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Section E
Model SHD-4000-Series
Small Hole Detection Sensor
Operator's Manual

Table of Contents

E.1 Introduction

The Small Hole Detection Sensor – Model SHD-4000-Series is a non-contact, electro-optical sensor designed specifically for the detection of small holes in strip materials. The SHD-4000-Series sensor operates with a Hole Detection Processing Computer – Model HDPC (Section S). Because of its versatility and reliability, the SHD-4000-Series sensor is one of the most reliable and cost effective small hole detection sensor systems on the market today.

E.1.a Sensor Overview

The SHD-4000-Series sensor set consists of an emitter with 20 foot [6.1m] emitter-to-processor cable and a receiver with 15 foot [4.6m] emitter-to-receiver cable for small hole detection applications {Figure E.1-1}. Longer cables are available upon request (XCB Option). Each emitter contains scanned high-intensity infrared (IR) light emitting diodes (LED's) grouped into 10-1 inch [25mm] arrays per 10 inch [254mm] section. The 10 diode groups pulse consecutively to permit 0.125 millisecond hole detection's anywhere along the length of the group. Additional groups may be connected to the first (up to four groups) and operate consecutively with the first group. The visible light filtered receiver with its IR filtered photocell detects holes in strips moving at typical production line speeds.

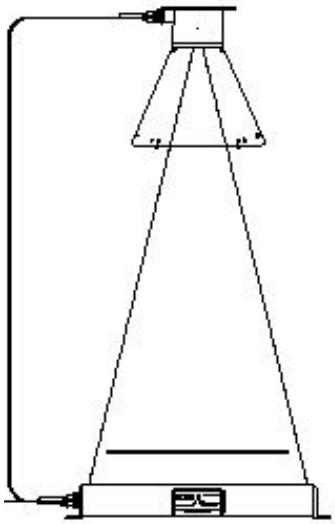

Figure E.1-1: Typical Single Sensor Small Hole Detection Sensor Setup

E.1.b Functional Description

The SHD-4000-Series emitter module contains a scanned array of 100 infrared LEDs that light sequentially with a scan rate of 0.125 milliseconds per ten inches [254mm]. The receiver light detector is a silicon photocell. All of the light focused by the receiver lens onto the photocell generates an electrical current. The light coming from the emitter is visible-light filtered and pulses at 400kHz, so the current generated in the receiver also pulses at 400kHz. This assists in preventing ambient light from interfering with the SHD-4000-Series sensor.

When the SHD-4000-Series receiver (Model SHD-4000R) is positioned to "see" all of the diodes in the emitter, the absence of light at the instant in time when a diode is being lit indicates that an object is blocking the light path at that diode. When light is detected, the photocell produces an electrical current proportional to the infrared energy falling on its surface. The resulting current is delivered to the input of a balanced low noise pre-amplifier that is tuned to pass only the 400kHz signals generated by the emitter infrared LED array(s).

E.2 Operational Considerations

The SHD-4000-Series sensor is highly resistant to most of the industrial environments that can cause problems with many hole detection systems.

Because the SHD-4000-Series sensor is producing and looking for light modulated at approximately 400kHz, it is unlikely that typical low level ambient light sources will be a problem. It is best to avoid placing a direct high-intensity light or reflected, modulated light source in the receiver view path. A bright light source can overload the receiver photocell and prevent it from detecting the emitter light.

Even though the SHD-4000-Series sensor is tolerant of most ambient light situations, high-intensity strobe lights can cause receiver cell overload, producing false detections. Because of the high frequency pulsing of strobe lights, the receiver can interpret the strobe pulses as an extra edge or trigger a fault detection. ***Care should be taken when installing a SHD-4000-Series sensor to locate the sensor as far as possible from any strobe light(s).*** If operational constraints require that the SCAN-A-LINE™ sensor be mounted in close proximity to a strobe light, horn blinders (HBLD Option – Section HH) are available for SHD-4000-Series receivers that may assist in preventing any strobe light interference.

A buildup of dust, dirt or oil will affect the operation or accuracy of a SCAN-A-LINE™ sensor. Dust, dirt and oil build-up can attenuate the sensor signal and the system's ability to detect small holes. Large pieces of material, opaque coatings of paint or heavy grease can completely block the beam of light or attenuate it below tolerable limits. To avoid erratic readings or maintenance difficulty, care should be taken to install the emitter and receiver where the danger of such contamination is minimized. A simple air wipe installed over the emitter viewing window can be helpful where contamination cannot be avoided.

