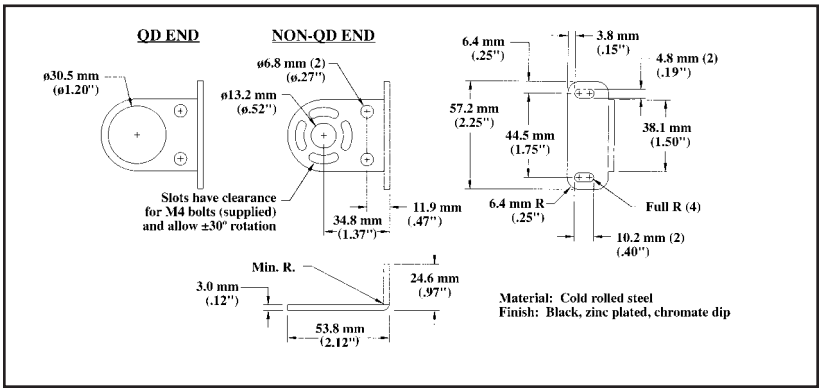


Figure 14. MINI-SCREEN Emitter and Receiver Mounting Bracket Dimensions.

MINI-SCREEN Sensor Dimensions

a.) With mounting bracket flanges "out"

b.) With mounting bracket flanges "in"

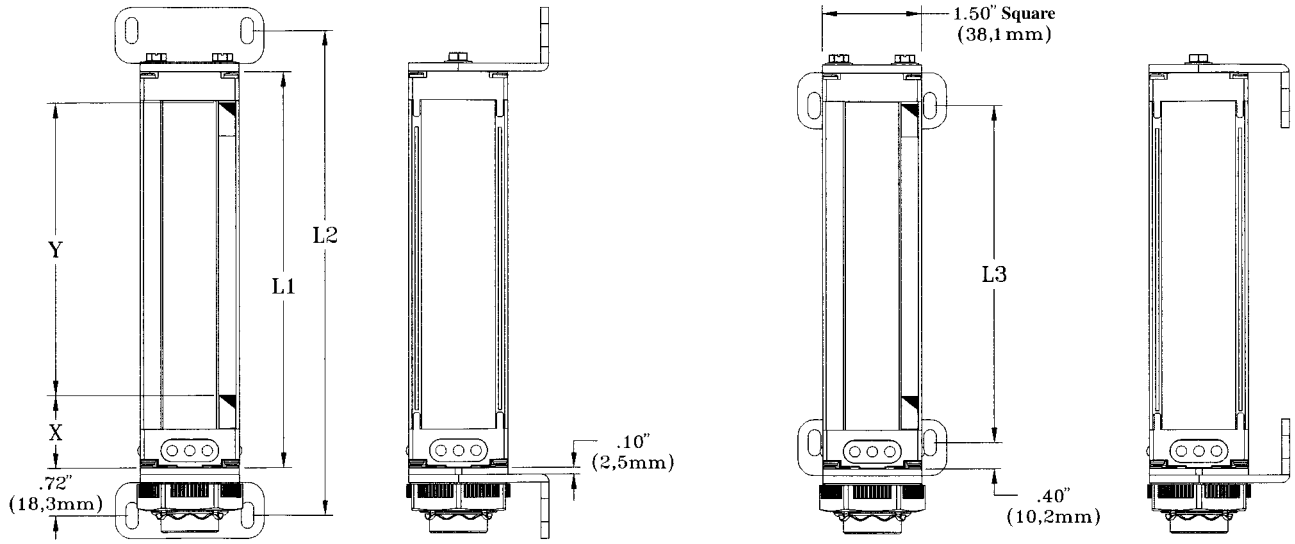


Figure 15. Emitter and receiver mounting dimensions and location of defined area for MINI-SCREEN sensors.

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

3.3.2 MACHINE-GUARD Mounting

The mounting brackets supplied with each MACHINE-GUARD sensor allow ±30 degrees of rotation for ease of alignment. Figure 18 on the following page gives the dimension between bracket mounting holes. Figure 17 details bracket dimensions.

From a common point of reference (e.g. - the building floor, etc.), make measurements to locate the emitter and receiver parallel to each other in the same plane with their midpoints directly opposite each other.

Mount the emitter and receiver brackets using the vibration isolators and 1/4"-20 Keps nuts (all supplied). See Figure 16. Standard 1/4" bolts may be substituted where the emitter and receiver are not subjected to shock or vibration forces. While the internal circuits of the emitter and receiver are able to 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 the red lenses of the two units directly facing each other. **Important: The connector ends of both sensors must point in the same direction (see drawings and WARNING, page 18).** 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 sensors are positioned exactly vertical or horizontal to the floor, a carpenter's level is useful for checking alignment. Make any necessary final mechanical adjustments and hand-tighten the bracket hardware.

If corner mirrors are used, the center of the length of the mirror's reflective area should be aligned with the center of the length of the sensor. A detailed alignment procedure is given in Section 6.1.

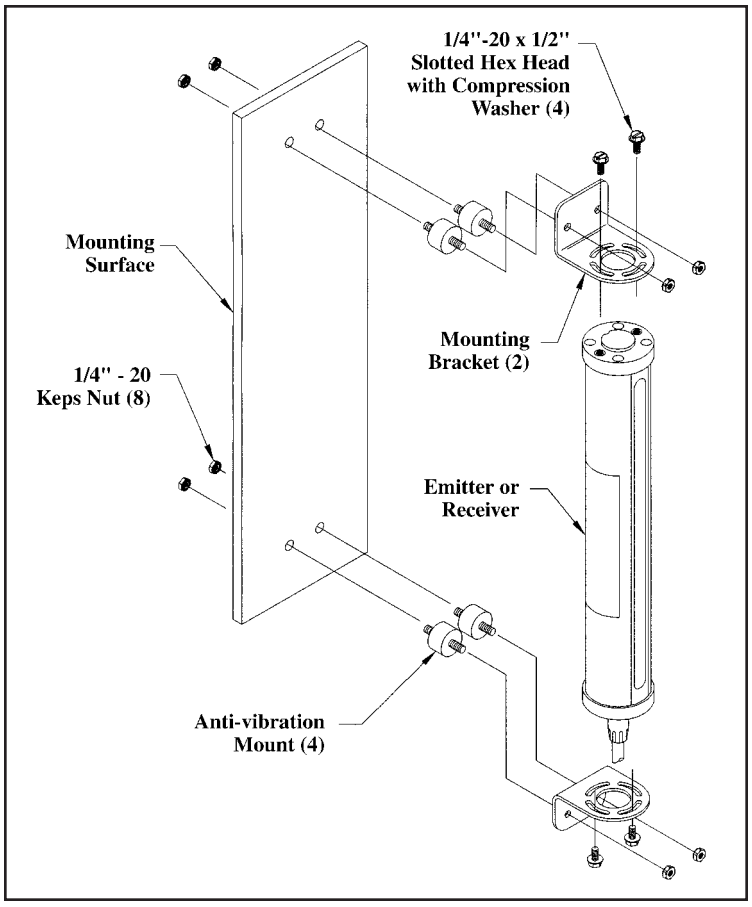


Figure 16. MACHINE-GUARD emitter and receiver mounting hardware

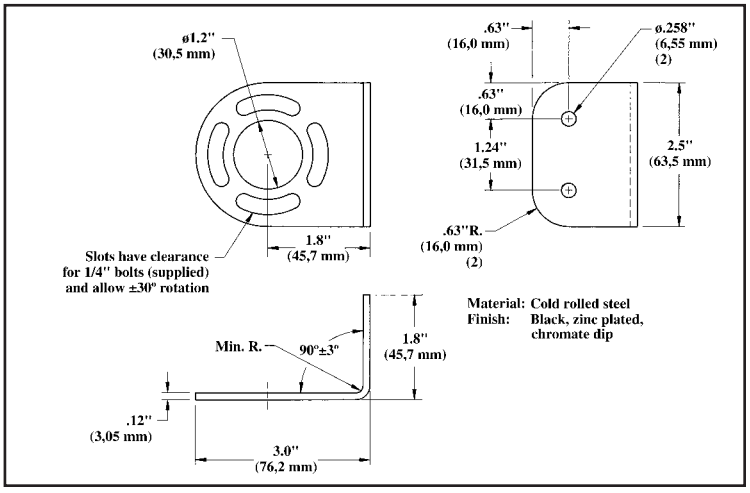
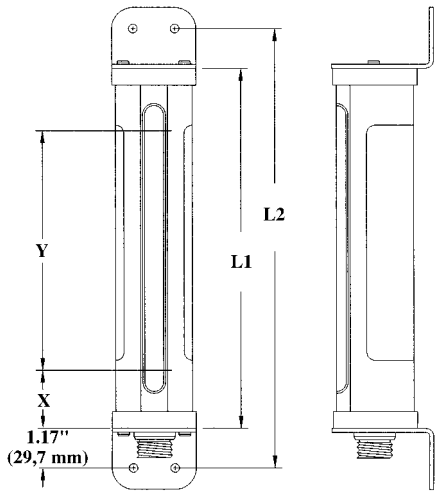


Figure 17. MACHINE-GUARD emitter and receiver mounting bracket dimensions.

MACHINE-GUARD Sensor Dimensions

a.) With mounting bracket flanges "out"



b.) With mounting bracket flanges "in"

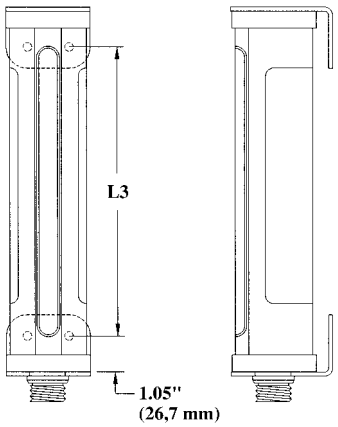


Figure 18. Emitter and receiver mounting dimensions and location of defined area for MACHINE-GUARD sensors.

Models	Housing Length		Distance Between Bracket Holes				Defined Area			
	L1		L2		L3		X		Y	
	(inch)	(mm)	(inch)	(mm)	(inch)	(mm)	(inch)	(mm)	(inch)	(mm)
MGE616 emitter **MGR616** receiver	9.4	239	11.7	298	7.3	185	6	152	1.7	43
MGE1216 emitter **MGR1216** receiver	15.4	391	17.7	451	13.3	338	12	305	1.7	43
MGE1816 emitter **MGR1816** receiver	21.4	544	23.7	603	19.3	490	18	457	1.7	43
MGE2416 emitter **MGR2416** receiver	27.4	696	29.7	755	25.3	643	24	610	1.7	43
MGE3016 emitter **MGR3016** receiver	33.4	848	35.7	908	31.3	795	30	762	1.7	43
MGE3616 emitter **MGR3616** receiver	39.5	1003	41.8	1063	37.4	950	36	914	1.8	44
MGE4216 emitter **MGR4216** receiver	45.5	1156	47.8	1215	43.4	1102	42	1067	1.8	44
MGE4816 emitter **MGR4816** receiver	51.5	1308	53.8	1368	49.4	1255	48	1219	1.8	44
MGE5416 emitter **MGR5416** receiver	57.5	1461	59.8	1520	55.4	1407	54	1372	1.8	44
MGE6016 emitter **MGR6016** receiver	63.5	1613	65.8	1672	61.4	1560	60	1524	1.8	44
MGE6616 emitter **MGR6616** receiver	69.5	1765	71.8	1825	67.4	1712	66	1676	1.8	44
MGE7216 emitter **MGR7216** receiver	75.5	1918	77.8	1977	73.4	1864	72	1829	1.8	44

3.3.3 Control Box Mounting

Mount the MULTI-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 both of the defined areas.** Mounting hole information is given in Figure 19 (below). The MULTI-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 20). The controller will automatically sense the length of the emitter and receiver, and set its response time accordingly.

