To Err is NOT Divine

Using Error-Proofing Concepts to Prevent Product Defects and Drive Customer Satisfaction

Everyone knows it: People make mistakes. And when it comes to manufacturing, mistakes equate to lost time, lost money and ultimately lost customers. In today's globally competitive market, product quality has emerged as a key differentiator. But if errors are so common and easy to make – and we all know they are – how does a manufacturer guarantee that they deliver quality product all the time? The answer: Design fool-proof products and processes that minimize the potential for mistakes to occur in the first place. Enter the concept of error-proofing.

What is Error Proofing?

Error-proofing is an industry term that relates to the implementation of mechanisms to prevent product defects. Also known as Poka Yoke from the Japanese 'poke' (inadvertent errors) and 'yokeru' (to avoid), error-proofing is a common-sense concept developed and popularized in that country. Based on the philosophy that even the smallest number of defects is unacceptable, Poka Yoke maintains that the best way to eliminate defects is to prevent them from happening in the first place.

In general, there are three keys to stopping the proliferation of defects: Awareness, Detection and Prevention.

Awareness involves the acknowledgement of breakdowns in the manufacturing/assembly process and employing training, audio-visual aids and general assistance for personnel to combat those issues.

Detection introduces manual or automated inspection techniques to filter out defects.

Prevention which includes process improvements or automation to ensure no errors are (or can be) made.

Essentially, error-proofing drastically reduces defects through a combined effort of preventing errors and catching those that have been made as soon as possible. Awareness and detection techniques are crucial but, ideally, this effort is about focus on prevention. Everyday examples of prevention-centric error-proofing include a dialog box on your computer asking if you want to save a file before closing it, childproof caps on medicine bottles or speed-dial buttons on your phone that improve accuracy as well as speed. Industry examples range from simple color-coding to distinguish between components that otherwise look similar to a sensor connected to the electric nut-runner in an automobile plant that triggers a horn if a suspension assembly is moved to the next operation before a bolt is properly tightened. Sensors play a key role in error-proofing, and while most are used as simple detection devices, there are also a few sensors designed to be used as preventive measures.

Awareness
Detection
Prevention

Sensors in Error-Proofing

Sensors are employed at various stages throughout the manufacturing process to either initiate warnings such as audible or visual alarms (for low defect processes and those where part repairs can be made), process shutdown (for applications where problems must be corrected before production can resume, processes with higher defect rates and those where part repair is not possible), or auto-correction controls to provide an integrated test-feedback-repair loop.

In manufacturing and assembly, there are four basic types of errors:

- Missing Parts
- Misassembled parts
- Incorrect processing
- Incorrect parts

The sensors used to detect these mishaps are of all shapes, sizes and technologies from standard inductive proximity and photoelectric sensors to vision sensors capable of analyzing a complex image and providing simple feedback, as well as specialty sensors designed specifically for the prevention aspect of error-proofing applications.

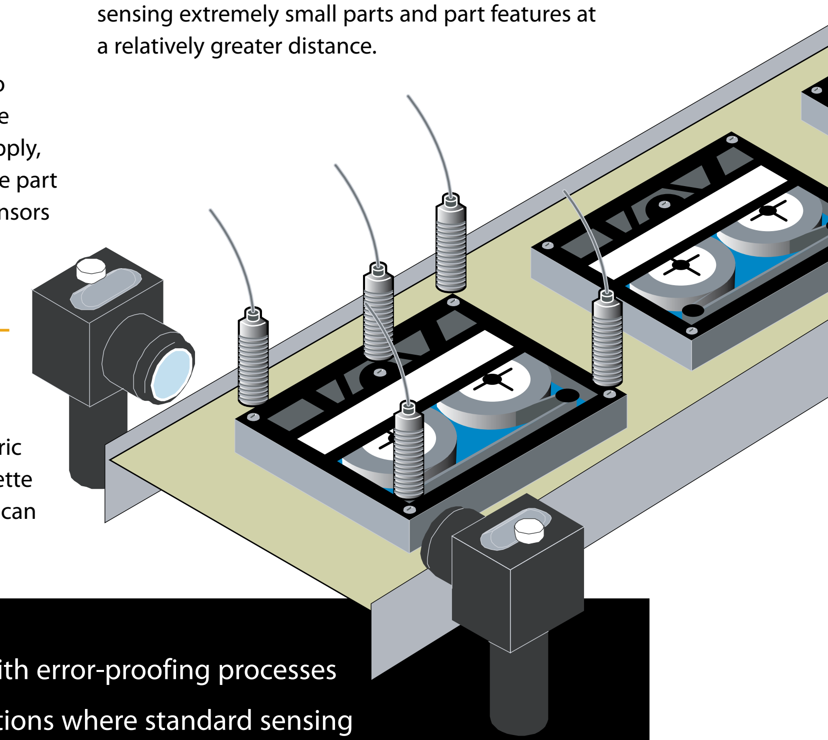
Discrete output (standard on/off) sensors are the most common in error-proofing applications, used primarily to determine presence and positioning of a part or a feature on a part. Limit switches are cost-effective and easy to apply, but the fact that their operation requires contact with the part prohibits their use from many applications. Inductive sensors are generally the most economical non-contact solution, assuming the parts to be detected are metallic and the sensor can be mounted close enough to the workpiece for the relatively small sensing ranges (less than 40mm) associated with inductive sensing technology. Available in a broad range of sizes, barrel/body materials and wiring configurations, inductive sensors are available in small barrel models ideal for space-critical applications, as well as flat pack and extended range versions for those applications where maximum sensing distance is key. Inductive proximity sensors are also extremely rugged – especially stainless steel-bodied and cube-style models – making them a good all-around error-proofing solution in harsh industrial environments.

