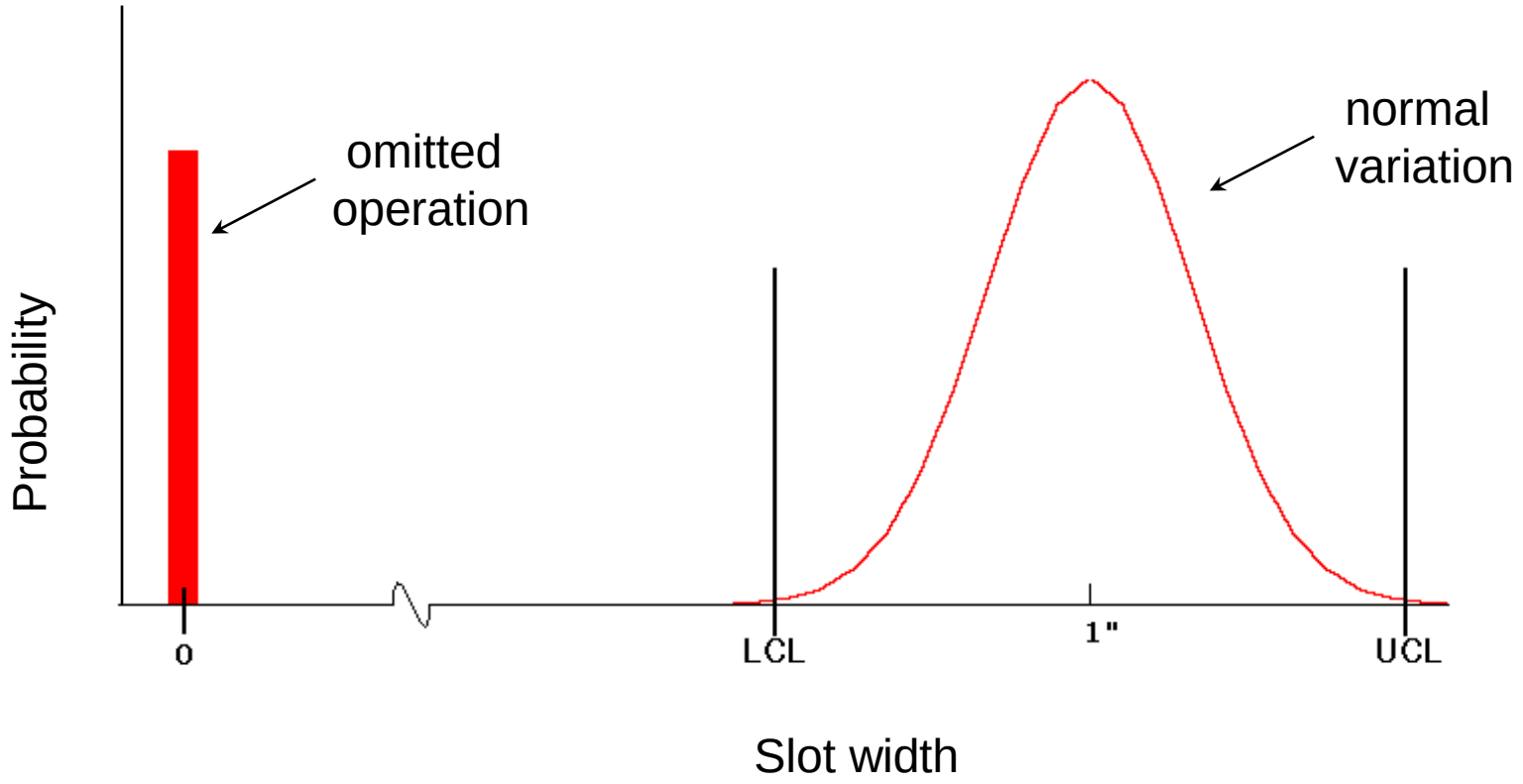


Mistake Proofing and Poka - Yoke

Don’t wait for the perfect
POKA YOKE. Do it now!

Outline

- What is Mistake Proofing?
- Everyday Examples
- Effectiveness & ROI
- Error Proofing and SPC
- Inspection Techniques
- Types of Poka Yokes

What is Mistake Proofing?

- The use of process or design features to prevent errors or their negative impact.
- Also known as ***Poka yoke***, Japanese slang for "avoiding inadvertent errors" which was formalized by Shigeo Shingo.
- Inexpensive.
- Very effective.
- Based on simplicity and ingenuity.

Principles of Mistake-proofing / Poka-Yoke

1. Elimination ("don't do it anymore") is to eliminate the possibility of error by redesigning the product or process so that the task or part is no longer necessary.

2. Prevention ("make sure it can never be done wrong") is to design and engineer the product or process so that it is impossible to make a mistake at all.

3. Replacement ("use something better") is to substitute a more reliable process to improve consistency.

4. Facilitation ("make tasks easier to perform") is to employ techniques and to combine steps to make work easier to perform.

Principles of Mistake-proofing / Poka-Yoke

5. **Detection** ("notice what is going wrong and stop it") is to identify an error before further processing occurs so that the user can quickly correct the problem.
6. **Mitigation** ("don't let the situation get too bad") is to seek to minimize the effects of errors

Elimination, Prevention, Replacement and Facilitation are to avoid the occurrence of mistakes. Detection and Mitigation are to minimize the effects of mistakes once they occur.

When and How to Use it?

- **Processing error:** Process operation missed or not performed per the standard operating procedure.
- **Setup error:** Using the wrong tooling or setting machine adjustments incorrectly.
- **Missing part:** Not all parts are included in the assembly, welding, or other processes.
- **Improper part/item:** Wrong part used in the process.
- **Operations error:** Carrying out an operation incorrectly; having the incorrect version of the specification.
- **Measurement error:** Errors in machine adjustment, test measurement, or dimensions of a part coming in from a supplier.

Benefits Of Poka- Yoke

- *Assures 1st Piece Quality*
- *Assures Consistency during Set-Ups*
- *Prevents Production of Defective Parts*
- *Makes Quality Problems More Visible*
- *Creates a Safer Work Environment*
- *Eliminates Waste of Inspection and Repair*
- *Lowers Cost of Design (DFM) and Cost to Manufacture (Poka-Yoke Devices)*

Everyday Examples

Which dial turns on the burner?

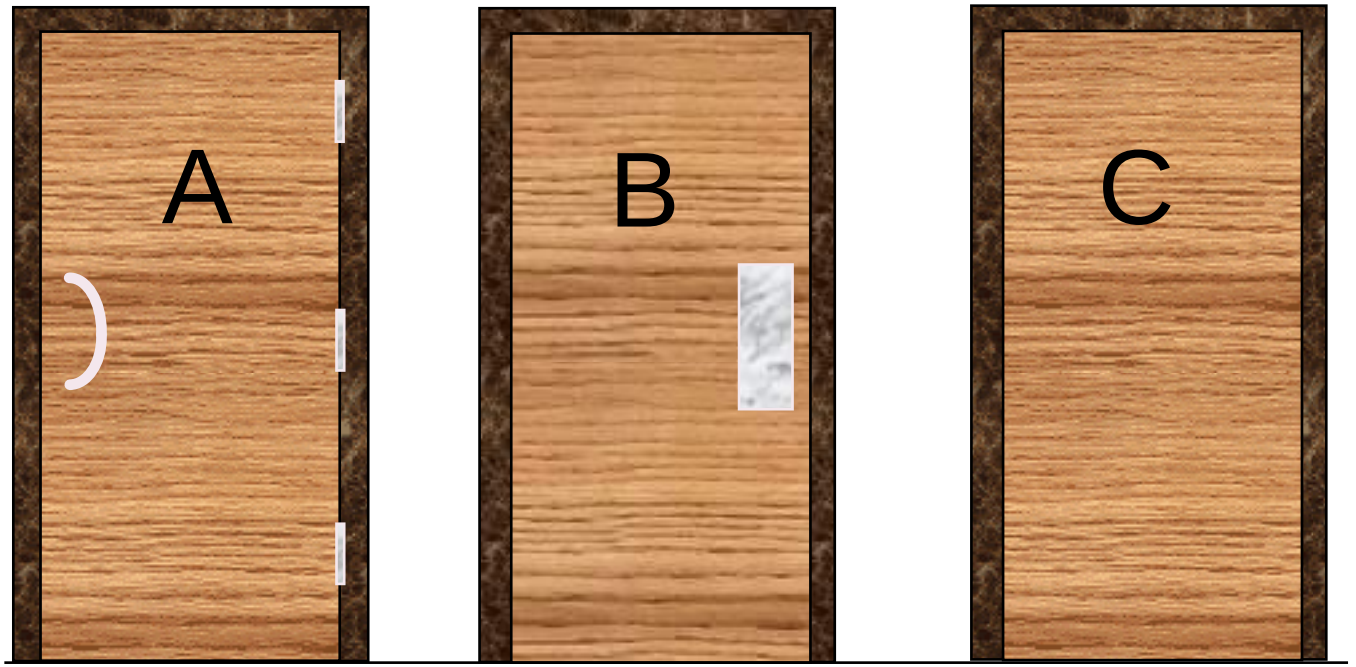
Stove A

Stove B

Everyday Examples

How would you operate these doors?