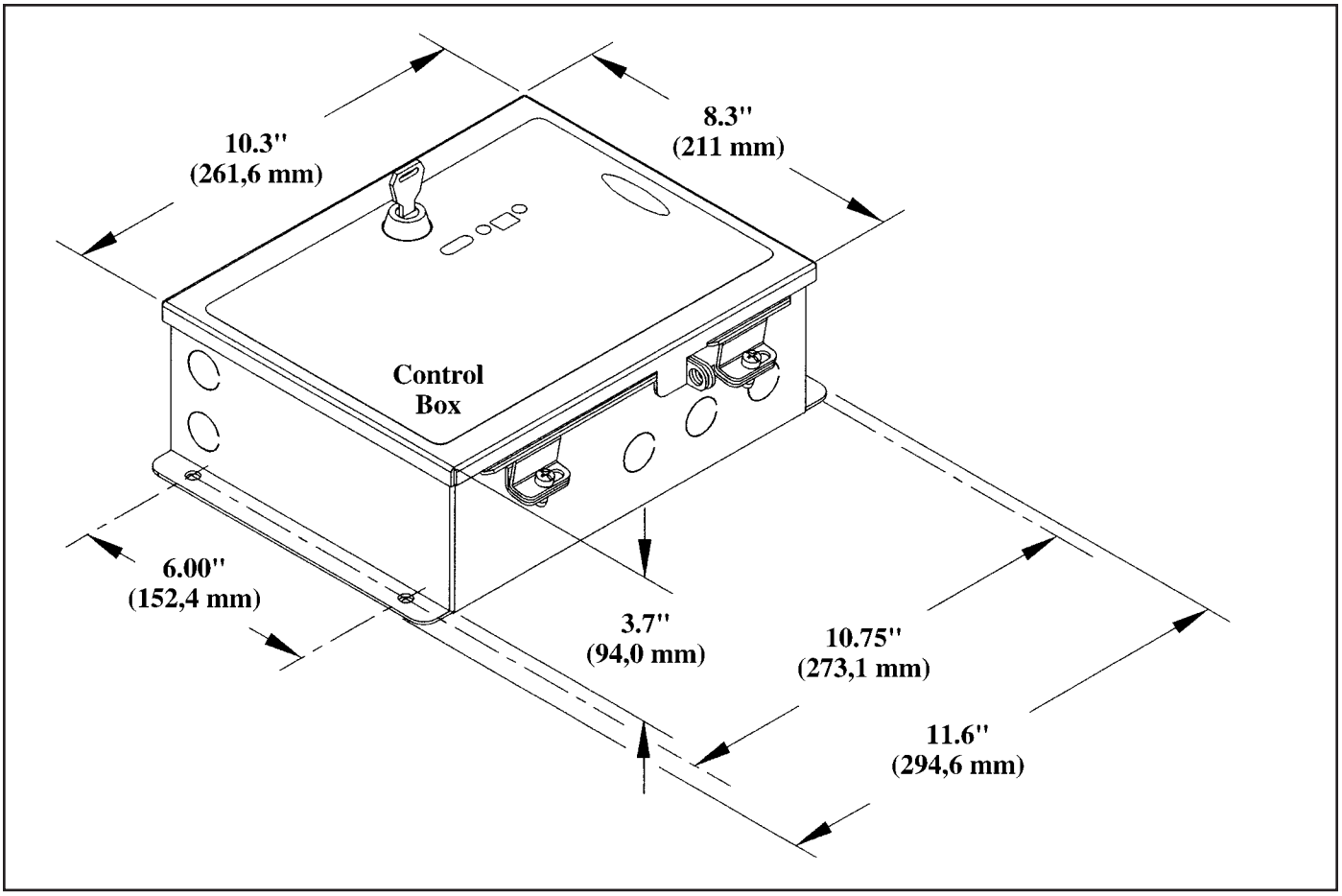


Figure 19. Control Box mounting hole locations

3.4 Control Module Configuration

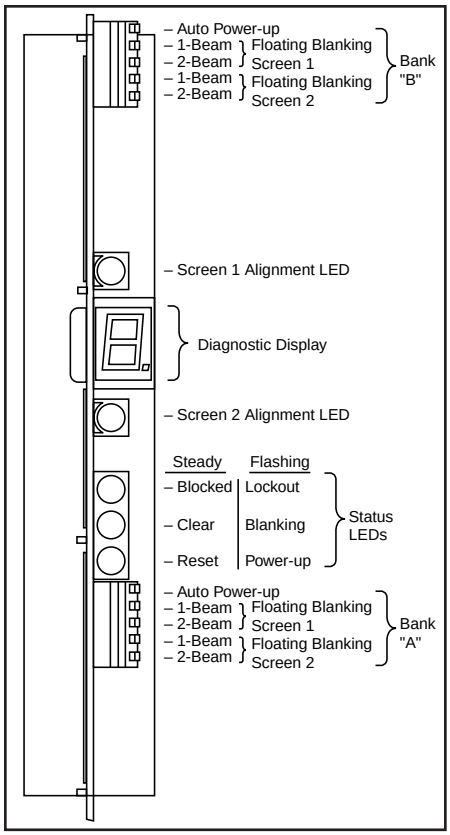


Figure 20. Controller configuration switches

The parameters to be manually configured are:

- Floating blanking: 1-beam, 2-beam 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 MULTI-SCREEN System must always be "off" when changing switch settings.** Changing switch settings with power "on" will cause a lockout condition. A switch pushed to the left is "on"; a switch pushed to the right is "off". Set the configuration switches as follows:

Floating Blanking ON or OFF

Locate the floating blanking (FB) configuration switches in bank A and B (see Figure 20). Set the switches identically at banks A and B. Be aware of the difference in minimum object sensitivity, penetration factor, and required light screen separation distance between the settings (refer to Sections 2.1 and 3.2.1). Floating blanking causes the MULTI-SCREEN System to ignore multiple objects of up to the size listed in the table, below. *NOTE: Both 1 & 2 beam floating blanking switches set to "ON" will cause a lockout.*

Sensor Type	Floating Blanking	Maximum Size of Undetected Objects	Minimum Object Sensitivity
MINI-SCREEN 9 m (30 ft) range	Off	(Not Applicable)	19.1 mm (0.75 in)
	1-Beam	7.6 mm (0.30 in)	32.0 mm (1.25 in)
	2-Beam	20 mm (0.8 in)	44.5 mm (1.75 in)
MINI-SCREEN 18 m (60 ft) range	Off	(Not Applicable)	25.4 mm (1.00 in)
	1-Beam	3.8 mm (0.15 in)	38.1 mm (1.50 in)
	2-Beam	16.5 mm (0.65 in)	50.8 mm (2.00 in)
MACHINE-GUARD	Off	(Not Applicable)	38.1 mm (1.50 in)
	1-Beam	25 mm (1.00 in)	57.1 mm (2.25 in)
	2-Beam	44 mm (1.75 in)	76.2 mm (3.00 in)

Auto Power-up feature ON or OFF

Locate the Auto Power-up (AP) configuration switch (see Figure 20) in banks A and B. If Auto Power-up is "on" (switches pushed to the left) when power is applied to the MULTI-SCREEN System, the controller will automatically reset after conducting and passing an internal system checkout. If the switches are "off" (pushed to the right), 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 both switches and push them to the left ("on") position. The switches must be set identically at banks A and B.

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),
- Auxiliary Monitor Relay, and
- Remote devices (key switch and test input).

Several conduit knockouts are provided around the sides of the control box. As you complete the wiring in the following sections, select knockout locations that are closest to the internal control box connection points that you want to access. Refer to Figures 21 and 22. *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 that 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. . .
Electrical hookup must be made by qualified personnel, and must comply with NEC (National Electrical Code) and local standards. Also, make no more connections to the MULTI-SCREEN System than are described in Sections 3.5.1 through 3.5.7. Connection of other wiring or equipment to the MULTI-SCREEN System could result in serious bodily injury or death.

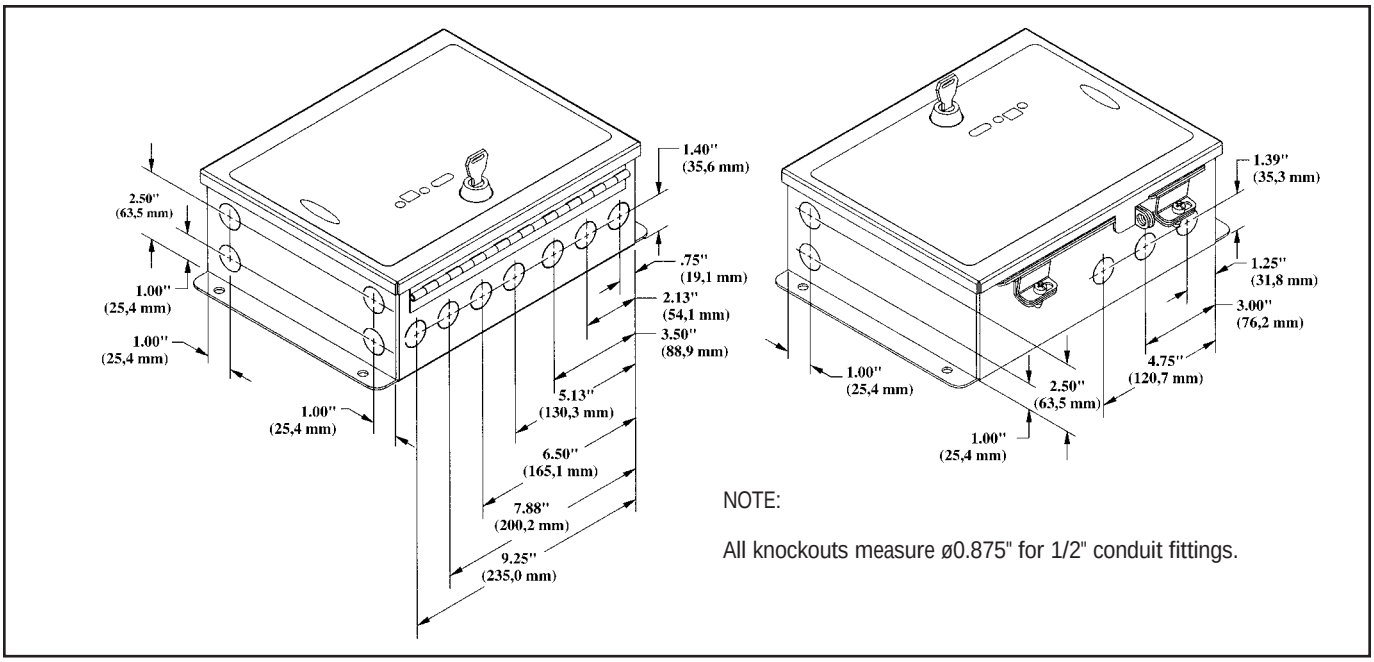


Figure 21. MULTI-SCREEN Control Box knockout locations.

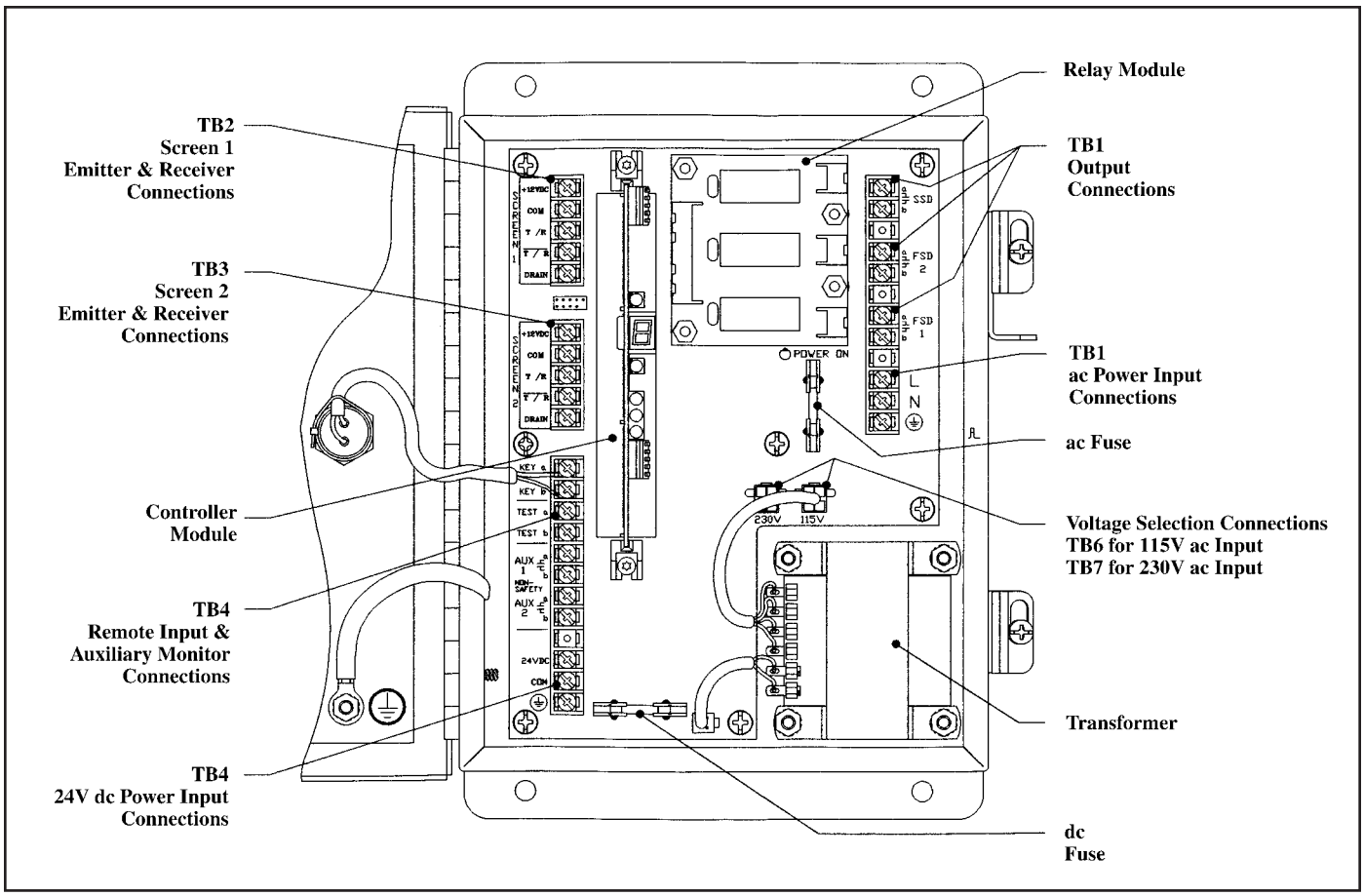


Figure 22. MULTI-SCREEN System electrical connections

3.5.1 Emitter and Receiver Hookup

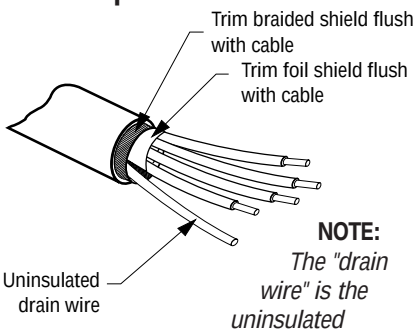
Connect the shielded cables to the emitter and receiver and route them (per local wiring code for low-voltage dc control cables) to the control box mounting location. The emitter and receiver cables require four control box knockouts. Four cable gland strain relief fittings are supplied with each control box for the entrance of emitter and receiver cables into the control box.

