Mistake Proofing (Poka-Yoke)

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Fifteenth Edition

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Mistakes: “To Err Is Human”

- **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?

Examples of Defects Caused by Mistakes

Problem: Cut surface is covered with burrs.

Mistake: Someone did not replace the cutting tools.

Problem: Machinery malfunctions, resulting in defects.

Mistake: PM of the machinery was neglected.

Problem: Processing mistakes resulted in defects.

Mistake: Someone mistook a work piece of one type for one of another type.

Mistake Proofing Course Objectives

- **To develop your knowledge and understanding of the philosophy, history and benefits of Mistake Proofing.**
- **To develop your understanding regarding how Mistake Proofing fits into a modern quality management system.**
- **To develop your ability to plan and deploy Mistake Proofing methods to achieve significant reductions in defect rates.**

Chapter 1

Introduction to Mistake Proofing

Where It All Began

- *"Zero Quality Control: Source Inspection and the Poka-yoke System."* – Shigeo Shingo

- **ZQC created by Shingo to help Toyota meet the goal of Zero Defects Production.**

"the relentless pursuit of perfection"

A Little Bit of History

- **Shigeo Shingo was a consultant to Toyota who has been credited with creating and formalizing Zero Quality Control (ZQC), an approach to quality management that relies heavily on the use of poka-yoke (pronounced POH-kah YOH-kay) devices.**
- **Poka-yoke is a Japanese term for mistake proofing. Poka-yoke devices are used to prevent the mistakes that result in defects or to inexpensively inspect each item that is produced to detect whether it is acceptable or defective.**

***Poka-yoke* is Japanese for *Yokeru* (avoid) and *poka* (inadvertent errors/mistakes).**

Mistake Prevention – The Problem

- **Early in the development of poka-yoke, Shingo cited an example as to how *finding mistakes at a glance helps to avoid defects*:**
  - A worker must assemble a device that has two push-buttons. A spring must be put under each button. ***Sometimes a worker will forget to put the spring under the button and a defect occurs.***
  - Shingo suggested that operators make **two types of errors – forgetting and forgetting that one has forgotten.**

Mistake Prevention – The Solution

- **Shingo developed a simple poka-yoke system to address this problem:**
  1. Operator takes two springs from the parts box and places them on a dish.
  2. Operator begins switch assembly, inserts springs and installs buttons.
  3. If a spring remains in the dish after assembly, the operator must re-assemble the switch.

The process now "reminds" the operator not to forget to install a spring under each switch!

Interchangeable Terms

- **When Shigeo Shingo first formalized the ZQC concept, he originally used the word "*Baka-yoke*" (Japanese for "fool proofing"), instead of "*poka-yoke*".**
  - The word was changed to "*poka-yoke*" because he was afraid he would offend the operators as the word "*Baka-yoke*" implied that "operators were fools".
- **For the purpose of this course we will not make a distinction between the following words, which can be used interchangeably: *Poka-yoke,* Mistake Proofing, Error Proofing, Fool Proofing, or Fail-safeing.**
  - Terms such as "Fool Proof" and "Idiot Proof" are pejorative terms.

Relationship Between Poka-yoke and Quality System Standards

- QS-9000 (3rd edition) and Mistake Proofing
- ISO9001 and Mistake Proofing (fool proofing)
- IATF 16949:2016 and Mistake Proofing

What does the AIAG APQP manual say about mistake proofing?

ISO 9001 and Mistake Proofing

7.1.5.2 Measurement traceability

….The organization should consider means to eliminate potential errors from processes, such as "fool-proofing," for verification of process outputs in order to minimize the need for control of measuring and monitoring devices, and to add value for interested parties.

8.3.3.2 Manufacturing Process Design Input

- The organization shall identify, document and review the manufacturing process design input requirements, including but not limited to the following:
  - Product design output data including special characteristics;
  - Targets for productivity, process capability and cost, timing and cost;
  - Manufacturing technology alternatives;
  - Customer requirements if any;
  - Product handling and ergonomic requirements; and
  - Design for manufacturing and design for assembly.

NOTE: the organization should use error-proofing methods in their manufacturing process design process to a degree appropriate to the magnitude of the problems and commensurate with the risks encountered.

8.3.5.1 Design and Development outputs – Supplemental

- The product design output shall be expressed in terms that can be verified and validated against product design input requirements.
- The product design output shall include but is not limited to the following ,as applicable:
  - Design risk analysis (FMEA);
  - Results of product design error-proofing,such as DFSS,DFMA and FTA;
  - Product design review results.

8.3.5.2 Manufacturing Process Design Output

- The organization shall document the manufacturing process design output in a manner that enables verification against the manufacturing process design inputs. The organization shall verify the outputs against manufacturing process design input requirements.
- The manufacturing process design output shall include but is not limited to the following:
  - Results of error-proofing identification and verification, as appropriate ;
  - Methods of rapid detection,feedback,and correction of product/manufacturing process nonconformities.

10.2.4 Error-proofing

– The organization shall have a documented process to determine the use of appropriate error-proofing methodologies. Details of the method used shall be documented in the process risk analysis (such as PFMEA) and test frequencies shall be documented in the control plan.

AIAG APQP Manual & Mistake Proofing

The AIAG, APQP Manual References to Mistake Proofing:

- Appendix B – Analytical Techniques: *"mistake proofing – mistake proofing (poka-yoke) is a technique to eliminate errors often referred to as "fail safeing." Mistake proofing should be used as a preventive technique to control repetitive tasks or actions. This technique is designed to reduce customer concerns."*
- Appendix A – A3 New Equipment, Tooling and Test Equipment Checklist: *"has tool and equipment design provided for: …mistake proofing?…"*

AIAG APQP Manual & Mistake Proofing

The AIAG, APQP Manual References to Mistake Proofing:

– **Appendix A – A4 Product/Process Quality Checklist:** *"has training been completed for: …mistake proofing?…"*

– **Appendix H – Glossary – Design Information Checklist:** *"a mistake proofing checklist designed to assure that all important items were considered in establishing design requirements."*

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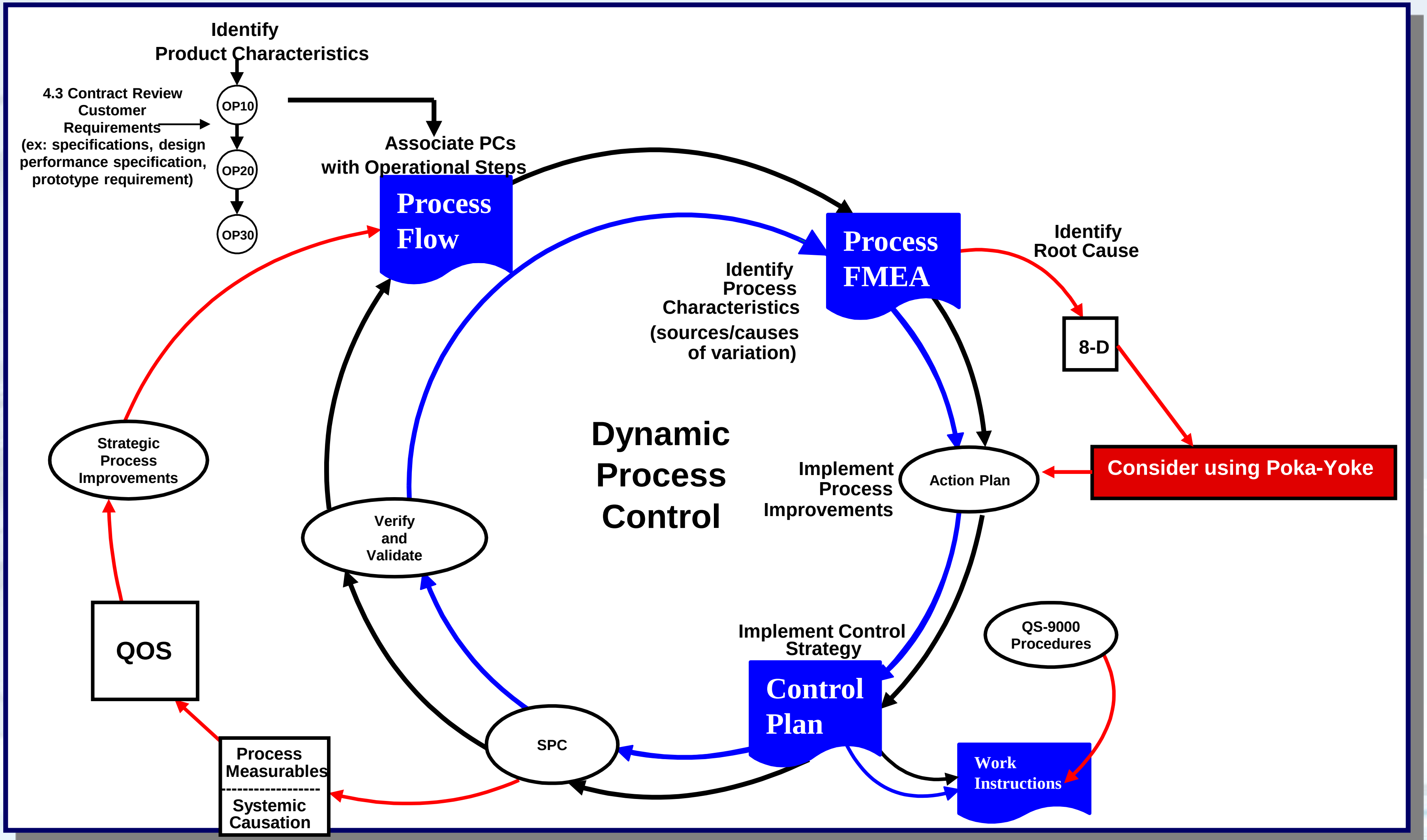
APQP/AQP Systems Diagram



