BANNER

iKnow™ GUIDE to SENSING

FIRST EDITION

An Overview of Banner's Extensive Knowledge-base

for Photoelectrics, Lasers, Ultrasonics and Vision Sensing

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more sensors, more solutions

BASICS OF PHOTOELECTRIC SENSING

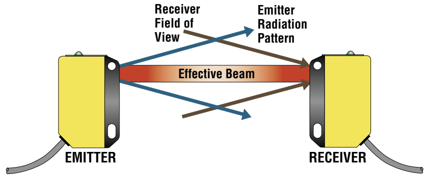
MORE INFO ONLINE What is a PE Sensor?

A photoelectric sensor is an optical control used in a variety of automated processes. It works by detecting a visible or invisible beam of light, and responding to a change in the received light intensity.

Effective beam: "Working" part of a photoelectric beam.

Radiation pattern: Total area of sensing energy emission.

Field of view: Area of response.



Components of a Sensor

Emitter contains the light source, usually an LED, and an oscillator which modulates the LED at a high rate of speed. The emitter sends a modulated light beam to the receiver.

Receiver decodes the light beam and switches an output device that interfaces with the load.

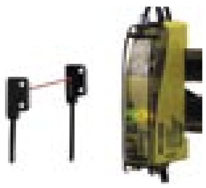
Types of Sensors

1. **Self-contained sensors:** one-piece photoelectric sensors that contain both the optics and the electronics. These sensors perform their own modulation, demodulation, amplification and output switching.

Right-Angle Housing

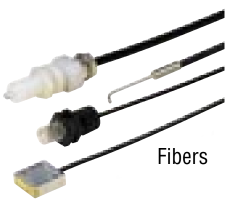
In-Line Housing

2. **Remote systems:** sensing systems in which the amplification and the optical sensing are divided. The opto-elements contain only the optical components, allowing the sensing heads to be extremely small. The amplifier module contains the power input, amplification and output switching. This allows the sensitive electronics to be located away from the sensing event.



Opto-Elements Amplifier

3. **Fiber optic systems:** sensing systems in which fiber optic cables are used with either remote or self-contained sensors. Fiber optic devices have no electrical circuitry and no moving parts, and can be used to safely pipe light into and out of hostile environments.



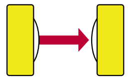
Fibers

Sensing Modes

MORE INFO ONLINE Sensing Modes

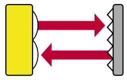
One way to tell sensors apart is by their **sensing mode,** the method in which a sensor sends and receives light. Photoelectric sensors are divided into three basic sensing modes: opposed, retroreflective and proximity.

Opposed mode: the sensor's emitter and receiver are housed in two separate units. The emitter is placed opposite the receiver. An object is detected when it breaks the effective beam.



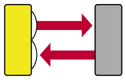
OPPOSED

Retroreflective mode: the sensor contains both the emitter and receiver elements. The effective beam is established between the emitter, the retroreflector and the receiver. As with an opposed-mode sensor, an object is sensed when it interrupts or breaks the effective beam.

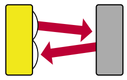


RETROREFLECTIVE

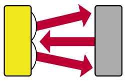
Proximity mode: these sensors contain both emitter and receiver elements. A proximity-mode sensor detects an object when emitted light is reflected off the object, back to the sensor.



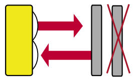
DIFFUSE



CONVERGENT



DIVERGENT



BACKGROUND SUPPRESSION

Range

The range is the specified operating distance of a sensor or sensing system.

- **Opposed mode:** the distance from the emitter to the receiver.
- **Retroreflective mode:** the distance from the sensor to the retroreflector.
- **Proximity mode:** the distance from the sensor to the object being sensed.

Contrast

MORE INFO ONLINE Understanding Contrast

Contrast is the ratio of the amount of light falling on a receiver in the "light" state, compared to the "dark" state. Increasing contrast in any sensing situation will increase the reliability of the sensing system.

Beam Pattern

MORE INFO ONLINE Understanding Beam Patterns

A beam pattern is plotted on a 2-dimensional graph to illustrate how the sensor responds to its emitter or sensing target. Use the beam pattern to estimate placement of the sensing system with respect to adjacent objects.

Excess Gain

MORE INFO ONLINE Understanding Excess Gain

Excess gain is a measurement of the amount of light falling on a receiver, over and above the amount of light required to operate the sensor.

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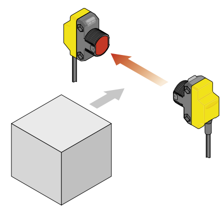
SENSING MODES

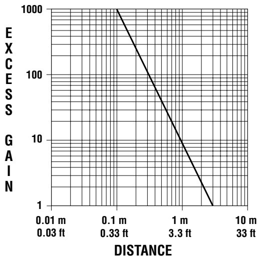
MORE INFO ONLINE *Sensing Modes*

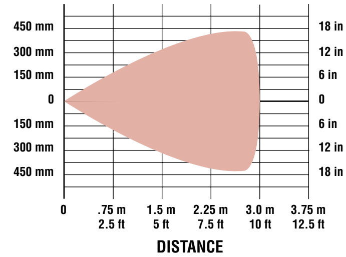
CONFIGURATION		FEATURES	EXCESS GAIN	BEAM PATTERN

OPPOSED

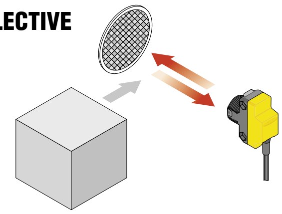


- Most reliable mode for opaque targets
- High excess gain results in long sensing range
- Good performance in contaminated environments
- High tolerance to misalignment

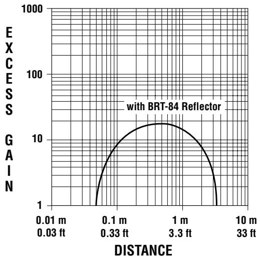


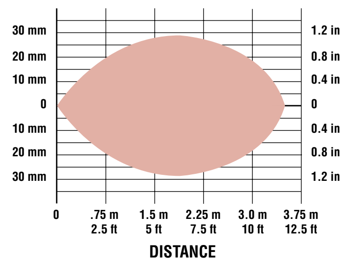


RETROREFLECTIVE

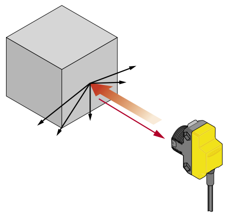


- Convenient when space is limited
- High excess gain results in long sensing range