The same cable type is used for both emitter and receiver (four cables required per system). Cables may be cut to length at the time of installation. Do not trim the cables until you are certain that you have routed all cables properly (see Figures 21 and 22). 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.

Emitter and receiver cables for Screen #1 connect in parallel to wiring barrier TB2. Similarly, the emitter and receiver cables for Screen #2 connect in parallel to barrier TB3. Route the cables through the knockouts nearest to barriers TB2 and TB3. *Only the use of Banner QDC Series cables (see page 61) can ensure reliable communication of data between the controller and the sensors.* Match the color-coded terminals of wiring barriers TB2 and TB3 to colors of the 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 or MACHINE-GUARD sensors themselves.

NOTE: The MULTI-SCREEN System will operate only when two emitter/receiver pairs are connected. A lockout condition will result from connection of only one sensor pair.

Emitter and Receiver Cable Preparation



NOTE: *The "drain wire" is the uninsulated stranded wire which runs between the braided shield and the foil shield. The foil shield should be removed at the point where the wires exit the cable. The braided shield may be either removed or twisted together with the drain wire for connection to wiring barrier TB2 and TB3.*

3.5.2 System Power (temporary connection)

As shown in Figure 26 (page 35), the power supply lines to the control box 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 to the control box. Connect earth ground at the terminal provided. This will allow the MULTI-SCREEN System to be checked out, by itself, before permanent power connections through the guarded machine's monitor contacts are made. *Permanent* power connection will be made after MULTI-SCREEN System initial checkout, and is covered in Section 3.5.5.

Referring to the "MULTI-SCREEN System Electrical Connections" diagram (Figure 22) on the previous page, TB6 and TB7 are connectors on the main circuit board which allow selection of either 115V ac or 230V ac input voltage for system power. The control box is factory-configured for 115V ac. To convert to 230V ac, simply squeeze the connector latch to remove the transformer connector from TB6 and plug the connector into TB7 until the connector latch engages. Also change the fuse. A fuse for 230V ac hookup is included in the hardware packet.

The control box may be powered, instead, from 24V dc at 1.5 amps. DC power is connected to the bottom end of TB4 (see Figure 22). If DC power is used, make no connections to the "L" or "N" terminals of TB1.

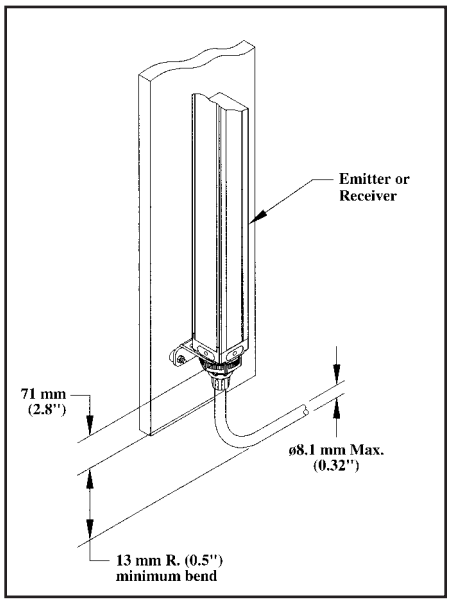


Figure 23. Quick disconnect cable clearance dimensions.

CAUTION. . .
Electrical shock hazard exists when the MULTI-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.**

3.5.3 MULTI-SCREEN System Initial Checkout

This initial checkout procedure must be performed by a *qualified person* (see WARNING, page 14). It must be done **after** connecting the emitters and receivers (Section 3.5.1) and temporary power (Section 3.5.2) is applied to the MULTI-SCREEN control box, but **before** the MULTI-SCREEN System is connected to the machine to be controlled.

This initial checkout procedure is done when the MULTI-SCREEN System is first installed, and must also be performed by a **qualified person** *whenever any maintenance or modification is performed on the MULTI-SCREEN System or on the machinery guarded by the MULTI-SCREEN System.* A schedule of required checkouts is given in Section 4.2.

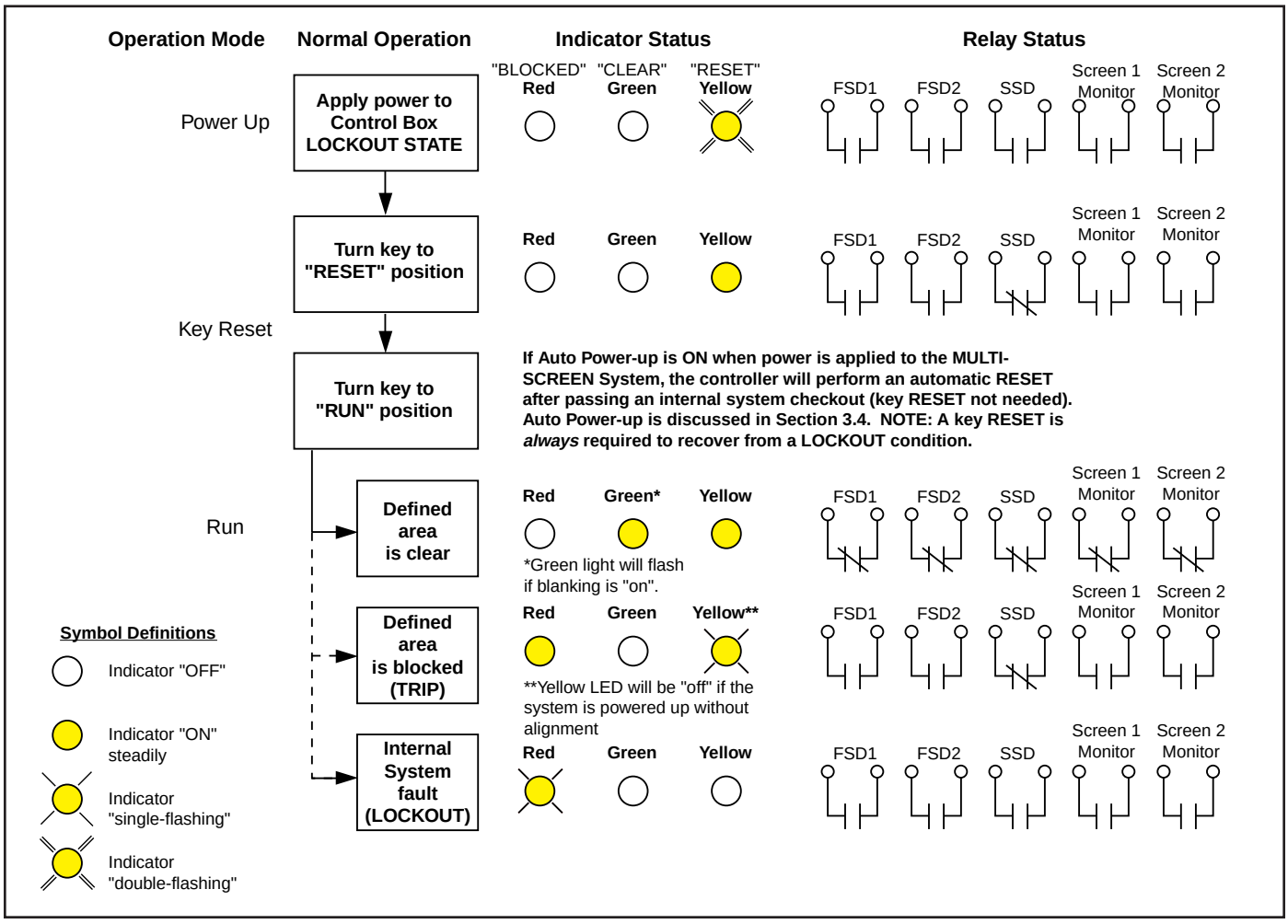


Figure 24. Operating Status LED conditions

INITIAL CHECKOUT PROCEDURE:

The MULTI-SCREEN System has three operating modes: POWER UP, KEY RESET, and RUN. Monitor the three status LEDs (red, yellow, and green, on the control box front panel) and refer to Figure 24.

1) **Enter the POWER UP mode** by applying power to the control box (see CAUTION, page 31). With Auto Power-up "off" the System will "power up" in a lockout condition (yellow status LED only will double-flash). With Auto Power-up "on", the System will automatically enter the RUN mode (step 3).

2) **Enter the key RESET mode** by turning the key to the RESET position. The yellow panel LED will glow steadily.

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

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

If the red status LED (only) lights and flashes when the system is placed in the 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 LEDs come "on", one (or both) defined area is not clear (one or more light beams are obstructed) or one (or both) light screen is misaligned. This is a *trip condition*. If this occurs, check the defined areas for obstruction(s). The red LED will be "on" steadily. One or both yellow Screen Alignment indicators on the control box will be flashing to indicate the relative number of *made (cleared)* light beams; the faster the flash rate, the more beams are "made". If MINI-SCREEN sensors are used, the yellow LEDs on the blocked receiver(s) will flash.

If the MULTI-SCREEN System is properly aligned and the blanking switches are properly set and all obstructing objects are removed from the defined area, the green and yellow status LEDs should come "on" after step #3 has been performed (the green LED will *flash* if blanking is "on", but the yellow status LED should be "on" steadily). **If you are setting up the MULTI-SCREEN System for the first time, or if the green and yellow LEDs do not come "on" in step #3, perform the alignment procedure in Section 6.1.** When you are certain that the emitter and receiver are aligned properly, tighten all emitter and receiver hardware in position and repeat steps #1-3, above.

4) **Next, "trip test" the MULTI-SCREEN** 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 the RUN position, the yellow status LED must be "on" steadily, and the green status LED must either be on steadily (to indicate blanking "off") or flashing (to indicate blanking "on").

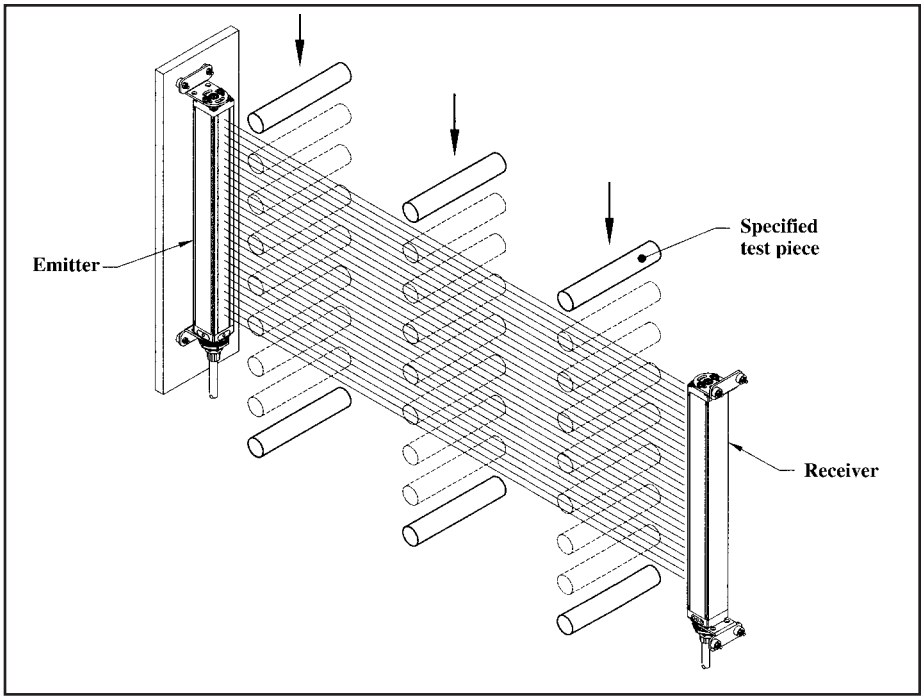


Figure 25. MULTI-SCREEN System Trip Test

The MULTI-SCREEN control box includes eight specified test pieces. Select the proper test piece based on system configuration, per the following chart:

Sensor Type	Floating Blanking Program	Specified Test Piece Model	Specified Test Piece Size
MINI-SCREEN 9 m (30 ft) range	None (off)	STP-2	19.1 mm (0.75 in)
	1-beam	STP-4	32.0 mm (1.25 in)
	2-beam	STP-3	44.5 mm (1.75 in)
MINI-SCREEN 18 m (60 ft) range	None (off)	STP-7	25.4 mm (1.00 in)
	1-beam	STP-1	38.1mm (1.50 in)
	2-beam	STP-8	50.8 mm (2.00 in)
MACHINE-GUARD	None (off)	STP-1	38.1 mm (1.50 in)
	1-beam	STP-5	57.1 mm (2.25 in)
	2-beam	STP-6	76.2 mm (3.00 in)

NOTE: Screen 1 and Screen 2 may be programmed independently and, therefore, may require different test pieces.