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The Classical View of Quality

Practical Meaning of *"99% Good"*

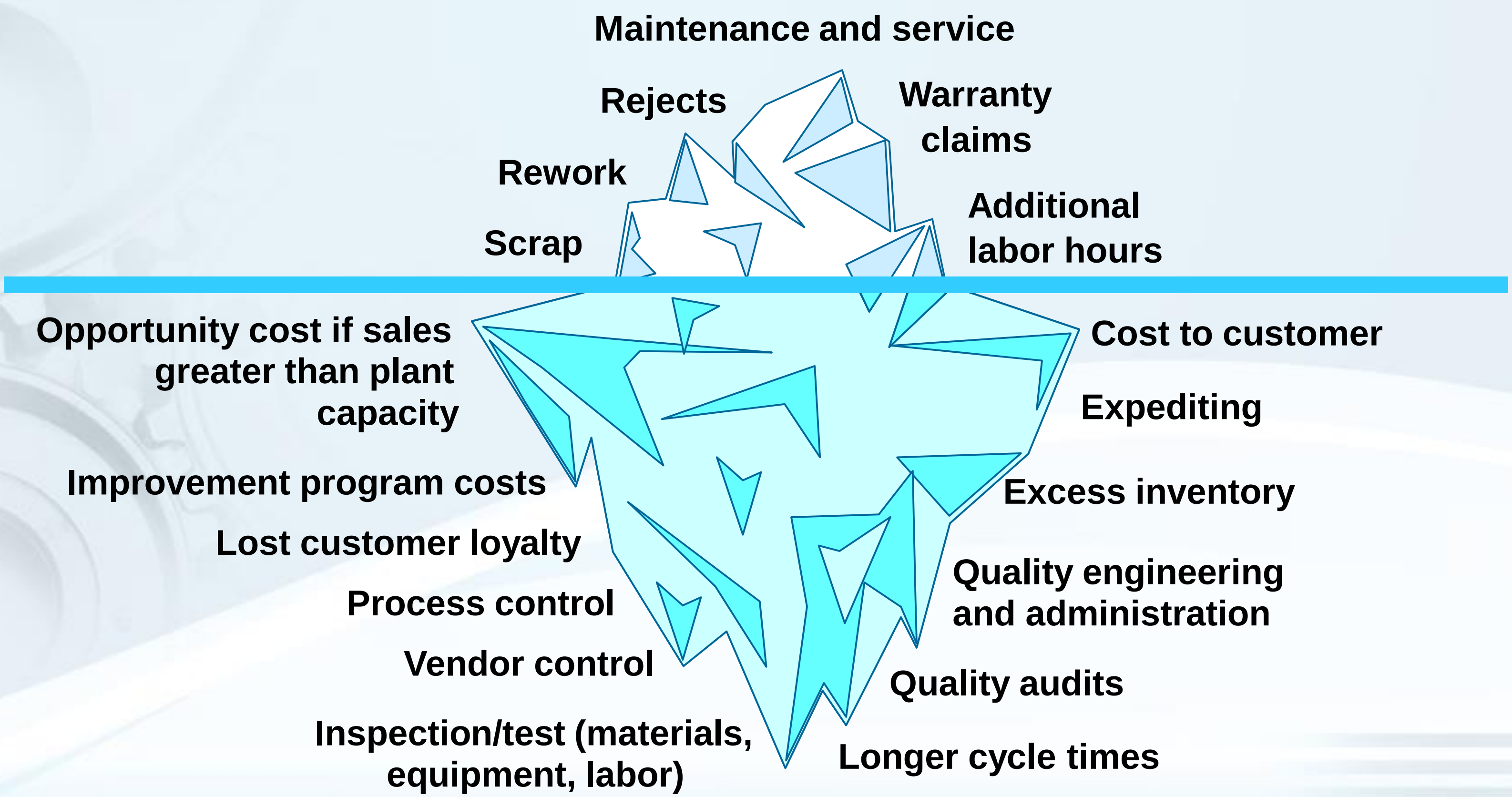
- 20,000 lost articles of mail per hour.
- 15 minutes of unsafe drinking water each day.
- 5,000 incorrect surgical operations per week.
- 2 unsafe landings at all major airports each day.
- 200,000 wrong drug prescriptions each year.
- No electricity for almost 7 hours each month.
- 50 newborn babies dropped at birth every day.

The Cost of Quality

- **Quality management is not just the control of quality – it also must consider the cost of the quality management system.**

- **The cost of quality is made up of two parts:**
  - Cost to find and fix defects
  - Cost to prevent defects

Cost of Poor Quality (COPQ) - The Tip of the Iceberg



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Five Categories of the COQ

1. **The Cost of Failure in the Field**
   - This includes costs such as warranty claims as well as the cost to service problems. Companies have access to data on the costs incurred by the customer as a result of the failure, but normally group these costs as part of the opportunity costs.
2. **The Internal Failure Costs, the Costs in Labor and Material Associated with Scrapped Parts and Rework**
   - These costs also include the additional inventory that we carry for safety stock to cover quality-related problems.
3. **The Costs of Appraisal and Inspection**
   - The material (for samples), test equipment, and labor costs to find defects before they escape out of our processes. It also includes the costs related to quality audits and monitoring vendors and dealing with their quality problems.

Five Categories of COPQ

4. The Costs Related to Improving Poor Quality, Including…

- Cost of equipment to better control processes, as well as the cost of programs to improve quality (CARs, 8-D's, etc.).

5. The Opportunity Cost of not Producing More Products with the Same Assets

- This is in addition to the opportunity cost due to lost customer loyalty and lost sales due to poor quality in the past.

The Hidden Factory

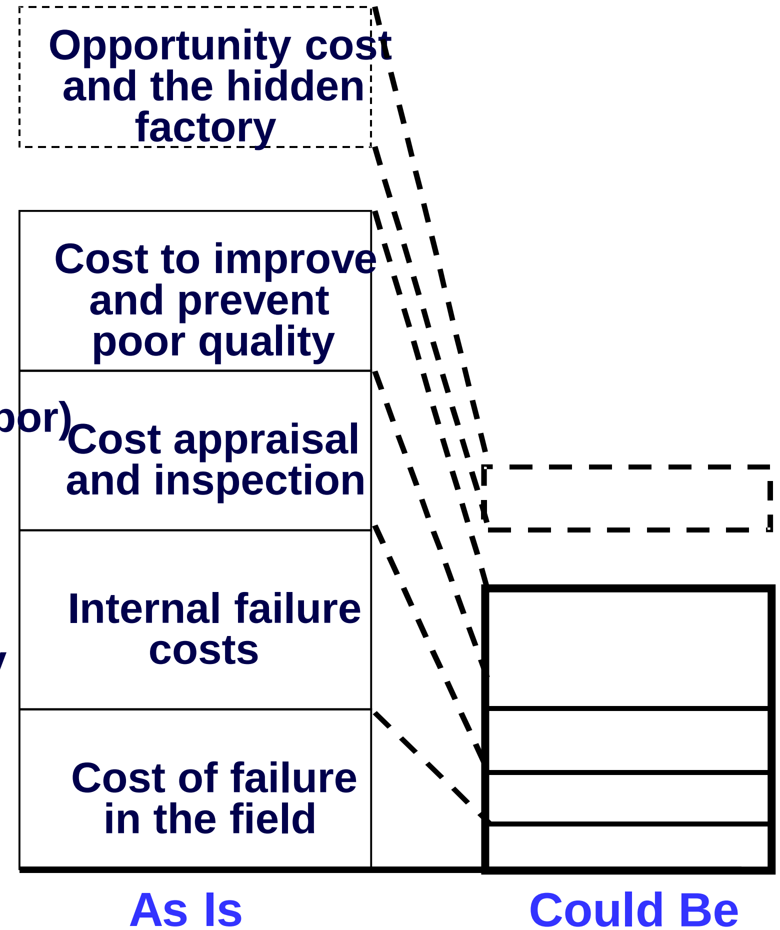
- Avoided capital cost
- Opportunity cost of additional volume if sales>capacity
- Lost customer loyalty
- Time spent expediting
- Cost to the customer