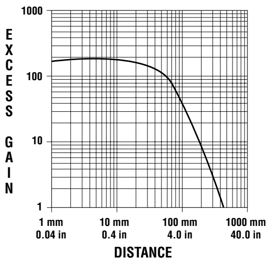


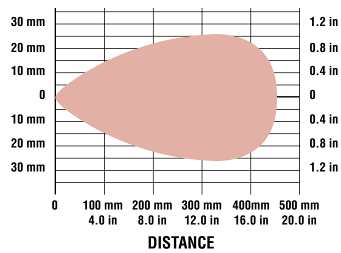


DIFFUSE

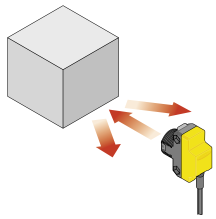


- Convenient when space is limited
- Used in applications requiring reflectivity monitoring

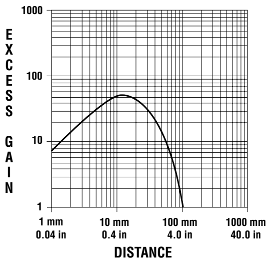


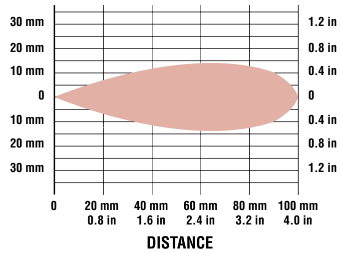


DIVERGENT

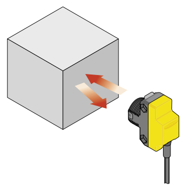


- Convenient when space is limited
- Good performance in detecting clear materials at close range
- Used in applications requiring reflectivity monitoring
- Reliable in detection of shiny or vibrating surfaces

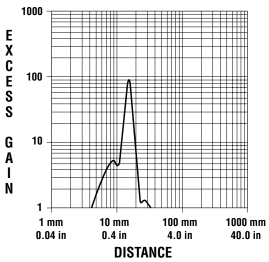


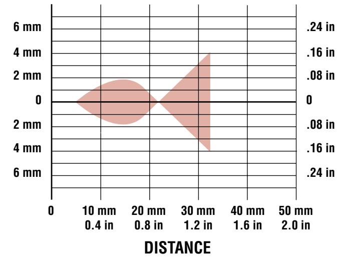


CONVERGENT

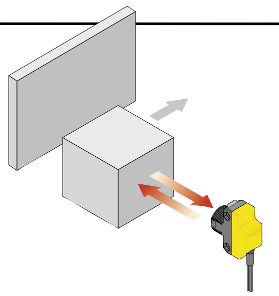


- Used for accurate positioning
- Excellent in small colormark or small object detection applications
- Used for accurate counting of radiused objects
- High excess gain allows detection of objects having low reflectivity

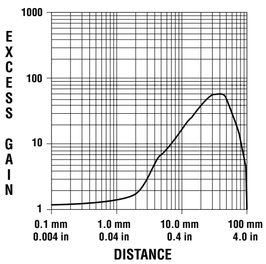




BACKGROUND SUPPRESSION



- Definite range limit used to ignore backgrounds
- High excess gain allows detection of objects having low reflectivity
- Good at detecting targets of varying reflectivity



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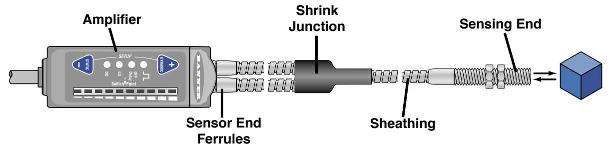
FIBER OPTICS

MORE INFO ONLINE Fiber Optics in Sensing

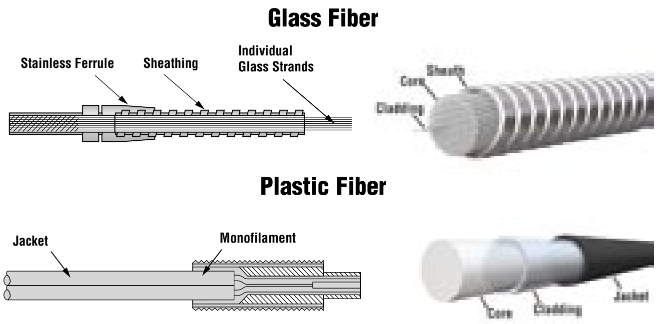
Fibers are transparent strands of optical quality glass or plastic that can be as thin as a strand of hair. In photoelectric sensing, these fibers are used to transmit and/or receive light from the LED of an attached sensor.



Fiber Optic Sensing System

Glass or Plastic Fibers

Fiber optics are available in **glass** or **plastic.** Glass fibers are arranged in bundles and plastic fibers are usually packaged as monofilaments.



Cross-sections of Fibers

Core – Thin glass or plastic center of the fiber through which light travels.

Cladding – Outer optical material surrounding the core that reflects light back into the core.

Jacket – Layer around plastic fiber to protect from damage and moisture.

Sheathing – Layer of stainless steel or PVC tubing to protect glass fiber bundles from damage.

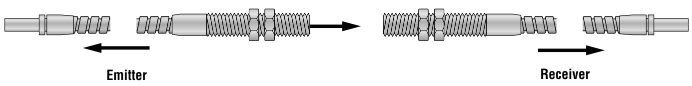
Uses for Fibers

- **Tight sensing locations:** Size and flexibility of fibers allow positioning and mounting in tight spaces.
- **Vibration and shock:** Low mass fibers are able to withstand high levels of vibration and mechanical shock.
- **Extreme environments:** Fibers can be constructed to survive in corrosive or extreme moisture environments.
- **Explosion-proof design:** Fibers can safely pipe light into and out of hazardous areas.
- **High temperatures:** Glass fibers can tolerate extreme temperatures.
- **Custom sensing end design:** Fiber sensing heads can be “shaped” to the physical and optical requirements of a specific application.
- **Noise immunity:** A fiber is a passive mechanical part that is completely immune to electrical noise.

Fiber Optics & Sensing Modes

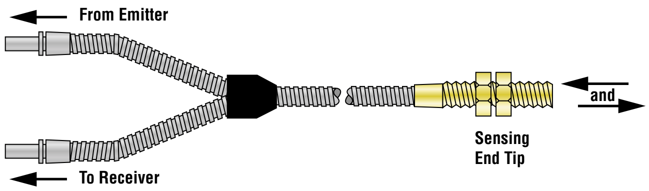
MORE INFO ONLINE Job Aid: Types of Sensors

The configuration of the fiber optic assembly and the type of amplifier used will determine the sensing mode.



Opposed Mode-Individual Fiber Optic Cable

Opposed-mode fiber assembly
Guides light from an emitter to a sensing location, or from the sensing location back to the receiver. Opposed-mode fiber sensing requires two individual fiber optic cables.



Diffuse Mode -Bifurcated Fiber Optic Cable

Diffuse-mode fiber assembly
Conducts emitted light and the received light within one fiber optic assembly. This lets a single sensor both illuminate and view an object through the same fiber optic assembly.

