Error-Proofing

Using sensors to prevent product defects and drive customer satisfaction

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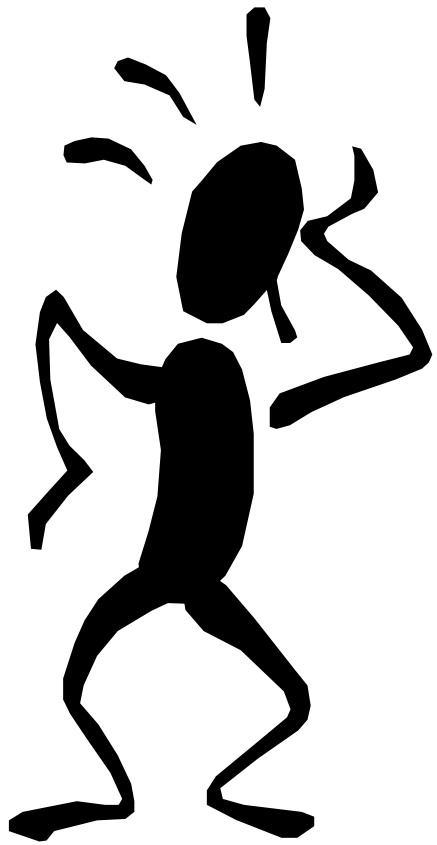
Product Manager
Error Proofing Sensors

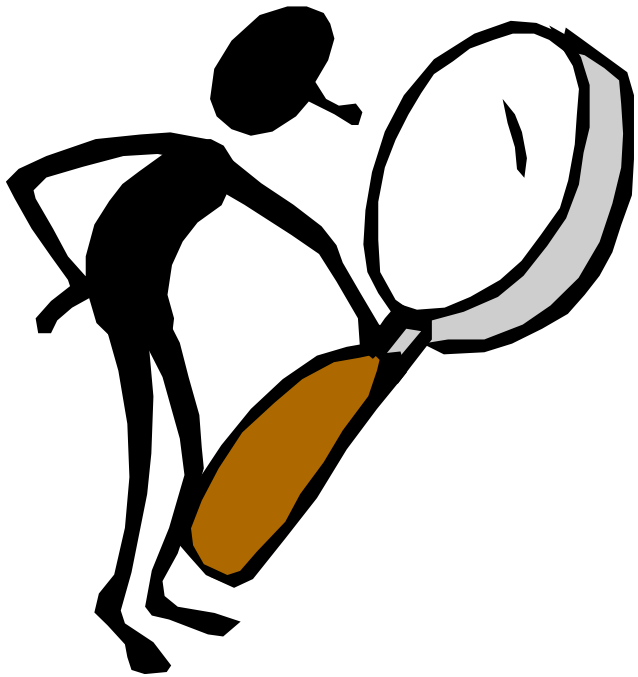
Why Error-Proofing?

Things done right 99.9% of the time means…

- One hour of unsafe drinking water per month
- Two unsafe landings at O'Hare Airport each day
- 16,000 lost pieces of mail per hour
- 20,000 incorrect drug prescriptions per year
- 500 incorrect surgical operations per week
- 50 newborn babies dropped each day by doctors
- 22,000 checks per hour deducted from wrong accounts
- 32,000 missed heartbeats per person each year



Why Error-Proofing?



- If errors are so easy to make, how will we ever send our customers 100% good product?????
- By designing our products and processes so that they minimize the opportunity for the mistakes to happen in the fist place
- This is where the concept of ERROR PROOFING comes in…….

Error-Proofing (Poka-Yoke)

Error-Proofing Definition: The implementation of mechanisms to prevent a process from producing defects.

- Also known as poka-yoke
  - Japanese - poka (inadvertent errors) and yokeru (to avoid)
  - Pronounced POH-kuh YOH-kay
- Common-sense concept - around for a long time
- Fully developed and popularized by Shigeo Shingo in Japan
- The philosophy - It is not acceptable to make even a very small number of defects
- This is where the concept of ERROR PROOFING comes in…….

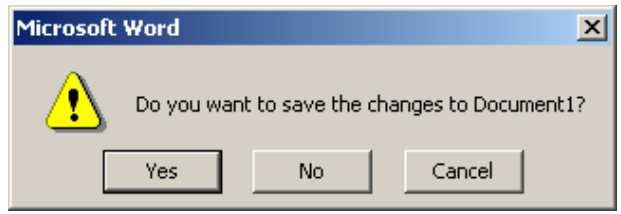
Aspects of Error-Proofing

- Error-Proofing consists of two main aspects:

1. Preventing errors
   - Designing parts and processes to prevent errors from occurring in the first place
   - Examples include painting similar parts two different colors, keying components so that they only fit together in the correct manner, and pick-to-light systems
2. Detecting errors as soon as possible
   - 100% inspection at the source rather than down the line, after additional value has been added (wasted)
   - Each step in the process is inspected and confirmed before the part moves down the line; if the inspection fails, the part is rejected or reworked
   - An error only becomes a defect if it makes it to your customer!

Every-Day Examples of Error-Proofing

- When you close a computer file, the operating system may ask you if you want to save your work first to prevent losing it inadvertently.



- Childproof caps on medicine bottles keep children from taking medication that could be harmful.

- A patient about to undergo surgery for a problem on his right arm, concerned about reports of surgery accidents, wrote "Wrong Arm" with a magic marker on his left arm.

- Speed-dial on your phone that improves accuracy as well as speed - if you hit the right speed dial button!

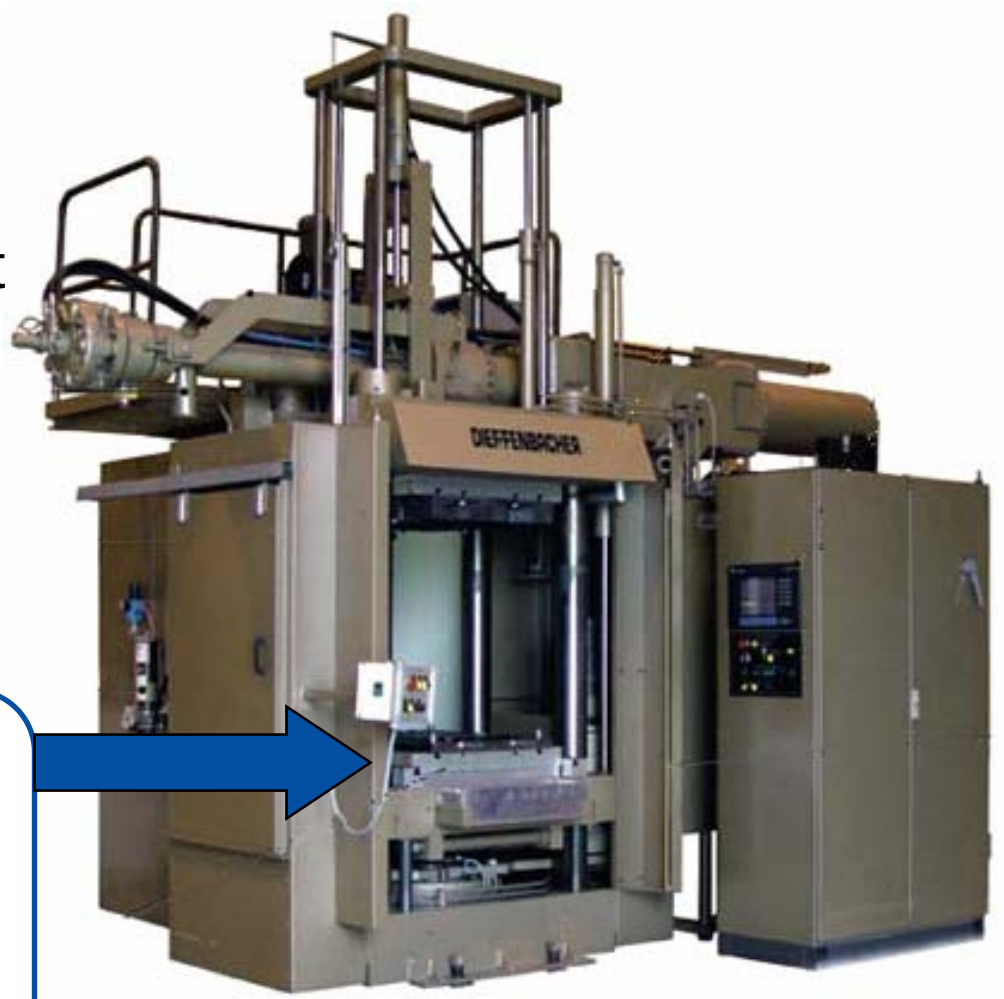
Industry Examples of Error-Proofing

- Color-coding of components that otherwise look similar.
- A sensor connected to the electric nut-runner in an automobile assembly plant triggers a horn if a suspension assembly is moved to the next operation before a bolt is properly tightened.
- Different color bins for different components

- Bins of parts that are electronically connected to the bill of materials through a bar code scanner, so that only the proper bin door opens for a given product.
- Bar-code scanning at the check-out lane to eliminate errors and increase speed

Industry Example

- Mechanical press
- If pressed part isn't removed before next cycle begins press could be damaged (and product will be destroyed)
- Use 45MLD laser sensor to confirm part has been removed before beginning next cycle