- Improvement program costs
- Process control
- Quality engineering and admin

- Inspection/test (materials, equipment, labor)
- Vendor control
- Quality audits

- Scrap/rejects
- Rework
- Longer cycle times and excess inventory

- Warranty claims
- Maintenance and service



Prevention System of Quality Control

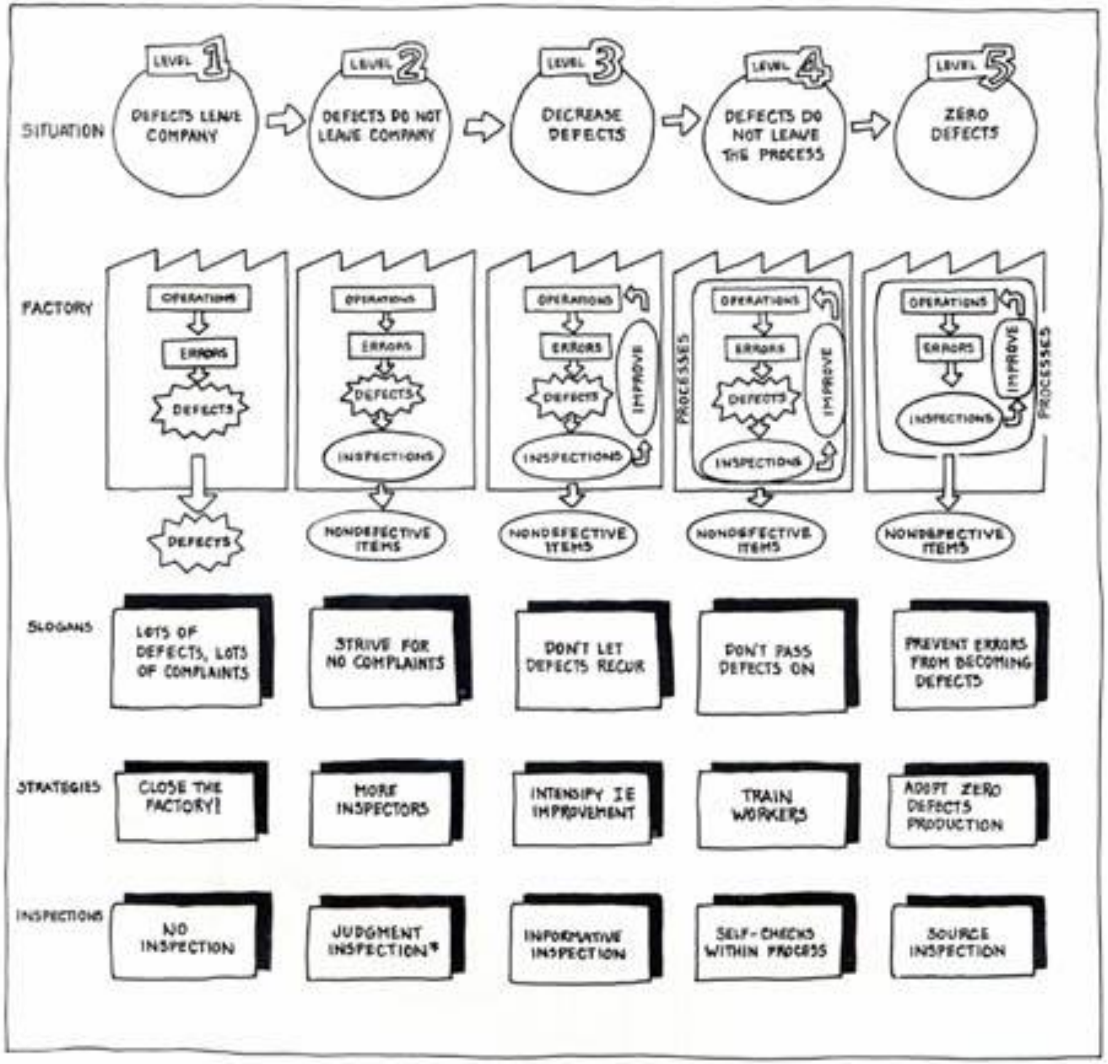
"for every $1 invested in the PREVENTION of defects…. you realize $12 return in reduced scrap, rework, repair and warranty (detection) costs."

– Philip Crosby, "*Quality is Free.*"

Cost is NOT Diametrically Opposed to Quality

The Highest Quality Producer is Typically the Low Cost Producer!

Zero Defect Strategies for Factories



Source: Poka-Yoke - Improving Product Quality By Preventing Defects
Ediited by: Nikkan Kogyo Shimbun, Ltd./ Factory Magazine

Zero Defects Approach

- **The ability to find mistakes at a glance is essential to Zero Defects Production because, as Shingo writes,**

  "the cause of defects lies in worker errors, defects are the results of neglecting those errors. It follows that mistakes will not turn into defects if worker errors are discovered and eliminated beforehand.“

  [Shingo 1986, p.50]

- **We suspect that Shingo and Deming would have a protracted discussion about whether workers or managers are responsible for defects. No resolution of that issue is undertaken here.**

Future Farmers of America

Farming Fathers of Farmington! The Future Farmers of America needs your help. We need the help of all the fathers of every family farm in Farmington. Please fill your family farms with four or five, maybe even fourteen or fifteen, children. Some of you fathers on family farms have fathered only one or two future farmers. For the future of farming in Farmington, we hope all of you family farmers find nothing but fertile fields in your future.

Why Mistake Proofing?

- **People make mistakes!**
- **Mistakes cause quality problems**
- **Parts-per-million (PPM) quality requires a system that is 100% effective**
- **Human inspection is NOT 100% effective**
- **Prevention systems are significantly more cost effective than are detection systems**

Terms & Definitions

- **Quality** – conformance to the requirements.
- **Defect** – a product or service that fails to conform to the requirements.
- **Control** – a system for measuring, monitoring, evaluating and taking corrective action to maintain a steady state of performance – think of your household thermostat.
- **Detection System** – a quality management system based upon product inspection and detection of defects.
- **Prevention System** – a quality management system based upon process controls and defect prevention methods.

Terms & Definitions

- **Feedback** – information given after-the-act.
- **Feed Forward** – information given before-the-act.
- ***Poka-yoke*** – translation: to avoid inadvertent errors. A system of quality control that uses inexpensive devices to perform 100% source inspections for the purpose of detecting or preventing abnormal conditions from becoming product defects.
- **Zero Quality Control** – a quality management system where defects = 0!

Chapter Two

Mistakes and Defects

Mistakes Vs Defects?

- Mistakes are inevitable
- As long as we have people we will have mistakes
- A mistake becomes a defect when it goes undetected to a customer
- Mistakes do not have to turn into defects

The point is that mistakes are not defects and we must understand & recognize the differences between them in order to manage them.

Mistakes vs. Defects

- **Operating Conditions can lead to Mistakes that can cause Defective Products**

Some Common Sources of Defects

- Omitted operations
- Processing errors
- Errors setting up work pieces
- Missing parts
- Wrong parts used
- Processing wrong work piece
- Mis-operation
- Adjustment errors
- Equipment not set up properly
- Tools and jigs improperly prepared

Different Kinds of Mistakes

1. **Forgetfulness**: we forget things when we are not concentrating. (*not concentrating*)
2. **Mistakes Due to Misunderstanding**: we make mistakes by jumping to the wrong conclusion. (*jump to conclusions*)
3. **Mistakes Due to Misidentification**: we misjudge a situation because we view it too quickly or are too far away to see it. (*view incorrectly…too far away*)

Different Kinds of Mistakes

4. **Mistakes Made by Amateurs: we make mistakes because we lack experience. (*errors made by untrained workers*)**
5. **Willful Mistakes: we decide that we can ignore rules under certain circumstances. (*ignore rules*)**
6. **Inadvertent Mistakes: we are absent-minded and make mistakes without knowing how they happened. (*distraction, fatigue*)**
7. **Mistakes Due to Slowness: we make mistakes when our actions are slowed down because we are uncertain in our decisions. (*lack of confidence in our abilities and decisions*)**