Push or pull? left side or right? How did you know?



Everyday Examples

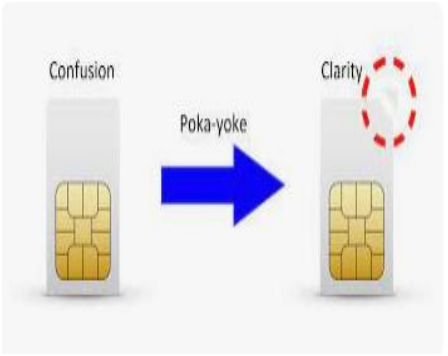
3.5 inch diskettes cannot be inserted unless diskette is oriented correctly. This is as far as a disk can be inserted upside-down. The beveled corner of the diskette along with the fact that the diskette is not square, prohibit incorrect orientation.

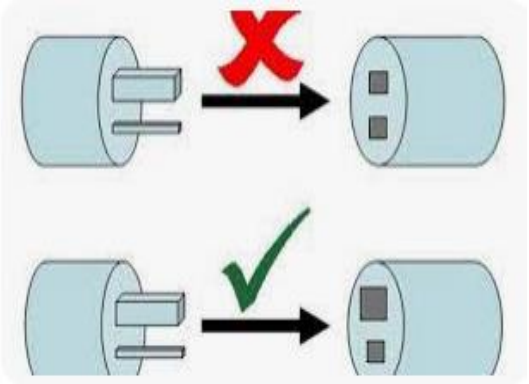
Fueling area of car has three error-proofing devices:

1. insert keeps leaded-fuel nozzle from being inserted
2. tether does not allow loss of gas cap
3. gas cap has ratchet to signal proper tightness and prevent over tightening.

New lawn mowers are required to have a safety bar on the handle that must be pulled back in order to start the engine. If you let go of the safety bar, the mower blade stops in 3 seconds or less.

Everyday Examples





Everyday Examples

Whose signature is required?

Before:

AUTHORIZING SIGNATURES

Operations Engineering Manager: _____ Date : _____

EM/EQA Supervisor: _____ Date : _____

Manufacturing Engineer: _____ Date : _____

Other (As Required): _____ Date : _____

Operations Manager: _____ Date : _____
(MED. or HIGH RISK ONLY)

EQA Manager: _____ Date : _____
(MED. or HIGH RISK ONLY)

After:

Required Authorizing Signatures	Release/Audit update per SOP <or> Experiment Request	ECO Implementation	Part Reconditioning per SOP 12-FP-23-000	Non-ECO associated PCN RISK: VERY LOW, LOW (1.2)	Non-ECO associated PCN RISK: MODERATE, HIGH (3,4)	DATE
Originator						
CCB Eng. Rep.						
Ops. Supervisor*						
QA Supervisor*/QE						
Prod. Ops.Manager						
QA Manager						
Manuf. Eng or Other ex. CTS (as required)						

* *Supervisor of area affected by the change.*

OM

Evidence of the Effectiveness

- **AT&T Power Systems** is first US manufacturer to win the Deming prize. Average outgoing defects reduced by 70%
- A washing machine drain pipe assembly line produced 180,000 units without a single defect (6 months).
- **TRW** reduced customer PPM's from 288 to 2.
- **Federal Mogul**: 99.6% less customer defects and 60% productivity increase
- **DE-STA-CO**: reduced omitted parts 800 to 10 ppm with a 15-30% productivity increase

Evidence of the Effectiveness

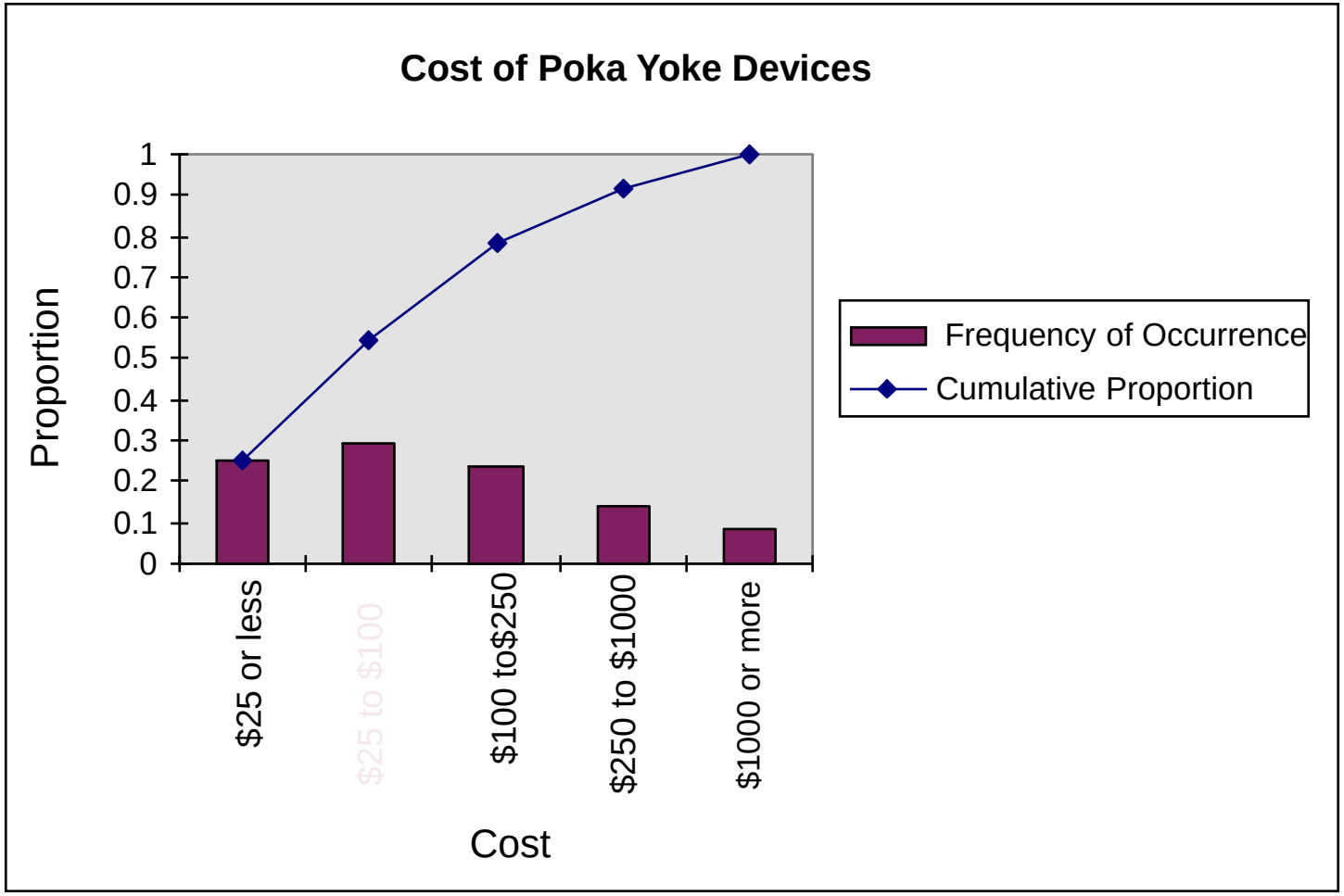
Cooper Automotive:

- 95% less defects than nearest competitor
- 75% less injuries
- 99.6% less customer defects (13 ppm)
- 88% in-plant defect reduction
- 70% less warranty cost
- 89% scrap reduction (0.7%)
- 60% productivity increase

Mistake Proofing ROI

- **Dana** corporation has reported a $500,000 savings resulting from a $6 device
- **Ortho-Clinical Diagnostics (Johnson & Johnson)** saved $75000 annually by discovering a new use of Post-It® notes
- **AT&T Power Systems** (Lucent Technologies) reported net saving of $2545 per device (3300 devices)
- **Weber Aircraft** reports saving $350,000 during their first year of implementation of approximately 300 devices.
- **GE Aircraft Engines** spends a minimum of $500,000 on any in-flight shut-down (IFSD). Spending $10,000 to stop one IFSD yields 50:1 benefit

Cost of Poka Yoke Devices



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Costs of Defects

Does it cost more to make processes better ?

No Making processes better leads to reduced

- Rework
- Scrap
- Warranty costs
- Inspection costs

1-10-100 Rule

The 1-10-100 rule states that as a product or service moves through the production system, the cost of correcting an error multiplies by 10.