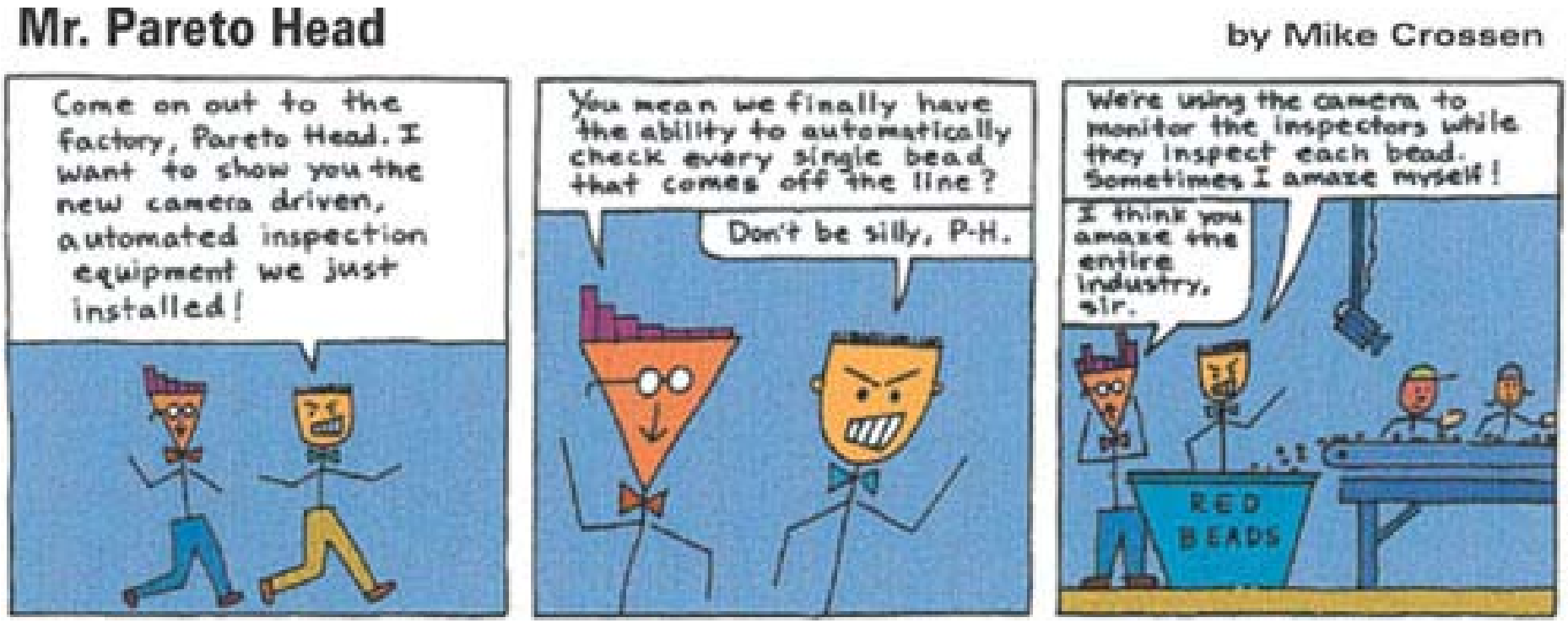


Error Notification

The most effective types of error notification

- Getting the Operator's Attention
  - Visual signal (flashing light is best)
  - Audio Signal (loud and persistent, e.g. burglar alarm)
  - Protective Barrier (to prevent defect or operator injury)
  - When used: low defect occurrence rate and when repairs can be made
- Shutting Down the Operation
  - Upon detecting a "non-conformance" the operation is simply shut down, i.e. the next part will not be processed
  - When used: relatively higher occurrence rates and when repairs are not possible.

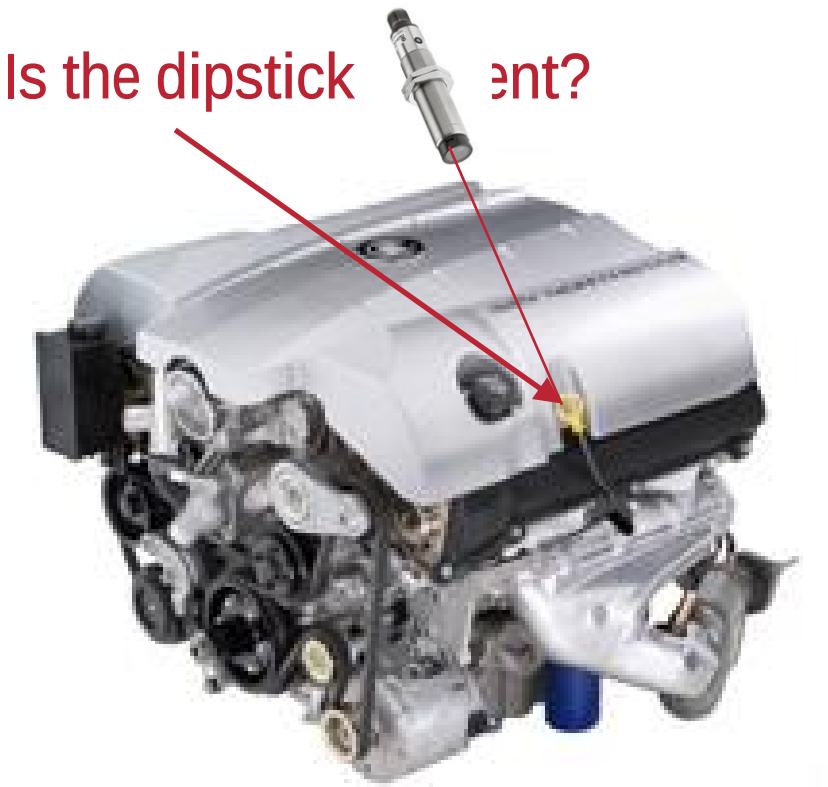
Definition of 100% Inspection



Inspection requires sensors -

Humans make mistakes!

Application Example



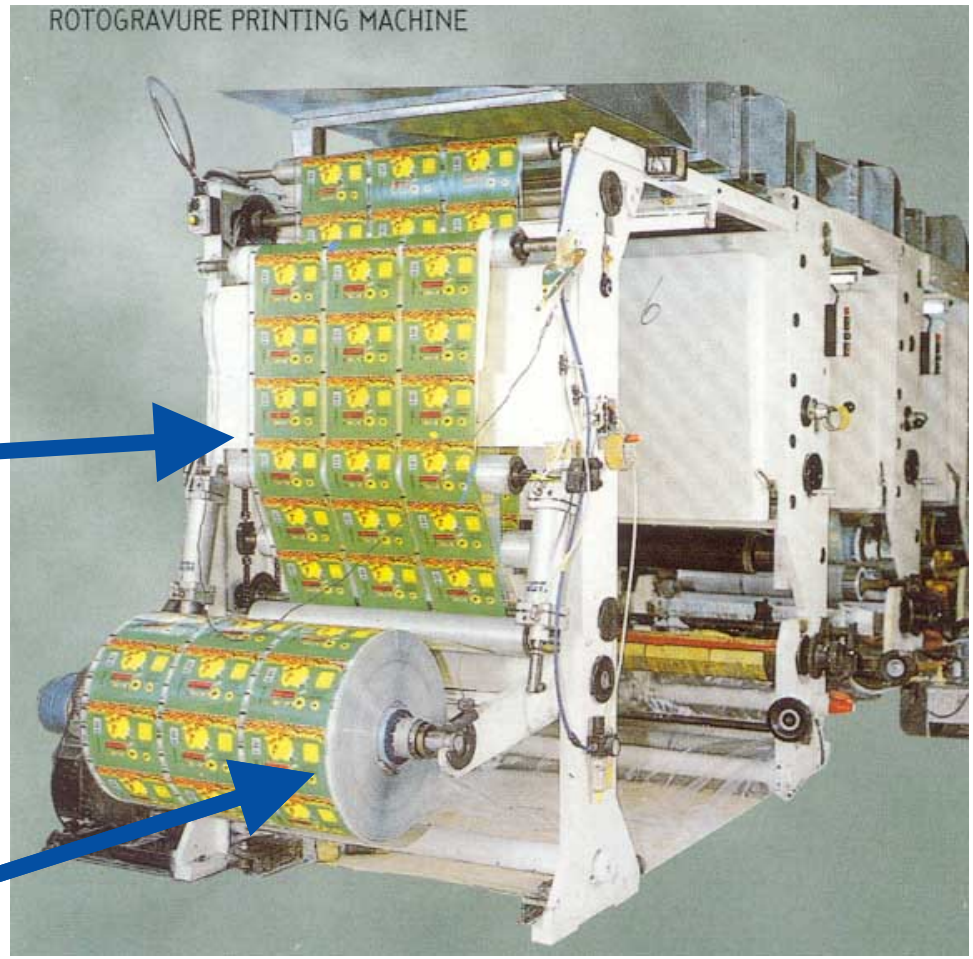
- Eddie is responsible for checking if the dipstick is installed
- Eddie is also responsible for checking the belt, a few other parts, the general workmanship, and the name on the engine (which changes every third unit)
- Eddie sometimes misses the dipstick
- Check with a photo sensor
  - Use background suppression for targets close to background

Application Example

Printing machine

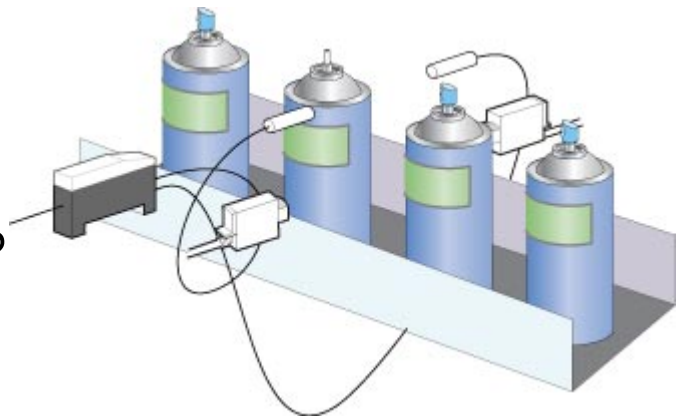
- Where to cut?
- Use Fixed Focus RightSight to detect registration mark