Different Kinds of Mistakes

8. **Mistakes Due to Lack of Clear Standards**: errors occur when there are no suitable instructions or clear work standards. (*written & visual*)
9. **Surprise Mistakes**: errors occur when equipment runs differently then expected. (*machine not capable, malfunctions*)
10. **Intentional Mistakes**: some people make mistakes deliberately. (*sabotage – the least common type*)

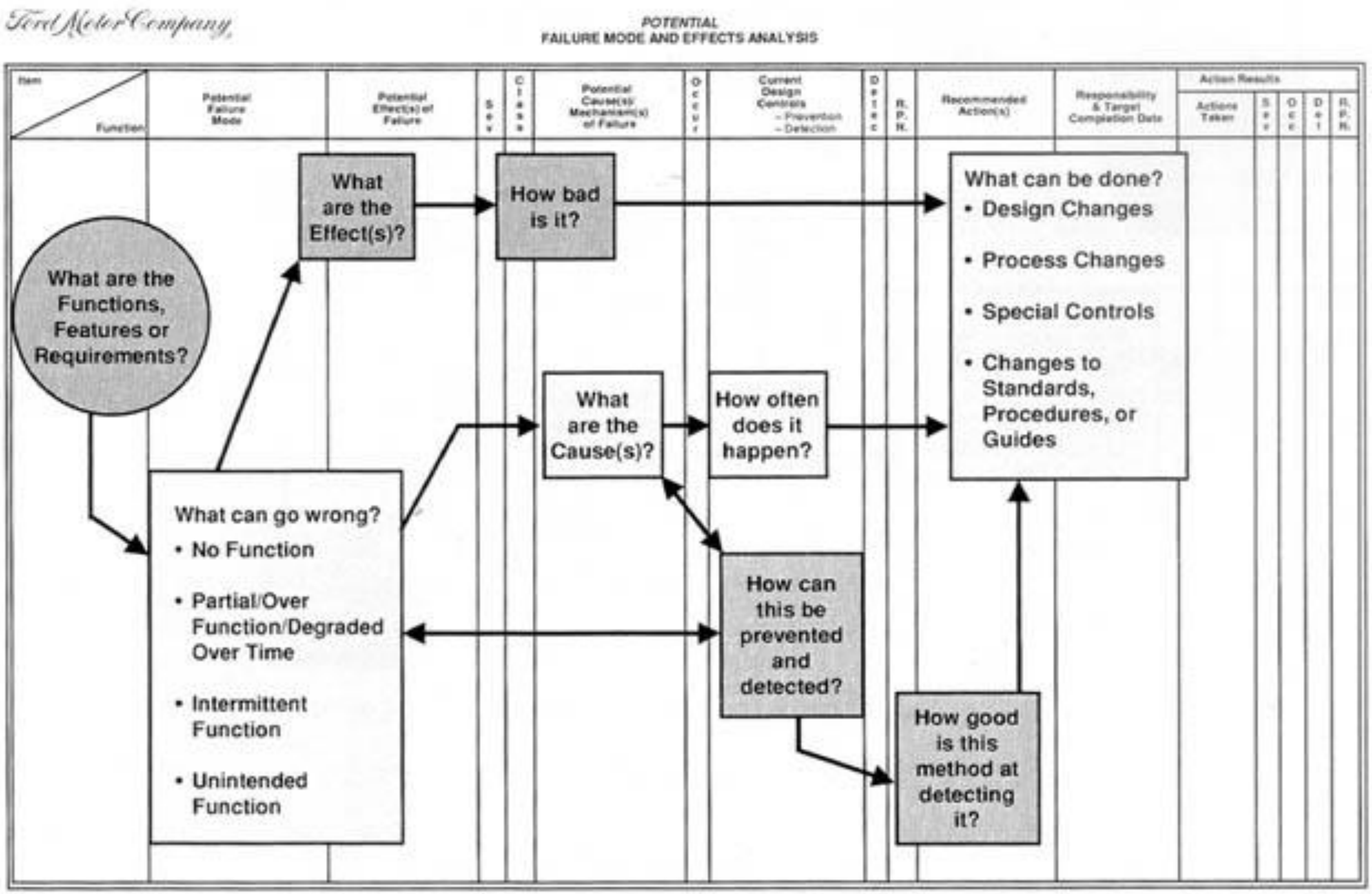
Mistakes happen for many reasons, but almost all can be prevented!!

Types of Mistakes

Source of Defects	Intentional	Misunderstanding	Forgetful	Misidentification	Amateurs	Willful	Inadvertent	Slowness	Non Supervision	Surprise
Omitted Processing										
Processing Errors										
Set-up mistakes										
Missing parts										
Wrong parts										
Using wrong piece										
Missed-operation										
Adjustment errors										
Equipment setup										
Improper tools and jigs										

 # Strongly Connected   * Connected

FMEA Model



Source: Ford Motor Company FMEA Handbook version 3.1 Copyright © 2000

Occurrence Ranking

- **Occurrence is the likelihood that a specific failure will occur.**
  - Occurrence rankings are based on the number of failures that are anticipated during the process execution.
  - A consistent scale must be used to ensure continuity.

Occurrence Rankings

Probability	Anticipated Failure Rate	Ranking
Very High	100 + per thousand pieces	10
High	50 per thousand pieces	9
	20 per thousand pieces	8
Moderate	10 per thousand pieces	7
	5 per thousand pieces	6
	2 per thousand pieces	5
Low	1 per thousand pieces	4
	.5 per thousand pieces	3
	.1 per thousand pieces	2
Remote	Less than .01 per thousand	1

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Current Process Controls and Detection Rankings

Detection	Criteria	Inspection Types			Suggested Range of Detection Methods	Ranking
		A	B	C		
Almost Impossible	Absolute certainty of non-detection			X	Cannot detect or is not checked.	10
Very Remote	Controls will probably not detect.			X	Control is achieved with indirect or random checks only.	9
Remote	Controls have poor chance of detection			X	Control is achieved with visual inspection only.	8
Very Low	Controls have poor chance of detection			X	Control is achieved with double visual inspection only.	7
Low	Controls may detect		X	X	Control is achieved with charting methods, such as SPC (Statistical Process Control)	6
Moderate	Controls may detect		X		Control is based on variable gauging after parts have left the station, or Go/ No Go gauging performed on 100% of the parts after parts have left the station.	5
Moderately High	Controls have a good chance to detect	X	X		Error detection in subsequent operations, OR gauging performed on setup and first piece check (for set-up causes only).	4
High	Controls have a good chance to detect	X	X		Error detection in-station, or error detection in subsequent operations by multiple layers of acceptance: supply, select, install, verify. Cannot accept discrepant part.	3
Very High	Controls almost certain to detect.	X	X		Error detection in-station (automatic gauging with automatic stop feature).Cannot pass discrepant part.	2
Very High	Controls certain to detect.	X			Discrepant parts cannot be made because item has been error-proofed by process/ product design.	1

Inspection Types:

A. Error-proofed
B. Gauging
C. Manual Inspection

Control Plan

AQuA Pro

Product: Spacer128 | Control Plan | Customer B/P Numbers: DOAF 11135 B, 2B-7106F, MC 209 A

Product Description: ______________

Process Revision Date: ______________ Process Revision Level: ________

Op#	Op Name	Tooling and Equipment: Number	Units	Name	Life	Characteristic: Number	Product	Process	Special Characteristic Class	Methods: Product/Process Tolerance	Control Method	Gage Number	Methods: Evaluation/ Measurement Technique	Sample: Size	Frequency	Reaction Plan
10	Receiving					LD01	Tube Length			12'+.25/-.0						
						OD01	Tube Diameter			.500 =/-.030						
15	Storage					MH01		JIT Delivery			Designated material storage locations					
											Operator instructions for handling					
											Operator training					
						ND04	no contaminatio n		@Critical		Operator training					
						ND05	no damage				Operator training					
20	Screw Machine					LD02	OAL/Thickne ss			1.2500+.–/-.010	Mill certification check					
											Operator training					
											Receiving checksheets	MC 00100	Micrometer	1	every lot	
											Setup checksheet with charts	MC 00100	Micrometer	5	tool change	
						ND03	Burr-free				In Process checksheet	VS 100	Visual Standard - Burrs	1	every hour	
											Setup checksheet with charts	VS 100	Visual Standard - Burrs	3	Setup	
30	Drill					CH01	Chamfer degree			45 degree	Setup checksheet					
						CH02	Chamfer Length			0.0625 typ						
						ID02	Spacer I.D.									
						ND03	Burr-free				In Process checksheet	FG 5123	Laser	1	100%	
											Strip-sensor					
						Set01		Machine speeds and feeds		1760 =/- 100	Setup checksheet					
40	Grind					M801	Surface Finish			40+/-3	Setup checksheet with charts	P 00100	Profilometer	3	Setup	
											Tool wear checksheet	VS 103	Visual Standard - Tool Wear	1	every hour	
						Set01		Machine speeds and feeds		1760 =/- 100	Setup checksheet					
											Setup checksheet	G 00100	Electronic	3	Setup	

Everyday Example of Mistake Proofing

- **Memory stick cannot be inserted unless it is oriented correctly. It will only go in about half way if inserted upside down.**

Everyday Example of Mistake Proofing

Fueling area of car has three poka-yoke devices:

1. Filling pipe insert keeps larger, leaded-fuel nozzle from being inserted.
2. Gas cap tether does not allow the motorist to drive off without the cap.
3. Gas cap is fitted with ratchet to signal proper tightness and prevent over-tightening.