Activity	Cost
Order entered correctly	$ 1
Error detected in billing	$ 10
Error detected by customer	$ 100

Dissatisfied customer shares the experience with others…

Mistake proofing Puts "Knowledge in the World" In addition to "Knowledge in the Head"

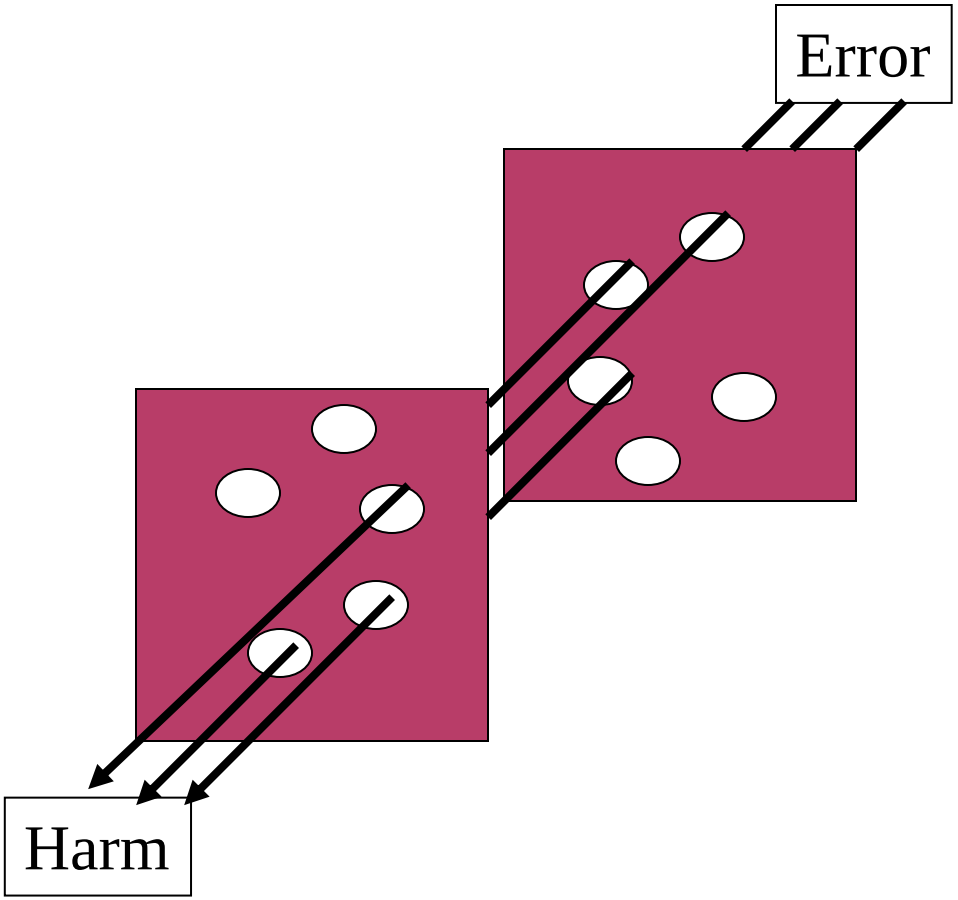
Head:

- "Improve" SOPs (increasing complexity?)
- Retrain
- Re-certify skills
- Manage & enhance attentiveness

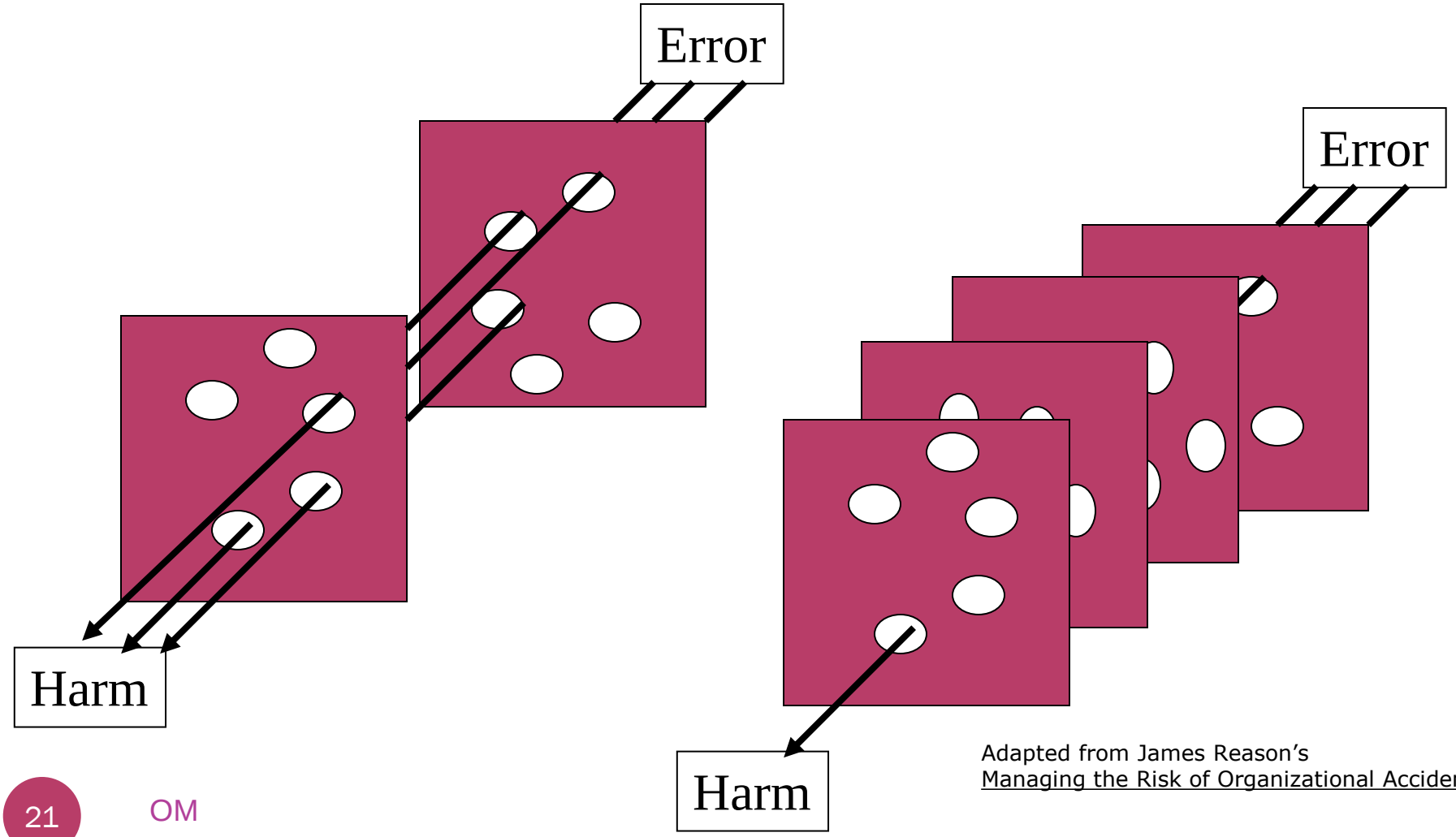
World:

- Provide clues about what to do
- Change process design: embed the details in the process
- Frees mind to consider the "big picture"
- Facilitates "knowledge work"

No System of Barriers is Perfect…



No System of Barriers is Perfect…
…But improvements can be made

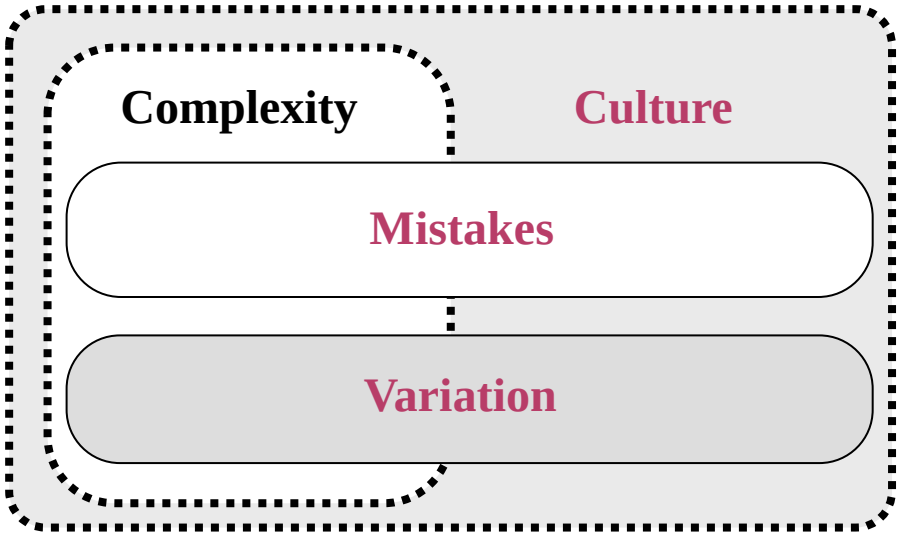


Adapted from James Reason's
Managing the Risk of Organizational Accidents

Where does mistake proofing fit?