Slowly pass the specified test piece down the length of the defined area of one of the light screens at three points: close to the receiver column, close to the emitter column, and midway between the emitter and receiver columns (Figure 25). In each case, the red status indicator should come “on” and remain “on” for as long as the test piece is within the defined area. When the test piece is withdrawn from the defined area, the green status indicator should come “on”. If the green indicator comes “on” at any time when the test piece is within the defined area, check for reflective surfaces, and correct the problem. Repeat this procedure for the second light screen.

If the MULTI-SCREEN System passes all of the checks in Section 3.5.3, go on to Section 3.5.4. If the MULTI-SCREEN System fails any of these checks, do not attempt to use it until the reason for the failure(s) is identified and the failures are corrected.

3.5.4 Output Relay Connection

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 (Figure 26). 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, right.**

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 in such a way that it is 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 26, 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 in such a way that it is 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 26, 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 MULTI-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 26, 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).

CAUTION. . .
Electrical shock hazard exists when the MULTI-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 MULTI-SCREEN System and the guarded machine before making any connections or replacing any component.**

WARNING. . .
The output relays of the MULTI-SCREEN System must be the *final switching devices* for the machinery being guarded. **Never wire an intermediate device (for example, a programmable logic controller - PLC), other than a safety relay, between either FSD and the machine control element is switches** (Reference ANSI B11.1-1988. Appendix B4). To do so could result in serious bodily injury or death.

Connection of the output relays to the guarded machine must be direct and must produce immediate stopping action.

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 (per ANSI B11, Section 5.5 "Control Reliability"). Refer to Figure 26 (page 35) or consult the machine manufacturer for additional information.

WARNING. . .
Use of MULTI-SCREEN Systems for Perimeter Guarding

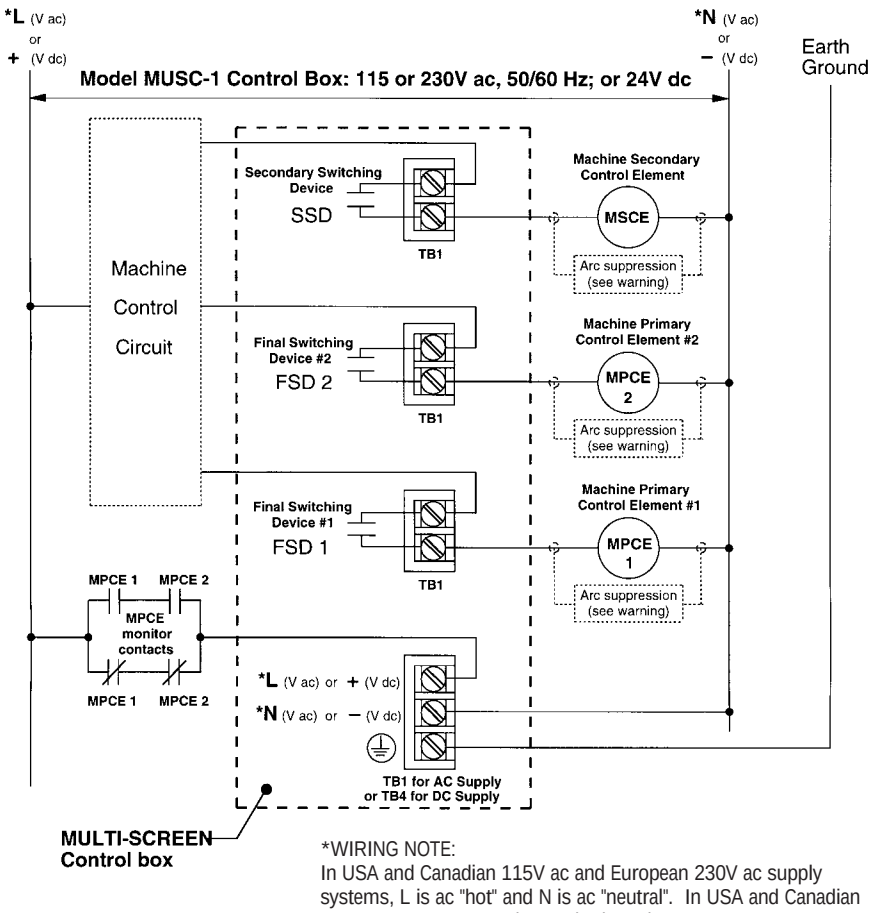
If a MULTI-SCREEN System is installed for use as a perimeter guarding system, the Machine Primary Control Elements (MPCEs) of the guarded machine must be wired such that any interruption of the defined area will cause immediate arrest of the dangerous motion of the guarded machine. Following any interruption, the dangerous machine motion must be able to be initiated *only* after actuation of a reset switch. This reset switch must be located outside of the area of dangerous motion, and must be positioned so that the area of dangerous motion may be observed by the switch operator during the reset operation. Failure to observe this warning could result in serious bodily injury or death.

NOTICE

Knockouts are provided along the sides of the control box for entrance of cables for input power, output connections, and accessories. It is the responsibility of the installer to provide suitable cable glands at these entrances in order to maintain the required degree of protection for the internal circuits, relative to the operating environment. The control box, itself, is rated at NEMA 13 (IP64).

The four cable glands supplied with the control box are meant for the sensor cables. Additional cable glands of this style are available from Banner. Contact the Banner Application Engineering Department or your local distributor for ordering information.

Figure 26 (below) shows output relay connections in a generic interfacing situation. The connections between the MULTI-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.



*WIRING NOTE:
In USA and Canadian 115V ac and European 230V ac supply systems, L is ac "hot" and N is ac "neutral". In USA and Canadian 230V ac systems, L and N are both ac "hot".

WARNING. . .
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 MULTI-SCREEN SWITCHING DEVICES! It is possible for suppressors to fail as a short circuit. **If installed directly across the contacts of a MULTI-SCREEN switching device, a short-circuited suppressor will create an unsafe condition.**

WARNING. . .
All MULTI-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 actual details of wiring of the MULTI-SCREEN system to any particular machine is solely the responsibility of the installer and end user.

Figure 26. Generic machine interface, MULTI-SCREEN System

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 MULTI-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. (This is discussed in the **NOTICE regarding MPCE Monitoring Hookup,** right).

AC System Power:
The control box is factory-configured for 115V ac power. Section 3.5.2 (page 30) explains how to configure the control box for 230V ac power. Connect AC system power to the L and N and earth ground terminals of TB1 (see Figure 26). Three-wire connection (ac "hot", ac "neutral", and earth ground) to ac power mains must comply with NEC and local wiring codes. Do not operate the MULTI-SCREEN System without an earth ground connection.

DC System Power:
The MULTI-SCREEN control box may be powered by 24V dc at 1.5 amps. DC power is connected to barrier TB4 (see Figure 22). Connect +24V dc to "+24 V dc" and dc common to "dc COM". Also, connect an earth ground to the ground terminal at the end of TB4. When using dc power, be certain to make no connections to the input power terminals of TB1. Removal of the barrier connection screws of the input power terminals of TB1 and removal of ac fuse is recommended when the system is powered by dc.

After power has been connected to the MULTI-SCREEN System and the output relay contacts have been connected to the machine to be controlled, the operation of the MULTI-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* given in Section 6.2 on page 48.**

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 26, page 35) as MPCE monitor contacts. If this is done, any inconsistency of action between the two MPCEs will remove power from the MULTI-SCREEN System, causing a lockout condition. ***The use of MPCE auxiliary contacts as MPCE monitor contacts is necessary in order to maintain redundancy.*** MPCE auxiliary contacts used for this purpose must be rated at 55 VA minimum.

In order to maintain redundancy, the MPCE monitor contacts must be wired as described in section 3.5.5 and Figure 26, page 35.

3.5.6 Auxilliary Monitor Relay

The MULTI-SCREEN control box is equipped with two auxiliary monitor relays. Each relay offers a SPST contact which follows the action in one of the light screens. The contact is closed when the sensors of that light screen are aligned and unblocked. The contact opens when that light screen is interrupted. "AUX 1" monitors screen #1 and "AUX 2" monitors screen #2.

In addition, both monitor contacts open with a lockout condition. These are light-duty contacts rated at 125V ac or dc max., 500 mA max. They are not safety-related contacts. They are meant for monitoring purposes, only, and typically communicate with a programmable logic controller (PLC) or other process monitoring device. Connections to the Auxiliary Monitor Relay contacts are on wiring barrier TB4 (see Figure 22, page 29).

3.5.7 Accessory Connections at Terminal Strip TB4

Terminal Barrier TB4 along the left side of the control box (see Figure 22, page 29) allows connection of remote inputs including the following:

Optional (see page 62) MGA-KSO-1 Remote Key Switch connects across the KEY a and KEY b terminals of TB4. 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 areas of both screens.*** We recommend use of shielded cable or separate wiring in a grounded conduit. See Section 5.2.

Remote Test Input connects to the TEST a and TEST b terminals of TB4 (see Figure 22, page 29). When connected together (shorted) for a minimum of 50 milliseconds, these terminals provide the MULTI-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 MULTI-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 Section). **Qualified persons only** *should have access to the* ***interior*** *of the MULTI-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.

Additional keys are available. See page 62.

4.2 Periodic Checkout Requirements

In addition to the checkouts that are performed by a qualified person or persons at the time that the MULTI-SCREEN System is installed and put into service, **the functioning of the MULTI-SCREEN System and the guarded machine 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 as follows:

1) By a designated person at every power-up of the MULTI-SCREEN System (use checkout procedure 6.3, page 50),

2) By a qualified person following the correction of every lockout condition (use checkout procedure 6.3, page 50),

3) By a designated person at every shift change or machine setup change (use checkout procedure 6.3, page 50),

4) By a qualified person semi-annually (every 6 months) following installation of the MULTI-SCREEN System (use checkout procedure 6.4, page 51).

WARNING. . .
The Banner MULTI-SCREEN System can do the job for which it was designed only if it and the guarded machine are operating properly, both separately and together. **It is your responsibility to verify this, on a regular basis, as instructed in Section 4.2 and Section 6.**

If the MULTI-SCREEN System and the guarded machine do not perform *exactly* as outlined in the checkout procedures, the cause of the problem must be found and corrected before the system is put back into service. Failure to correct such problems can result in serious bodily injury or death.

4.3 Normal Operation

Power-up
If the Auto Power-up feature is "on" when power is applied to the System, the controller performs a system checkout and resets itself, without the need for a key reset. If the Auto Power-up feature is "off" when power is applied to the MULTI-SCREEN System, it is normal for it to "power up" into a lockout condition. To prepare the MULTI-SCREEN System for operation after a "power-up" lockout, the designated person must perform a key reset:

a) Turn the key to the RESET position (yellow status LED goes "on" steadily).

Wait at least one-half second, then

b) Turn the key to the RUN position.

If both defined areas are clear, the green* and yellow status LEDs will go "on" (red LED goes "off").

If either emitter and receiver pair are misaligned, the red status LED will come "on". The yellow alignment LED for the misaligned screen will single-flash at a rate that indicates the relative number of light beams established.

If either defined area is blocked and the emitters and receivers are in alignment, the red status LED will come "on", and the yellow alignment LED for the blocked screen will single-flash at a rate that indicates the relative number of light beams established.

The green and yellow status LEDs will be "on" steadily when both screens are properly aligned and clear*. Now perform checkout procedure 6.2 on page 48.

Floating Blanking **Operation**

With floating blanking “on”, multiple objects, each up to the size listed in the table, below may enter the defined area at any point without causing a “trip” condition. The use of floating blanking also increases the minimum object sensitivity, as indicated in the table.

Sensor Type	Floating Blanking	Maximum Size of Undetected Objects	Minimum Object Sensitivity
MINI-SCREEN 9 m (30 ft) range	Off	(Not Applicable)	19.1 mm (0.75 in)
	1-Beam	7.6 mm (0.30 in)	32.0 mm (1.25 in)
	2-Beam	20 mm (0.8 in)*	44.5 mm (1.75 in)
MINI-SCREEN 18 m (60 ft) range	Off	(Not Applicable)	25.4 mm (1.00 in)
	1-Beam	3.8 mm (0.15 in)	38.1 mm (1.50 in)
	2-Beam	16.5 mm (0.65 in)*	50.8 mm (2.00 in)
MACHINE-GUARD	Off	(Not Applicable)	38.1 mm (1.50 in)
	1-Beam	25 mm (1.00 in)	57.1 mm (2.25 in)
	2-Beam	44 mm (1.75 in)*	76.2 mm (3.00 in)

The use of floating blanking increases the Penetration Depth Factor (Dpf) and also, therefore, the separation distance required between the defined area and the closest machine danger point. If the separation distance was calculated on the basis of 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.