Chapter Three

Prevention and Detection

Mistake Detection

- **The use of product and/or process design modifications to detect the occurrence of mistakes.**

- **The goal of Mistake Proofing is ZERO DEFECTS shipped to the customer.**

Mistake Prevention

- **Use of product and/or process design modifications to make certain that mistakes can not occur – mistakes are prevented, not detected.**
- **The goal of mistake prevention is ZERO MISTAKES.**

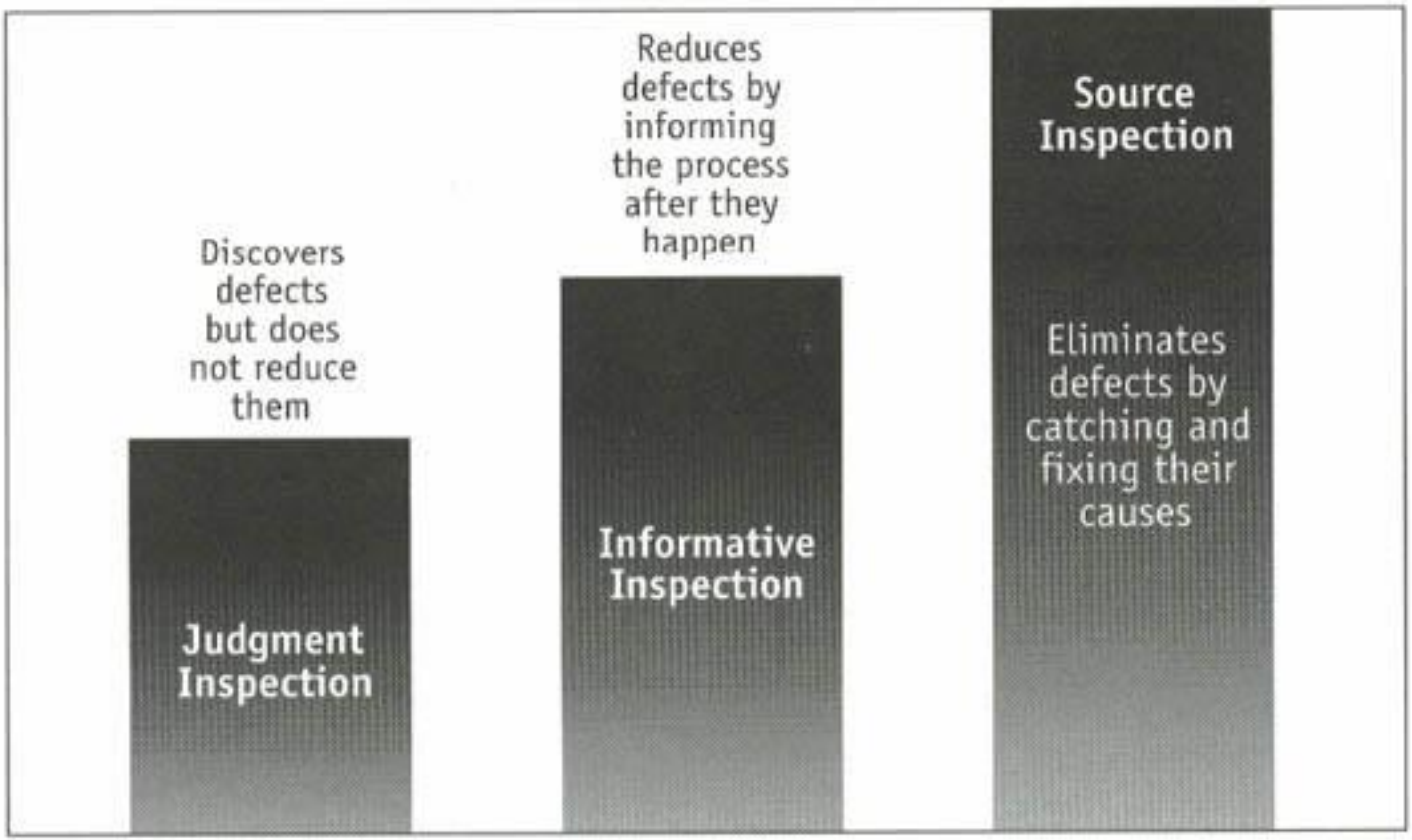
Four Basic Elements of Mistake Proofing

1. **Source inspection is used to detect abnormal operating conditions before they cause defects.**
2. **100% inspections are performed to check every part, not just a sample of parts.**
3. **Immediate feedback is provided to shorten the time for corrective actions to be taken.**
4. **Poka-yoke devices are used on processing or assembly equipment to economically carry out 100% inspections (quality is built-in to products and processes).**

Three Types of Inspections

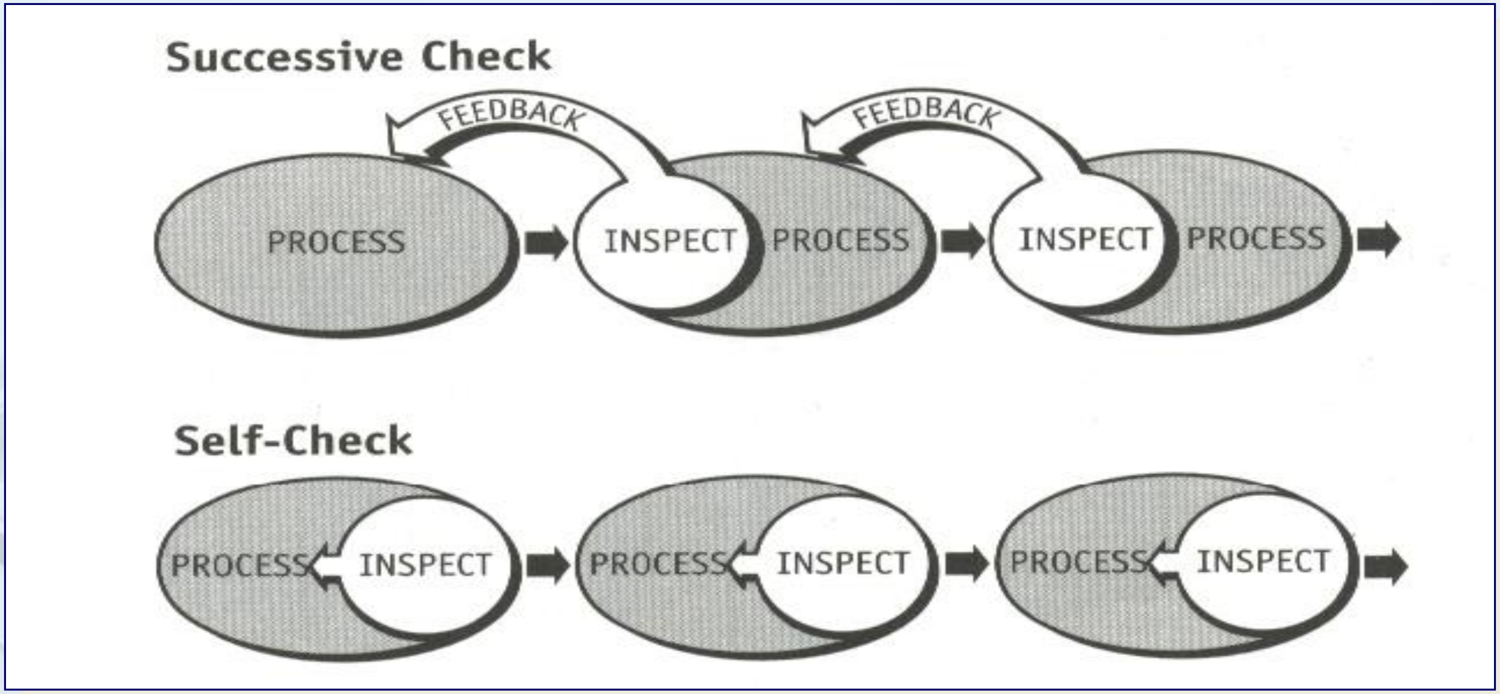
1. **Judgment Inspections** – inspections used to separate defective product from acceptable product. (*sorting system*)
2. **Informative Inspections** – inspections performed to investigate the cause(s) of defects. Information is gathered to determine the course of actions necessary to reduce the defect rate in the future. (*SQC*)
3. **Source Inspections** – inspections performed prior to the operation to detect abnormal conditions that could cause defects. This information is then used to take immediate corrective action to prevent the abnormal condition from causing a defect.