- *Non-Conformances come from many sources including:*
- **Variation**
- **Culture**
- **Complexity**
- **Mistakes**

Each must be managed to improve quality and reliability.



The difficulties with human error

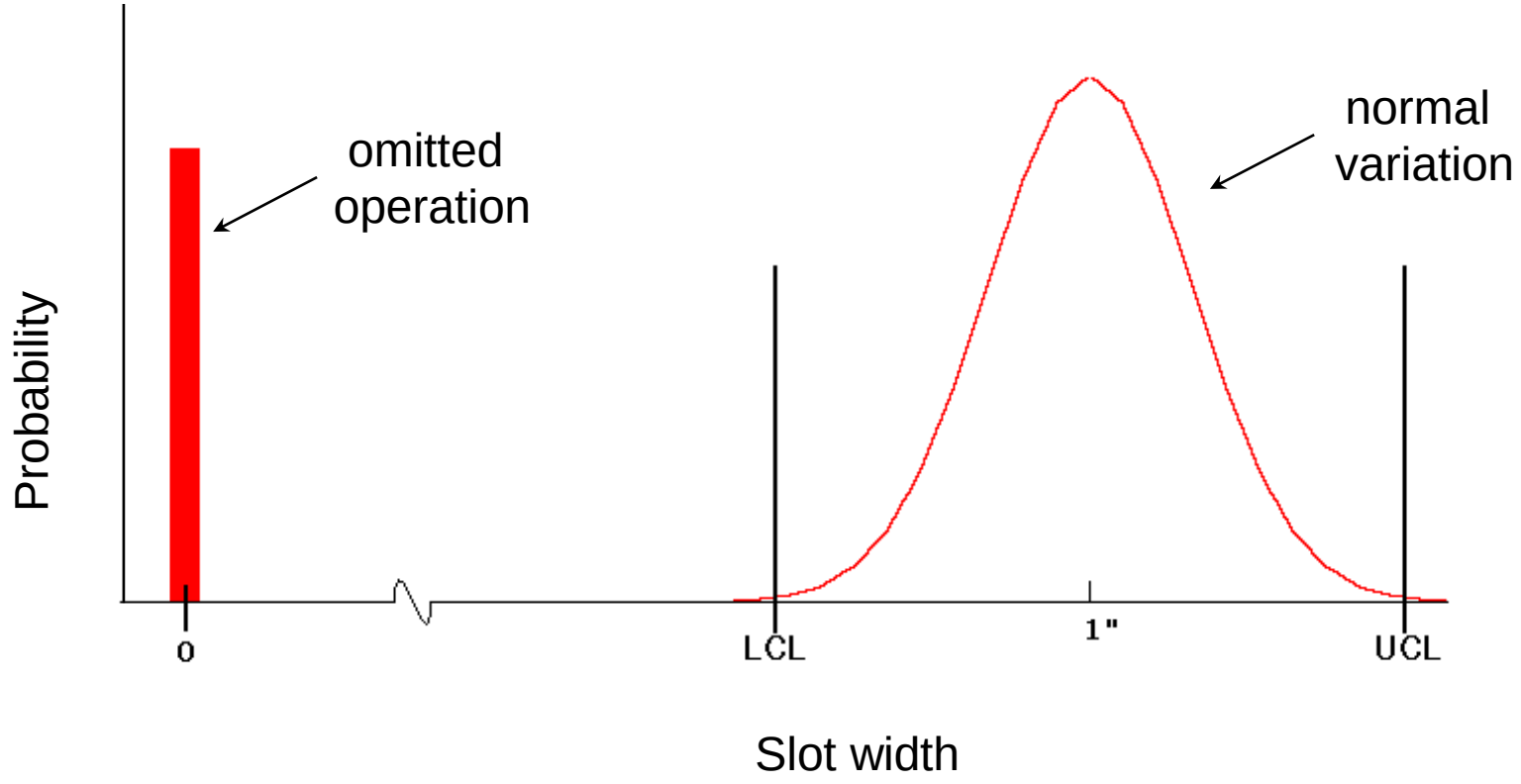
Why existing tools are not enough

Motorola findings:

…it became evident early in the project that achieving a C_p greater than 2 would go only part of the way. Mistake proofing the design would also be required … Mistake proofing the design is an essential factor in achieving the [total number of defects per unit] goal.

Smith, B. IEEE Spectrum 30(9) 43-47

Errors are difficult to manage using statistics.



Poka yoke & SPC

	X-bar chart (measurement data)	**p-chart (attribute data)**
Successive-checks or Self-checks	use to sort out defects, will not improve the process	special case of np-chart, ad hoc design, will also sort out defects
Source-Inspection	use as corrective action for special causes	use to eliminate specific types of defects

Error proofing & SPC

- SPC is good at detecting shifts in the process mean or variance. Changes to the process must be ongoing to be readily detected.
- Human errors tend to be rare, intermittent events. They are not readily detected by control charts.
- Use error proofing (not SPC) to reduce defects caused by human error

Motorola got an order of error proofing. magnitude closer to their goal using a combination of SPC and

Individually, mistakes are *rare*

Task Type	Probability
Detection of deviation or inspection	0.07
Alpha input per character	0.008
Numeric input per character	0.003
Assembly per task element	0.00007

As a group they are *common*

Research study #1 (Harris)	>0.80
Research study #2 (Rook)	0.82
Research study #3 (Voegtlen)	0.60
Research study #4 (Headlamps)	>0.70
NASA mishaps	>0.50
FAA Maintenance problems	>0.94

Human Error

Have you ever done the following:

- Driven to work and not remembered it?
- Driven from work to home when you meant to stop at a store?

It happens to workers, too

- Workers finish the shift and don't remember what they have done.
- After building green widgets all morning, the workers put green parts on the red widgets in the afternoon.

Corrective action

- Recent poll on the Quality newsgroup on the internet: A majority reported at least 20-30% of corrective actions were "worker reprimanded and retrained."
- The admonition to "be more careful" or "pay attention" are not effective for humans, especially in repetitive environments.

"Be more careful" not effective

- "The old way of dealing with human error was to scold people, retrain them, and tell them to be more careful … My view is that you can't do much to change human nature, and people are going to make mistakes. If you can't tolerate them … you should remove the opportunities for error."
- "Training and motivation work best when the physical part of the system is well-designed. If you train people to use poorly designed systems, they'll be OK for awhile. Eventually, they'll go back to what they're used to or what's easy, instead of what's safe."
- "You're not going to become world class through just training, you have to improve the system so that the easy way to do a job is also the safe, right way. The potential for human error can be dramatically reduced."

A New Attitude Toward Preventing Errors

"Think of an object's user as attempting to do a task, getting there by imperfect approximations. Don't think of the user as making errors; think of the actions as approximations of what is desired."*

A New Attitude Toward Preventing Errors

- Make wrong actions more difficult
- Make it possible to reverse actions —to "undo" them—or make it harder to do what cannot be reversed.
- Make it easier to discover the errors that occur.
- Make incorrect actions correct.

Processes and quality defects

- Almost any business activity can be considered a process.
- Production processes involve the flow of material. Machining, assembly, and packaging are typical production processes.
- Business processes involve the flow of information. Financial planning, purchasing & order entry are typical business processes.
- All processes have the potential for defects. Hence, all processes offer a opportunity for the elimination of defects and the resultant quality improvement.

What Causes Defects?

1. **Poor procedures or standards.**
2. **Machines.**
3. **Non-conforming material.**
4. **Worn tooling.**
5. ***Human Mistakes.***

Except for human mistakes these conditions can be predicted and corrective action can be implemented to eliminate the cause of defects

What Causes Defects?

Human Mistakes

Simple errors- the most common cause of defects- occur unpredictably.

The defect goal is zero! Make certain that the required conditions are in place and controlled to make acceptable product 100% of the time.