E.2.a Temperature Range

The operating temperature for the SHD-4000-Series sensor is 32ºF to 122ºF [0ºCF to 50ºC]. Operations outside this range are possible with special provisions made to protect the equipment, such as heat shields and water jackets.

E.2.b Vibration Considerations

Vibration is of little or no consequence to the detection of holes with the SCAN-A-LINE™ sensor. In very high vibration applications, simple vibration dampening will solve most vibration problems encountered.

E.3 Specifications for SHD-4000-Series Sensor

Power for the SHD-4000-Series sensor must be supplied by a SCAN-A-LINE™ Hole Detection Processing Computer (Model HDPC – Section S), with one up to three sensor(s) per processing unit. A good system earth ground can be helpful in reducing the possibility of interference from other electrical equipment. Care should be taken to insure that the SCAN-A-LINE™ earth ground is separate from the grounds used by high current or high noise systems (such as motor controllers and welding equipment). This is most important when high current (i.e., welding equipment) and high voltage is involved.

E.3.a Power Requirements

Power Supply (rated at 50°C):

+12VDC ±0.25VDC @ 250mA
-12VDC ±0.25VDC @ 50mA

E.3.b Signal Output

The output signal from the SHD-4000-Series sensor is a 12VDC CMOS signal that goes to the logic zero state any time the emitter light is detected by the receiver. The position of holes and number of edges encountered by the sensor during a scan can be determined by observing the output signal from the emitter. This signal MUST be processed by a Model HDPC Hole Detection Processing Computer. Older systems have used the Model HDPU Hole Detection Processing Unit for this purpose.

E.3.c Physical Dimensions

Drawings showing the dimensions of the SHD-4000-Series sensors are located in Section D.8 of this manual. The following list shows the dimensional drawings for these sensors:

1295004 Rev. B	Model 10X Emitter Dimensions
1295015 Rev. C	Model 10XR Receiver Dimensions

The SHD-4000-Series emitter measures 3 inches [76.2mm] tall by 2.8 inches [71.4mm] wide in lengths from 14.06 inches [357mm] (Model SHD-4000-10) to 34.06 inches [865mm] (Model SHD-4000-30) and integrates a mounting plate, with four 5/16 inch [7.9mm] mounting holes, into the base of the emitter. The emitter is constructed of an extruded aluminum enclosure with 2 (two) extruded aluminum end caps. The extruded aluminum enclosure incorporates the Lexan window and includes 2 (two) MS-Style circular connectors for emitter-to-receiver and emitter-to-processing unit cable connections.

The SHD-4000-Series receiver measures 6.6 inches [168mm] long by 3 inches [76mm] wide by 3.6 inches [91mm] tall. It is constructed of a cast aluminum housing with extruded aluminum mounting plate and bezel containing the borosilicate glass viewing window. A MS-style circular connector is for the emitter-to-receiver cable connection.

E.3.d Minimum Hole Size

The minimum hole size(s) that the SHD-4000-Series sensor can detect are 0.0625 inch [1.6mm] plus the product thickness. Hole sizes that the SHD-4000-Series sensor can detect are dependent upon several factors, such as line speed, product thickness (when greater than 0.0625 inch [1.6mm]), sensor size and the position of the sensor in relation to the hole position in the strip. The sensor size relates to the overall scan time of the emitter LED's. Positioning the sensor with the receiver directly over the material hole location can also increase the likelihood of a hole detection by eliminating the product thickness variable.

For sizes other than specified, contact Harris Instrument Corporation for more information.

Sensor Model - Sensor Size	Scan Time in Seconds
SHD-4000E-10	0.125ms
SHD-4000E-20	0.250ms
SHD-4000E-30	0.375ms
Table E.3.d: Small Hole Detection Sensor Scan Times	

E.3.e Operational Configurations

The SHD-4000-Series sensor is available in several optional configurations to meet a variety of application requirements. The various configurations may be specified as follows:

Model Number & Suffix	Description
SHD-4000E	Indicates that the unit is a emitter for the Small Hole Detection System.
SHD-4000R	Indicates that the unit is a receiver for the Small Hole Detection System.
HBLD	Indicates that the receiver is configured with a horn blinder. This blinder is typically used with system that will be installed on lines that may have interference from strobe or other pulsing light sources.
XCB	Indicates that the cables supplied with the system are longer than the standard cables (15 feet [4.6m] to 20 feet [6.1m] up to 50 feet [15.2m]).
Table E.3-1: Optional Configurations for 10XHD-Series Sensors	

E.4 Installation

The SHD-4000-Series sensor is designed for operation with a Hole Detection Processing Computer – Model HDPC for hole small hole detection applications. The Model HDPC uses 1 (one) up to 3 (three) sensors of the same type and size.