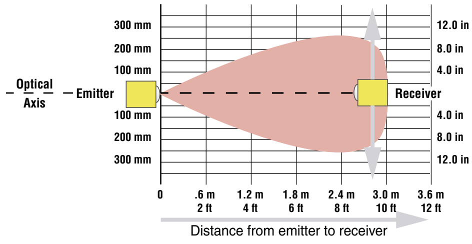
Considerations

- Larger bundle or core size leads to longer range and effective beam.
- Light signal attenuation occurs with longer fiber lengths.
- Optical fibers that have been ground and polished cannot be shortened, spliced or otherwise modified.
- Range and gain depend on both the amplifier and the fiber.
- Due to light transmission properties, plastic fibers are recommended for use only with visible light sensors.
- Glass fibers should not be subject to bending, pinching, repeated flexing, or high levels of radiation.

BEAM PATTERNS

MORE INFO ONLINE *Understanding Beam Patterns*

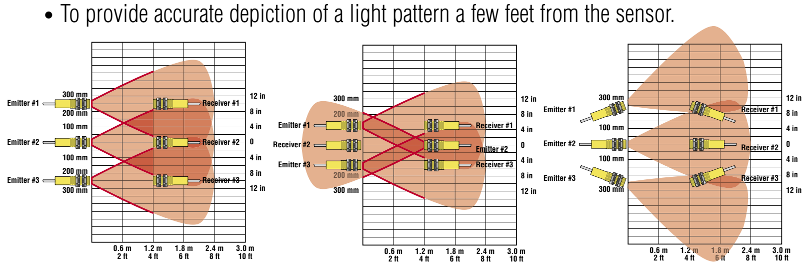
A beam pattern is plotted on a 2-dimensional graph to illustrate how the photoelectric receiver is designed to respond to its emitter. Maximum light energy occurs along the sensor's optical axis. The light energy decreases towards the beam pattern boundaries. The horizontal axis usually shows the range of the sensor.



Beam Pattern (Opposed Mode shown)

Uses for Beam Patterns

- To predict general radiation pattern given a specific target.
- To predict how multiple sensors can be mounted on a line without generating crosstalk.
- To provide accurate depiction of a light pattern a few feet from the sensor.



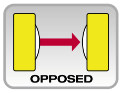
Mechanical Separation *Altering Emitter/Receiver* *Off-Angle*

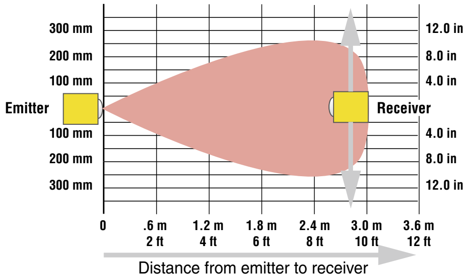
Using Beam Patterns to Avoid Optical Crosstalk

Reading a Beam Pattern

MORE INFO ONLINE *Job Aid: Understanding Beam Patterns*

OPPOSED MODE





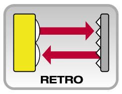
Opposed-Mode Beam Pattern

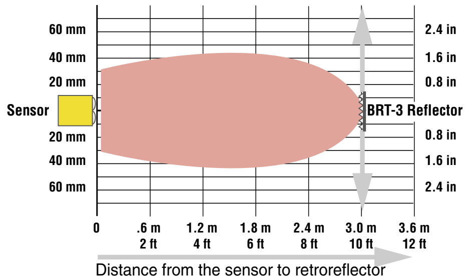
Uses: To predict how closely adjacent, parallel opposed-mode sensor pairs can be placed to each other without generating optical crosstalk.

Horizontal: Scale shows separation distance between the emitter and receiver.

Vertical: The balloon-shaped plot defines the boundary of the receiver's response to the emitter. The receiver response is measured on either side of the optical axis. Effective beam is related to the lens size of the sensor. Banner-specified effective beam size does not change if using a matched emitter/receiver pair.

RETROREFLECTIVE MODE





Retroreflective-Mode Beam Pattern

Retroreflective beam patterns are plotted using a model BRT-3 (75 mm) retroreflector (except where otherwise specified).

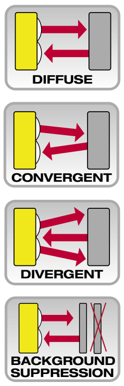
Uses: To show the area within which the sensor will respond to the retroreflector. The size of the beam pattern is proportional to the size and the reflective efficiency of the retroreflector.

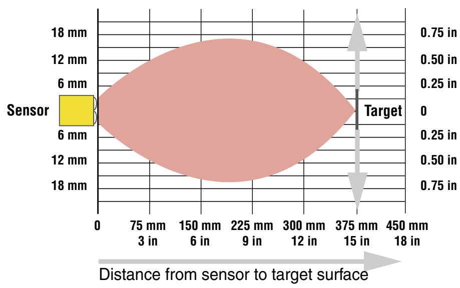
Horizontal: The scale shows the related distance between the retroreflective sensor and the retroreflector.

Vertical: The scale depicts the farthest distance on either side of the sensor's optical axis where a retroreflector can establish a beam with the sensor.

Blind Spot: If a beam pattern shows an area of no response at close range, it is indicating that the sensor has a "blind spot" area, where a retroreflector should not be located.

PROXIMITY MODE





Proximity-Mode Beam Pattern

Proximity-mode beam patterns are plotted using an 8 x 10 90% reflective white Kodak test card.

Uses: To show the boundary within which the edge of a light-colored diffuse surface will be detected as it moves past the sensor. The sensor's optical axis is represented as "0" on the vertical scale.

Horizontal: The scale shows the distance from the sensor to the target's surface.

Vertical: The scale shows the width of the sensor response measured on either side of the optical axis.

EXCESS GAIN (EG)

MORE INFO ONLINE *Understanding Excess Gain*

Excess gain is a measurement of the sensing light energy over and above the minimum amount required to operate the sensor's amplifier. This extra sensing energy is used to overcome signal attenuation caused by contaminants in the sensing environment.

Choose a sensor that will give you the optimal excess gain for your application. In most sensing situations, high excess gain relates directly to sensing reliability.

Measuring Excess Gain

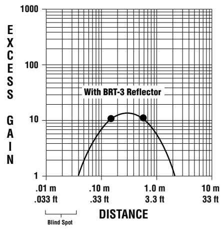
$$\text{Excess Gain} = \frac{\text{Light energy falling on receiver element}}{\text{Sensor's amplifier threshold}}$$

Threshold: the level of sensing energy required to cause the sensor's output to switch "on" or "off."

Excess gain of one (1x) is the measured voltage at the amplifier threshold level. Excess gain charts are useful when comparing sensors for an application, as direct measurement of amplifier voltage is often impractical.

Excess Gain Curve

Excess Gain Curve

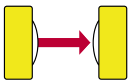


An excess gain curve is plotted on an x/y axis. It shows the excess gain available for a particular sensor or sensing system as a function of distance.