Ten Types of Human Mistakes

- Forgetfulness
- Misunderstanding
- Wrong identification
- Lack of experience
- Willful (ignoring rules or procedure)
- Inadvertent or sloppiness
- Slowliness
- Lack of standardization
- Surprise (unexpected machine operation, etc.)
- Intentional (sabotage)

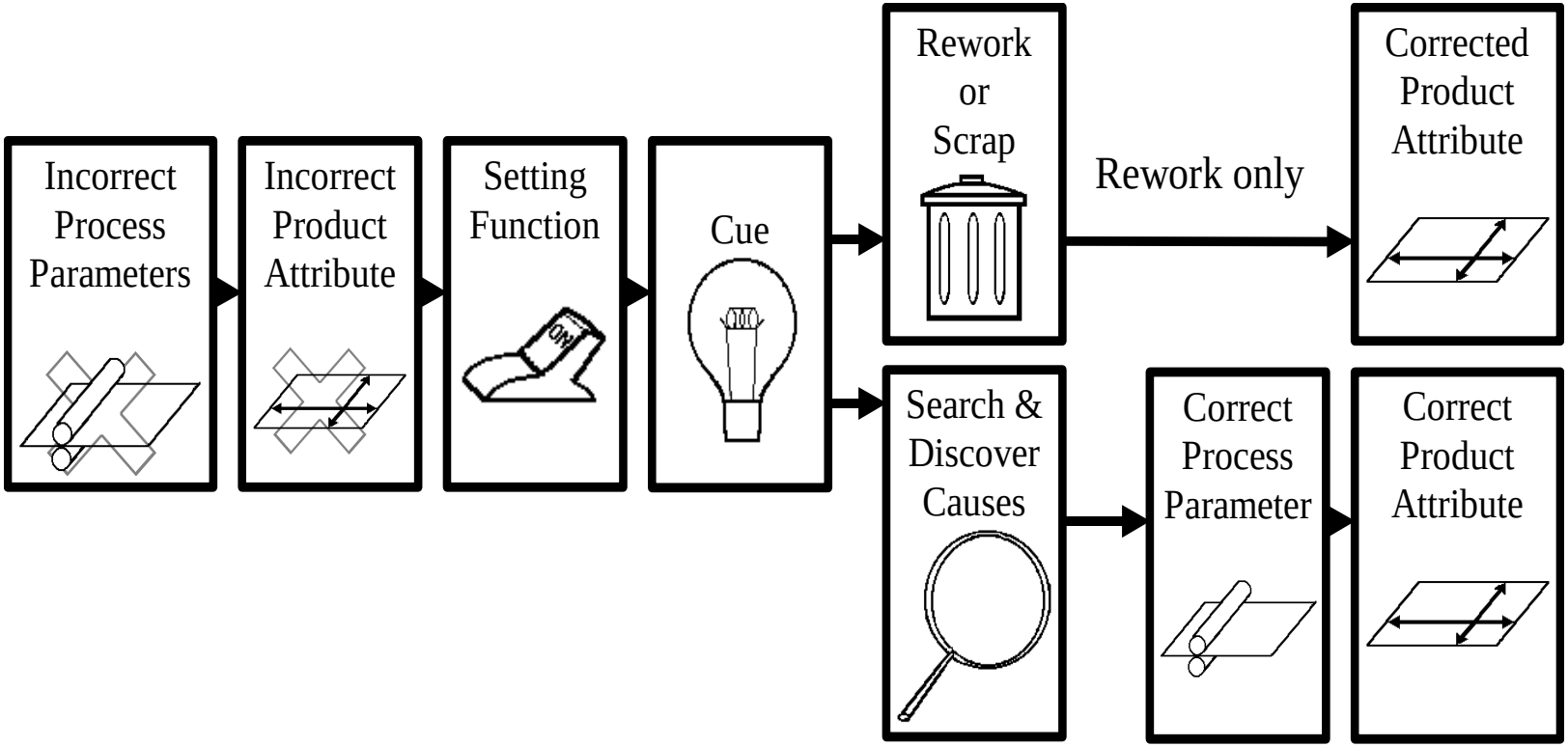
Achieving Zero Defects

1. **Point of Origin Inspection**
2. **100 % Audit Checks**
3. **Immediate Feedback**
4. **Poka Yoke**

Judgment Inspection

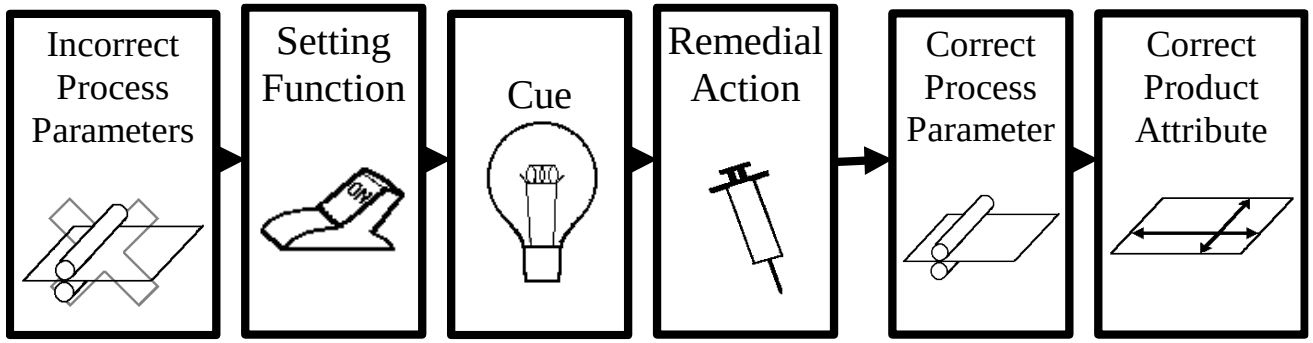
- Involves sorting the defects out of the acceptable product, sometimes referred to as "inspecting in quality."
- The consensus in modern quality control is that "inspecting in quality" is not an effective quality management approach.
- Judgment inspection does not improve process and should be used only in the short term.

Successive checks & Self-check (post-production product inspection)

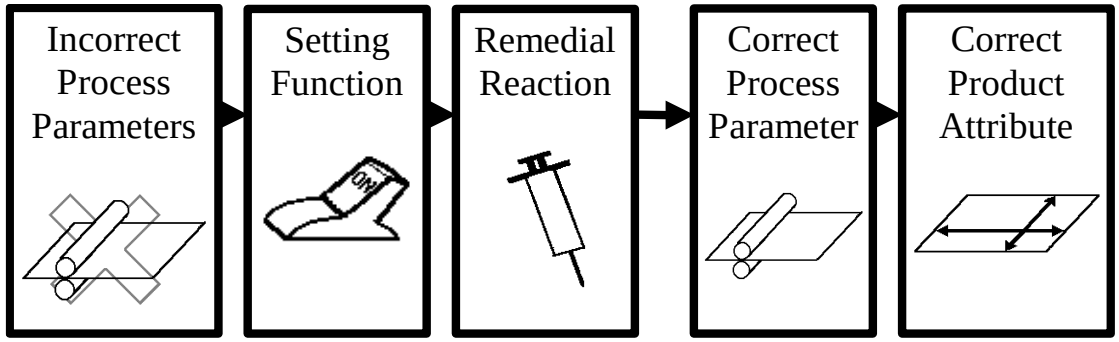


Source Inspection

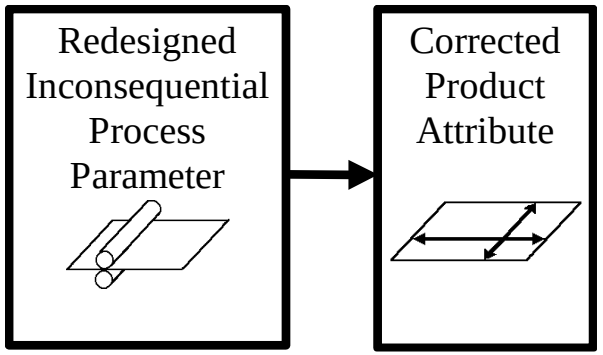
Source Inspection



Self-Correcting Process



Error opportunity elimination (Mistake-Proof Design)



Inspection

The 3 basic approaches to inspection of processed product are:

Judgement/Standard Inspection

Informative Inspection

Point of Origin Inspection

The first two approaches are widely used and considered traditional.

Only Point of Origin Inspection actually eliminates defects.

Point of Origin Inspection

Focus on prevention, not detection.

One of the 4 basic elements.

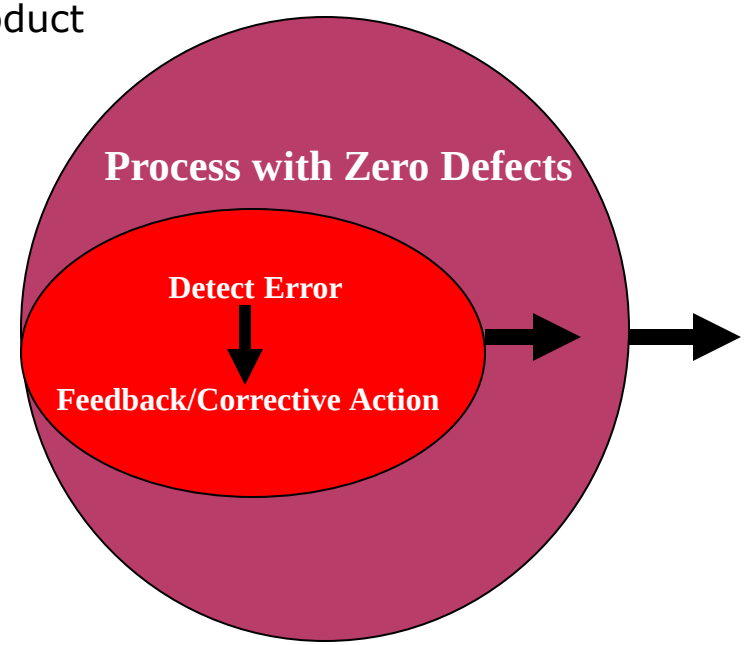
Differs from Judgement and Informative:

- Catches errors
- Gives feedback before processing
- No risk of making more defective product

May include: Switches that detect miss-fed parts

- Pins that prevent miss-feeding
- Warning lights
- Sound signals

By combining Check and Do, the Doing is controlled so it cannot be wrong 100% of the time!