When installing the SHD-4000-Series sensor, procedures to protect the sensor from any line collision should be taken. Damage to sensors from line collisions is the primary cause of SCAN-A-LINE™ sensor failures. Install the sensor in a position on the line where it is protected as much as possible from strip collisions. Many times, a simple deflection bar mounted above the sensor components will prevent such collisions. Once properly installed (refer to your system configuration drawing provided with your new system purchase) and protected, the SHD-4000-Series sensor will provide a lifetime of reliable operation.

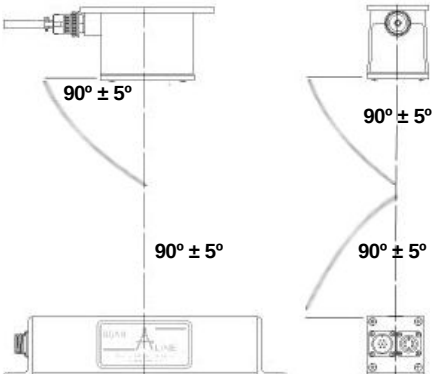

Figure E.4-1: Emitter-to-Receiver Alignment

NOTE:

If any welding is to be performed near a SHD-4000-Series sensor, COVER THE LEXAN® BEZEL with a protective material (i.e., metal plate, wood sheet, etc.) to prevent the welding flash from coming in contact with the bezel. Such welding flash is hot enough to melt the Lexan®, causing pitting of the bezel that can result in incorrect readings.

E.4.a Hole Detection Installation

The SHD-4000-Series emitter and SHD-4000-Series receiver are mounted parallel with the receiver typically positioned directly above the center of the emitter. The centerline of the emitter and receiver should be perpendicular to the strip, with a maximum tip of ±5°. The wedge of light is approximately 30° wide. The receiver lens system has a more narrow angle (10°) and may require mounting adjustment. A greater emitter-to-receiver separation creates a greater requirement for proper aim adjustment {Figure E.4-1}.

Sensor	Emitter-to-Receiver Separation
SHD-4000E-10	14 Inches [355.6mm]
SHD-4000E-20	24 Inches [609.6mm]
SHD-4000E-30	34 Inches [863.6mm]
Table E.4-1: Hole Detection Sensor Scan Times and Emitter-to-Receiver Separation	

(Refer to your system configuration drawing that was provided with your new system purchase.)

Emitter-to-Receiver Separation

Emitter-to-receiver separation for a SHD-4000-Series sensor is optimized to match emitter length {Figure E.4-2 and Table E.4-1} and offer well-balanced receiver viewing sensitivity. The emitter-to-receiver distance depends upon the length of the emitter and several other factors**.** Emitter-to-Receiver separations that are less than or greater than those specified in {Figure E.4-2, Table E.4-1 or the configuration drawing provided with your new system} should be avoided. Close emitter-to-receiver separation will limit the width inspection range of the sensor and may cause a loss of sensitivity at the outside edges. Emitter-to-receiver separations greater than those specified in {Figure E.4-2, Table E.4-1 or the configuration drawing provided with your new system } may allow interference from ambient light sources although low level ambient light sources are largely rejected by the 400kHz tuning of the video signal processing circuits and the IR filtering in the silicon cells.

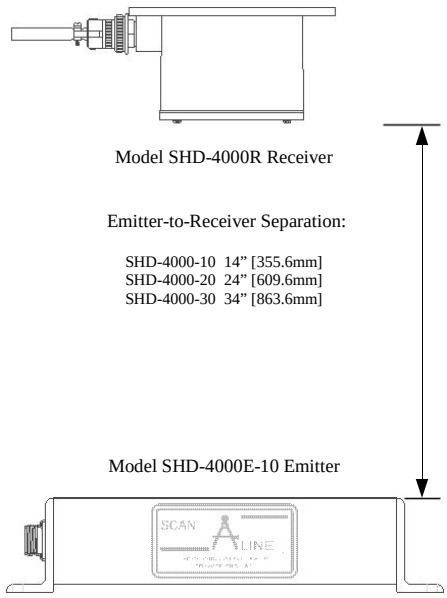

Figure E.4-2: Sensor Separation for SHD-4000-Series Sensors

Strobe lights or any pulsed IR light source in close proximity to the SHD-4000-Series sensor can pose special problems. Keeping the field of view of the sensor as small as possible with close emitter-to-receiver separation reduce the possibility of false hole detection's while also improving smaller hole sensitivity. Shielding the receiver from interfering light sources to reduce such light interference will improve performance.