Upon power-up (and also at every shift change or machine setup change), checkout procedure 6.3 on page 50 must be performed.

** If floating blanking is "on", the green LED will be flashing.*

5. Troubleshooting and Maintenance

5.1 Troubleshooting Lockout Conditions

A MULTI-SCREEN System lockout condition occurs:

1) Routinely upon MULTI-SCREEN System "power-up" (unless Auto Power-up is "on", see Section 4.3),

2) If power to the MULTI-SCREEN System is interrupted, unless Auto Power-up is "on",

3) 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 the RUN mode,

4) If an FSD (Final Switching Device) relay does not "drop out" within its specified time,

5) If the SSD (Secondary Switching Device) relay has de-energized,

6) If the controller module switch settings are inconsistent with each other or are changed while the system is in RUN mode,

7) If the self-checking circuits of the microprocessor detect a component failure within the MULTI-SCREEN System itself.

A lockout condition causes all output relays (FSD1, FSD2, and SSD) plus the auxiliary monitor relays to open, shutting down the MPCEs and MSCE of the guarded machine.

Power-up/power interrupt lockouts (Auto Power-up "off", conditions #1 or 2 above, yellow status LED only double-flashing) are normal and require a key reset for operation to continue.

Use the following procedure to resume operation after a power interruption (condition #2):

a) Turn the key to the RESET position (yellow status indicator LED should light) and wait at least one-half second, then

b) Turn the key to the RUN position:
If defined area is clear and the emitter and receiver are properly aligned, the green and yellow status LEDs will light.

If the lockout condition was due to a momentary power interruption that has been corrected, the MULTI-SCREEN System will now operate normally.

Upon recovery from a power interruption, checkout procedure 6.3 on page 50 must be performed.

WARNING. . .
Power failures or other MULTI-SCREEN System lockout conditions should always be investigated immediately by a qualified person. *With the exception of lockout conditions #1 and #2 (left), lockout is a positive indication of a problem and should be investigated at once.* **Attempts to operate machinery by bypassing the MULTI-SCREEN System are dangerous and could result in serious bodily injury or death.**

CAUTION. . .
Dangerous voltages are present inside the MULTI-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!**

A lockout condition resulting from an internal system fault is indicated by the red status LED flashing, and an error code number which appears on the Diagnostic Display. In this case, the qualified person must note the error code and interpret the cause of the lockout from the table in Figure 27, below. This diagnostic table is also found on the control box cover and inside the control box on one side of the controller module.

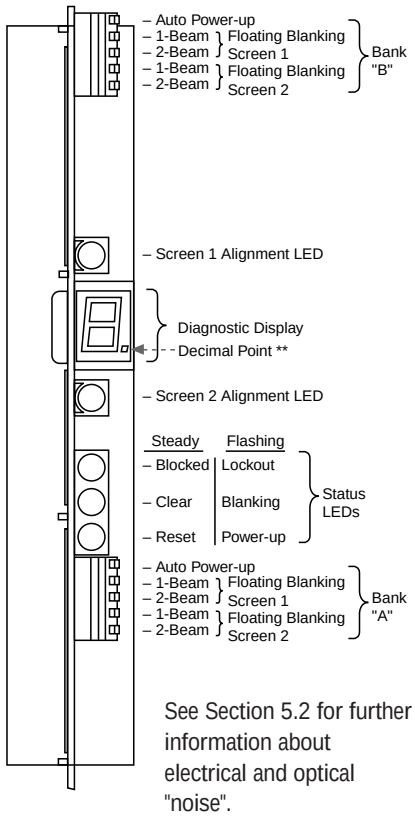
If the lockout is caused by one of the sensor pairs or their cables, the Diagnostic Display indicates which screen to investigate by flashing “1” or “2”, along with the primary error code (see the table, below). It is possible under some conditions that the System will not be able to discern which screen is at fault. When this happens, only the primary error code will be displayed.

The MULTI-SCREEN System will not operate if its self-checking circuits detect an internal problem. A key reset will have no effect. Take the corrective measure(s) corresponding to the error code. If further assistance is required, contact your Banner field service engineer or the factory Applications Engineering Department.

If no status indicators are "on", power to the system *may* have been lost. The green LED on the power supply board (see Figure 22, page 29) indicates the presence (LED "on") or absence (LED "off") of **dc power at the power supply board.** 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 terminals of TB1 (for ac power input) or across the + and - terminals of TB4 (for dc power input). If voltage is not present at the power input terminals in use, power to the MULTI-SCREEN System has been lost, and the cause is outside the system. If input power checks okay, turn off the power to the control box and check continuity of the appropriate fuse (there are two fuses: one for ac input and one for dc input - see Figure 22, page 29). If the fuse has continuity, a power supply failure has occurred.

Diagnostic Indicator LEDs
Controller Module Assembly



See Section 5.2 for further information about electrical and optical "noise".

Error No.	ERROR TYPE / Action
–	**SYSTEM IS O.K.**
1	**RELAY SIGNAL ERROR** • Replace Relay Module • Replace Controller • Replace Power Supply
2	**KEY INPUT ERROR** • Check Key Position • Invalid Key Reset • Replace Key Switch
3	**CONTROLLER ERROR** • Replace Controller
41 *42	**RECEIVER ERROR** • Check Receiver Cable(s) • Replace Receiver(s)
51 *52	**EMITTER ERROR** • Check Emitter Cable(s) • Replace Emitter(s)
61 *62	**COMMUNICATION ERROR** • Check Cable Connections • Observe Noise Indicator • Replace Emitter/Receiver(s)
7	**DIP SWITCH ERROR** • Check Switch Settings • Replace Controller
8	**CPU ERROR** • Replace Controller

* Note: 2-digit code. Second digit indicates which screen has the error

**Note: Flashing decimal point indicates noisy environment

Figure 27. Interpretation of diagnostic display

5.2 Effects of Electrical and Optical Noise

The MULTI-SCREEN System is designed and manufactured to be highly resistant to "noise" and to operate reliably in industrial settings. However, serious electrical and/or optical "noise" may cause a random "trip" condition. In *very extreme cases*, a "lockout" is possible. In order to minimize the effects of transitory noise, the MULTI-SCREEN System will respond to noise only if the noise is detected on multiple consecutive scans. The decimal point of the Diagnostic Display 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 decimal point 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 MULTI-SCREEN System, use of shielded cable or a separate grounded conduit is recommended.

Electrical and Optical Noise

Check the following if the red decimal point of the Diagnostic Indicator display is flashing:

- Poor connection between control box and earth ground
- Drain wire of emitter and/or receiver not connected to TB2 or TB3 (see Figure 22)
- Sensor wires or output wires routed too close to "noisy" wiring
- Optical interference from adjacent light curtains or other photoelectrics

5.3 Servicing and Maintenance

5.3.1 Fuse Test and Replacement

Turn off ac power to the control box before proceding.
The MULTI-SCREEN System control box has two fuses: one for ac input power and a separate fuse for dc input power. Remove the suspect fuse from its holder and visually inspect it and/or test its conductivity using an ohm meter or a continuity tester. The fuses are both 3AG or 5x20 mm slow-blow type (see specifications, pages 58-60).

WARNING. . .
Servicing the MULTI-SCREEN System while the hazardous machinery is operational could result in serious bodily injury or death. You may be working close to the hazardous area of your machinery while servicing the MULTI-SCREEN System. **The machinery that the MULTI-SCREEN System is connected to must not be operating at any time during this procedure.**

5.3.2 Servicing and Maintenance

MULTI-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.

CAUTION. . .
Electrical shock hazard exists when the MULTI-SCREEN System has power applied to it and/or the machine control elements and the control box door is open. 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 MULTI-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. . .
If replacement parts are ever required, **always use only genuine Banner-supplied replacement parts** (see page 62). Do not attempt to substitute parts from another manufacturer. To do so could impair the operation of the MULTI-SCREEN System and could result in serious bodily injury or death.

The output relays are configured on one module (see Figure 22, page 29). To remove the module, remove the four 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 any MULTI-SCREEN component to the factory, pack it carefully.

Return to:
Repair Department
Banner Engineering Corp.
715 North County Road 19
Aberdeen, SD 57401

Damage that occurs in return shipping is not covered by warranty.

5.3.3 Cleaning

The MULTI-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.

MINI-SCREEN and MACHINE-GUARD emitter and receiver units are constructed of aluminum with a black anodized or a yellow painted finish and are rated NEMA 4, 13 (IP65). 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 Procedures

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 (address, telephone, and FAX information is on page 2).

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

6.1 MULTI-SCREEN System Alignment

This alignment procedure begins with the assumption that the sensors of both light screens have been mechanically aligned as described in Section 3.3.

Follow the measures outlined below to maximize light screen excess gain. If there are reflective surfaces near either defined area, read alignment step #5 (page 45) before proceding further, to prevent possible reflection problems.

Only a ***qualified person*** may align the sensors of the MULTI-SCREEN System, as follows:

1) Turn off power to the MULTI-SCREEN System and to the guarded machine. Leave power to the guarded machine "off", and power-up the MULTI-SCREEN System only.

2) The MULTI-SCREEN will power up into a *power-up lockout condition* (unless Auto Power-up is "on"). *Remove all obstructions from the defined area* of both light screens and reset the MULTI-SCREEN System as follows:

   a. Turn the control box front-panel key reset switch to the RESET position,

   b. Leave the key in the RESET position for at least 1/2 second to allow time for internal system checks, and

   c. Turn the key switch to the RUN position.

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

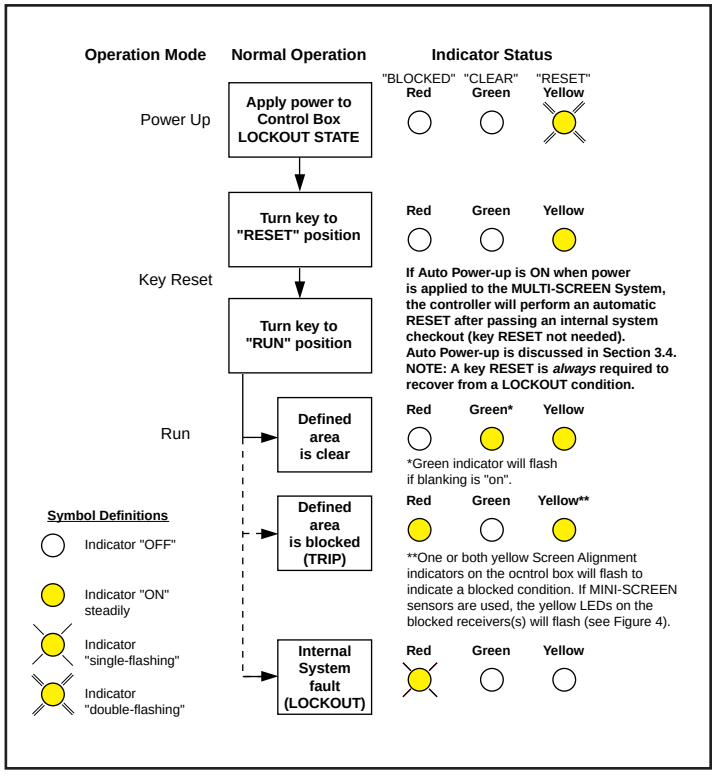


Figure 28. Operating Status LED conditions

3) Upon completion of the key RESET (step #2), the MULTI-SCREEN will indicate either a BLOCKED or a CLEAR condition:

   a) A BLOCKED condition is indicated by the red status LED “on” steadily and the yellow Alignment LED for the blocked screen(s) flashing at a rate which is proportional to the number of beams which are aligned and unblocked. Go to step #4.

   b) A CLEAR condition is indicated by the red status LED “off’, and the green and yellow status and both yellow alignment LEDs “on” steadily. Further alignment is not necessary.

4) A BLOCKED 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 of the light screen to be aligned (the limits of which are indicated in Figure 15, page 23 for MINI-SCREEN sensors and Figure 18, page 25 for MACHINE-GUARD sensors).

   b) Loosen the hardware which fastens the receiver to its mounting brackets brackets. Slowly rotate the receiver first to the right and then the left while watching the yellow alignment indicator corresponding to screen being aligned. The flash rate of the yellow alignment indicator increases as alignment improves.

   c) If the green status LED does not come “on”, regardless of angular position of the receiver, then loosen the emitter and rotate both sensors relative to each other until the green LED comes “on”. Secure the emitter and receiver in the center of the area of rotation where the yellow alignment and green and yellow status LEDs are “on” steadily.

   d) If the green and yellow status LED still fails to come “on”, then re-check the sensor mounting per the procedure in Section 3.3, and then re-align per this alignment procedure.

5) "Trip test" the MULTI-SCREEN System for object detection capability using the test piece(s) supplied with the control box. To perform this test, the key switch must be in the RUN position and the green and yellow status and yellow alignment indicators LEDs must be "on" steadily*. Reset the system (key reset), if necessary, to attain this condition.