- Is print roll full?
- Use 45MLD laser sensor for edge detection



Gating Application

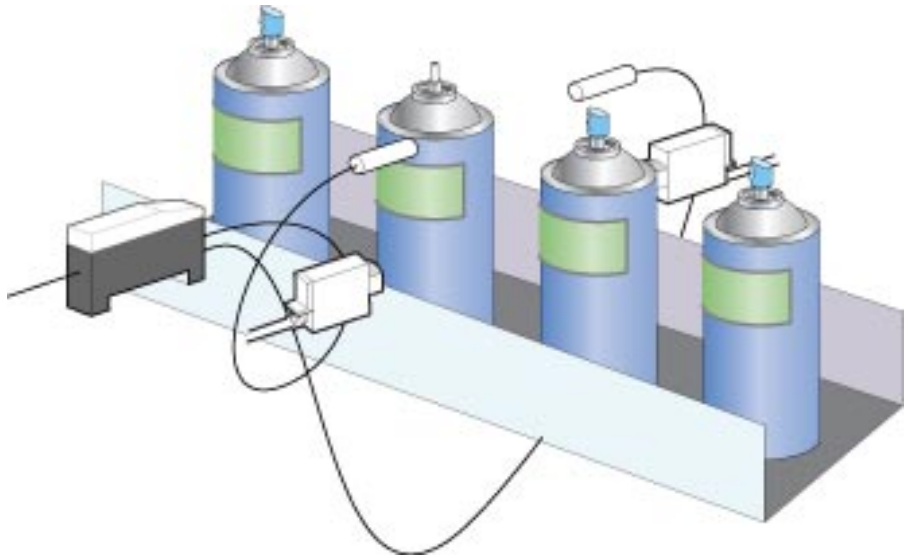
- Check bottle for nozzle
- Nozzle detection is two part question:
  - Is the bottle present?
  - If the bottle is present, is the nozzle present?
- How do we solve this application?



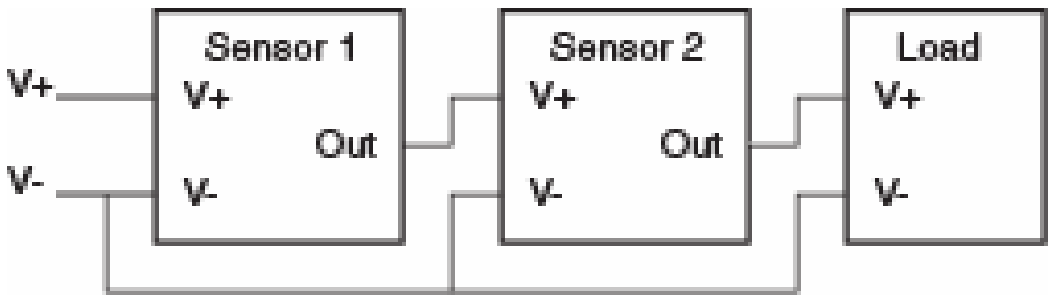
Is the nozzle present?
(Gating App.)

Gating Application - Solution

- Two part question requires two sensors
  - One sensor checks for bottle presence
  - Second sensor checks for nozzle
- Sensors connected in series – called “Gating”
- Output of first sensor provides power to second sensor

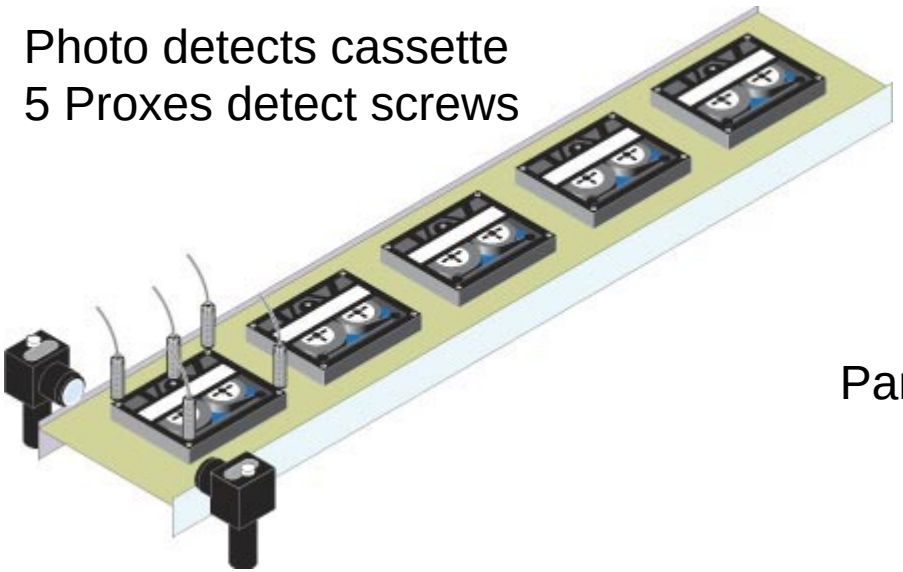


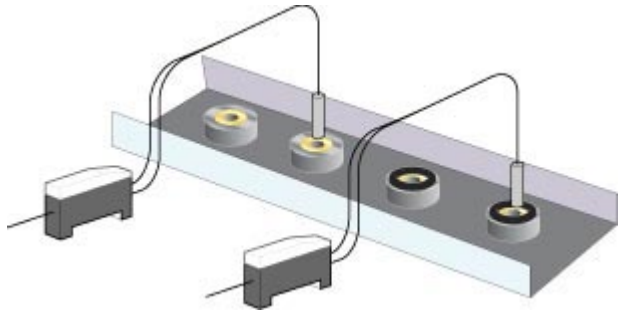
Wiring Diagram - Series PNP



Additional Error Proofing Examples

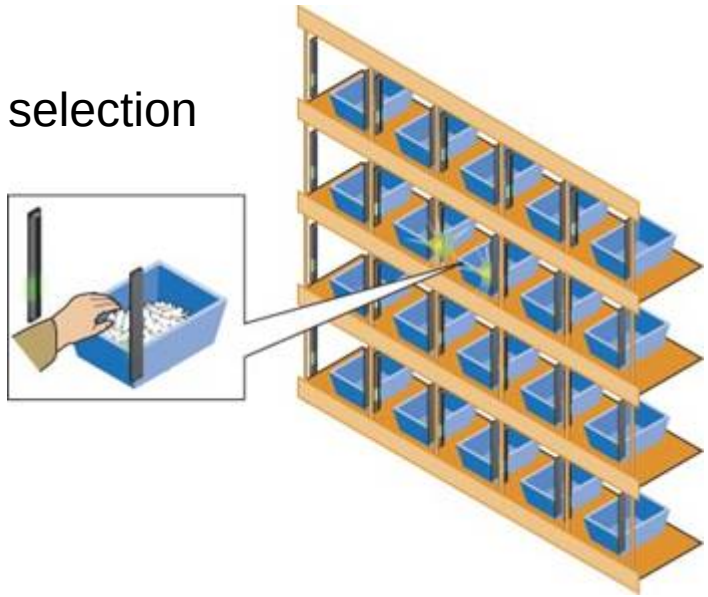
Photo detects cassette
5 Proxes detect screws





Was the black washer placed?

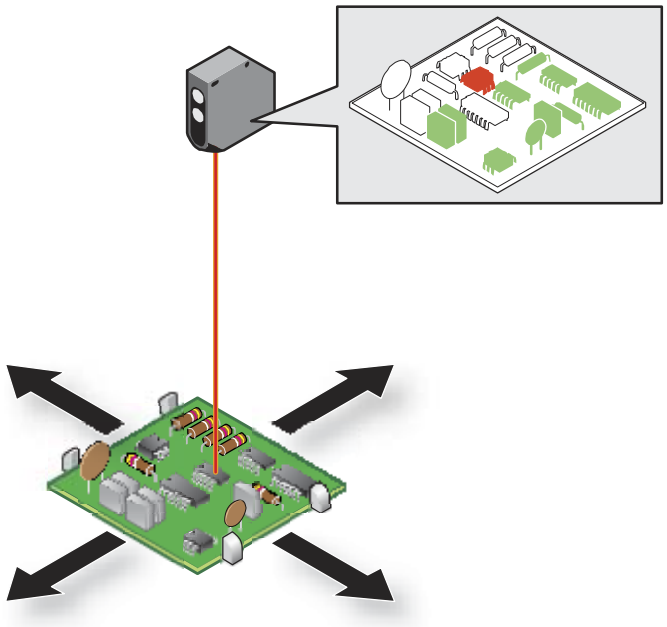
Parts selection



Error-Proofing with Laser Measurement Sensors

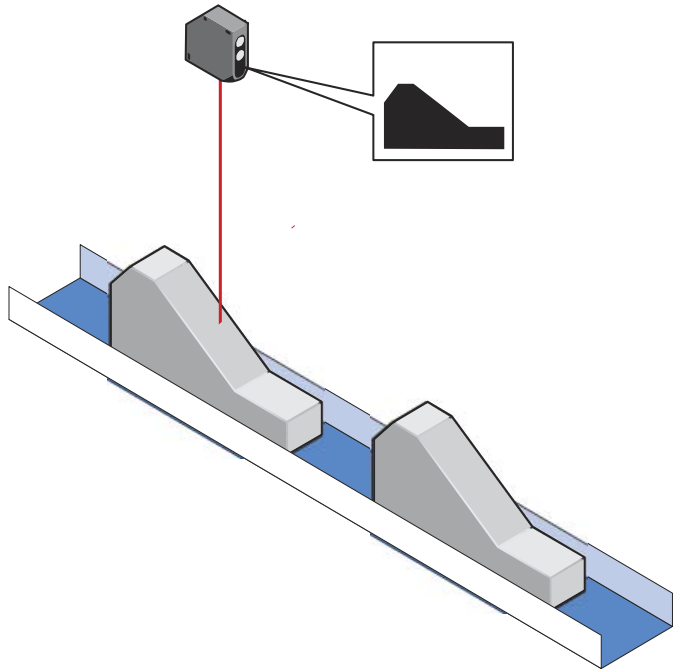
- Precise position or distance measurement
- Detect small objects due to a smaller beam spot than standard photoeyes and ultrasonic sensors
- Visible red sensing beam makes sensor alignment easier
- Precise analog signal proportional to the distance between the target and sensor
- 6m (19.7ft) or 300mm (1 ft) range
- 4-20 mA output plus discrete (on/off) output
- Improve quality, throughput and overall process by performing in-line inspections, measurement and positioning