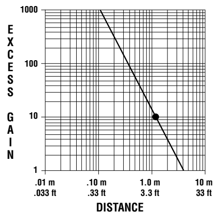
Excess gain curves are plotted for conditions of perfectly clean air and maximum receiver gain.

Reading an Excess Gain Curve

OPPOSED MODE



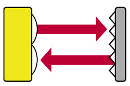
The excess gain of an opposed-mode sensor pair is directly related to sensing distance. If the sensing distance is doubled, the excess gain is reduced by a factor of one-fourth, so the curve is always a straight line.



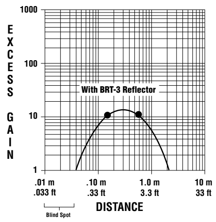
Reading an Opposed Mode Curve

If an environment is moderately dirty (with 10x minimum excess gain required), sensors can be mounted up to approximately 1.2 meters apart.

RETROREFLECTIVE MODE



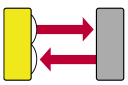
The shape of a retroreflective excess gain curve is significantly influenced by the size of the retroreflector. The larger the retroreflector, the larger the shape and size of the curve



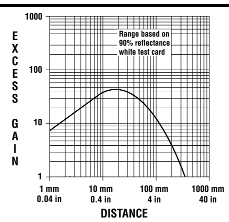
Reading a Retro Mode Curve

If an environment is moderately dirty (with 10x minimum excess gain required), a BRT-3 retroreflector can be mounted 0.15 to 0.5 meters away from the sensor for reliable sensing.

PROXIMITY MODE



Excess gain for proximity-mode sensors is usually lower than that of other photoelectric sensing modes, because proximity modes depend on light reflected off the surface of a target. The curves are plotted using a Kodak 90% reflectance white test card as the reference material. Other materials are ranked compared to the test card in the table below.



Reading a Proximity Mode Curve

Use the Relative Reflectivity Chart on-line to estimate the excess gain required. Multiply the excess gain required to sense the material by the excess gain level required for the environment.

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Excess Gain Guidelines

Excess gain of one (1x) describes the measured sensing energy at the amplifier threshold level. These guidelines show how much excess gain is required to overcome environmental conditions.

E.G.	General Conditions
1.5x	**Clean air:** no dirt buildup on lenses or reflectors.
5x	**Slightly dirty:** slight buildup of dust, dirt, oil, moisture, etc. on lenses or reflectors. Lenses are cleaned on a regular schedule.
10x	**Moderately dirty:** obvious contamination of lenses or reflectors (but not obscured). Lenses cleaned occasionally or when necessary.
50x	**Very dirty:** heavy contamination of lenses. Heavy fog, mist, dust, smoke, or oil film. Minimal cleaning of lenses.

Relative Reflectivity

MORE INFO ONLINE *Relative Reflectivity Chart*

When using a proximity sensor, refer to the Relative Reflectivity chart to determine how reflectivity of different target surfaces will affect the excess gain requirements. Here are some sample targets.

Material	General Reflectivity	Minimum Excess Gain Required
Stainless steel, microfinish	400%	0.2
Natural aluminum, unfinished	140%	0.6
Kraft paper, cardboard	70%	1.3
Clear plastic bottle	40%	2.3
Tissue paper (1 ply)	35%	2.6
Rough wood pallet (clean)	20%	4.5

CONTRAST

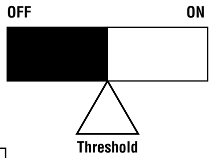
Sensing Contrast

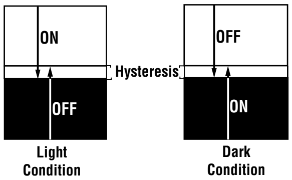
Contrast is also referred to as the light-to-dark ratio. While most sensors do not allow direct measurement of light signals, contrast can be estimated. The higher the contrast ratio, the better and more accurately your sensor will detect its target.

Contrast can be defined as:

$$\text{Contrast} = \frac{\text{Received light in the light condition}}{\text{Received light in the dark condition}}$$

Threshold: point where output change-of-state occurs.





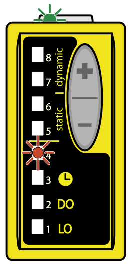
Hysteresis: difference of output switchpoint (threshold) from on-to-off, vs. off-to-on. Prevents output chatter.

Contrast Guidelines

Follow these contrast guidelines to improve sensing reliability:

1. Choose a sensor or lensing option that will optimize contrast in any photoelectric sensing situation.
2. Adjust alignment and gain for maximum contrast during sensor installation.
3. If light and dark conditions are separated by 1/3 or more of the adjustment range of a sensor's sensitivity potentiometer, contrast is sufficient. Most Banner sensors intended for low-contrast applications are microprocessor-driven and will provide feedback of relative contrast.

Bargraph LED Number	Relative Contrast/ Recommendation
6 to 8	**Excellent:** Very stable operation.
4 to 5	**Good:** Minor sensing variables will not affect sensing reliability.
2 to 3	**Low:** Minor sensing variables will affect sensing reliability.
1	**Marginal:** Consider an alternate sensing scheme.

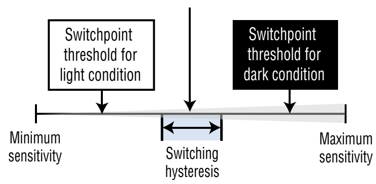
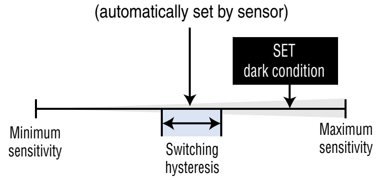
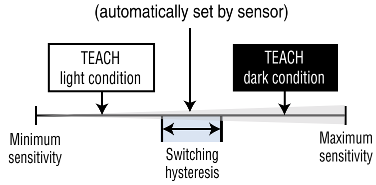


Bargraph sensors offer relative feedback in low-contrast applications.

Adjusting Sensitivity

Job Aid: Sensitivity Adjustment

Field-adjust the sensitivity of a sensor in order to maximize the contrast in an application.

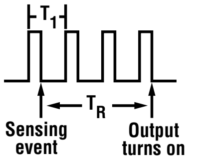
TECHNIQUE	PROCESS	CONCEPT
Potentiometer Adjustment Manually adjust sensitivity with the potentiometer.	1. Adjust potentiometer to minimum. 2. Present the light and dark sensing conditions individually, turning the potentiometer slowly clockwise, until the Alignment indicator just comes on. Note the settings. 3. Adjust the potentiometer to approximately midway between the two settings.	
SET Mode Adjustment Sensor's microprocessor automates sensitivity adjustment.	Present the dark sensing condition, and press the SET button. The sensor automatically sets the operating sensitivity below the switch point threshold for the dark condition.	
TEACH Mode Adjustment Sensor's microprocessor optimizes sensitivity adjustment between two user-set reference points.	1. Present the light sensing condition, and single-click the TEACH button. 2. Present the dark sensing condition, and (again) single-click the TEACH button. 3. The sensor automatically sets the operating sensitivity.	