Source Inspection vs. Traditional Inspection



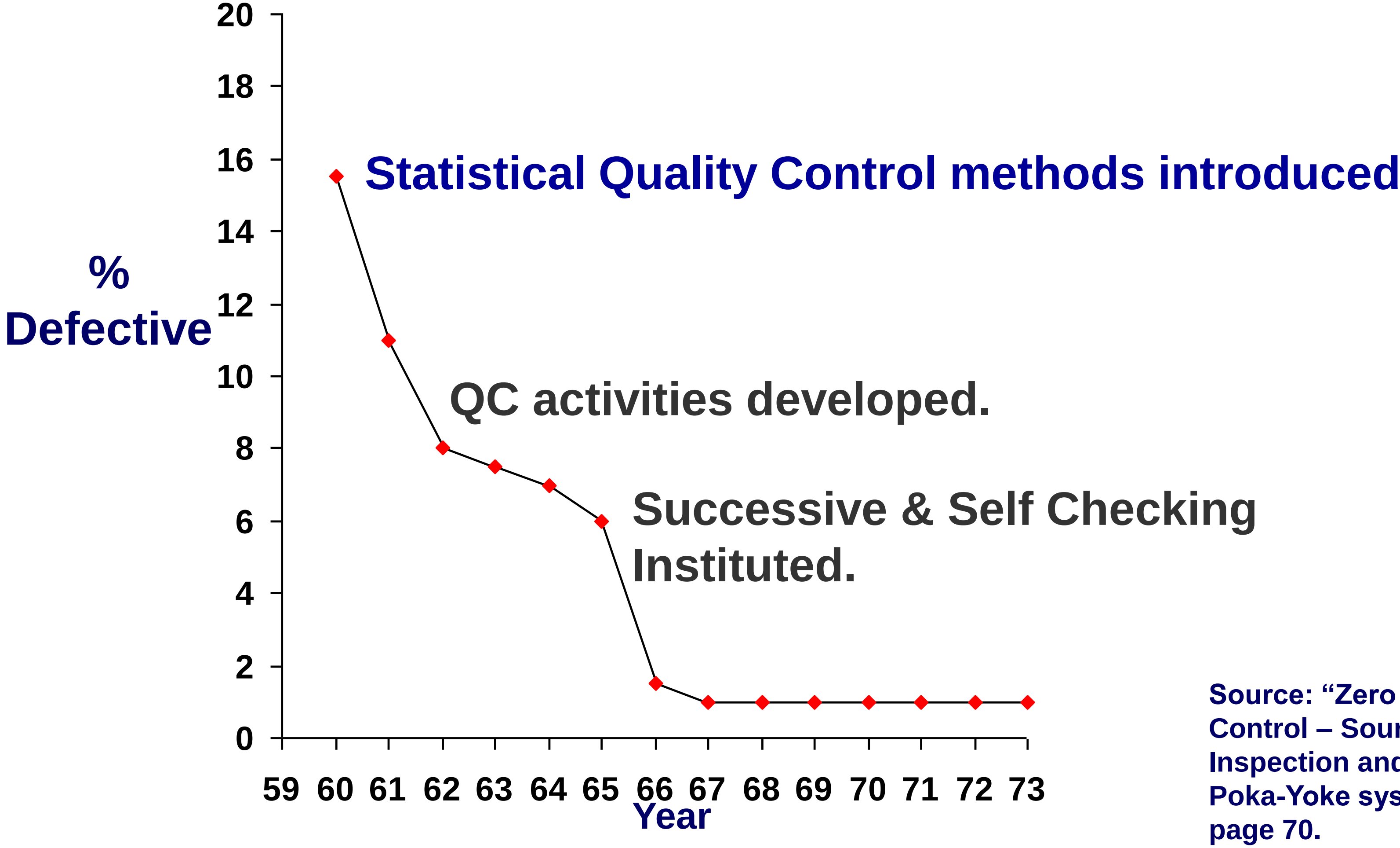
Detection
Correction
Prevention

Successive Checks and Self Checks



Both Successive Checks and Self Checks provide information after-the-fact. Self Checks provide more immediate feedback.

Successive Checks and Self-checks Effect on Defect Rate at Matsushita



Source: "Zero Quality Control – Source Inspection and the Poka-Yoke system." page 70.

Why Are Successive Check and Self-check Systems Superior to SQC Methods?

- **100% inspections detect all abnormalities:**
  - SPC/SQC only checks a subset of the population

- **Rapid corrective action is possible:**
  - Immediate feedback from self-checks
  - Feedback from next operation from successive checks

Informative Inspections

- **Informative inspections provide feed-forward information gained from inspections to make improvements to the process to prevent defects from being produced in the future.**
- **The focus is on informing the defect-producing process about the problem as quickly as possible in order to identify and correct the abnormal conditions.**
- **There are three methods of informative inspection:**
  - Statistical Process Control (SPC)
  - Successive Checks of Each Product
  - Self-check of Each Product

100% Inspection

- **100% inspection must be carried out on every single product if the goal is Zero Defects to the customer.**
- **SQC, on the other hand, relies on inspecting only a sample of the product.**
- **SQC methods assume that a certain number of defects is unavoidable. This is inconsistent with the goal of Zero Defects.**

ZQC requires that you inspect 100% of the products produced

Immediate Feedback

- **Immediate feedback is necessary so that abnormal conditions can be corrected right away – *before they result in defects*.**

- **In a Mistake Prevention system, inspections are carried out to detect abnormal operating conditions before they become defects – allowing for the abnormal conditions to be corrected before the operation is performed.**
  - This is only possible through **SOURCE INSPECTIONS**.

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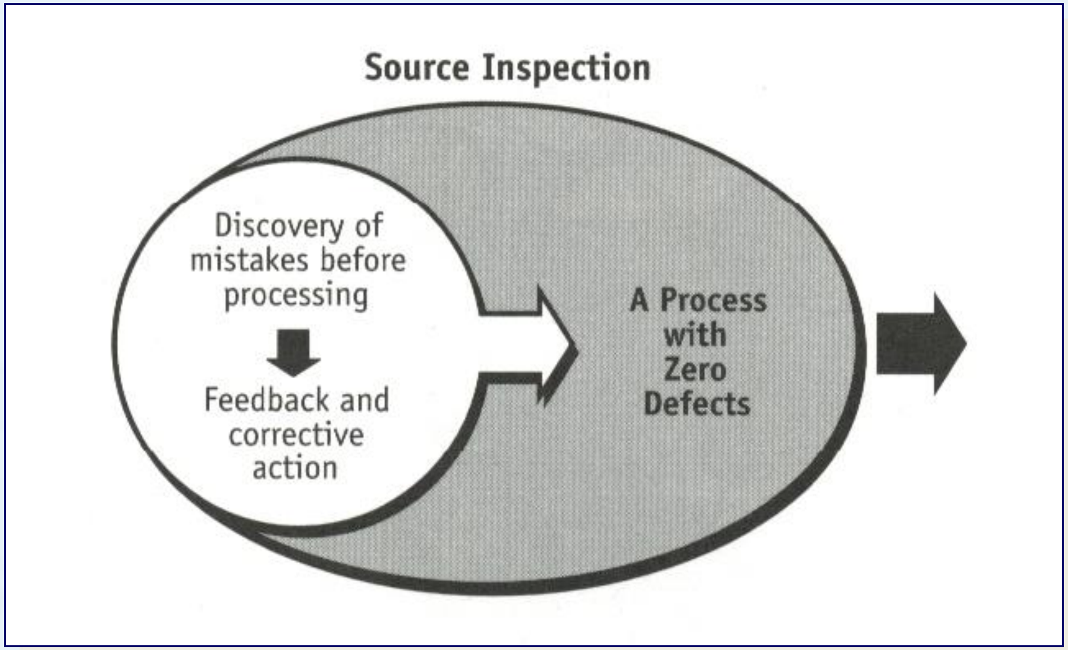
Source Inspection is Used



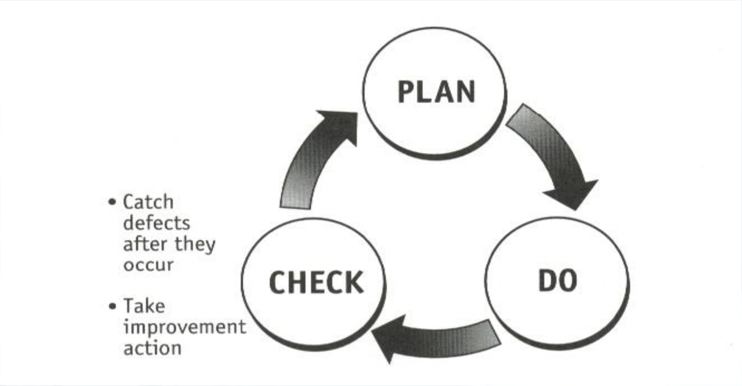
Source Inspection prevents mistakes from becoming defects.