Check and Do/Point of Origin Inspection

Point of Origin Inspection

- Check for optimum process conditions before processing is done and errors can be made.
- Instant feedback.
- Corrections made before defects occur.

Setting Functions

How are you going to detect an error?

- automatic, not dependent on human attention
- fail in “detect” mode
- simple & low cost if possible

Regulatory Function

The real questions you need to ask:

- How are you going to stop the process?
  - the worker needs to get the message?
    - By audible or visible warning
    - By prohibiting further processing
- How are you going to eliminate the possibility of error?
  - The Contrapositive of Murphy's Law
    - Simplicity
    - Symmetry

Put “Knowledge in the World”

Precise outcomes without precise knowledge or action?

provide clues about what to do:

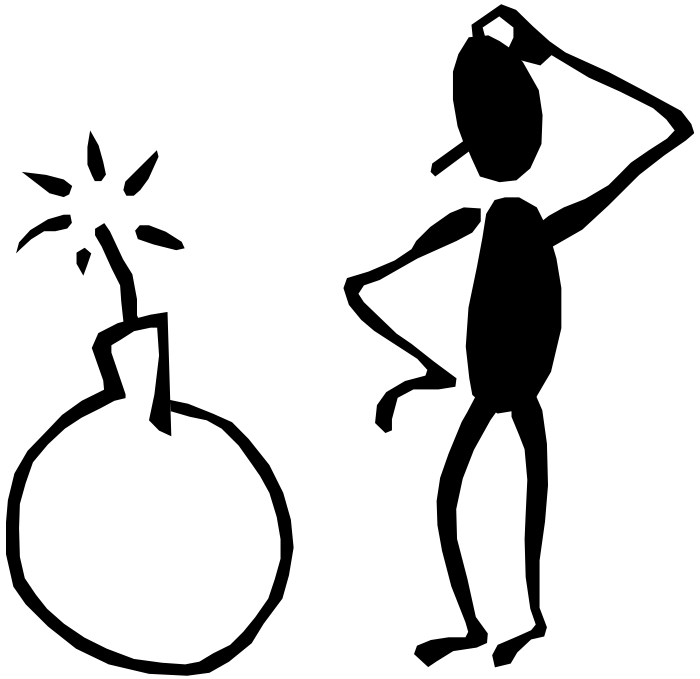
- natural mappings
- affordances
- visibility
- feedback
- constraints

Visibility and Feedback

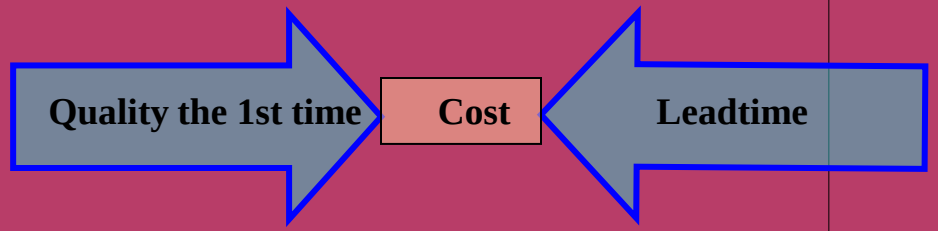
- Visibility means making relevant parts visible, and effectively displaying system status.
- Feedback means providing an immediate and obvious effect for each action taken.

Mistake Proof or Poka yoke the process!

Not noticing that an error is made or a machine is not functioning does not make a person stupid or foolish.



Poka Yoke results in Quality of Processes



Transformation = Quality production the 1st time

Inspection….eliminated ???

Transport

Storage

Delay/wait

Dedicated lines

One piece flow

Quick Feedback

Error correction as soon as possible

Differs from traditional inspection approaches that:

- Correct problems after the process
- Address the problem when errors are already defects
- In some cases never identify an error has occurred

Poka yoke

Mistake proofing systems

Does not rely on operators catching mistakes

Inexpensive Point of Origin inspection

Quick feedback 100% of the time

Seven Guidelines to Poka Yoke Attainment

1. Quality Processes - Design “Robust” quality processes to achieve zero defects.
2. Utilize a Team Environment - leverage the teams knowledge,experience to enhance the improvement efforts.
3. Elimination of Errors - Utilize a robust problem solving methodology to drive defects towards zero.
4. Eliminate the “Root Cause” of The Errors - Use the 5 Why’s and 2 H’s approach
5. Do It Right The First Time - Utilizing resources to perform functions correctly the “first” time.
6. Eliminate Non-Value Added Decisions - Don’t make excuses-just do it !
7. Implement an Incremental Continual Improvement Approach-implement improvement actions immediately and focus on incremental improvements; efforts do not have to result in a 100% improvement immediately.

Poka yoke

Poke-yoke and Point of Origin Inspections(Proactive Approach):

A fully implemented zero defect system requires Poka yoke usage at or before the inspection points during the process.

Poka yoke will catch the errors before a defective part is manufactured 100% of the time.

Poka-yoke

Poka yoke and Informative Inspection(Reactive Approach):

- Check occurs immediately after the process.
- Can be an operator check at the process or successive check at the next process.
- Not 100% effective, will not eliminate all defects.
- Effective in preventing defects from being passed to next process.

*Although not as effective as the Source inspection approach, this methodology is **more** effective than statistical sampling and **does** provide feedback in reducing defects.*

Poka yoke Systems Govern the Process

Two Poka Yoke System approaches are utilized in manufacturing which lead to successful zero defect systems:

1. Control Approach

Shuts down the process when an error occurs.

Keeps the "suspect" part in place when an operation is incomplete.

2. Warning Approach

Signals the operator to stop the process and correct the problem.

Control Approach

- Takes human element out of the equation;does not depend on an operator or assembler.
- Has a high capability of achieving zero defects.
- Machine stops when an irregularity is detected.

Warning Approach

- Sometimes an automatic shut off system is not an option.
- A warning or alarm system can be used to get an operators attention.
- Below left is an example of an alarm system using dials, lights and sounds to bring attention to the problem.
- Color coding is also an effective non automatic option.

Common Mistake proofing Devices

- Guide Pins
- Blinking lights and alarms
- Limit switches
- Proximity switches
- Counters
- Checklists

Methods for Using Poka yoke

Poka yoke systems consist of three primary methods:

1. Contact
2. Counting
3. Motion-Sequence

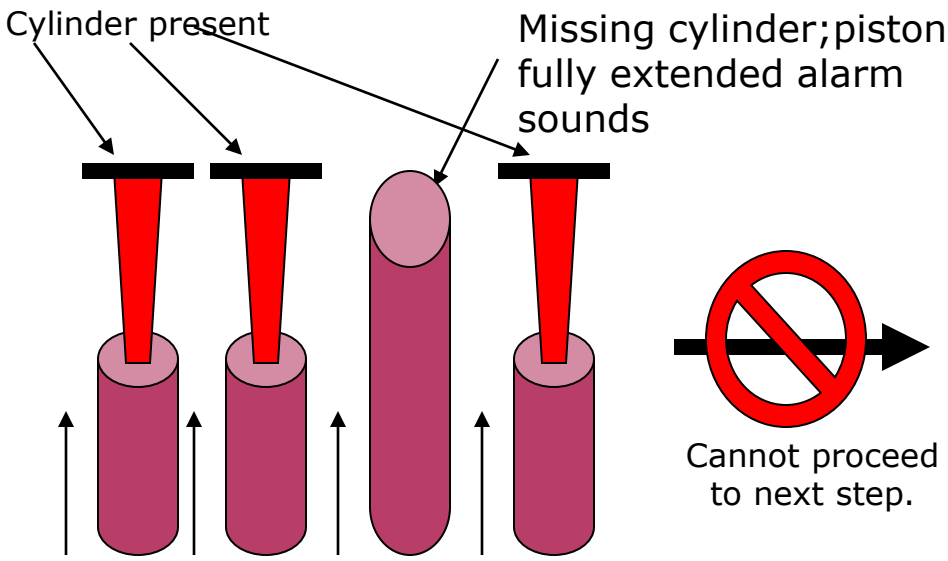
Each method can be used in a control system or a warning system.