Assembly and Part Verification



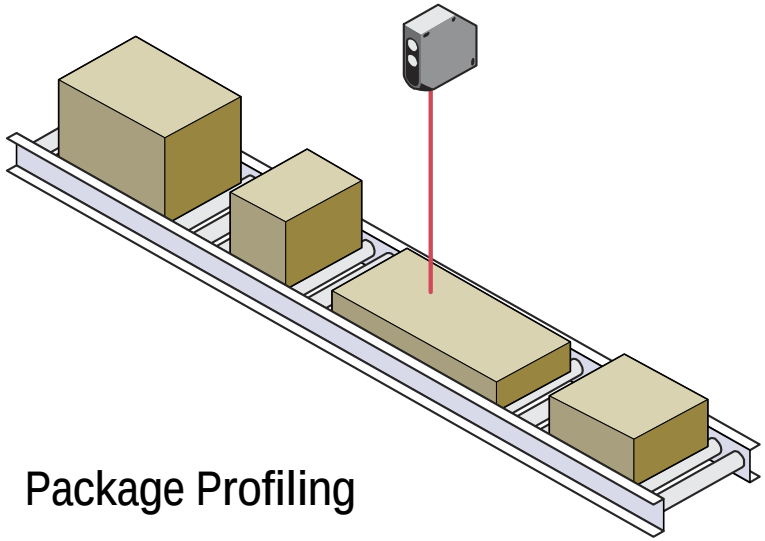
Component Insertion

Hole Depth Inspection

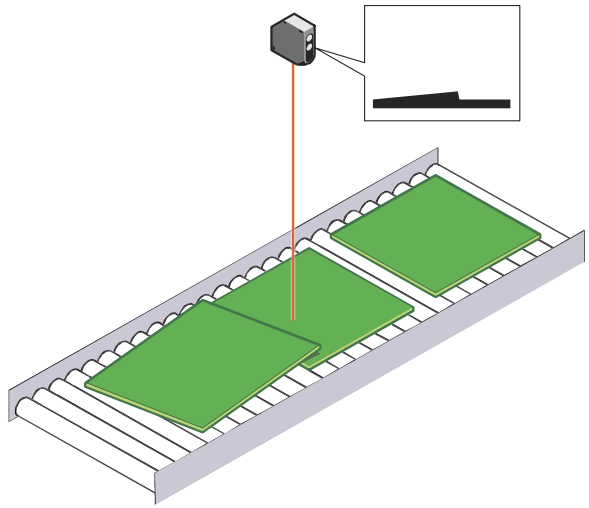


Part Profile Inspection

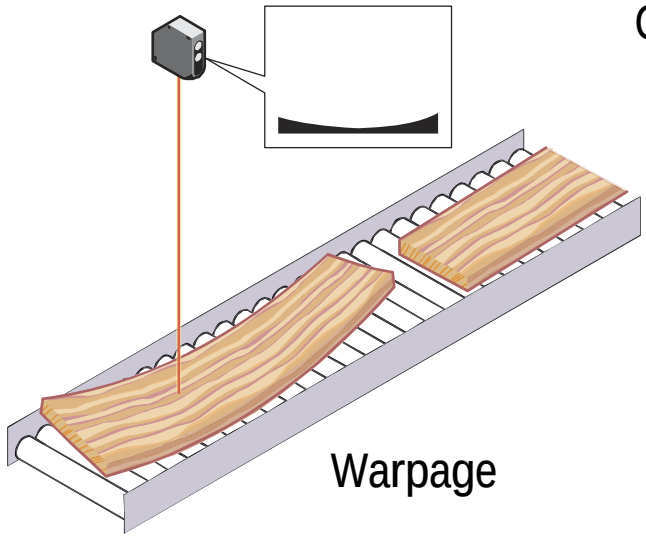
Profiling and Material Inspections



Package Profiling

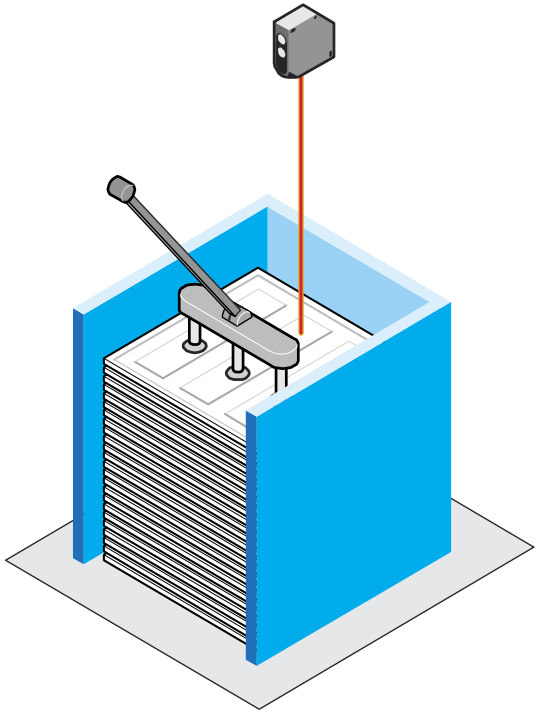


Overlapping Boards

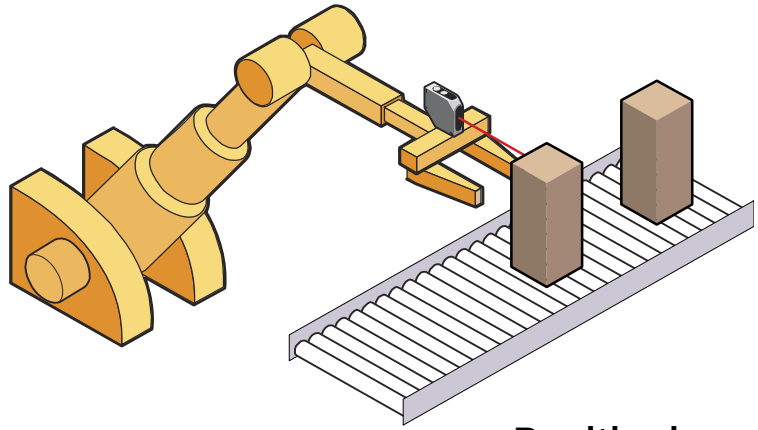


Warpage

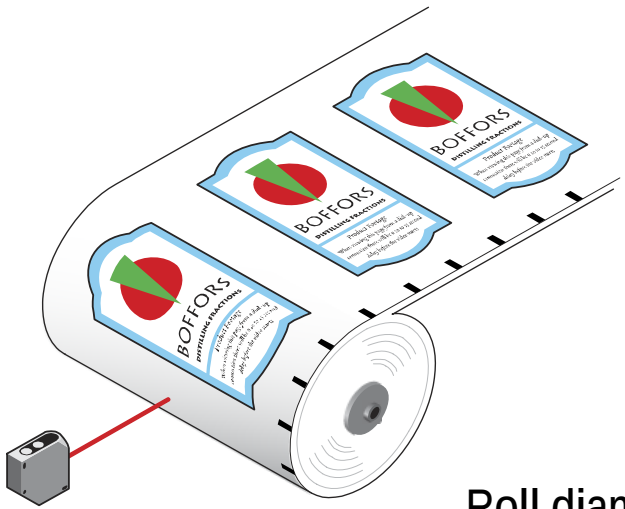
Level, Diameter and Position Measurements