Source Inspection & P-D-C-A

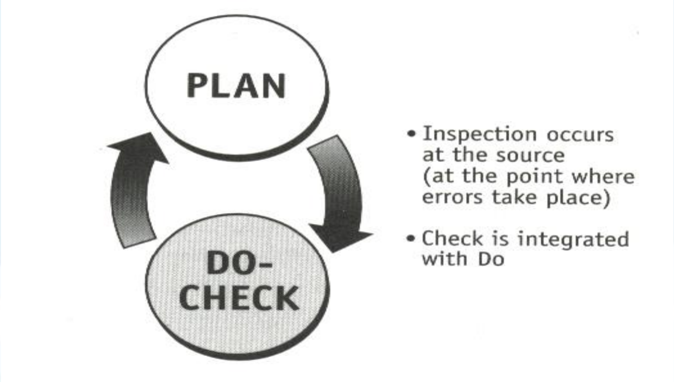
- **Source inspections detect abnormal operating conditions and provide feed forward information to the operator before the operation is completed – mistakes do not become defects.**
- **Source inspections determine quality “*before the fact*”.**
- **Integrating the Do and Check activities of P-D-C-A provides controls so that an operation cannot be done wrong – with source inspection, the cycle is Plan-Check-Do.**
  - *“I realized that the idea of checking operating conditions before the operations rather than after them, was precisely the same as my concept of source inspection.”*
    - [Shingo, 1986, p.51]

Mistake Proofing and the PDCA Cycle

Plan, Do, Check Cycle of the Traditional Quality Improvement Cycle



Integrating Do and Check in the Zero Quality Control



The PDCA cycle catches and contains defects after they occur, but can't make sure that work is done according to plan in the first place. The ZQC approach integrates the Check and Do stages. This provides feed-forward information so that problems can be corrected *before* defects happen…. Plan – Check – Do.

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Informative & Source Inspections

- **Source inspections require information about the types of abnormal operating conditions that can potentially cause product defects.**
  - Informative studies are necessary in order to identify and verify the relationship of specific abnormal conditions (***sources/causes***) to product defects (***effects***).
- **Once the sources of defects have been identified and verified, then source inspection methods (including poka-yoke devices) can be developed and incorporated into the control plan.**

Control Plan

AQuA Pro

Product Spacer128 | Control Plan | Customer B/P Numbers

DOAF 11135 B

2B-7106F

MC 209 A

Product Description: __________

Process Revision Date: __________ Process Revision Level: __________

Op#	Op Name	Tooling and Equipment				Characteristic			Special Characteristic Class	Methods		Gage Number	Methods			Reaction Plan
		Number	Units	Name	Life	Number	Product	Process		Product/Process Tolerance	Control Method		Evaluation/ Measurement Technique	Sample Size	Sample Frequency	
10	Receiving					LD01	Tube Length			12'+.25/-.0						
						OD01	Tube Diameter			.500 =/-.030						
15	Storage					MH01		JIT Delivery			Designated material storage locations					
											Operator instructions for handling					
											Operator training					
						ND04	no contamination		@Critical		Operator training					
						ND05	no damage				Operator training					
20	Screw Machine					LD02	OAL/Thickness			1.2500+.--/-.010	Mill certification check					
											Operator training					
											Receiving checksheets	MC 00100	Micrometer	1	every lot	
											Setup checksheet with charts	MC 00100	Micrometer	5	tool change	
						ND03	Burr-free				In Process checksheet	VS 100	Visual Standard - Burrs	1	every hour	
											Setup checksheet with charts	VS 100	Visual Standard - Burrs	3	Setup	
30	Drill					CH01	Chamfer degree			45 degree	Setup checksheet					
						CH02	Chamfer Length			0.0625 typ						
						ID02	Spacer I.D.									
						ND03	Burr-free				In Process checksheet	FG 5123	Laser	1	100%	
											Strip-sensor					
						Set01		Machine speeds and feeds		1760 =/- 100	Setup checksheet					
40	Grind					MI01	Surface Finish			40+/-3	Setup checksheet with charts	P 00100	Profilometer	3	Setup	
											Tool wear checksheet	VS 103	Visual Standard - Tool Wear	1	every hour	
						Set01		Machine speeds and feeds		1760 =/- 100	Setup checksheet					
											Setup checksheet	G 00100	Electronic	3	Setup	

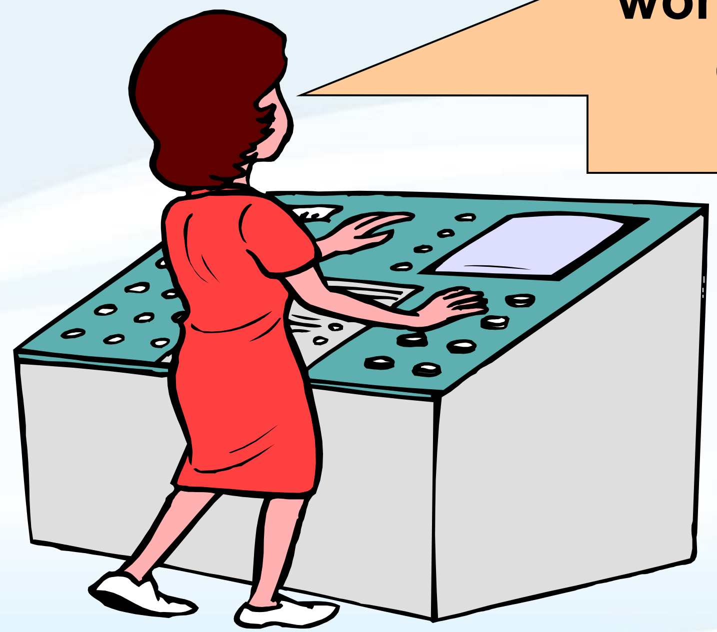
Two Types of Poka-yoke Systems

1. **Warning systems produce signals to indicate the presence of an abnormal product or process condition. Warning systems require human intervention to respond to the signal.**

2. **Control systems find abnormal product or process conditions and produce actions to correct the abnormal conditions.**

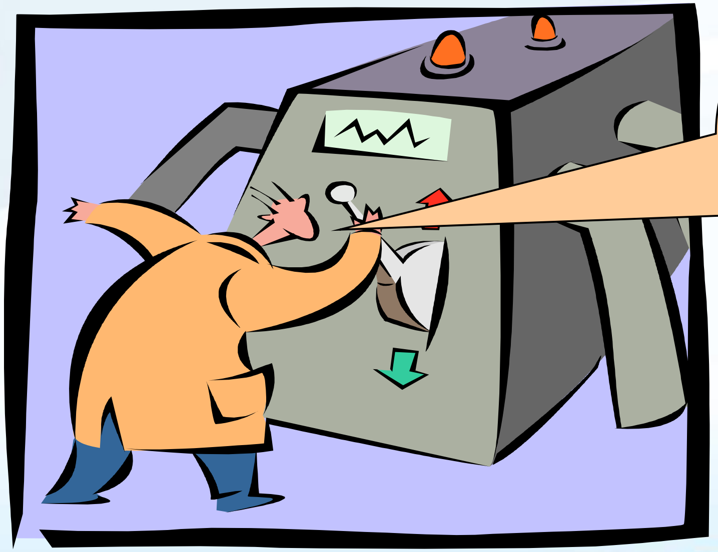
Warning System

"I'm glad the alarm went off, now I know that I won't be making defects!"



Control System

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



“There must have been a mistake detected; the machine shut down by itself!”