Each method uses a different process prevention approach for dealing with irregularities.

Contact Method

A contact method functions by detecting whether a sensing device makes <u>contact</u> with a part or object within the process.

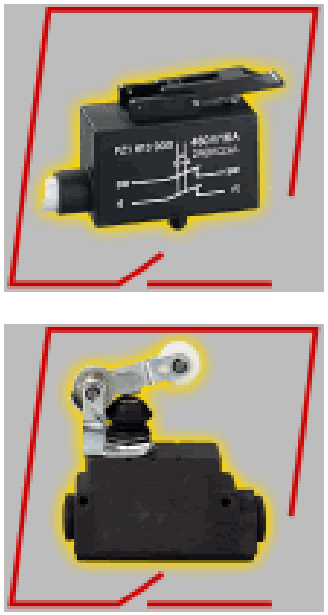
An example of a physical contact method is limit switches that are pressed when cylinders are driven into a piston. The switches are connected to pistons that hold the part in place. In this example, a cylinder is missing and the part is not released to the next process.

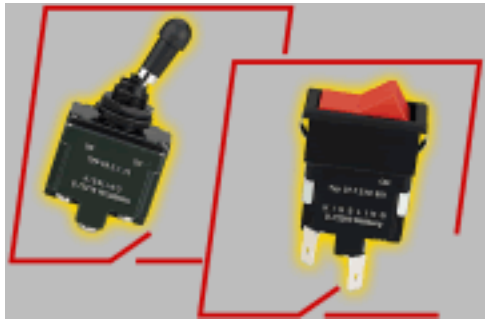


Contact Method using limit switches identifies missing cylinder.

Physical Contact Devices

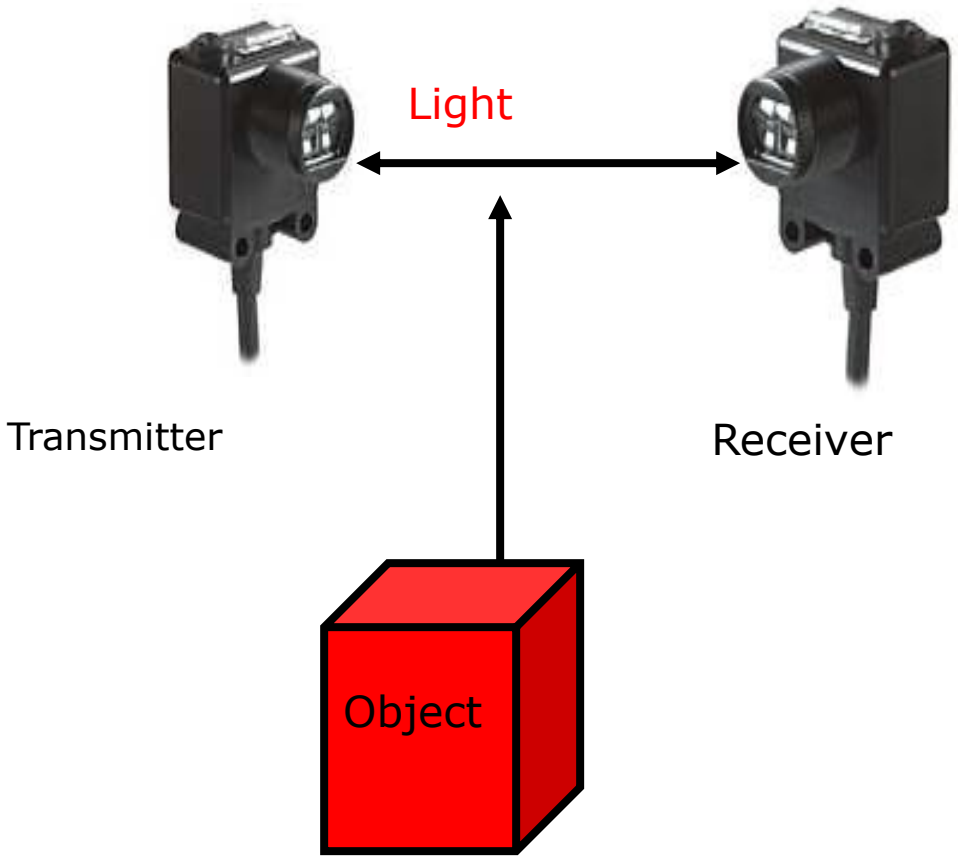
Limit Switches





Toggle Switches

Energy Contact Devices



Photoelectric switches can be used with objects that are translucent or transparent depending upon the need.

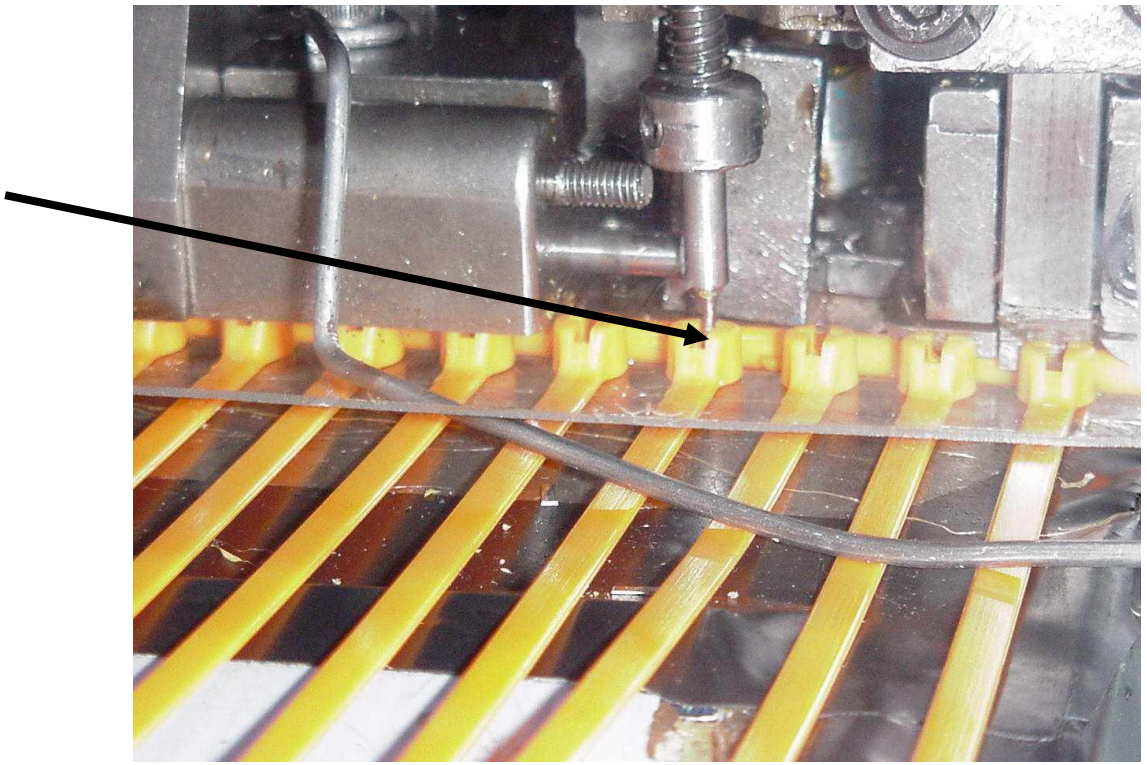
Transmission method: two units, one to transmit light, the other to receive.

Reflecting method:PE sensor responds to light reflected from object to detect presence.

If object breaks the transmission, the machine is signaled to shut down.

Contact Device

An example of a *contact* device using a limit switch. In this case the switch makes *contact* with a metal barb sensing it's presence. If no *contact* is made the process will shut down.



Contact Methods

Do not have to be high tech!

Passive devices are sometimes the best method. These can be as simple as guide pins or blocks that do not allow parts to be seated in the wrong position prior to processing

Take advantage of parts designed with an uneven shape!

A work piece with a hole a bump or an uneven end is a perfect candidate for a passive jig. This method signals to the operator right away that the part is not in proper position.

Counting Method

Used when a *fixed* number of operations are required within a process, or when a product has a fixed number of parts that are attached to it.

A sensor counts the number of times a part is used or a process is completed and releases the part only when the right count is reached.