Stack Height



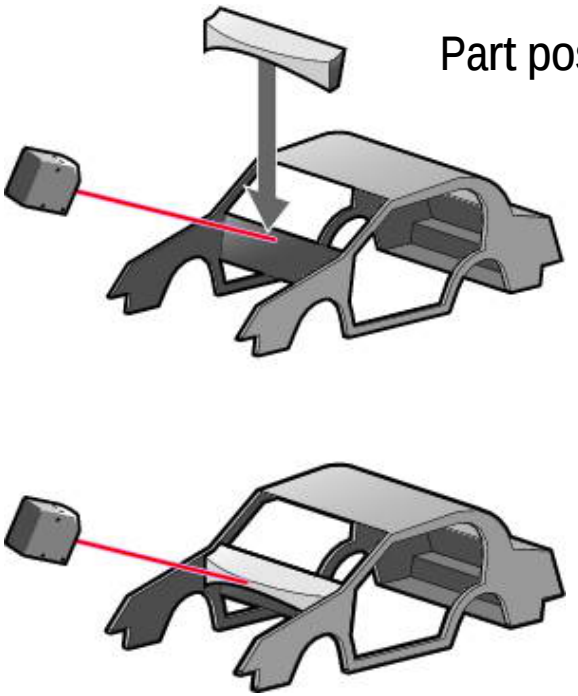
Positioning



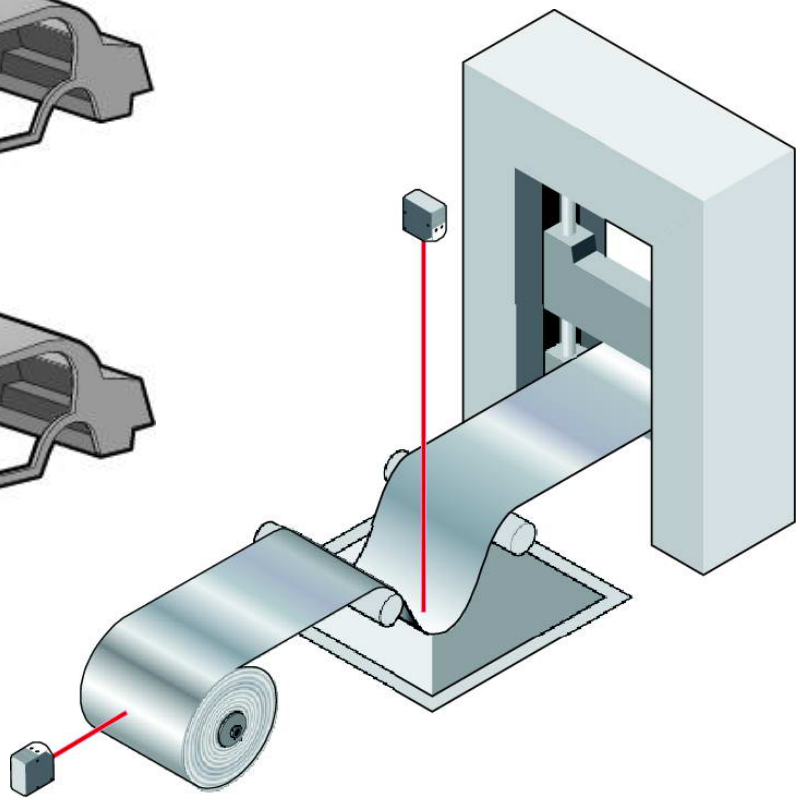
Roll diameter

Long Range Error-Proofing and Inspection

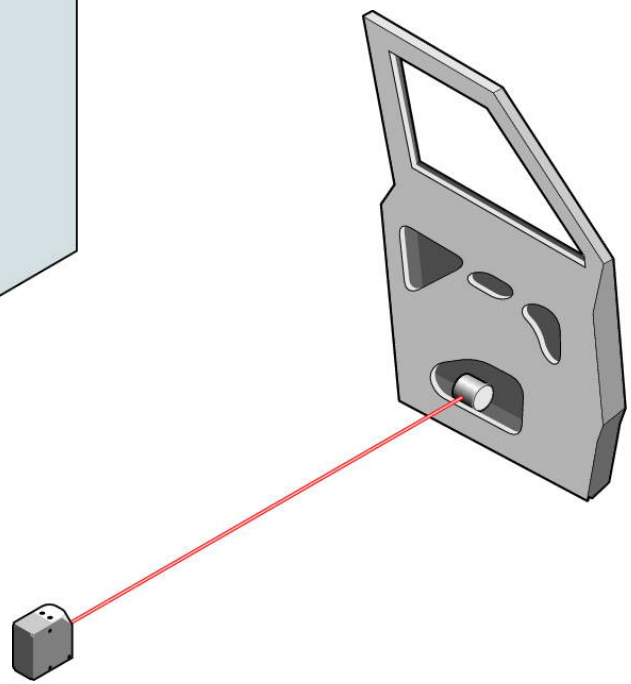
Part position



Diameter and web control



Confirm component placement (discrete output)



45CLR ColorSight™ Color Sensor

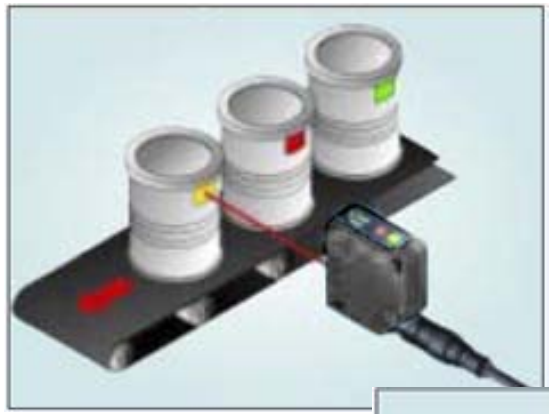
- Sensing range:12-32 mm
- Wide sensing range tolerance
  - detects target even with varying distance to target
- 3 output channels (concurrent 3 color detection)
- 50 x 50 x 12 mm rectangular package
- 500 Hz switching frequency

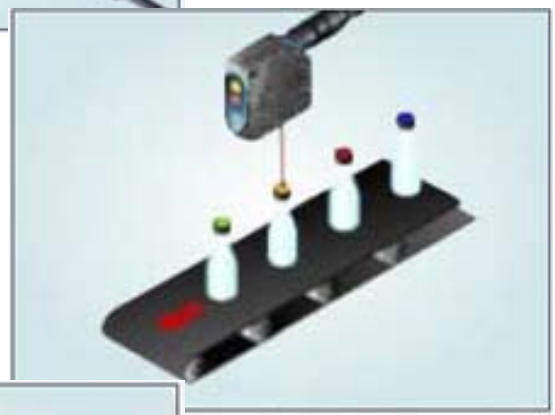
  (1mS response time)
- Local and Remote Teach
- Teachable color tolerance

- Color Scan
  - Teach multiple colors per output channel
- Models with RS-485 communications also available:
  - Internally match up to 5 colors
  - True RGB values communicated for remote processing of additional colors
  - One discrete output available

Typical Color Sensor Applications

- Detection of different color labels
- Detection of different color caps
- Object orientation detection
- Additional Applications
  - Paint color matching in Automotive
  - Paint mark detection on tires and brake drums (used for balancing)
  - Paint mark on lumber (to differentiate board quality)
  - Packaging color matching applications

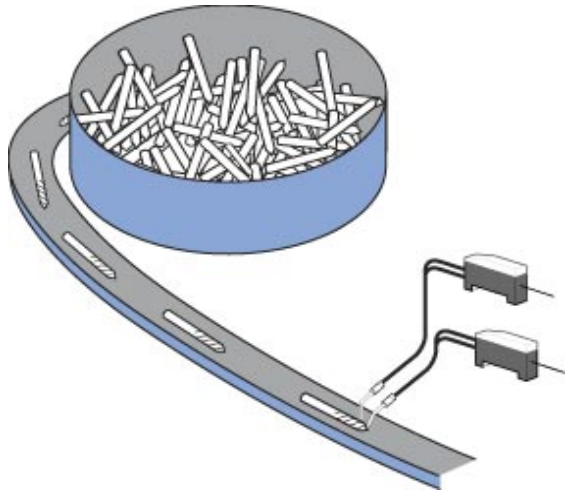




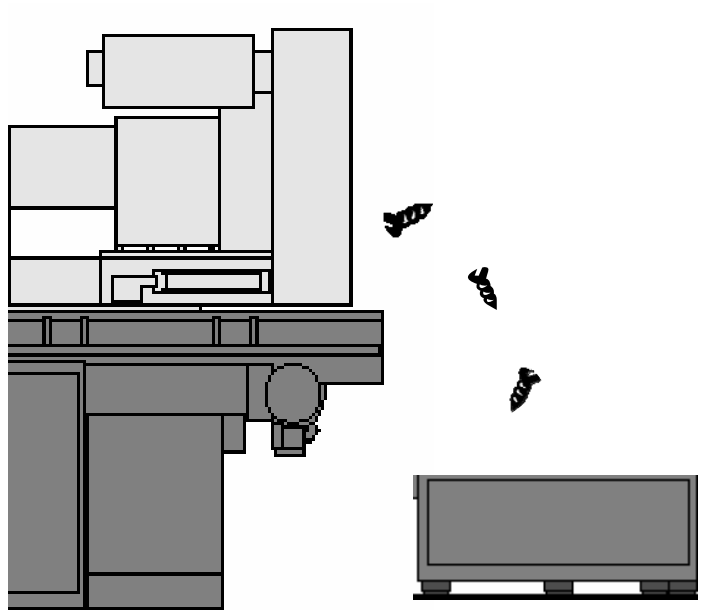
Common Industry Applications

Applications that typically require error proofing:

- Feeder bowls → Small parts coming out must be oriented and assembled.

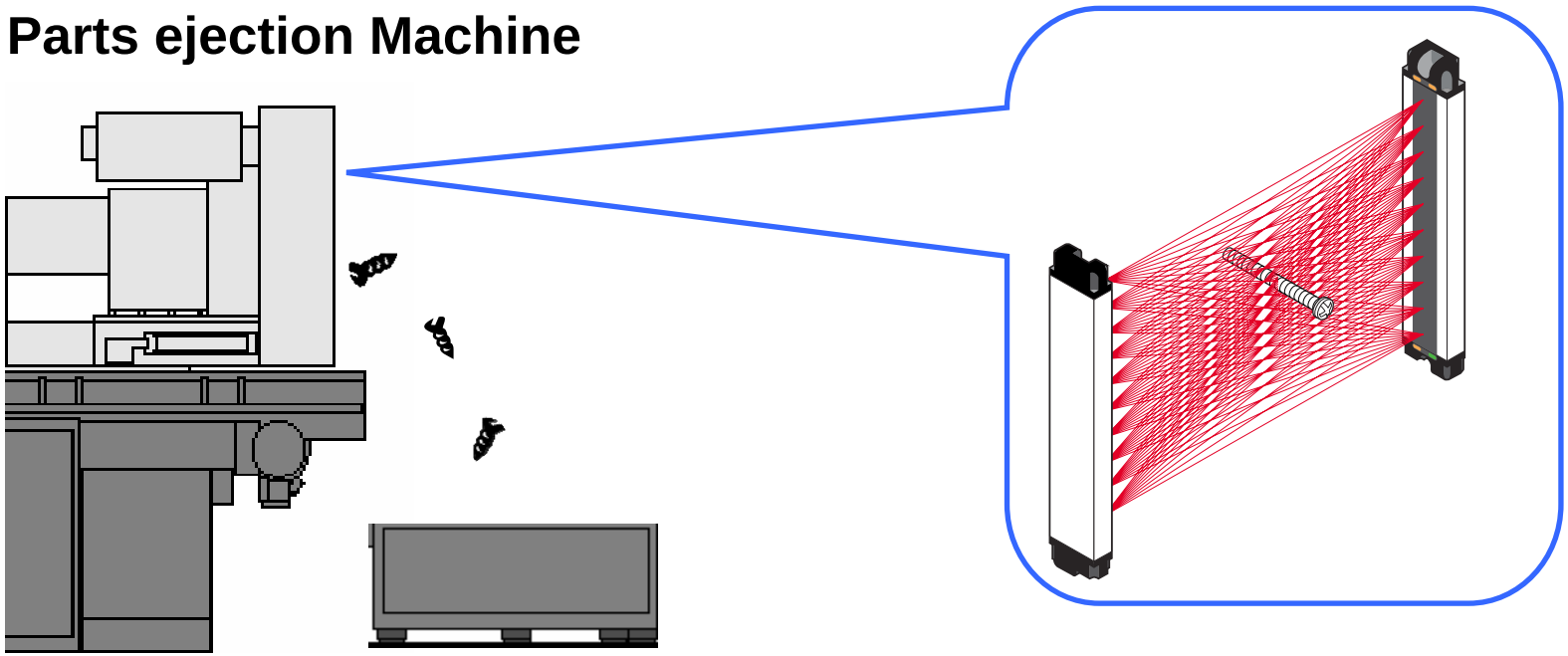


- Injection molding / parts stamping → Small parts being created must be ejected from machine