RESPONSE TIME

MORE INFO ONLINE *Response Time*

Response time is the maximum time required for the sensor to respond to a change in the input signal. It is the time from when the sensor sees its target to when it gives an output signal to the load.

Response time is the time between the leading (or trailing) edge of the sensing event and the output's change of state.



T1 = Time of one light pulse
TR = Response time

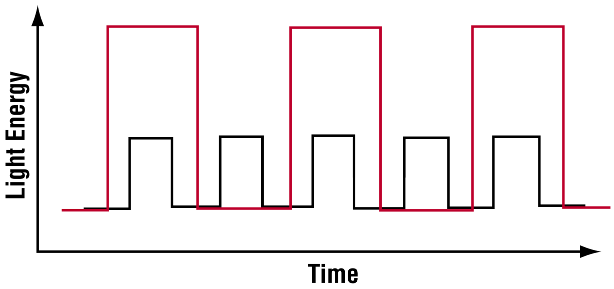
Importance

Response time can help determine how long a fast-moving object must stay in the sensor's field of view in order to be detected. It is especially important when your application requires detection of:

- High-speed events
- Small objects moving at high speeds
- Narrow gaps between objects
- Brief intervals between sensing events

Modulation

The speed of response of a modulated photoelectric sensor is limited by its frequency of modulation. There is a direct trade-off between sensor response time and sensing range (excess gain). High-speed sensors are modulated faster, thus yielding shorter range. If an LED is pulsed less often, it can be pulsed with a higher current, thereby producing more light energy.



Fast Response Time Yields Lower Excess Gain

Repeatability

The repeatability specification is used in applications where customers need to know the precise position of a moving part.

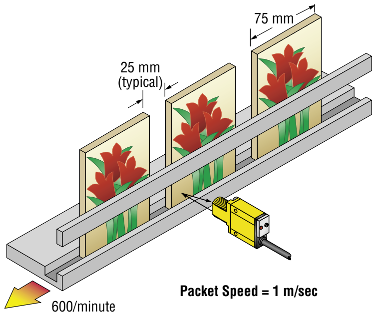
The sensor's output is allowed to switch only after a few modulated light pulses are counted. The response time before a modulated sensor turns on is equal to the time required for the sensor to count that number of pulses, and the sensor output changes state as soon as the sensor counts enough light pulses of the correct frequency.

Since the sensing event can occur at any time during a modulation cycle, the actual time between the sensing event and the sensor's output change can vary by up to one modulation cycle. This variation is the sensor's repeatability.

Calculating Response Time

You can determine a sensor's required response time when you know the size, speed and spacing of the objects to be detected.

$$\textbf{Response Time} = \frac{\textbf{Object width (or gap between objects)}}{\textbf{Object velocity}}$$



Calculate Response Time for Seed Packets with a Convergent Sensor

Application Example

To calculate the required sensor response time, the production line speed is first converted to the speed of, in this case, a seed packet.

When calculating the speed of the seed packet, take into account the space between the packets.

1. Determine how many packets are being processed per second:
   600 packets/minute = 10 packets per second
2. Determine the distance of linear travel: 75 mm (packet width) + 25 mm (space between packets) = 100 mm
3. Calculate speed of packet = 100 mm/packet x 10 packets/sec

Packet Speed = 1 m/sec

Light condition: sensing condition characterized by higher level of received sensing energy.

Knowing the speed of the object (1 m/sec), it is possible to calculate the time during which the sensor "sees" a packet of seeds.

$$\frac{\textbf{Object width (75 mm)}}{\textbf{Object velocity (1 m/sec)}} = \textbf{.075 sec}$$

Time of each packet passing the sensor = 75 ms

Calculating Light Condition

Dark condition: sensing condition characterized by lower level of light energy (or none).

$$\frac{\textbf{Space width (25 mm)}}{\textbf{Object velocity (1 m/sec)}} = \textbf{.025 sec}$$

Time of each space passing the sensor = 25 ms

Calculating Dark Condition

In this application, the time between the packets is much less than the time during which the sensor "sees" a packet. As a result, the dark (or "off") time between packets is the more important consideration.

Basics of Sensing
Sensing Modes
Fiber Optics
Beam Patterns
Excess Gain
Contrast
Response Time
Outputs
Ultrasonic Sensors
Measuring Screens
Light Gauging
Vision Sensors
Environmental

OUTPUTS

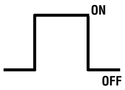
Outputs

The output circuit is the section of the sensor that interfaces to the external load. Output also refers to the useful energy delivered by the sensor.

Knowing the voltage and current requirements of the load is crucial to selecting the best sensor. Sensors with analog outputs always interface to circuits or devices which operate at low levels of dc voltage and current. Sensors with digital outputs interface to either ac or dc loads.

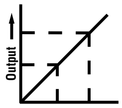
Digital/Analog Output

The output of a sensor is either digital or analog. A **digital,** or switched, output has only two states: "on" and "off." On and off commonly refer to the status of the load that the sensor output is controlling.



Digital

An **analog** sensor is one that varies over a range of voltage (or current) and is proportional to some sensing parameter. Analog sensors provide a metered or gradual response.



Analog

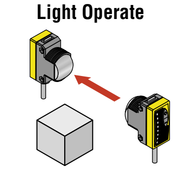
Light Operate/Dark Operate

Training Note: Light Operate/Dark Operate

The sensor should be active when the application requires it. With digital photoelectric sensors, the input and the output are characterized by one of two sensing terms: Light Operate and Dark Operate.

Light Operate (LO): a condition where a photoelectric sensor's output energizes its load when the sensor "sees" a sufficient amount of its own modulated light.

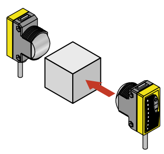
Light Operate



The sensor "sees" light.

Dark Operate (DO): the complement of LO, where the sensor output energizes its load when it no longer "sees" the modulated light.

Dark Operate



The sensor "sees" dark.

Response Time

The response time of sensors with digital output depends largely on the sensor's output switching device. In general, sensors with solid-state outputs provide faster switching.

Sensors with electromechanical relays can only provide slow switching; the relay switching speed is the largest component of the specified sensor response time.

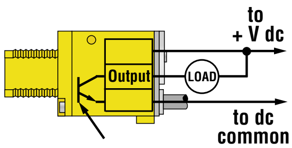
Contact Configuration Types

Solid-State Relays

Switching is accomplished by elements such as a transistor or SCR, without moving parts, heated filament or vacuum gaps.