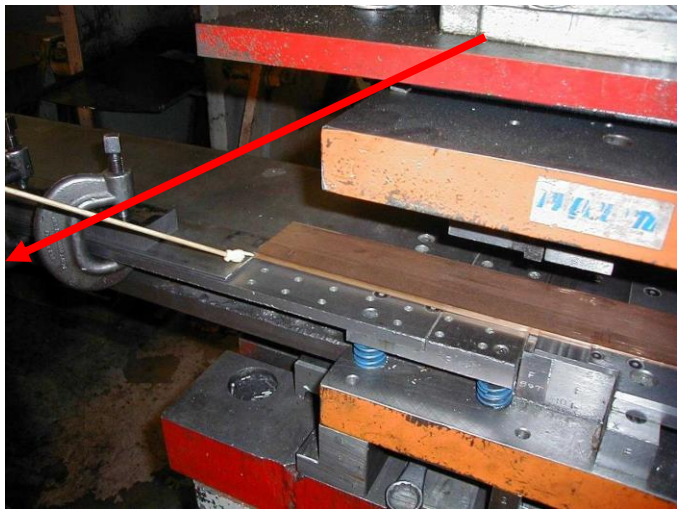
Counting Method

Another approach is to count the number of parts or components required to complete an operation in advance. If operators find parts leftover using this method, they will know that something has been omitted from the process.

Motion-Sequence Method

The third poka yoke method uses sensors to determine if a motion or a step in a process has occurred. If the step has not occurred or has occurred out of sequence, the the sensor signals a timer or other device to stop the machine and signal the operator.

This method uses sensors and photo-electric devices connected to a timer. If movement does not occur when required, the switch signals to stop the process or warn the operator.



Motion-Sequence Method

In order to help operators select the right parts for the right step in a process the "sequencing" aspect of the motion-step method is used. This is especially helpful when using multiple parts that are similar in size and shape.

In this example, each step of the machine cycle is wired to an indicator board and a timer. If each cycle of the machine is not performed within the required "time" and "sequence", the indicator light for that step will be turned on and the machine will stop.

Machine

Indicator Board

Types of Sensing Devices

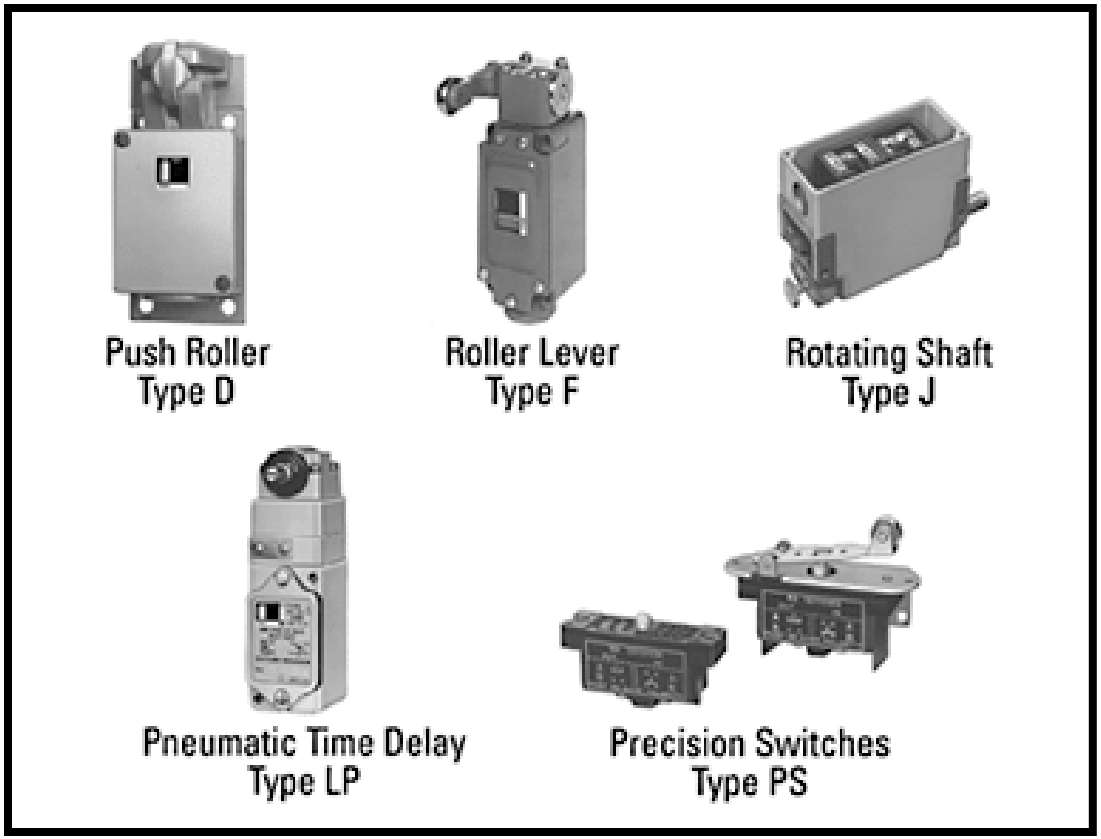
Sensing devices that are traditionally used in poka yoke systems can be divided into three categories:

1. Physical contact devices
2. Energy sensing devices
3. Warning Sensors

Physical Contact Sensors

These devices work by physically touching something. This can be a machine part or an actual piece being manufactured.

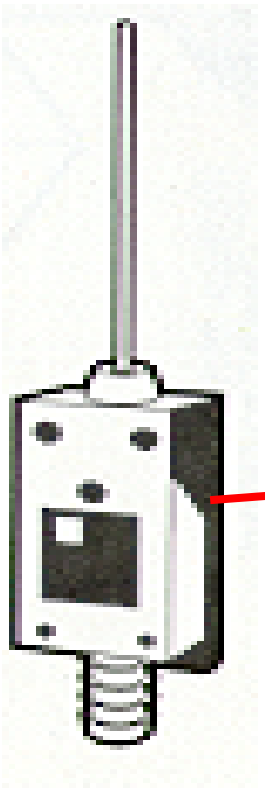
In most cases these devices send an electronic signal when they are touched. Depending on the process, this signal can shut down the operation or give an operator a warning signal.

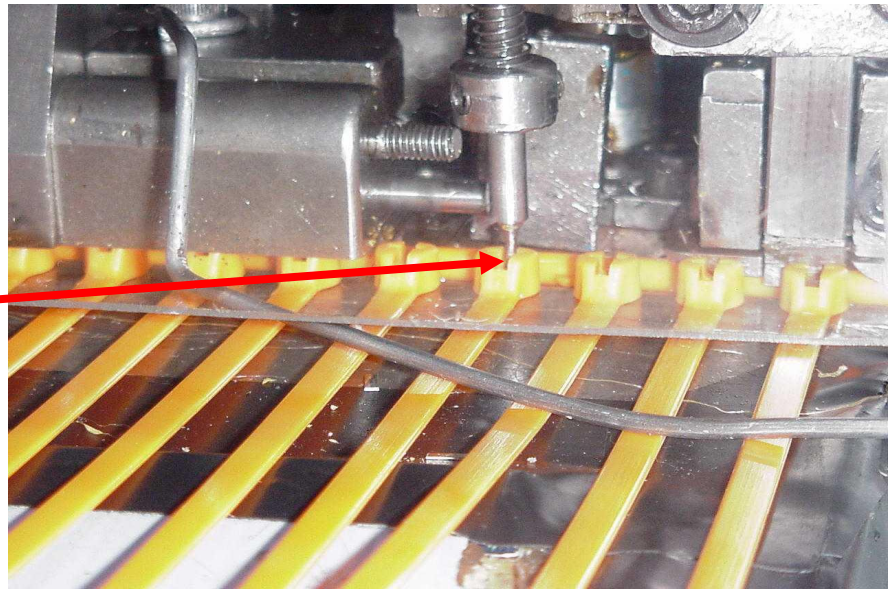


Touch Switch

Used to physically detect the presence or absence of an object or item-prevents missing parts.

Used to physically detect the height of a part or dimension.





Energy Sensors

These devices work by using energy to detect whether or not an defect has occurred.

PFS-PRESSURE & FORCE

Vibration

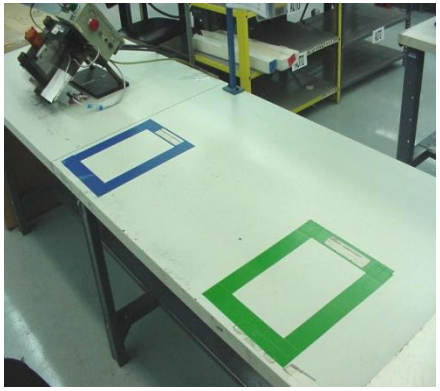
Photoelectric

Fiber optic

Warning Sensors

Warning sensors signal the operator that there is a problem. These sensors use colors, alarms, lights to get the workers attention !

These sensors may be used in conjunction with a contact or energy sensor to get the operators attention.



Color Code

Lights

Lights connected to Micro switches & timers

3 Rules of POKA YOKE

- Don’t wait for the perfect POKA YOKE. Do it now!
- If your POKA YOKE idea has better than 50% chance to succeed…Do it!
- Do it now….improve later!