The maximum detection width range for the SHD-4000-Series sensor varies depending upon the length of the emitter. However, operational considerations, such as lateral strip deviation {Figure E.4-3} and product passline (distance from the emitter face to the strip) {Figure E.4-4} can lessen the width range. The SHD-4000-Series sensor should be placed on the line where the strip lateral position is relatively stable to prevent loss of range from lateral deviation.

Typically, the detection width range is approximately two (2) inches [50.8mm] less than the length designation of the sensor (i.e. a Model SHD-4000-10 sensor will have an effective detection width range of eight (8) inches [203.2mm]).

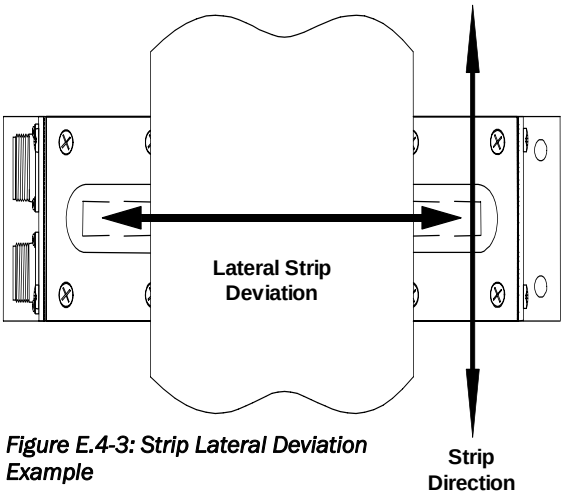

Figure E.4-3: Strip Lateral Deviation Example

Product Passline

The product passline spacing for the SHD-4000-Series sensor is (1) one inch [25mm] {Figure E.4-4}. As the product passline increases the active inspection range of the sensor decreases, so any passline spacing higher than one (1) inch [25mm] may seriously degrade the detection abilities of the system.

E.4.b Sensor Connections

When connecting a SHD-4000-Series sensor set to the processing unit, the type of processing unit dictates the way in which the sensor(s) are connected.

Emitter-to-Receiver Connection

Connect the receiver to the emitter via the 6-pin MS-style circular connectors receiver cable and tighten securely. The Model SHD-4000-Series receiver has a 6-pin male MS-style circular connector. This cable attaches to the emitter-to-receiver cable (female 6-pin MS-style inline circular connector) {Figure E.4-5}. Be sure to tighten all connectors securely.

Emitter-to-Processing Unit Connection

The emitter-to-processing unit cable attaches to the emitter at the 7-pin male MS-style circular connector. This cable is terminated with a 7-pin male circular connector for attachment to the Model HDPC - Hole Detection Processing Computer.

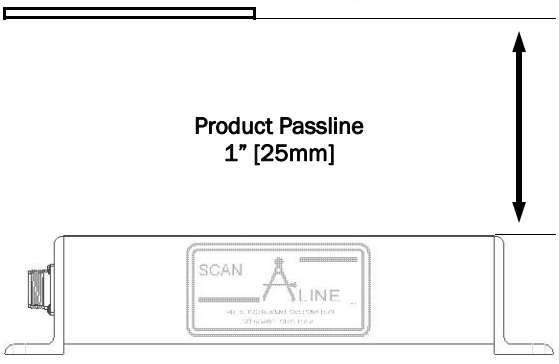

Figure E.4-4: Product Passline Example

Single Sensor Connection: Requires one emitter-to-processing cable

Connect one emitter cable to the Sensor A 7-pin circular MS-style connector located on the bottom panel of the Model HDPC - Hole Detection Processing Computer. {Figure E.4-6}

Dual Sensor Connection: Requires two emitter-to-processing cables

Connect one emitter cable to the Sensor A 7-pin circular MS-style connector and the second emitter cable to the Sensor B 7-pin circular MS-style connector located on the bottom panel of the Model HDPC - Hole Detection Processing Computer. {Figure E.4-6}