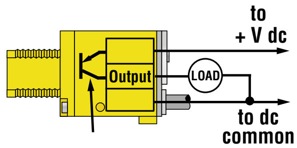
Complementary outputs: the dual-output configuration of a sensing device, where one output is Normally Open and the other is Normally Closed. In this case, both outputs have the same switchpoint, but only one output conducts at a time.

NPN output (sinking): output switch configured with its collector open and its emitter connected to ground (dc common). The load is connected between the output (collector) and the positive of the dc supply.



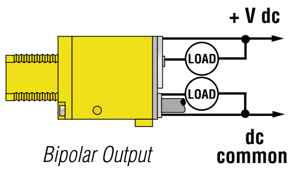
NPN Transistor

PNP output (sourcing): output switch configured with its collector open and its emitter connected to the positive of the sensor supply voltage. The load is connected between the output (collector) and ground (dc common).



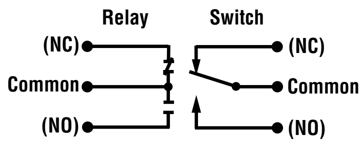
PNP Transistor

Bipolar outputs: the dual-output configuration of a dc sensing device, where one output switch is a sinking device (NPN) and the other output switch is a sourcing device (PNP). BOTH OUTPUTS HAVE THE SAME SWITCHPOINT.



Bipolar Output

E/M Relays



Used when a sensor provides direct control of a load that draws more current than can be handled by a solid-state relay. Double-throw contacts are used in interfaces that require complementary switching. E/M relays are useful when a string of sensor outputs are wired together in series for AND logic. Some E/M relay configurations include SPST, SPDT, DPST and DPDT.

Normally Open (NO): designation for contacts of a switch or relay that are not connected when at rest. When activated, the contacts close (become connected).

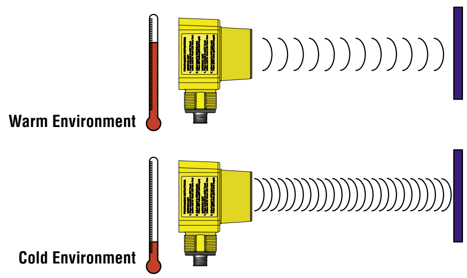
Normally Closed (NC): designation for contacts of a switch or relay that are connected when at rest. When activated, the contacts open (separate).

ULTRASONIC SENSORS

Ultrasonic sensors emit a pulse of energy which travels at the speed of sound. A portion of this energy is reflected off of a target and travels back to the sensor. The sensor measures the total time required for the energy to reach the target and return to the sensor and calculates the distance from the sensor to the target.

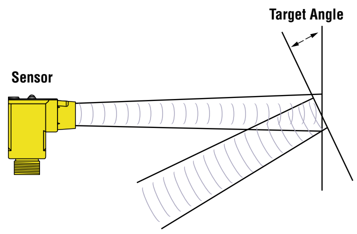
Temperature Effect

The speed of sound depends on chemical composition, pressure and temperature of the gas in which it is traveling. In most ultrasonic applications, the composition and pressure of the gas are relatively fixed, while the temperature is not. The speed of sound increases roughly 1% per 10°F (6°C) temperature increase.



Target Angle

A flat target that is perpendicular to the beam axis will reflect the most sound energy back to the sensor. As the target angle increases, the amount of energy received by the sensor decreases. For most ultrasonic sensors, the target angle should be 10° or less.

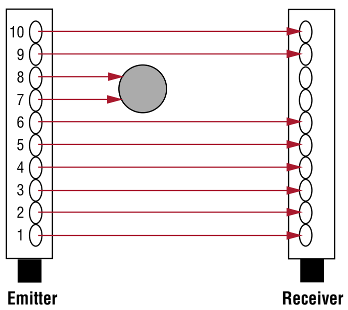


Air Currents

Air currents due to wind, fans, pneumatic equipment or other sources can deflect or disturb the path of the ultrasonic energy, so a sensor may fail to recognize the correct location of the target.

MEASURING LIGHT SCREENS

Banner light screens have a vertical array of photoelectric emitters and receivers: the emitters in one housing, the receivers in another. An object placed between the emitter and receiver will block the emitted light from reaching the corresponding receivers.



Synchronous Scanning

Identifies which of the beams is blocked, by enabling one emitter channel to pulse light while simultaneously directing its corresponding receiver to look for a signal. The system records which beam channels are blocked and which are clear, and then outputs a signal, either analog or discrete.

Sensor Response Time

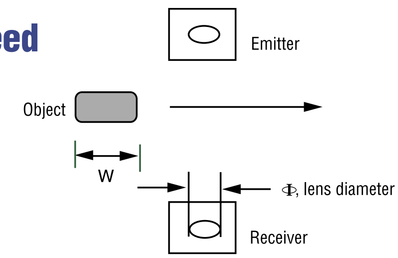
The time required for an array system to "see" an object varies depending on *which channel* is blocked, *when* the object blocks a particular channel and *when* that particular channel is scanned. The result is that the minimum response time is equal to 1 ms; the maximum response time is equal to twice the scan time. The scan time, in turn, varies according to array length and scanning mode, and is specified in the product literature.

Minimum Object Detection

The minimum object detection size is a function of the lens diameter for an individual channel and the spacing between channels. The minimum object detection size is defined as the smallest diameter rod that can be detected reliably.

Maximum Part Speed

The maximum speed of a passing part is a function of the part size, the lens diameter and the maximum response time of the system.



Measuring Modes

Banner's measuring light screens can be configured, with a simple Windows setup program, for several measuring modes for both analog and discrete outputs. For example, the output can be based on the:

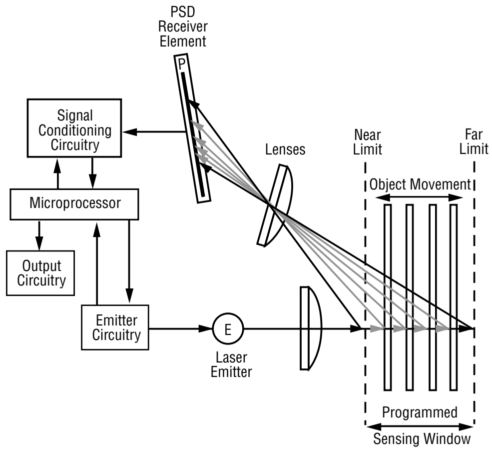
- First beam blocked
- Last beam blocked
- Total number of beams blocked
- First beam made
- Last beam made
- Total number of beams made
- Center beam of several blocked beams
- Number of transitions from blocked to made
- Highest number of contiguous beams blocked

LIGHT GAUGING SENSORS

Light gauging sensors utilize either "Time of Flight" or triangulation technology to detect the presence and position of targets.

Time of Flight: measurement of the amount of time that emitted light takes to travel to the target and return to the sensor. This technology is used in long-range sensing applications.