45AST Scanner Solution

Parts ejection Machine



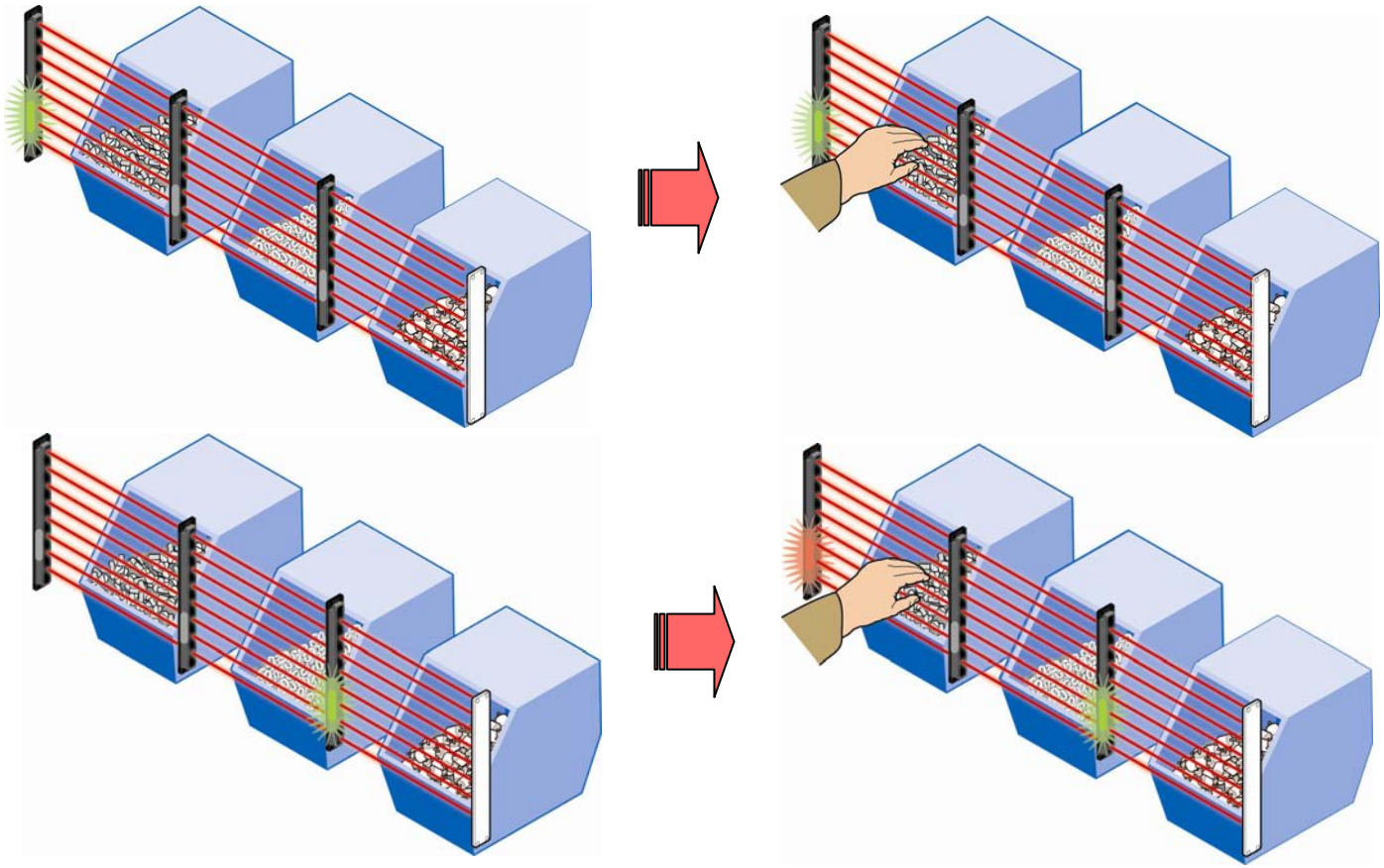
Application Examples:

- Parts Ejection
- Gravity Feed

Features include:

- 2 Dimension Scanning Technology
- 50, 100, 150mm Sensing Heights
- Rugged Housing (IP67)
- 4 ms / 8 ms response time (depending on model)

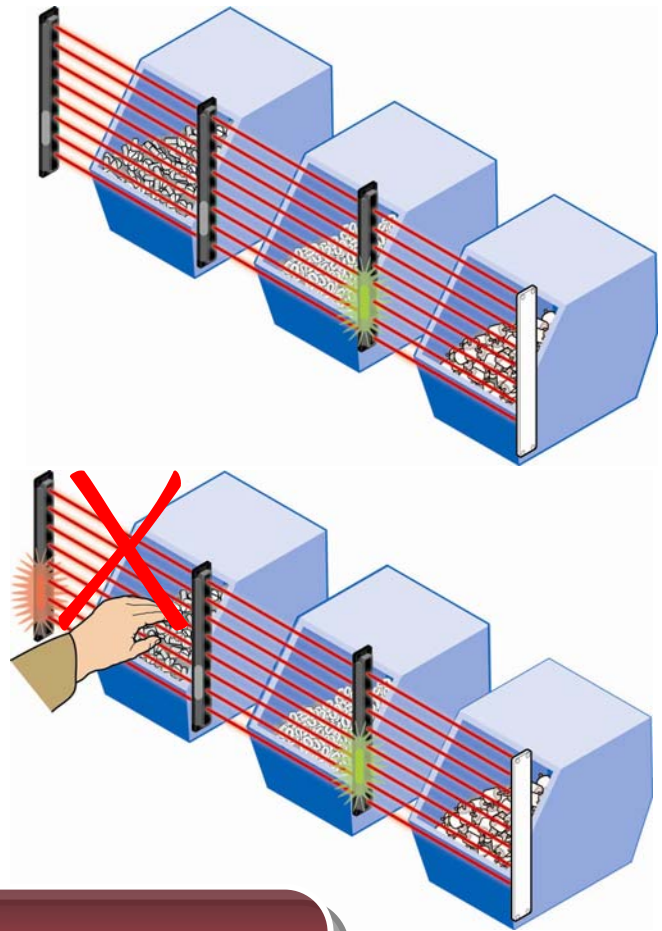
Parts Verification Array for Bin Picking Applications



Parts Verification Array

45PVA for Bin Selection Applications

1. Provides visual indication of correct – AND incorrect – bin selection
2. Allows tracking of bin selection
3. Significantly reduces potential for operator error in assembly areas
4. Provides Error-Proofing solution – Prevent mistakes before they happen!



45PVA – Preventative Error-Proofing with a sensor!

45PVA Parts Verification Array

Low Voltage
12-24VDC

Four Height Styles
100mm, 225mm, 300mm, 375mm

Green Job Light
“pick from this bin”

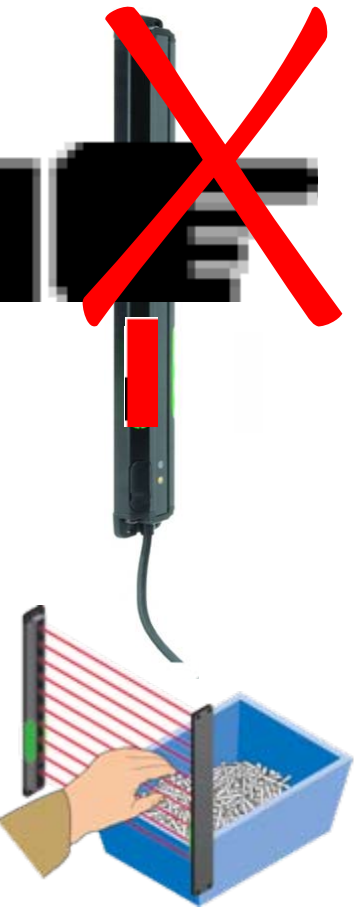
Red Warning Light
“wrong bin picked”

Optical Sensing
2m range

Transmitted Beam or Retro / Diffuse models available

Switch Selectable Operating Modes
NPN/PNP, frequency, flash rate

Error Proofing : PVA to I/O Interface



Bin Picked = Output ON

Job light ON

You Picked The Wrong Bin!

Job light ON

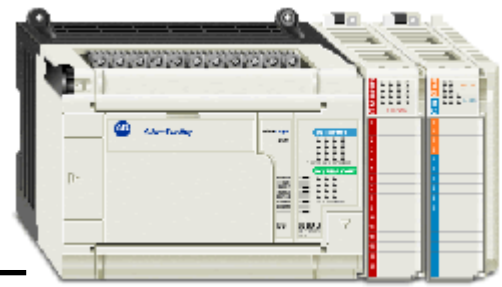
Bin Picked = Output ON

PROCESS

- Initiate Logic
- Pick Bin
- Wrong Bin ?