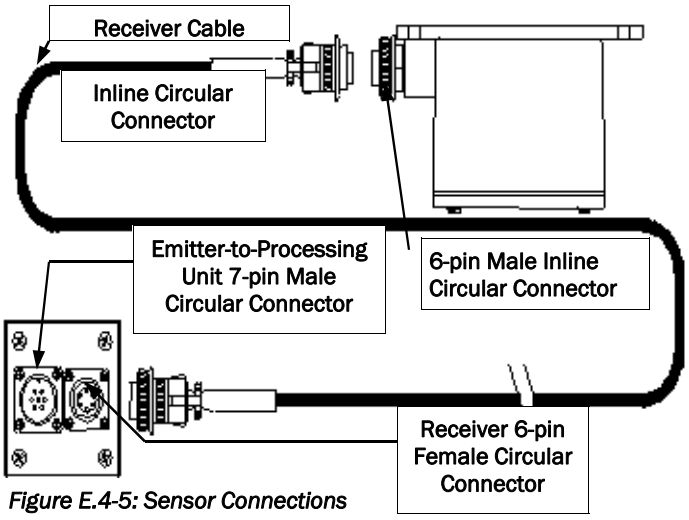

Figure E.4-5: Sensor Connections

Triple Sensor Connections: Requires three emitter-to-processing cables

Connect one emitter cable to the Sensor A 7-pin circular MS-style connector the second emitter cable to the Sensor B 7-pin circular MS-style connector and the third emitter cable to the Sensor C 7-pin circular MS-style connector located on the bottom panel of the Model HDPC - Hole Detection Processing Computer. {Figure E.4-6}

Model HDPC - Hole Detection Processing Computer Connections

The Model HDPC Processing Computer has three sensor connectors located on the bottom panel of the unit. The sensor connectors are labeled Sensor A, Sensor B, and Sensor C. Each sensor(s) used in your system is connected to the Model HDPC by a 7-pin emitter-to-processor cable. One 7-pin emitter-to-processor cable is required for each SHD-4000-Series sensor(s) used in your system configuration. Before connecting the emitter cable(s) to the processing computer, verify that the connectors are free of foreign materials and check the number of pins on each connector.

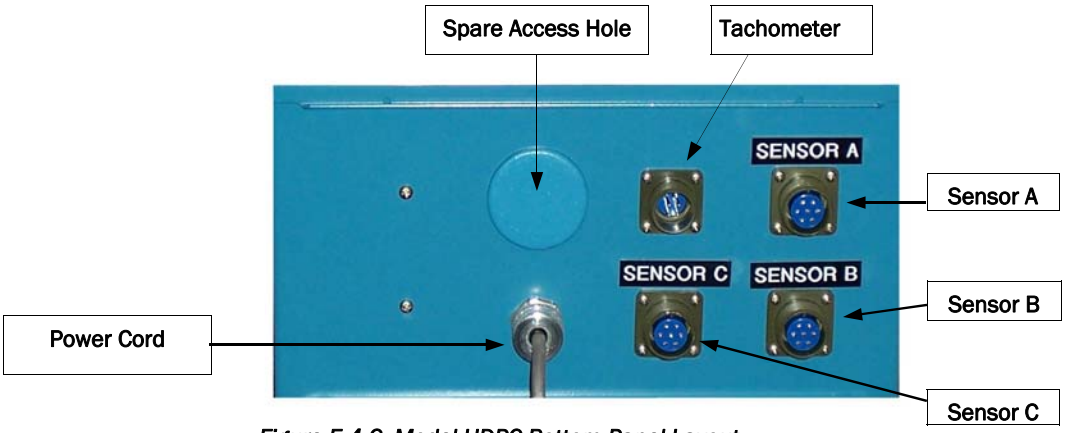

Figure E.4-6: Model HDPC Bottom Panel Layout

E.5 Receiver Horn Blinder Option

The Horn Blinder Option – HBLD Option is designed for SCAN-A-LINE™ SHD-4000-Series Receivers {Figure E.5-1 Pg. 8} in applications where ambient light may cause improper edge detection's. In conditions where high intensity lamps, strobe lights, or other bright light conditions may hamper the sensor edge, hole detection or measurement, the HBLD Option will assist in restricting the receivers field of view. This means that ambient light will have a smaller chance to interfere with the proper operation of the sensor.