   **Note: The green status LED will flash if blanking is programmed for either light screen.*

The MULTI-SCREEN control box includes eight specified test pieces. Select the proper test piece based on system configuration, per the following chart:

Sensor Type	Floating Blanking Program	Specified Test Piece Model	Specified Test Piece Size
MINI-SCREEN 9 m (30 ft) range	None (off)	STP-2	19.1 mm (0.75 in)
	1-beam	STP-4	32.0 mm (1.25 in)
	2-beam	STP-3	44.5 mm (1.75 in)
MINI-SCREEN 18 m (60 ft) range	None (off)	STP-7	25.4 mm (1.00 in)
	1-beam	STP-1	38.1mm (1.50 in)
	2-beam	STP-8	50.8 mm (2.00 in)
MACHINE-GUARD	None (off)	STP-1	38.1 mm (1.50 in)
	1-beam	STP-5	57.1 mm (2.25 in)
	2-beam	STP-6	76.2 mm (3.00 in)

NOTE: Screen 1 and Screen 2 can be programmed independently and, therefore, may require different test pieces.Perform the trip test in both light screens as follows:

Pass the appropriate specified test piece downward through the defined area at three points (see Figure 29):

a) close to the receiver,
b) close to the emitter, and
c) midway between the emitter and receiver.

In each case, the red status indicator must come “on” and remain “on” for as long as the test piece is within the defined area.

WARNING. . .
If the MULTI-SCREEN System does not respond properly to the trip test, do not attempt to use the System. If the MULTI-SCREEN System does not respond properly to the trip test, it 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.

The green status indicator must come “on” only when the test piece is withdrawn from the defined area. (The yellow status indicator stays "on" when the light screen is tripped.) If the green status indicator comes “on” at any time when the test piece is within the defined area, the cause may be from light reflected from the emitter to the receiver by a nearby reflective surface (see page 19). If a reflective surface can be identified, move either the defined area (i. e. - 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 (i. e. by angling, painting, masking, etc.).

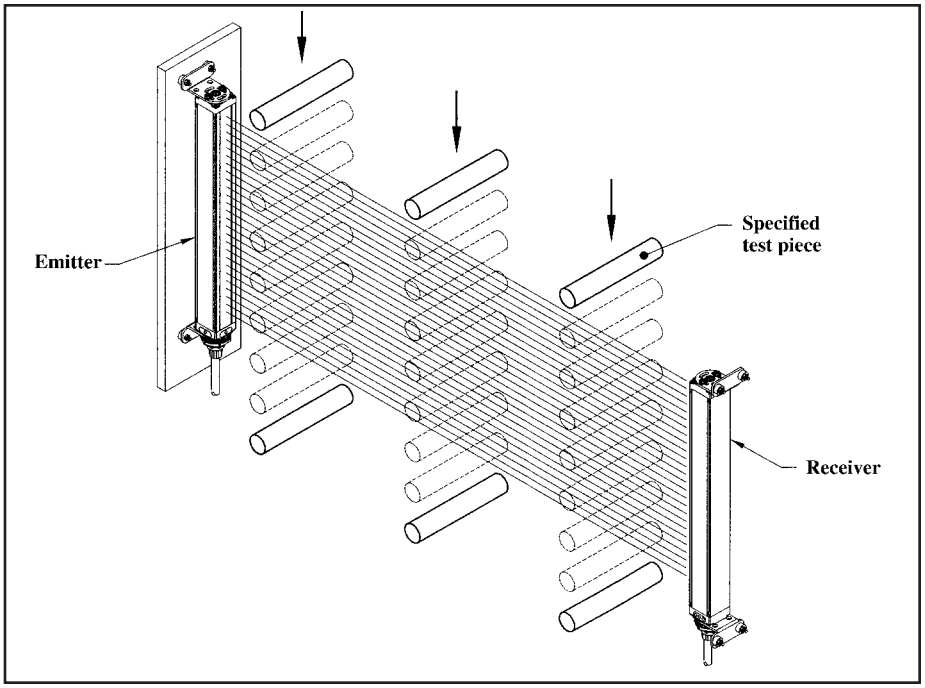


Figure 29. MULTI-SCREEN Trip Test. Perform the Trip Test on BOTH light screens.

Use of Corner Mirrors

The MULTI-SCREEN System requires connection of two sensor pairs for operation. One or both of the sensor pairs may be used with corner mirrors. MINI-SCREEN sensors and MACHINE-GUARD sensors up to 4 feet in length 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 63). These are rear-surface glass mirrors which are rated at 85 percent 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.

Number of MSM Series Mirrors				
	1	**2**	**3**	**4**
9 meter (30 ft) MINI-SCREEN range	28 ft (8.5 m)	25.5 ft (7.8 m)	23.5 ft (7.2 m)	22 ft (6.7 m)
18 meter (60 ft) MINI-SCREEN range	55 ft (16.8 m)	51 ft (15.5 m)	47 ft (14.3 m)	43 ft (13.1 m)
MACHINE-GUARD range*	41.5 ft (12.6 m)	38 ft (11.6 m)	35 ft (10.7 m)	32.5 ft (9.9 m)

**NOTE: MACHINE-GUARD sensor range is the separation between emitter and receiver where there remains 3x excess gain.*

Mirrors should be securely mounted to a solid surface that is free from vibration. Using a level, mount the mirror(s) exactly parallel to (i. e. in the same plane as) its (their) sensors, with the midpoint of the mirror(s) directly in line with the midpoint of the sensor's 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 23. The midpoint of the defined area of MACHINE-GUARD sensors corresponds to the midpoint of the sensor length.

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 30, 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.

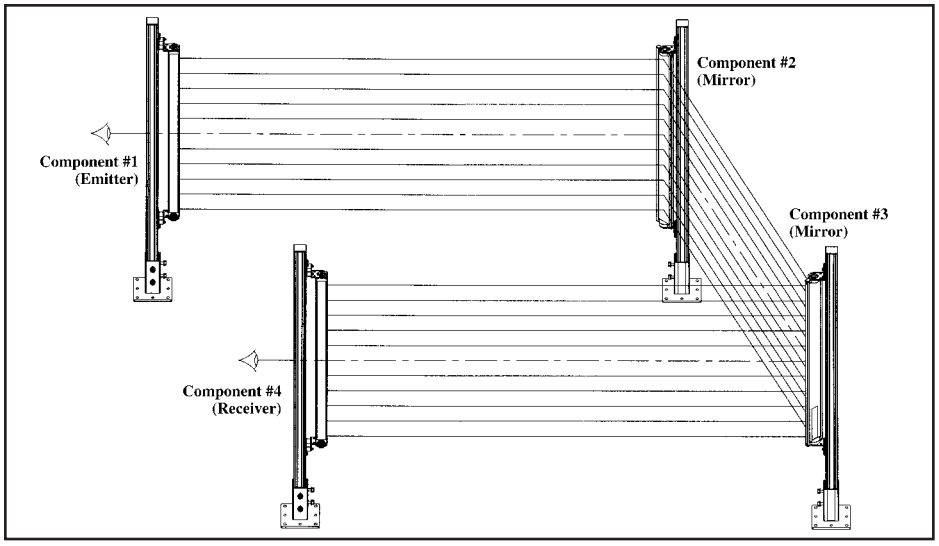


Figure 30. Corner Mirror Alignment

Use the yellow alignment indicator corresponding to the screen being aligned for final alignment. Refer to the data sheet (P/N 43685) packed with each MSM Series corner mirror for complete information on the use of corner mirrors.

6.2 Commissioning Checkout to be Performed at Time of Installation

This commissioning checkout must be done by a *qualified person* who possesses all of the manufacturer-provided information on the MULTI-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 MULTI-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 31, below).
3) Verify that access to the dangerous parts of the guarded machine is not possible from any direction not protected by the MULTI-SCREEN System, hard guarding, or supplemental guarding, and verify that all supplemental guarding devices and hard guarding are in place and operating properly.

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

The formula used to calculate the separation distance is:

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

where:

Ds = the separation distance;

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

Ts = 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 NOTE 2, below.

Tr = the response time of the MULTI-SCREEN System:

T_r	MINI-SCREEN Sensors	MACHINE-GUARD Sensors
.048 sec.	4.5 in. to 16 in. sensors	6 in. to 24 in. sensors
.060 sec.	20 in. to 32 in. sensors	30 in. to 48 in. sensors
.072 sec.	36 in. to 48 in. sensors	54 in. to 72 in. sensors

Determine the value of Tr for each of the two sensor pairs and use the GREATER value in the separation distance formula.

Dpf = the added distance due to depth penetration factor, as prescribed in OSHA 1910.217 and ANSI B11 standards:

Blanking Program	MINI-SCREEN 9 m (30 ft) Sensors	MINI-SCREEN 18 m (60 ft) Sensors	MACHINE-GUARD
Floating Blanking "Off"	Dpf = 1.6 in	Dpf = 2.5 in	Dpf = 4.0 in
One-beam Blanking	Dpf = 3.3 in	Dpf = 4.2 in	Dpf = 7.0 in
Two-beam Blanking	Dpf = 5.0 in	Dpf = 5.9 in	Dpf = 31.5 in

WARNING. . .
Calculate the separation distance carefully. Failure to maintain appropriate separation distance can result in serious bodily injury or death.

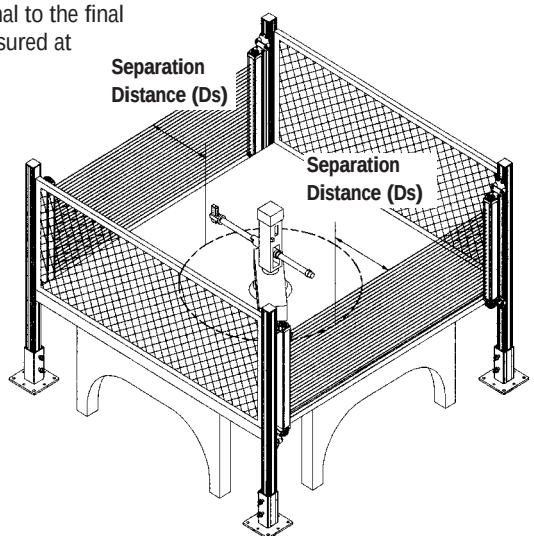


Figure 31. Calculation of D_s

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) Ts 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 will always cause the required Ds to increase.

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 MULTI-SCREEN System.

5) Examine the electrical wiring connections between the MULTI-SCREEN output relays and the guarded machine's control elements to verify that the requirements stated in Section 3.5.4.

6) Test the effectiveness of both MULTI-SCREEN light screens with system power "on", as described in steps (a) through (e), below. The MULTI-SCREEN control box includes eight specified test pieces. Select the proper test piece based on system configuration, per the following chart:

Sensor Type	Floating Blanking	Specified Test Piece Model	Specified Test Piece Size
MINI-SCREEN 9 m (30 ft) range	None (off)	STP-2	19.1 mm (0.75 in)
	1-beam	STP-4	32.0 mm (1.25 in)
	2-beam	STP-3	44.5 mm (1.75 in)
MINI-SCREEN 18 m (60 ft) range	None (off)	STP-7	25.4 mm (1.00 in)
	1-beam	STP-1	38.1mm (1.50 in)
	2-beam	STP-8	50.8 mm (2.00 in)
MACHINE-GUARD	None (off)	STP-1	38.1 mm (1.50 in)
	1-beam	STP-5	57.1 mm (2.25 in)
	2-beam	STP-6	76.2 mm (3.00 in)

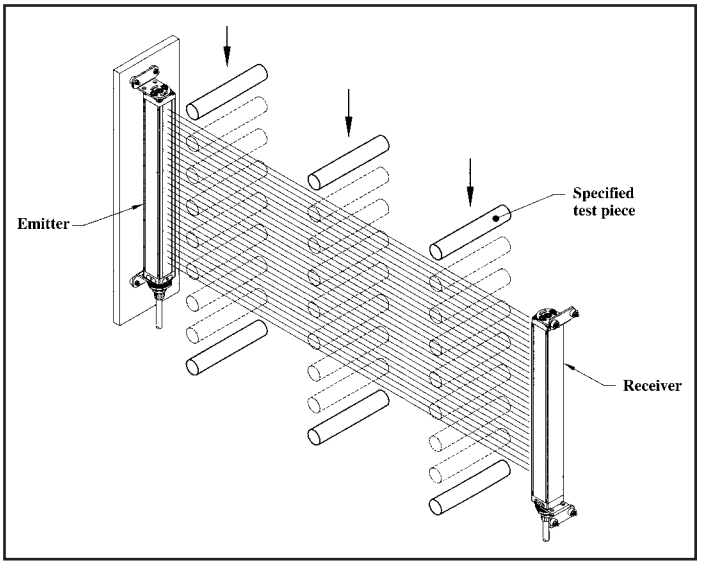


Figure 29. Use of Test Piece

a) Verify that the MULTI-SCREEN System is in the RUN mode (green and yellow status indicator LEDs "on"). See section 4.3 for RESET procedure. The green LED will flash if blanking is programmed for either light screen.

b) With the guarded machine at rest, slowly pass the *appropriate 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 (Figure 32). In each case, the red status indicator should come "on" and remain "on" for as long as the test piece is within the defined area. When the test piece is withdrawn from the defined area, the green status indicator should come "on". 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.

c) Initiate machine motion of the guarded machine and, during motion, insert the *appropriate 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.

d) With the guarded machine at rest, insert the *appropriate 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.

e) Repeat steps a through d for the second light screen.