Triangulation: an emitter transmits visible light through a lens, towards a target. The beam bounces off the target, returning some light to the sensor's Position Sensitive Device (PSD) receiver element. The target's distance from the receiver determines the angle at which the light travels to the receiver element. This angle, in turn, determines where the received light will fall along the PSD receiver element. The position of the light on the PSD receiver element is processed through analog and/or digital electronics to calculate the appropriate output value.



Triangulation Technology

Surface Reflectivity and Texture

Triangulation sensors depend on the diffuse reflections of light from the target. A diffuse reflection is one in which the light tends to scatter equally in all directions from the target. If the target surface is mirror-like, then light will tend to reflect in only one direction (If this target is not perpendicular to the sensor, the light will be reflected away from the sensor).

Triangulation sensors also require a non-porous, opaque surface for accurate operation. Measurement errors will result from semi-transparent targets such as clear plastic, or from porous materials such as foam.

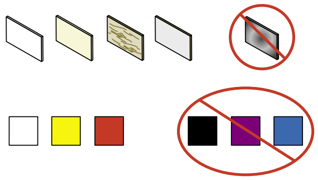
***Diffuse** targets (e.g., matte finish white ceramic) reflect light consistently in all directions*

***Specular** targets (e.g., a mirror) reflect light in only one direction*

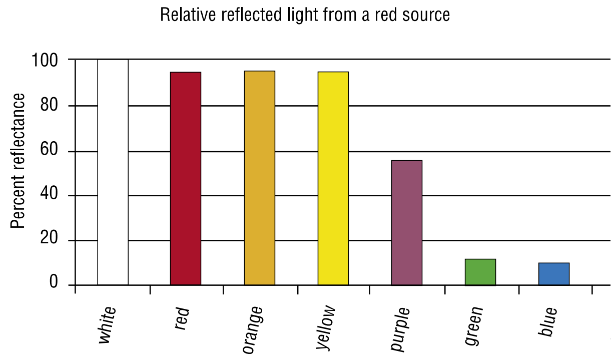
***Mixed** targets (most objects) display traits of both diffuse and specular targets*

Color Effects

The color of the object being measured can affect the resolution and accuracy of the readings. White, red, yellow and orange targets will reflect more light than green, blue or black targets. The resolution for dark targets may be up to four times less that for white targets.

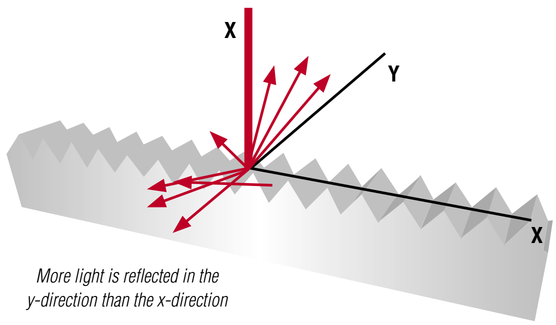


The graph below shows the relative amount of received light that is reflected from various target colors, using visible red light. The resolution is roughly affected according to the square of the received light. For example, reducing the amount of light by a factor of nine will degrade the resolution by a factor of three.



Metal Surfaces

Bare metal surfaces do not exhibit consistent reflectivity across their surfaces. As a result, the repeatability from one point on a metal surface to another, even at the same distance from the sensor, will degrade. This effect varies from metal to metal and is dependent upon surface finish.



More light is reflected in the y-direction than the x-direction

Total Expected Measurement Error

Keep in mind that the overall expected accuracy of an analog sensor is the combination of several performance parameters, not simply the sensor's resolution. Linearity and temperature effect can also affect accuracy.

VISION SENSORS

Vision sensing is electronic imaging, applied in a manufacturing setting for the purpose of control: process control, machine tool control, robot control or quality control. Vision sensing is used to improve production processes and quality.

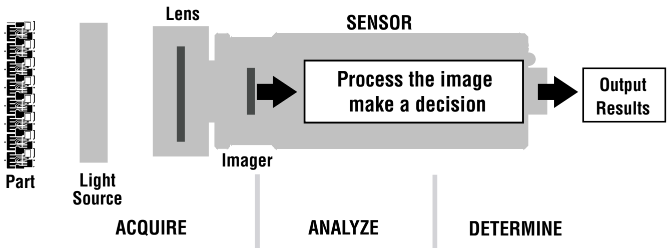
Vision sensing is comprised of two major elements: a **hardware** element (camera, controller, and lighting) and a **software** element (control system, graphical user interface and image algorithms).

Process

MORE INFO ONLINE: How A Vision Sensor Works

Visual inspection is a three-step process:

1. The sensor **acquires** an image of the part.
2. The microprocessor **analyzes** the image.
3. Another microprocessor **determines** if the inspection passes or fails, and reports the results to the manufacturing line. The part is then either passed to the next process, or it is rejected and removed.



Inspection

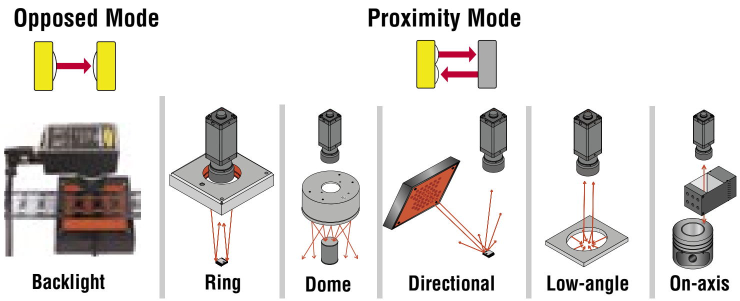
"Visual inspection" refers to the process of acquiring an image, analyzing that image based on set parameters, and reporting the results. For some Banner vision sensors, inspections are set up using a remote PC. A digital camera captures images and the sensor software analyzes the images using vision tools to pass or fail the product.

Vision tools are specific software algorithms used to analyze an image. Each vision sensor uses a specific **tool set** to extract and isolate certain features within the image in order to determine whether a part passes or fails an inspection.

Parts

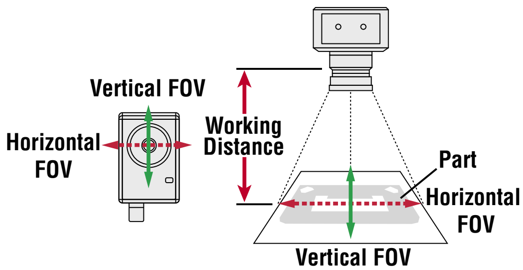
MORE INFO ONLINE: Choosing Lighting

1. **Light Source:** the light source is a critical component of any vision inspection system. Lighting is the most powerful tool for creating contrast to amplify the feature of interest, while minimizing other features of the part. Selecting the best light source depends on the shape, surface texture, color and opacity of the part.