HBLD Option Overview
The HBLD Option is built of aluminum and is mounted directly to the bezel on the Model SHD-4000-Series receiver. Each receiver in a system will be supplied with a blinder when the HBLD Option is ordered (one per receiver).

Functional Description
The SHD-4000-Series receivers have an approximate 30° field of view of the emitter {Figure E.5-2}. The horn blinder restricts that field of view, permitting the receiver to view only the emitter LED light. This will assist in eliminating any intense ambient or strobe light interference.

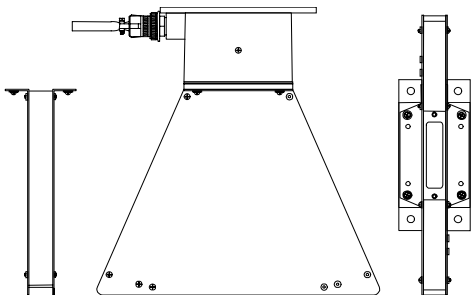

Figure E.5-1: HBLD Option Installed on Model SHD-4000R-Series Standard Duty Receiver

E.5.a Horn Blinder Specifications

The HBLD Option is typically supplied pre-installed on the Model SHD-4000-Series receivers from the factory. The HBLD Option is 12.25 inches [311mm] wide by 9 inches [229mm] tall by 1.325 inches [34mm] thick. It is attached to the receiver with the bezel face plate mounting . Units already in the field can be upgraded to use Horn Blinders. Please contact Harris Instrument Corporation for upgrades or spares.

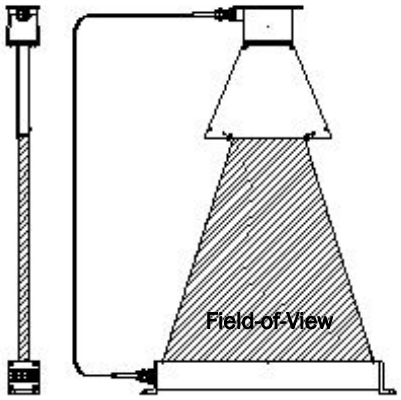

Figure E.5-2: Field of View with Model SHD-4000-20E-B Standard Duty Sensor with Horn Blinder

E.5.b Installation

The HBLD Option is usually supplied with the sensor when it is ordered. Sometimes though the HBLD Option must be ordered after the sensor has been installed. The following section details the installation of the HBLD Option on the standard Model SHD-4000-Series receiver.

SHD-4000-Series Receiver
The installation of SHD-4000-Series receivers can be performed with the receiver on-line. If your company policies allow and/or if the receiver is easily accessible. If either of these cases exist, remove the receiver from the line BEFORE performing the following procedure. The HBLD Option kit should contain the assembled horn blinder and four screws, flat washers and lock washers.

1. Remove any existing blinder from the receiver, if applicable.
2. Determine the separation of the emitter-to-receiver and set the end bars for that separation {Figure E.5-3} by loosening the 'A' screws and removing the 'B' screws. Rotate the end bars until 'B' holes line up and insert the 'A' screws. Tighten all screws securely.