7) Remove electrical power to the MULTI-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 the Auto Power-up feature 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. . .
If *all* of the above checks cannot be verified, the MULTI-SCREEN System/guarded machine should not be used until the defect or problem has been corrected (see Section 5). Attempts to use the guarded machine under such conditions could result in serious bodily injury or death.

6.3 To Be Performed at Every Power-up, Shift Change, and Machine Setup Change

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 MULTI-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 either 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 either 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 either defined area and any danger point which is large enough to allow a person to stand undetected by the MULTI-SCREEN System.

4) Verify that the MULTI-SCREEN control box is latched and locked. The key or combination to the control box latch lock should be in the possession of a qualified person.

WARNING. . .
A shock hazard exists while the control box door is open. Before continuing, verify that the control box door is closed and latched.

5) Test the effectiveness of both MULTI-SCREEN light screens with system power "on", as described in steps (a) through (e), below. The MULTI-SCREEN control box includes eight specified test pieces. Select the proper test piece based on system configuration, per the following chart:

Sensor Type	Floating Blanking	Specified Test Piece Model	Specified Test Piece Size
MINI-SCREEN 9 m (30 ft) range	None (off)	STP-2	19.1 mm (0.75 in)
	1-beam	STP-4	32.0 mm (1.25 in)
	2-beam	STP-3	44.5 mm (1.75 in)
MINI-SCREEN 18 m (60 ft) range	None (off)	STP-7	25.4 mm (1.00 in)
	1-beam	STP-1	38.1mm (1.50 in)
	2-beam	STP-8	50.8 mm (2.00 in)
MACHINE-GUARD	None (off)	STP-1	38.1 mm (1.50 in)
	1-beam	STP-5	57.1 mm (2.25 in)
	2-beam	STP-6	76.2 mm (3.00 in)

a) Verify that the MULTI-SCREEN System is in the RUN mode (green and yellow Status Indicator LEDs "on"). See Section 4.3 for RESET procedure. Refer to Figure 28.

b) With the guarded machine at rest, pass the *appropriate 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 (see Figure 32). In each case, the red status indicator should come "on" and remain "on" for as long as the test piece is within the defined area. When the test piece is withdrawn from the defined area, the green status indicator should come on. 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 51).

c) Initiate machine motion of the guarded machine and, during motion, insert the appropriate 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.

d) With the guarded machine at rest, insert the *appropriate 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.

e) Repeat steps a through d for the second light screen.

6) Check carefully for external signs of damage to the MULTI-SCREEN System, the guarded machine, and their electrical wiring. Any damage found should be immediately reported to management.

6.4 To Be Performed at Six Month Intervals (Semi-annually)

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

WARNING. . .
A shock hazard exists while the control box door is open. Before continuing, verify that the control box door is closed and latched.

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 MULTI-SCREEN System.
4) Examine and inspect the machine controls and connections to the MULTI-SCREEN System to ensure that no modifications have been made which adversely affect the system.

WARNING. . .
If *all* of the above checks cannot be verified, the MULTI-SCREEN System/guarded machine should not be used until the defect or problem has been corrected (see Section 5). Attempts to use the guarded machine under such conditions could result in serious bodily injury or death.

WARNING – Reflective Surfaces. . .
It may be possible for a highly reflective surface (such as a shiny machine surface or a shiny workpiece) to reflect sensing light around an object in the defined area, thus 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). If possible, relocate the sensors to move the curtain of light beams away from the reflective surface(s). If relocating the sensors, be 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. 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 curtain, 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 MULTI-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 64.

Auxiliary monitor contact: a low load capacity, non safety-related relay contact within the MULTI-SCREEN System that follows the action of the associated light screen, and whose primary purpose is to communicate system status to a PLC. The MULTI-SCREEN System has two auxiliary monitor contacts: one for each light screen. An auxiliary contact opens for a trip condition resulting from an interruption of the associated light screen. Both auxiliary contacts open for a lockout condition.

Auto Power-up: a feature of the MULTI-SCREEN control box which, when switched "on", enables the MULTI-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 MULTI-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 MULTI-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 Relays.*

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

Defined area: the "curtain of light" generated by the sensors of the MULTI-SCREEN System. When the defined area is interrupted by an opaque object of a specified cross section, a *trip condition results* (see Figure 1). The MULTI-SCREEN System uses two sensor pairs and, therefore, has two defined areas.

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 components of the MULTI-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.* The MULTI-SCREEN System uses two emitter/receiver pairs–either MINI-SCREEN or MACHINE-GUARD types.

Final switching device (FSD): the two output relays (FSD1 and FSD2) of the MULTI-SCREEN System which respond to an interruption of either 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 MULTI-SCREEN System to be programmed to produce an intentionally disabled light beam, within either "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 MULTI-SCREEN System offers either one-beam or two-beam floating blanking. Floating blanking may be independently programmed for each of the two light screens.

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 MULTI-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". MULTI-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 MULTI-SCREEN Systems may **not** be used with full-revolution devices.

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

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

Internal lockout: a lockout condition that is due to an internal MULTI-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 MULTI-SCREEN System.

Lockout condition: a condition of the MULTI-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 MULTI-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. *Except when the system is programmed for auto power-up.

Machine primary control element (MPCE): an electrically powered element, external to the MULTI-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 screen 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 power supply to the MULTI-SCREEN System. Any inconsistency of action between the two sets of monitor contacts will remove power from the MULTI-SCREEN System and cause a *lockout condition*. See Figure 26.

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

ON state (of Final and Secondary Switching Devices): in the ON state, the output circuit is complete (closed) 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 64.

Output relays: the devices (within the MULTI-SCREEN System) that are used to initiate an emergency stop signal. The MULTI-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 removeable printed circuit board which contains the power supply circuit and is located inside the MULTI-SCREEN System *control box*. A green LED on the power supply board lights whenever power is present on the board.

Power-up/power interrupt lockout: a *lockout condition* of the MULTI-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) double-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 MULTI-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 components of the MULTI-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.* The MULTI-SCREEN System uses two emitter/receiver pairs–either MINI-SCREEN or MACHINE-GUARD types.

Secondary switching device (SSD): the output relay of the MULTI-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 MULTI-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 MULTI-SCREEN System into a *trip condition* when inserted into any part of either *defined area.* See also *minimum object sensitivity and Section 3.2.1.*

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 areas* of an installed MULTI-SCREEN System and into the *point of operation* of the *guarded machine*.

Trip condition: 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.

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.

MINI-SCREEN Sensor Specifications

Models	Defined Area (in)	Defined Area (mm)	Number of Beams	Models	Defined Area (in)	Defined Area (mm)	Number of Beams
MSE424 emitter **MSR424** receiver	4.5	114	8	**MSE2824** emitter **MSR2824** receiver	28	711	56
MSE824 emitter **MSR824** receiver	8.5	215	16	**MSE3224** emitter **MSR3224** receiver	32	813	64
MSE1224 emitter **MSR1224** receiver	12	305	24	**MSE3624** emitter **MSR3624** receiver	36	914	72
MSE1624 emitter **MSR1624** receiver	16	406	32	**MSE4024** emitter **MSR4024** receiver	40	1016	80
MSE2024 emitter **MSR2024** receiver	20	508	40	**MSE4424** emitter **MSR4424** receiver	44	1118	88
MSE2424 emitter **MSR2424** receiver	24	610	48	**MSE4824** emitter **MSR4824** receiver	48	1219	96

Emitter/receiver separation:	6 inches (15 cm) to 30 feet (9 m) for standard sensors 6 inches (15 cm) to 60 feet (18 m) for optional long-range sensors
Minimum object sensitivity:	19.1 mm (0.75 in) for 9 m (30 ft) range sensors with floating blanking “off” 32.0 mm (1.25 in) for 9 m (30 ft) range sensors with 1-beam floating blanking “on” 44.5 mm (1.75 in) for 9 m (30 ft) range sensors with 2-beam floating blanking “on” 25.4 mm (1.00 in) for 18 m (60 ft) range sensors with floating blanking “off” 38.1 mm (1.50 in) for 18 m (60 ft) range sensors with 1-beam floating blanking “on” 50.8 mm (2.00 in) for 18 m (60 ft) range sensors with 2-beam floating blanking “on”
Response time:	Less than 48 milliseconds using emitter/receiver with 4.5 to 16 inch defined area Less than 60 milliseconds using emitter/receiver with 20 to 32 inch defined area Less than 72 milliseconds using emitter/receiver with 36 to 48 inch defined area
Self-checking interval:	20 milliseconds
Ambient light immunity:	>10,000 lux at 5° angle of incidence
Strobe light immunity:	Totally immune to one Federal Signal Corp. "Fireball" model FB2PST strobe.
Emitter elements:	Infrared LEDs; 880nm peak emission
Status Indicators:	Emitter: Green LED for power “on” indication Receiver: Red, yellow, and green status indicators with same functions as those on control box. (see Control Box Specifications). Yellow LED also indicates alignment. Indicators are visible on three sides of receiver base.
Enclosures: **Emitter and receiver:**	*Size:* see Figure 15, page 23 *Material:* Aluminum, with black anodized finish or yellow polyester painted; acrylic lens cover *Rating:* NEMA 4, 13 (IP 65)
Mounting hardware:	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.
Operating Temperature:	0 to 50ºC (+32 to 122ºF); 95% max. rel. humidity (non-condensing)

MACHINE-GUARD Sensor Specifications

Models	Defined Area (in)	Defined Area (mm)	Number of Beams	Models	Defined Area (in)	Defined Area (mm)	Number of Beams
MGE616A emitter **MGR616A** receiver	6	152	8	**MGE4216A** emitter **MGR4216A** receiver	42	1067	56
MGE1216A emitter **MGR1216A** receiver	12	305	16	**MGE4816A** emitter **MGR4816A** receiver	48	1219	64
MGE1816A emitter **MGR1816A** receiver	18	457	24	**MGE5416A** emitter **MGR5416A** receiver	54	1372	72
MGE2416A emitter **MGR2416A** receiver	24	610	32	**MGE6016A** emitter **MGR6016A** receiver	60	1524	80
MGE3016A emitter **MGR3016A** receiver	30	762	40	**MGE6616A** emitter **MGR6616A** receiver	66	1676	88
MGE3616A emitter **MGR3616A** receiver	36	914	48	**MGE7216A** emitter **MGR7216A** receiver	72	1829	96

Emitter/receiver separation:	6 inches (15 cm) minimum; 3x excess gain at 45 feet (14 m)
Minimum object sensitivity:	1.5 inches (38 mm) with no blanking in use 2.3 inches (58 mm) with one-beam floating blanking “on” 3.0 inches (76 mm) with two-beam floating blanking “on”
Response time:	Less than 48 milliseconds using emitter/receiver with 6 to 24 inch defined area Less than 60 milliseconds using emitter/receiver with 30 to 48 inch defined area Less than 72 milliseconds using emitter/receiver with 54 to 72 inch defined area
Self-checking interval:	20 milliseconds
Ambient light immunity:	>10,000 lux at 5° angle of incidence
Strobe light immunity:	Totally immune to one Federal Signal Corp. "Fireball" model FB2PST strobe.
Emitter elements:	Infrared LEDs; 880nm peak emission
Enclosures: **Emitter and receiver:**	*Size:* see Figure 18, page 25 *Material:* Extruded Aluminum, with black anodized finish; acrylic lens cover *Rating:* NEMA 4, 13 (IP 65)
Mounting hardware:	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.
Operating Temperature:	0 to 50ºC (+32 to 122ºF); 95% max. rel. humidity (non-condensing)

MUSC-1 Control Box Specifications	
Control Box:	*Size:* see Figure 19, page 26 *Material:* Welded steel box with black polyester powder paint finish *Rating:* NEMA 13 (IP 56)
System Power Requirements:	115V ac ±15% (50/60 Hz), 85VA: 230V ac ±15% (50/60 Hz), 85VA or 24V dc±15%, 10% maximum ripple, 2.5 amps max
Fuse rating:	115V ac: 1 amp, 250V (3AG or 5x20mm slow blow); 230V ac: 1/2 amp, 250V (3AG or 5x20mm slow blow); 24V dc: 3 amp, 250V (3AG or 5 x 20mm slow blow);
Status indicators: **(on control box and receiver)**	Red = BLOCKED Flashing red = LOCKOUT Green = CLEAR Flashing green = BLANKING "on" Yellow = RESET Double-flashing yellow = waiting for power-up manual key reset ALIGNMENT Yellow alignment indicator for each light screen: flash rate increases with the number of sensing beams “made”; solid yellow when aligned and defined area is clear.
Diagnostic indicator	Single-digit numeric display indicates cause of lockout condition. (see fig. 27, page 41)
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	Two Reed relays; 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). *Mechanical life* 10,000,000 operations (minimum). *Electrical life* (at full rated load) 100,000 operations (typical). *Arc suppression is recommended when switching inductive loads. See Figure 23, page 30.*
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, BS6491and IEC 1496-1.
Cables:	*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.* 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 .32inch (8,1 mm) in 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 feet* (each). See *Cables,* page 61. ***NOTE: Contact factory Applications Department for information on cable lengths greater than 50 ft.See cable and sensor drawing, figure 23, page 30.***
Certifications:	UL LISTED Presence Sensing Device 10Y8 C UL

MULTI-SCREEN Systems consist of one control box, two sensor pairs, and four cables. All components are ordered separately. The only requirement is that the emitter and receiver of either sensor pair must be of equal length. However, the two sensor pairs may be different lengths, and MINI-SCREEN and MACHINE-GUARD sensor pairs may be used together in the same system. Cables are interchangeable between emitters and receivers. See page 63 for system accessories.