For applications requiring increased sensing distances and/or detection of non-metallic parts, discrete photoelectric sensors are often the best – and simplest – solution. Infrared sensors in standard sensing modes (diffuse, retroreflective and transmitted beam) as well as more specialized sensors in background/foreground suppression, wide angle and fixed focus modes, address the lion's share of error-proofing applications. Laser-based models are also available for sensing extremely small parts and part features at a relatively greater distance.

application example

Discrete inductive and photoelectric sensors

In this application, a 42EF RightSight photoelectric transmitted beam pair is used to position a cassette such that five 872C WorldProx inductive sensors can confirm screw presence.



Specialized photoelectric sensors designed with error-proofing processes in mind are available that address those situations where standard sensing packages are not suitable or are too difficult to apply. Photoelectric light arrays utilizing two-dimensional scanning technology can create a light screen to sense an object regardless of its orientation provided that one axial dimension meets the minimum resolution requirements. This is ideal for the detection of parts being ejected from a machine and a host of other applications focused on "early detection" error-proofing.

Sensors in Error-Proofing continued

This same scanning technology is also used in Parts Verification Arrays (PVA) that are specifically geared toward error prevention, notably in bin picking applications. By spanning the sensing fields of multiple PVAs across assembly station bins and wiring them into a controller programmed with the necessary logic, a virtually error-free bin-picking process can be achieved. 'Job lights' on the sensors not only show the assembler the bins required to complete the current process, but will also indicate the correct picking sequence. In the event the assembler attempts to pick an incorrect part, a selectable warning light illuminates to indicate the error; additional fault enunciation can be achieved via controller logic in conjunction with a tower light or audible alarm.

Analog output sensors on the other hand, are used for precise part positioning with continuous monitoring. Associated with true distance/position measurement, analog output sensors provide a linear current or voltage output (4-20mA or 0-10V, respectively), often in conjunction with discrete switchpoints. While many inductive, ultrasonic and photoelectric sensors are offered in analog versions, the precision of laser measurement sensors has made them the predominant technology for error-proofing applications including not only distance measurement and position verification, but such diverse functions as part profiling, thickness measurement, hole depth checking and material warpage detection.

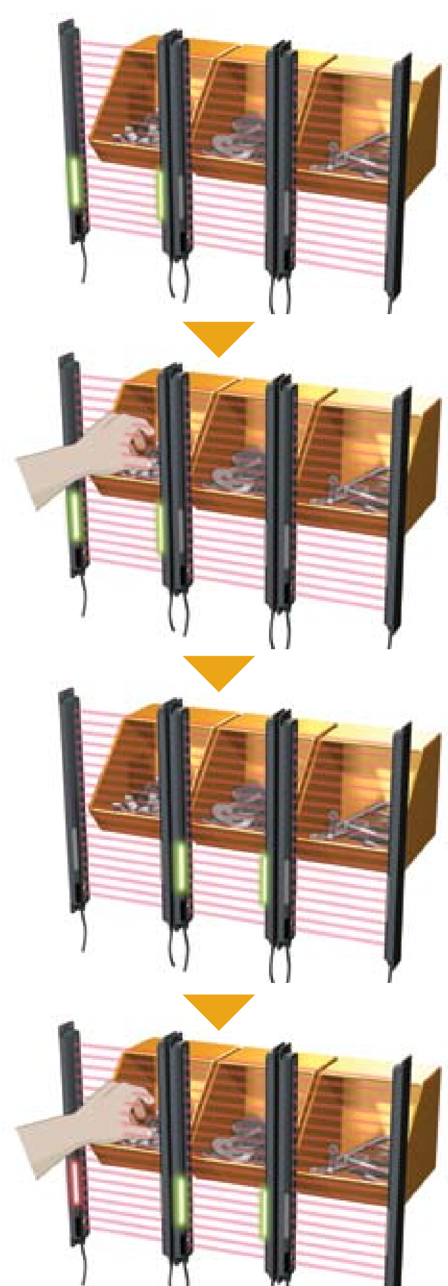
At the high-end of the sensing spectrum for error-proofing applications is vision technology, ranging from standalone vision sensors to complete vision systems. Complete vision systems are used for complex inspection applications and require the integration of a camera, lighting, a processor (usually a PC) and software, typically involving a fair degree of customization and programming expertise. But for many error-proofing applications, vision systems are overkill and cost-prohibitive. As a result, vision sensors have emerged as the preferred technology for applications requiring economical yet advanced sensing for determining presence or absence, completeness, position, markings, labeling, packaging and components. Vision sensors combine an imaging device, lighting and the necessary logic into a single, self-contained unit that provides a simple Pass/Fail output. Using multiple methods of evaluation (pattern matching, contrast and brightness) to detect or differentiate objects by means of previously defined optical characteristics, this Pass/Fail output is used to separate good parts from defective ones. Detection parameters are set up through simple configuration of pre-defined functions as opposed to the detailed software programming associated with vision systems. For more details on vision sensors, their operation and how they differ from vision systems, see Tech Tips on page 16.