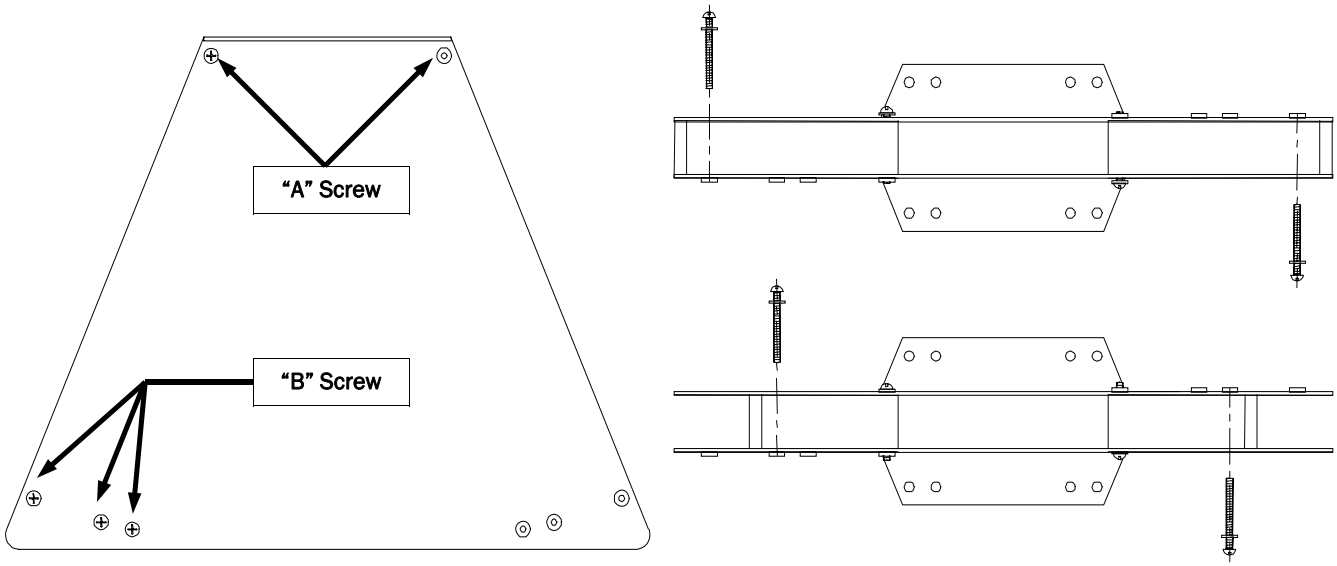

Figure E.5-3: Horn Blinder Adjustment of End Bars

3. Remove the four bezel retaining screws {Figure E.5-4}. Be sure to hold the bezel in place when the screws are removed.
4. Exchange the four bezel retaining screws with the new screws, lock washers and flat washers supplied with the horn blinder.
5. Align the Horn Blinder with the outer holes over the bezel retaining holes {Figure E.5-5}.

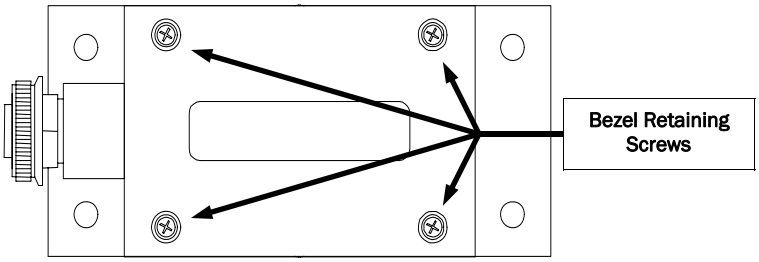

Figure E.5-4: Model SHD-4000R Bezel Retaining Screws

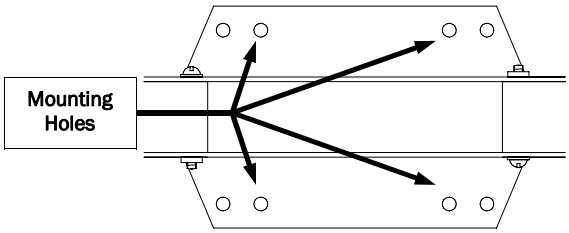

Figure E.5-5: Blinder Mounting Holes

6. Assemble the screws with the lock washer first and the flat washer second {Figure E.5-6 on Pg. 11}.
7. Insert the four mounting screws into the bezel and finger tighten {Figure E.5-6 on Pg. 11}.
8. Visually inspect that the horn blinder is aligned properly {Figure E.5-7 on Pg. 11} and tighten the mounting screws securely (be careful not to over-tighten the screws, as they are stainless steel screws threading into cast aluminum).