MINI-SCREEN Emitters (E) and Receivers (R)

Defined Area	Models			Number of Beams
	Black Anodized	Yellow Painted		
	Range 9 m (30 ft)	Range 9 m (30 ft)	Range 18 m (60 ft)	
114 mm (4.5 in)	**MSE424 MSR424**	**MSE424Y MSR424Y**	**MSXLE424Y MSXLR424Y**	8
215 mm (8.5 in)	**MSE824 MSR824**	**MSE824Y MSR824Y**	**MSXLE824Y MSXLR824Y**	16
305 mm (12 in)	**MSE1224 MSR1224**	**MSE1224Y MSR1224Y**	**MSXLE1224Y MSXLR1224Y**	24
406 mm (16 in)	**MSE1624 MSR1624**	**MSE1624Y MSR1624Y**	**MSXLE1624Y MSXLR1624Y**	32
508 mm (20 in)	**MSE2024 MSR2024**	**MSE2024Y MSR2024Y**	**MSXLE2024Y MSXLR2024Y**	40
610 mm (24 in)	**MSE2424 MSR2424**	**MSE2424Y MSR2424Y**	**MSXLE2424Y MSXLR2424Y**	48
711 mm (28 in)	**MSE2824 MSR2824**	**MSE2824Y MSR2824Y**	**MSXLE2824Y MSXLR2824Y**	56
813 mm (32 in)	**MSE3224 MSR3224**	**MSE3224Y MSR3224Y**	**MSXLE3224Y MSXLR3224Y**	64
914 mm (36 in)	**MSE3624 MSR3624**	**MSE3624Y MSR3624Y**	**MSXLE3624Y MSXLR3624Y**	72
1016 mm (40 in)	**MSE4024 MSR4024**	**MSE4024Y MSR4024Y**	**MSXLE4024Y MSXLR4024Y**	80
1118 mm (44 in)	**MSE4424 MSR4424**	**MSE4424Y MSR4424Y**	**MSXLE4424Y MSXLR4424Y**	88
1219 mm (48 in)	**MSE4824 MSR4824**	**MSE4824Y MSR4824Y**	**MSXLE4824Y MSXLR4824Y**	96

Machine Guard

Defined Area	Models	Number of Beams
	Black Anodized	
	Range - 13.7 m (45 ft)	
152 mm (6.0 in)	**MGE616A MGR616A**	8
305 mm (12.0 in)	**MGE1216A MGR1216A**	16
457 mm (18.0 in)	**MGE1816A MGR1816A**	24
610 mm (24.0 in)	**MGE2416A MGR2416A**	32
762 mm (30.0 in)	**MGE3016A MGR3016A**	40
914 mm (36.0 in)	**MGE3616A MGR3616A**	48
1067 mm (42.0 in)	**MGE4216A MGR4216A**	56
1219 mm (48.0 in)	**MGE4816A MGR4816A**	64
1372 mm (54.0 in)	**MGE5416A MGR5416A**	72
1524 mm (60.0 in)	**MGE6016A MGR6016A**	80
1676 mm (66.0 in)	**MGE6616A MGR6616A**	88
1829 mm (72.0 in)	**MGE7216A MGR7216A**	96

Control Boxes

MUSC-1 115V or 230V ac or 24V dc control box (One per system)

Cables (Two required per system)*

QDC-515C 4.5 m (15 ft) cable, straight QD connector. One cable per sensor.

QDC-525C 7.6 m (25 ft) cable, straight QD connector. One cable per sensor.

QDC-550C 15 m (50 ft) cable*, straight QD connector. One cable per sensor.

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

Pigtail Quick Disconnect Option

Any yellow emitter or receiver may be ordered with a 305 mm (12 in) 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 receiver. The same mating quick disconnect cables, as listed above, are used (ordered separately). To specify a pigtail quick disconnect cable, add suffix "**P**" to the model number of the emitter or receiver, for example: **MSE1624YP**.

Documentation

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

Instruction Manual for MULTI-SCREEN Systems: order p/n 42492 (this manual).

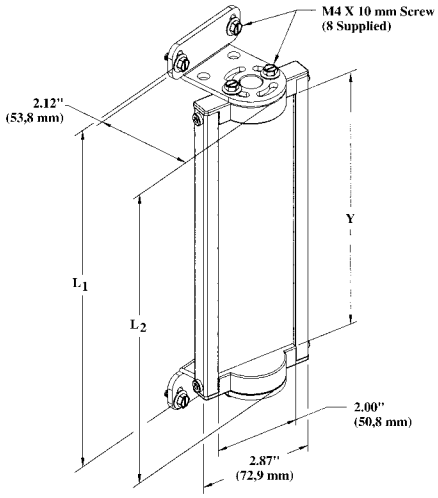
Checkout Procedure Card (Daily): order p/n 43840

Checkout Procedure Card (Semi-annual): order p/n 43841

Replacement Parts, MINI-SCREEN Systems

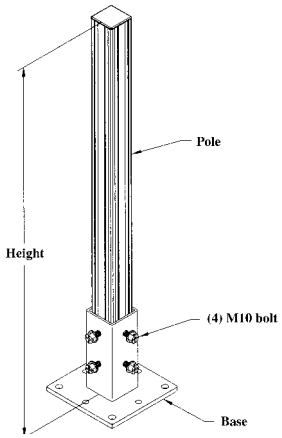
40091	**BA2MB**	Mounting Hardware Kit for one MINI-SCREEN emitter or receiver
27506	**BAMB**	Mounting Hardware Kit for one MACHINE-GUARD emitter or receiver
27850	**MGA-GSA-1**	Ground strap, control box door
28513	**MGA-K-1**	Replacement key
30140	**MGA-KSO-1**	Key switch, only (no wires)
39023	**MSA-KS-1**	Key switch, pre-wired
39025	**MSA-RM-1**	Relay module
43831	**MUSA-MH-1**	Control box mounting hardware
43832	**MUSA-PS-1**	Replacement power supply board
43834	**MUSA-TA-1**	Replacement Transformer
43833	**MUSAB-1**	Microporcessor control module
43835	**STP-1**	Specified test piece (1.50" dia.)
43957	**STP-2**	Specified test piece (.75" dia.)
43958	**STP-3**	Specified test piece (1.75" dia.)
43836	**STP-4**	Specified test piece (1.25" dia.)
43837	**STP-5**	Specified test piece (2.25" dia.)
43838	**STP-6**	Specified test piece (3.00" dia.)
48981	**STP-7**	Specified test piece (1.00" dia.)
49162	**STP-8**	Specified test piece 2.00" dia.)

MSA Series Corner Mirrors



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

MSM Series Stands



Model of Stand	Part Number	Stand Height	Mirror Length (Brackets Outward)	Mirror Length (Brackets Inward)
MSA-S24-1	43174	24 inches	4 to 8 inches	4 to 12 inches
MSA-S42-1	43175	42 inches	4 to 24 inches	4 to 28 inches
MSA-S66-1	43176	66 inches	4 to 48 inches	4 to 48 inches

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 MULTI-SCREEN Systems as they are supplied to the original purchaser. Proper installation, operation, and maintenance of the MULTI-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 MULTI-SCREEN System. This warranty is in lieu of any other warranty either expressed or implied.

See also warranty-related return shipping information, page 43.

MSA Series 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 in) clear polycarbonate.

Shield models are available for every length of sensor from 4 inches to 48 inches (see chart, below). The shields attach to the sensor using two adhesive-backed Neoprene foam strips.

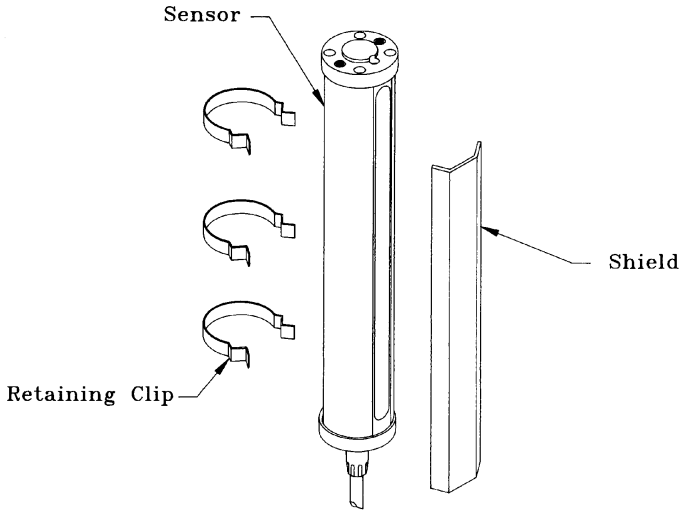
Application Note: When shields are installed on both the emitter and receiver, excess gain is reduced by 36 percent (and maximum operating range is reduced by 20 percent).

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

MACHINE-GUARD Series Lens Shields

These are replaceable protective covers for MACHINE-GUARD sensors. They are constructed of clear polycarbonate, and are supplied with corrosion-protected steel retaining clips. Shields may be quickly installed or removed without disturbing sensor alignment. Use of these shields results in somewhat reduced sensing range. Contact Banner Application Engineers for more information. See drawing, right.

Model	Model	Model
MGS6A	29376	Shield kit for 6" sensor
MGS12A	29377	Shield kit for 12" sensor
MGS18A	29401	Shield kit for 18" sensor
MGS24A	29402	Shield kit for 24" sensor
MGS30A	29403	Shield kit for 30" sensor
MGS36A	29404	Shield kit for 36" sensor
MGS42A	29405	Shield kit for 42" sensor
MGS48A	29406	Shield kit for 48" sensor
MGS54A	33555	Shield kit for 54" sensor
MGS60A	29982	Shield kit for 60" sensor
MGS66A	33556	Shield kit for 66" sensor
MGS72A	29917	Shield kit for 72" sensor



U.S. Federal Regulations Applicable to Use of Safety Light Curtains

OSHA 29 CFR 1910.212
General Requirements for (guarding of) All Machines

OSHA 29 CFR 1910.217
(Guarding of) Mechanical Power Presses

Part of:
Code of Federal Regulations
Title 29, Parts 1900 to 1910

Address:
Superintendent of Documents
Government Printing Office
Washington, D.C. 20402-9371
Telephone: 202-783-3238

ANSI B11 Standards: Standards Applicable to Use of Safety Light Curtains

ANSI B11.1-1988
Mechanical Power Presses

ANSI B11.2-1982
Hydraulic Power Presses

ANSI B11.3-1982
Power Press Brakes

ANSI B11.4-1993
Shears

ANSI B11.5-1988
Iron Workers

ANSI B11.6-1984
Lathes

ANSI B11.7-1995
Cold Headers and Cold Formers

ANSI B11.8-1983
Drilling, Milling, and Boring Machines

ANSI B11.9-1975
Grinding Machines

ANSI B11.10-1990
Metal Sawing Machines

ANSI B11.11-1985
Gear Cutting Machines

ANSI B11.12-1983
Roll Forming and Roll Bending Machines

ANSI B11.13-1992
Single- and Multiple-Spindle Automatic Bar and Chucking Machines

ANSI B11.14-1983
Coil Slitting Machines/Systems

ANSI B11.15-1984
Pipe, Tube, and Shape Bending Machines

ANSI B11.16-1988
Metal Powder Compacting Presses

ANSI B11.17-1982
Horizontal Extrusion Presses

ANSI B11.18-1992
Machinery and Machine Systems for the Processing of Coiled Strip, Sheet, and Plate

ANSI B11.19-1990
Performance Criteria for the Design, Construction, Care, and Operation of Safeguarding when Referenced by the Other B11 Machine Tool Safety Standards

ANSI B11.20-1991
Manufacturing Systems/Cells

ANSI/RIA 15.06
Safety Requirements for Industrial Robots and Robot Systems

ANSI B11 Documents
American National Standards Institute
11 West 42nd Street
New York, NY 10036

-or-

Safety Director
National Machine Tool Builders Assn.
7901 Westpark Drive
McLean, VA 22102-4269

ANSI/RIA Documents
Obtain from ANSI (above) or:

Robotic Industries Association
900 Victors Way, P.O Box 3724
Ann Arbor, MI 48106
Telephone: 313-994-6088

Standards Applicable to Design of Safety Light Curtains

UL 491
The Standard for Power-operated Machine Controls and Systems

Address:
Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062-2096
Telephone: 708-272-8800

BS 6491
General Requirements for Electro-sensitive Safety Systems for Industrial Machines

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

Notes

Banner Engineering Corp. 9714 10th Avenue No. Minneapolis, MN 55441 Telephone: (612) 544-3164 FAX (applications): (612) 544-3573