2. **Lens:** the lens focuses the light onto the sensor's imager. The main consideration for selecting a lens is focal length. To determine the focal length, the field of view and working distance must be determined. The field of view is the area of the inspection captured on the sensor's imager. The working distance is the distance between the back of the lens and the target object.

Field of View (FOV) and Working Distance



3. **Sensor:** the sensor contains the imager, microprocessors and I/O. The imager has an array of tiny light-sensitive cells that convert the target into an image. Microprocessors analyze the image and make determinations about it based on user-determined tolerances and criteria. The I/O module is used to communicate the results of the inspection to the line.

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Vision Sensors
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ENVIRONMENTAL CONSIDERATIONS

ENVIRONMENT	TYPICAL INDUSTRIES & APPLICATIONS	RECOMMENDATIONS
Normal Temperature	All non-abusive applications from -20°(-4°) to +55°C (+131° F).	• All sensor types; choice depends on range, excess gain and electrical and performance requirements.
High Temperatures	• Metal processing • Painting applications • Paper manufacturing • Outdoor applications	• Glass fiber optics: Use when above +100°C (+212°F); max. to 480°C (900°F). • Plastic fiber optics: Use polycarbonate fibers up to +125° C (+257° F). • Remote sensors: Use up to +100°C (+212°F).
Low Temperatures	• Meat processing • Food processing • Chemical processing • Outdoor applications	• Glass fiber optics: Use below -40°C (-40°F); min. to -140°C (-220°F). • Remote sensors: -40°C (-40°F) to +100°C (+212°F).
Moisture	• Food processing • Car washes • Pharmaceuticals • Bottling plants • Outdoor applications	• Sensors with NEMA 6 ratings represent the best moisture seals and can resist occasional and prolonged (NEMA 6P) submersion. • NEMA 4 and 6 ratings: can withstand low-pressure washdown. • NEMA tests do not take into account the elevated pressures and temperatures of solutions used to wash equipment in food processing applications. • See NEMA and IP enclosure ratings chart online. • Condensation can be eliminated by using unlensed fiber optics.
Corrosive Agents	• Semiconductors • Chemical • Lumber • Pulp/paper • Amusement parks (UV light)	**Solvents/Alkalis** • Stainless steel sensor housings. • Glass fiber optic assemblies in stainless steel sheathing. • Fiber optic assemblies without epoxy (available by special order). **Bases** • Fiber optic assemblies with PVC jackets. **Acids** • Thermoplastic polyester housings; see chart online. • Teflon® sheathing; protect the sensing tip from direct contact with concentrated acids. • Polyethylene jacket of standard plastic fiber optic cables resists acids, but can degrade with prolonged contact.
Dirt, Dust, Fog	• Lumber • Ceramics ovens • Paper • Steel • Mining	**High Excess Gain** • Excess gain data should be carefully evaluated. • Opposed-mode sensors with excess gain above 1000x. **Lens Size** • Smaller lens concentrates the beam for greater penetrating ability. • Larger lenses will yield greater range, but will disperse available sensing energy. **Inductive Proximity Sensors** • For metal targets and short sensing ranges.
Vibration & Shock	• Metal (stamping) • Printing (presses) • Package	• Lightweight sensing components; smaller sensors. • Anti-vibration mounts placed between the sensor and mounting bracket. • Glass or plastic fiber optic assemblies can withstand more than 100 Gs of acceleration. • Glass fibers cannot tolerate repeated flexing. Use plastic, hi-flex or coiled fibers. • Remote sensors can withstand up to 15 Gs of acceleration. • One-piece self-contained sensors with epoxy-encapsulated circuitry withstand up to 10 Gs of acceleration.
Hazardous Areas	• Chemicals/Gas/Oil/Refinery • Grain elevators • Airbag manufacturers	• Special sensing equipment must be installed, using measures to avoid sources of ignition. • See chart defining Hazardous Location Classifications online. • NAMUR photoelectric sensors. • Glass and plastic fiber optics. (Plastic fiber optics are preferred, as it is easier to seal around the fiber bundle at the barrier between the hazardous and safe environment).

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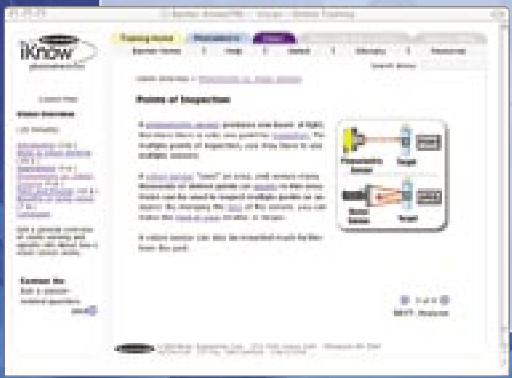

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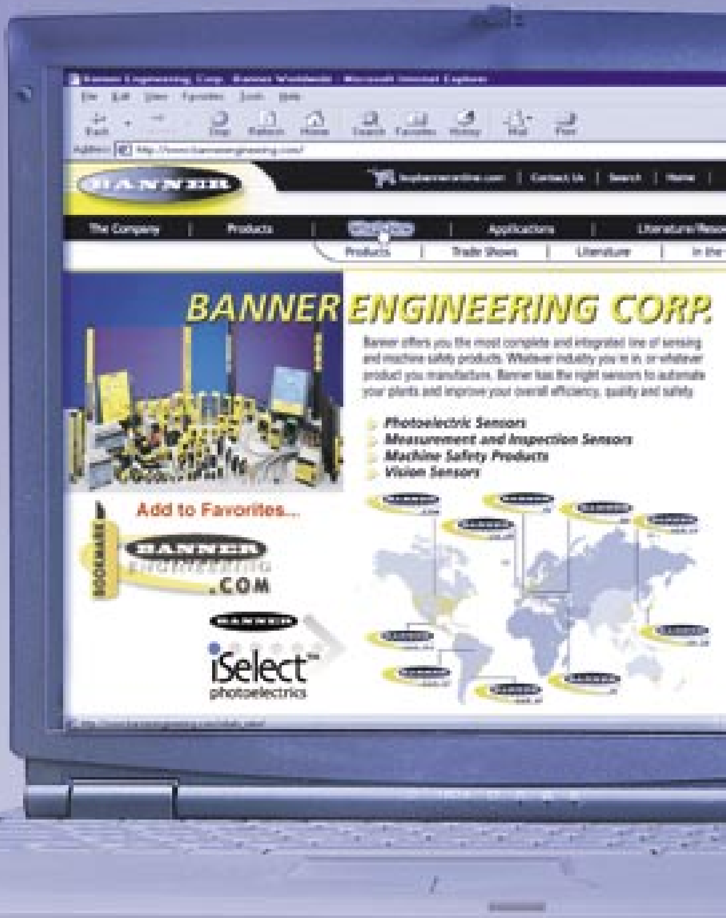

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