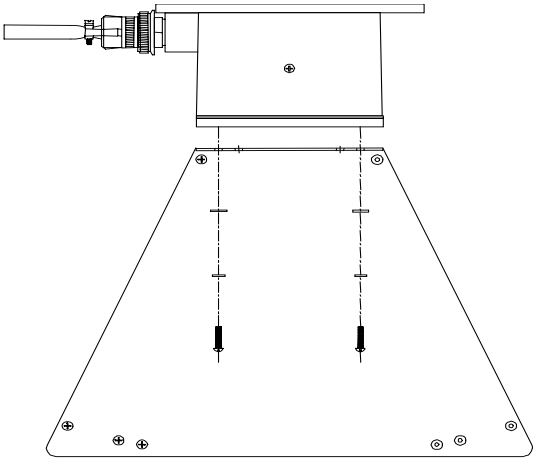

Figure E.5-6: Horn Blinder Screw Assembly on Model SHD-4000-Series Receiver

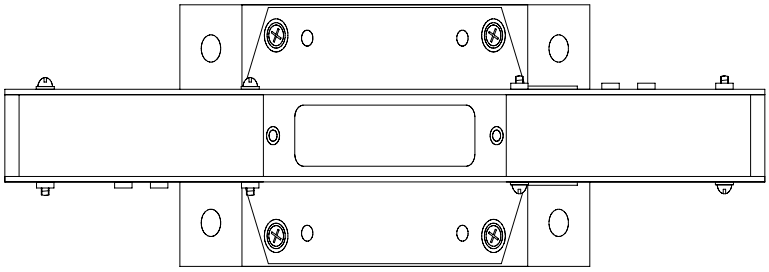

Figure E.5-7: Horn Blinder Properly Aligned on Model SHD-4000-Series Receiver

E.5.c HBLD Option Trouble Shooting

Trouble shooting the HBLD Option is relatively simple. First, verify that all screws of the unit are secure. The alignment of the receiver to the emitter is critical because of the restricted field-of-view. Review the sensor section of this manual and the system configuration drawing that was provided with your system for information on the alignment of the receiver and the emitter.

E.6 General Maintenance

All SCAN-A-LINE™ sensors are highly reliable and tolerant to most industrial environments. Maintenance of the SHD-4000-Series sensor after installation is extremely limited. Since there are no moving parts in the SHD-4000-Series sensor, there is nothing to lubricate. If any form of maintenance is performed on the line near the SHD-4000-Series sensor, be sure to cover the sensor view windows to protect the glass from hot or falling objects.

NOTE:

If welding is to be performed anywhere on the process line where the SHD-4000-Series sensor is installed, disconnect ALL cables from the SHD-4000-Series sensor. This prevents a system overload from the current generated by the welding.

E.7 Trouble Shooting

The following procedures are designed to isolate problems that may occur in systems that are installed and have been operating properly. For installation problems, see the installation portion of this manual, contact your SCAN-A-LINE™ representative or Harris Instrument Corporation for more information.

1) Begin with a thorough visual inspection of the system under test. Before testing for circuit malfunctions, ensure the power switch on the processing unit is on and that power is supplied to the system processing unit.
2) Verify that the emitter and receiver lenses are unbroken, reasonably clean and free of foreign material. Cracked lenses, excessive dirt and foreign material on the lens can cause the system to perform incorrect detection's.
3) Examine all cables for cuts, nicks or crimps that could cause open or short circuits. Ensure that all connectors are secure and free of foreign material.

Further trouble shooting of the sensors is only possible with the sensor(s) are connected to the processing unit (Model HDPC). All diagnostics for the sensor relies upon the diagnostic circuitry in the processing unit. See the Model HDPC Operators Manual (Section S) for more information.

E.8 Related Drawings

The following pages contain Various drawings for the Model SHD-4000-Series sensors. For drawings of other configurations, please contact Harris Instrument Corporation.

Drawing #	Description	Drawing Format
1203004 Pg. 1	10X-Series B-Style Emitter Dimensions	AutoCAD LT Rel. 3
1295004 Rev. B Pg. 1	10X-Series Emitter Dimensions	AutoCAD LT Rel. 3
1295015 Rev. C	10X-Series Receiver Dimensions	AutoCAD LT Rel. 3
1495176 Rev. E Pg. 1	Hole Detection System - Single Sensor	AutoCAD LT Rel. 3
1495176 Rev. B Pg. 2	Hole Detection System - Dual Sensor	AutoCAD LT Rel. 3
1495176 Pg. 3	Hole Detection System - Triple Sensor	AutoCAD LT Rel. 3
1495176 Pg. 4	Hole Detection System - Triple Sensor - Top View	AutoCAD LT Rel. 3
1495176 Pg. 5	Hole Detection System - Triple Sensor - Side View	AutoCAD LT Rel. 3
3486060 Rev. A	Emitter-to-Processing Unit Cable	AutoCAD LT Rel. 3
3495104 Rev. A	Emitter-to-Receiver Cable	AutoCAD LT Rel. 3
4496184 Rev. C	10XR-Series Horn Blinder Assembly	AutoCAD LT Rel. 3
4497015 Rev. C	HBLD Option Attachment to Model 10XR Receiver	AutoCAD LT Rel. 3

Table E.8-1: Drawing Information