PLC or I/O

Driven with Ladder Logic

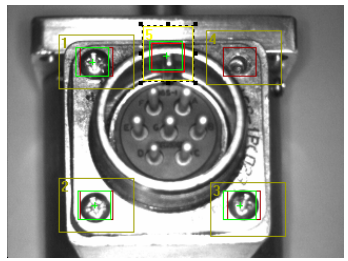


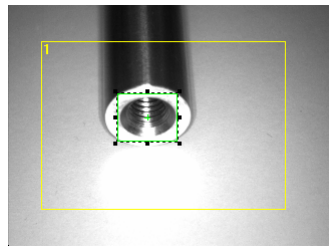
MultiSight™ Vision Sensor

- Pass/Fail Output
- Robust sensor-like enclosure / IP67
- Integrated LED lighting
- Configure via PC - Ethernet connection
- Multiple virtual detectors
- Evaluation methods - Pattern Match, Contrast, Brightness
- Self contained imager, processing, I/O, lighting

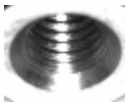
MultiSight™ Target Applications

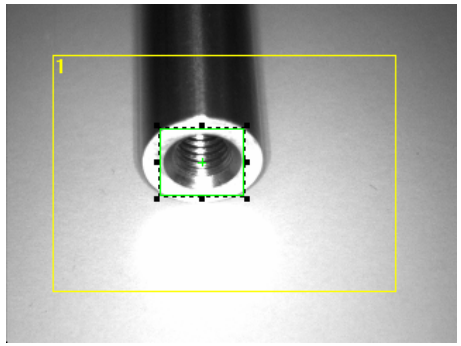
- Multiple - Inspections, Positions, Products
  - Multiple photo sensors required to inspect part
    - Multiple sensors, complex set-up, bracket design, spacing, cost
  - Difficult photoelectric sensor applications
    - Presence, shape, pattern, position, completeness, count, orientation, flaws
  - Part position uncertainty
    - Expensive part fixture required to present target
    - Standard photoelectric sensors require precise part positioning
  - Product mix
    - Customers requiring flexible changeovers on their machine
    - Requires complex and time consuming sensor adjustments for each setup