application example

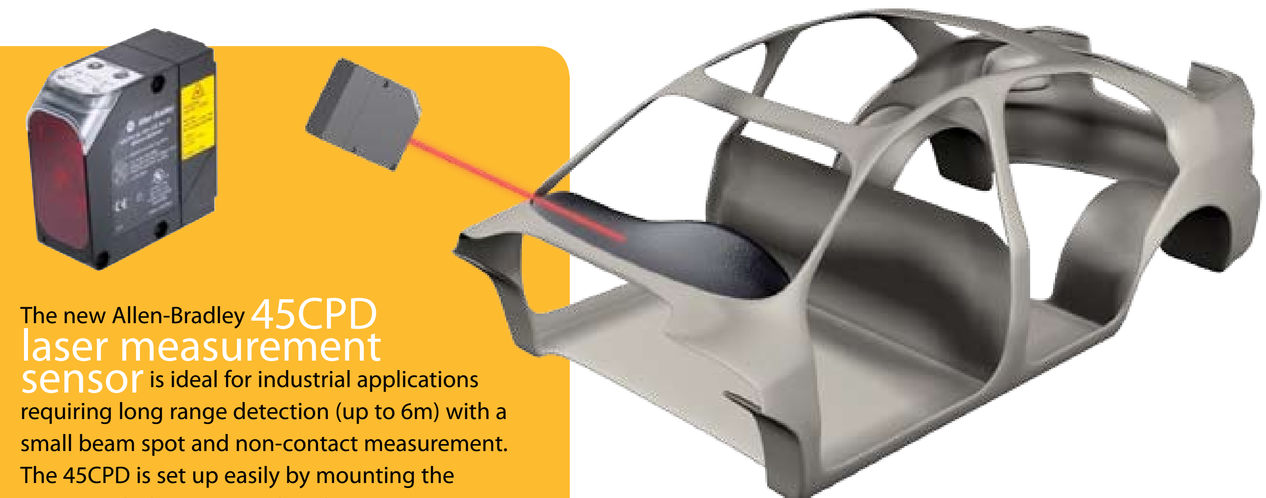
45PVA Bin Picking Application

In this assembly process, an Allen-Bradley 45PVA is used for preventative error-proofing to show the worker the proper picking sequence and alert them in the event of a mis-pick.

- The PLC tells Bin 1 it is next and the Part Verification Array on Bin 1 lights up green. When the user selects from Bin 1, this is a 'good' selection. The process then moves on to the next step.
- But if the PLC tells Bin 3 it is next and the user selects from Bin 1, the Bin 1 PVA red warning light turns on indicating a 'bad' pick. An optional audible alarm could also be triggered by the PLC to indicate the error.



No matter what you call it – error-proofing or Poka Yoke – sensors are an integral part of the quality control process. And there's no shortage of sensing technologies to effectively address all your error-proofing applications, whether it's simple presence sensing or complex inspection. A complete and successful error-proofing effort will most likely involve a mix of these sensing technologies as well as audio-visual aids, awareness training for personnel and some creative thinking in the development of new preventative processes. All are key to driving not only product quality, but customer satisfaction; manufacturing errors only become product defects if they make it out the door – and into your customer's hands.



The new Allen-Bradley 45CPD laser measurement sensor is ideal for industrial applications requiring long range detection (up to 6m) with a small beam spot and non-contact measurement. The 45CPD is set up easily by mounting the sensor with the target within the sensing range and teaching the appropriate set-points for the application via convenient Teach-In buttons on the top of the sensor. In this application example, the 45CPD is used to determine dashboard presence and positioning in automotive assembly.

application examples

The MultiSight is an optical multi-pixel sensor with a pass/fail PNP output. Using three different methods of evaluation (pattern matching, contrast, and brightness), the MultiSight can detect or differentiate objects by means of previously defined optical characteristics, e.g. for separating "good" and "bad" parts. The main applications are in the field of industrial automation for quality assurance purposes. The MultiSight is an easy-to-use economical alternative to conventional vision systems for detecting presence or absence, completeness, position, markings, labeling, packaging, and components. For details on the 48MS MultiSight and its application, see Tech Tips, page 16.

Transmitted beam photoelectric light arrays such as the Allen-Bradley 45AST utilize two-dimensional scanning technology to sense an object regardless of its orientation. This is ideal for the detection of parts being ejected from a machine as shown in the application to the left.