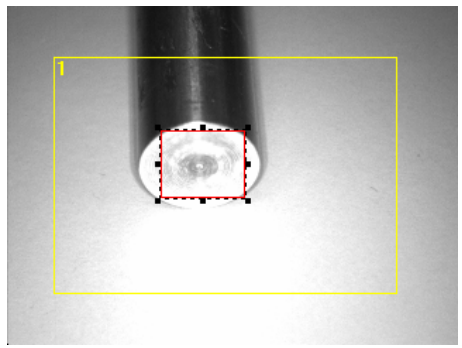


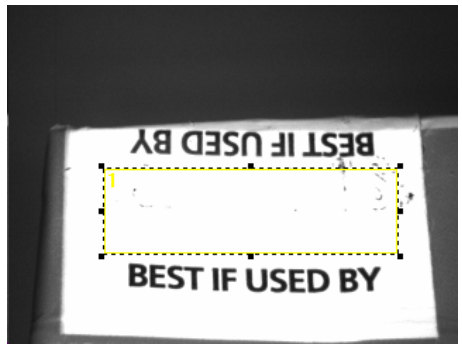


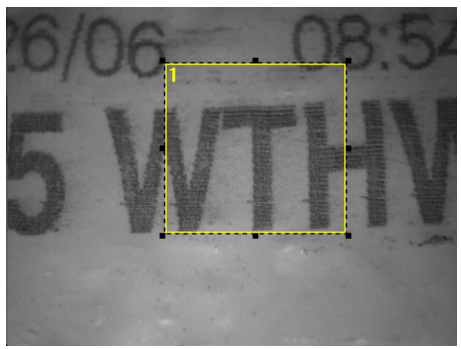
Good and Bad Parts

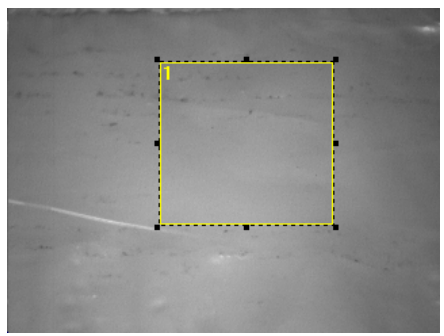




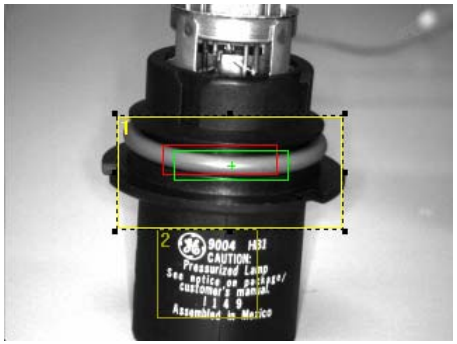


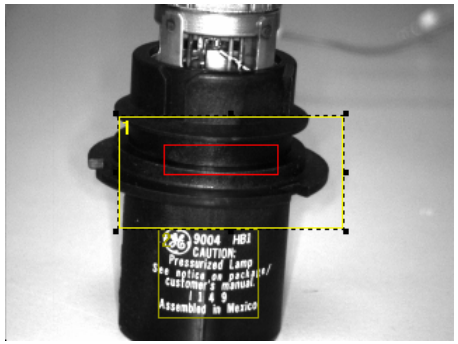


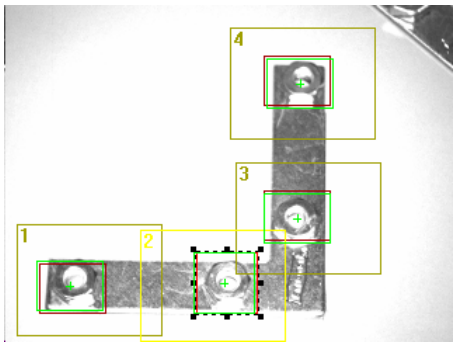


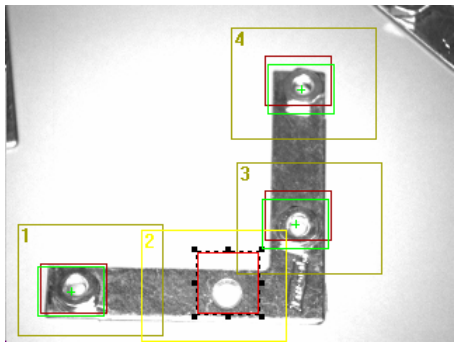


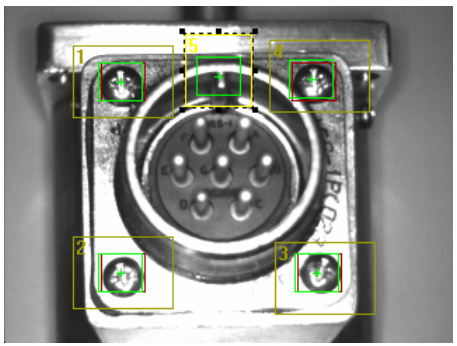
Good and Bad Parts

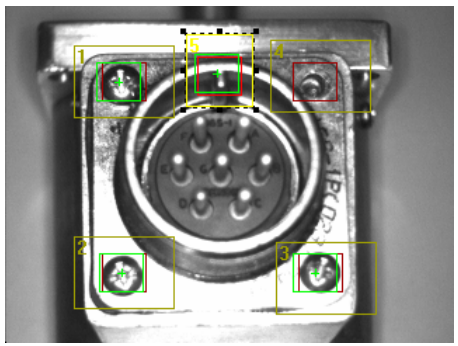




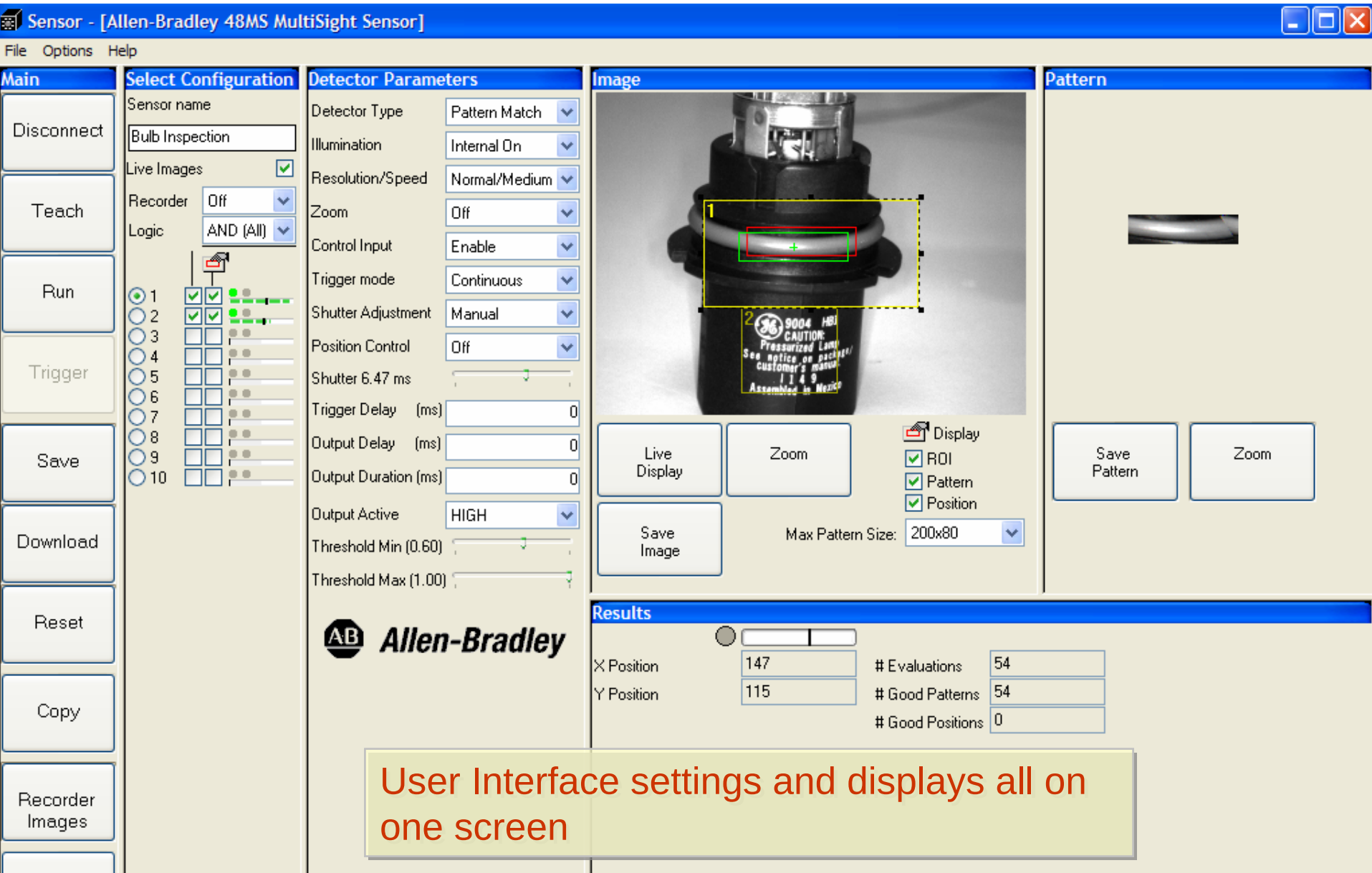








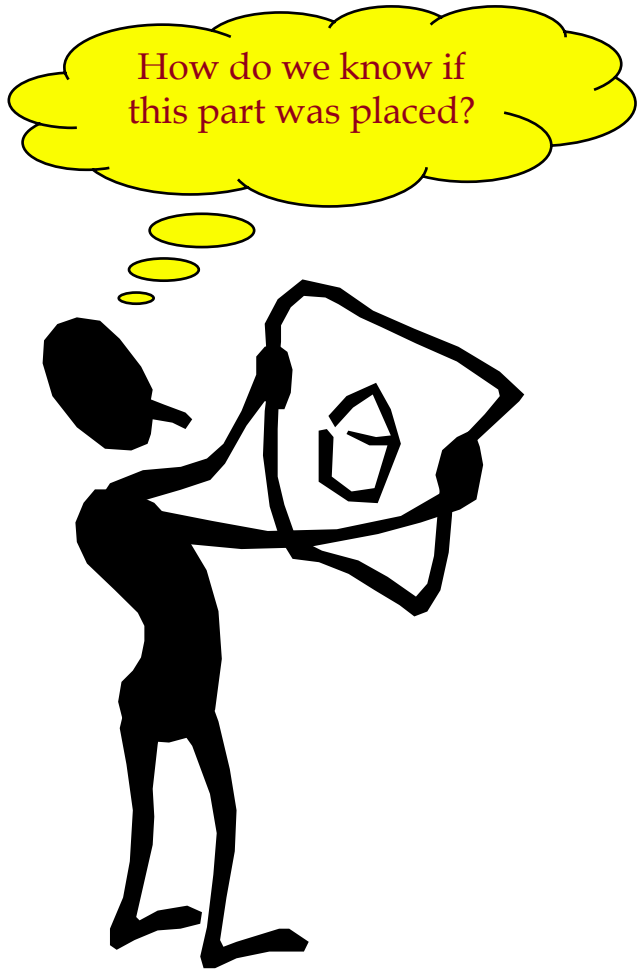
MultiSight™ Configuration Software



User Interface settings and displays all on one screen

Keys to Successful Error Proofing

- Consider Error Proofing early in the design phase
  - Error Proofing solutions are much easier to implement on new machines than existing ones
- Ask lots of questions
  - How will we distinguish between these two parts?
  - What happens if this part isn't installed?
- Remember importance of early detection
  - A mistake only becomes a defect if it is passed along to the next process
  - Any value add after a mistake is wasted

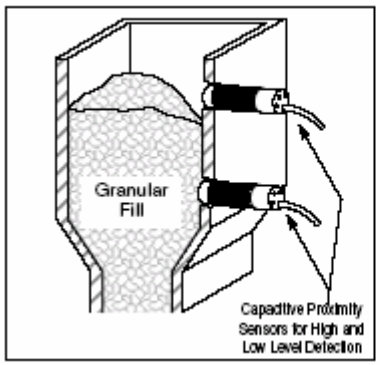


Error Proofing

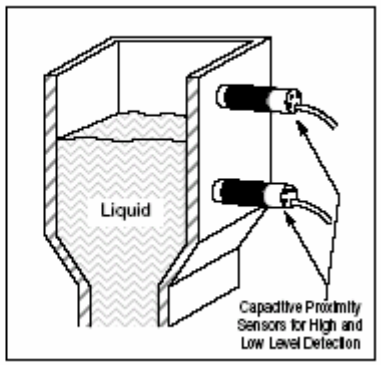
Additional Application Examples

Capacitive Applications

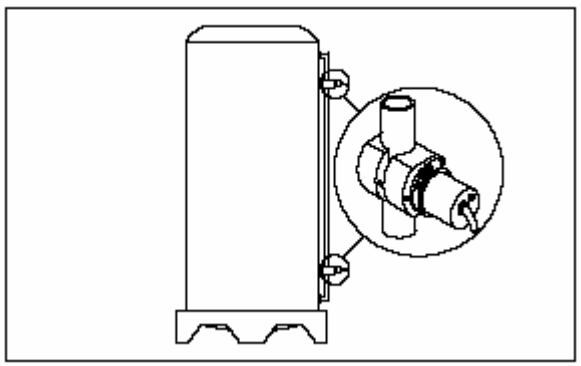
Level Detection



Liquid Level Detection



Sight-Tube Level Detection



- Non-metal solid or liquid sensing
- Pallet detection
- Liquid level monitoring
- ‘Container full’ verification
- ...and more!

Detecting the spring in a pen

Problem: You need to detect if the spring is on the ink cartridge before final assembly.

Solution: How would you solve this application?

What questions would you ask?

- How fast?
- What material?
- What is the background?
- What is the orientation?
- How can the sensor be mounted?

What are the advantages of your solution?

What are the drawbacks?

Detecting the spring in a pen

Solution: Small Prox

Pros

- Lowest cost
- Easy set up

Cons

- Metal ink tip may cause false reading
- Mounting proximity

Detecting the spring in a pen

Solution: MultiSight Vision Sensor

Pros

- Part can move without affecting inspection
- Product changeover is easy

Cons

- Expensive
- More difficult to set up

Detecting the spring in a pen

Solution: Wide Angle Diffuse

Pros

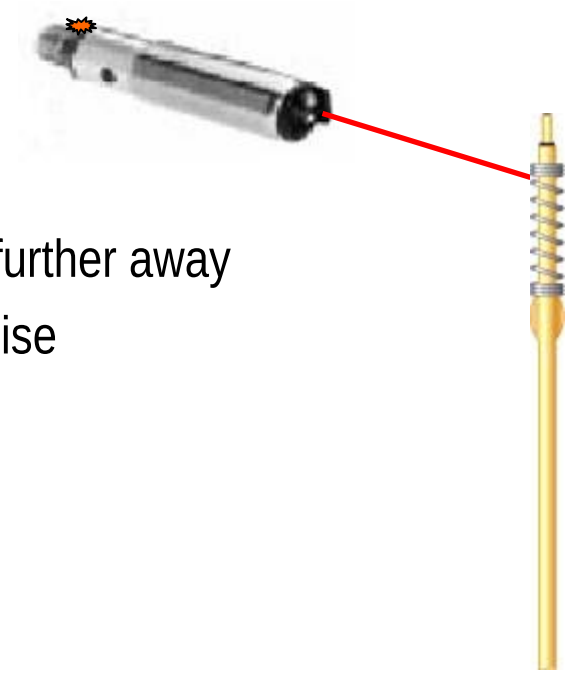
- Good for detecting springs, wires, etc
- Low cost

Cons

- Depth of field – detects cartridge in addition to spring
- Mounting concerns

Detecting the spring in a pen

Solution: Laser



Pros

- Mounted further away
- Very Precise

Cons

- Expensive
- Larger – mounting requires more space
- Spring must be in exact same position and orientation

Detecting the spring in a pen

Solution: Fixed Focus Diffuse

Pros

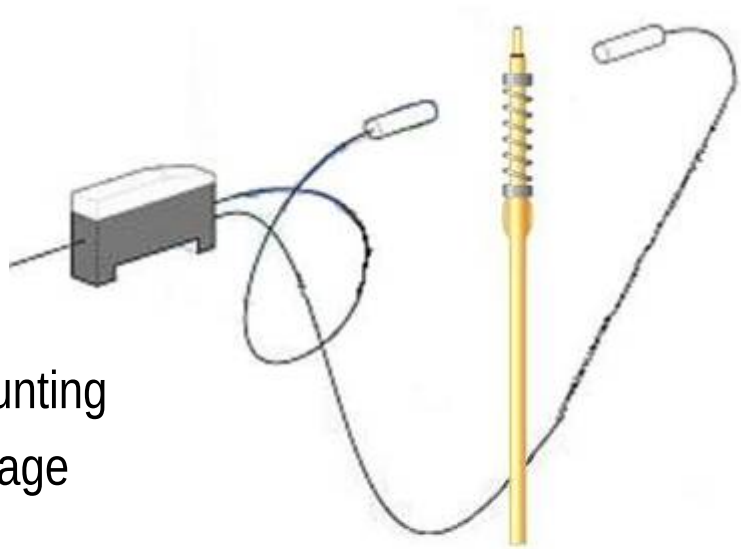
- Cost

Cons

- Mounting concerns
  - Enough space?
  - Requires precise position

Detecting the spring in a pen

Solution: Fiber Optics



Pros

- Ease of Mounting
- Size advantage

Cons

- Expensive