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Chapter Four

Developing and Using Mistake Proofing Systems

Developing Mistake Proofing Systems

1. **Define the process**
2. **Describe the defect – provide a picture or sketch of the problem**
3. **Study the operations**
4. **Identify the abnormal operating conditions (*the mistakes*) that cause the defect**
5. **Design, develop and deploy devices (*poka-yoke*) to prevent the mistakes from affecting customers**
6. **Update control plans**

1. Define the Process

- **Processes are comprised of a series of operations.**
- **Processes turn inputs into outputs.**
- **Processes are defined by:**
  - Process Maps
  - KPIV's and KPOV's with Standards and Specifications

Define the Key Process Input Variables KPIV's and Customer Key Process Output Variables KPOV's

INPUTS → **Assembly AD-SP Air Dryer Body** → **OUTPUTS**

INPUTS

- Assembly Labor
- Procedures
- Materials
- Equipment,
- Fixtures
- Environment
- Cleanliness
- Rework

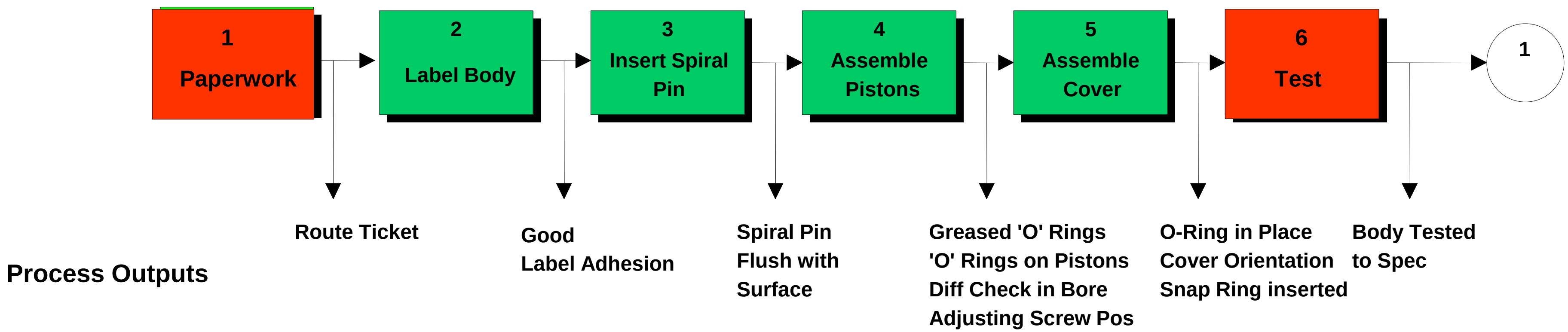
OUTPUTS

- Part to Print
- Performance to Spec
- Visually acceptable
- Leak free
- Identified
- Clean
- Packaged for use
- Consistent standard

List the Key Outputs (KPOV`s) for each Operation

AD-SP Air Dryer

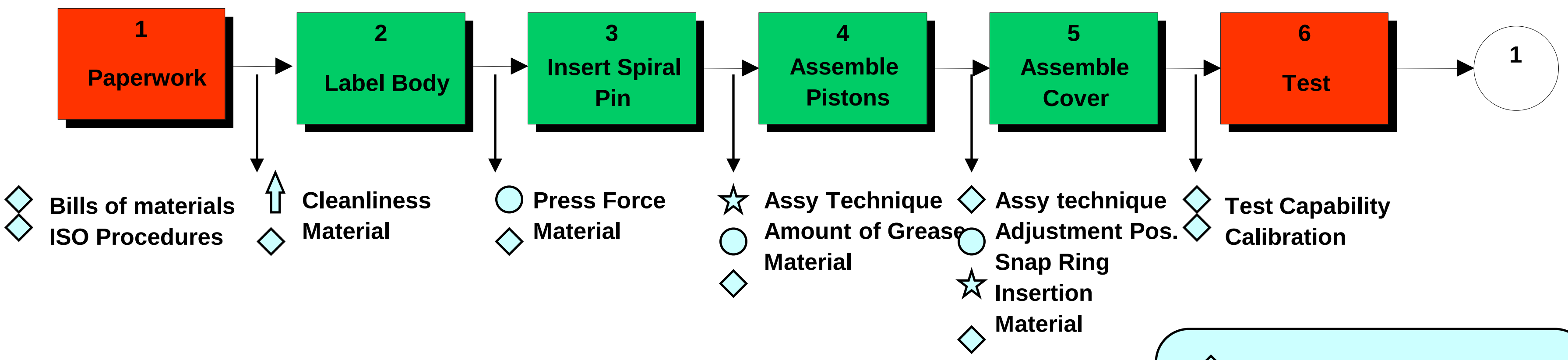
Station 1   Body Assembly



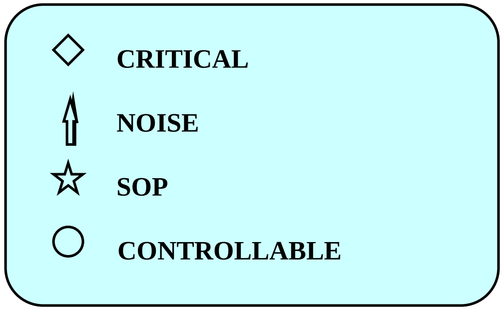
Add the Operating Specifications and Process Targets for the KPIV's and KPOV's

AD-SP Air Dryer

Station 1 Body Assembly



Controllable Input Variable	Target	Upper Spec	Lower Spec
Press Force	10 lbs	12 lbs	8 lbs
Amount of Grease	2 cc's	1.5 cc's	2.5 cc's
Adj. Pos'n	3 turns	3.5 turns	2.5 turns



2. Describe the Defect

- **Refer to FMEA's, historical data, similar part family issues, customer complaints, warranty issues, etc., to identify the potential and/or existing customer problems. (*defects*)**

- **Use pictures, drawings or written descriptions to describe the problem. (*defect*)**

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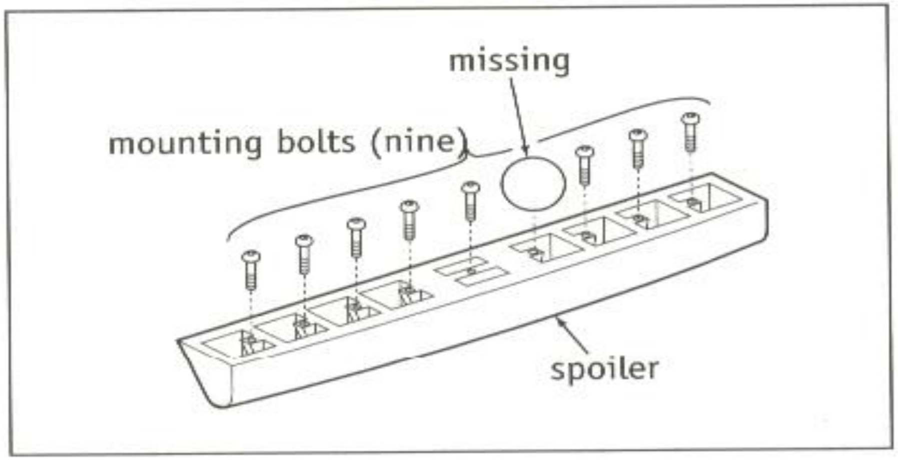
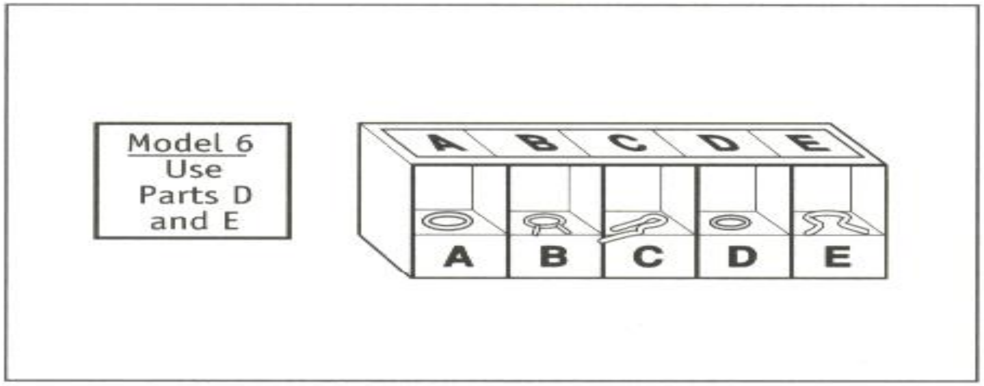
Before Improvement

In assembly of an automobile spoiler, nine mounting bolts are to be installed. The bolts are taken directly out of a bin containing many bolts, and sometimes some of the bolts are forgotten.



Before Improvement

An auto parts assembly operation involves installing several parts, which vary from model to model. The parts are taken from bins according to a list of parts for each model. Sometimes the wrong part is installed by mistake, or parts are forgotten.



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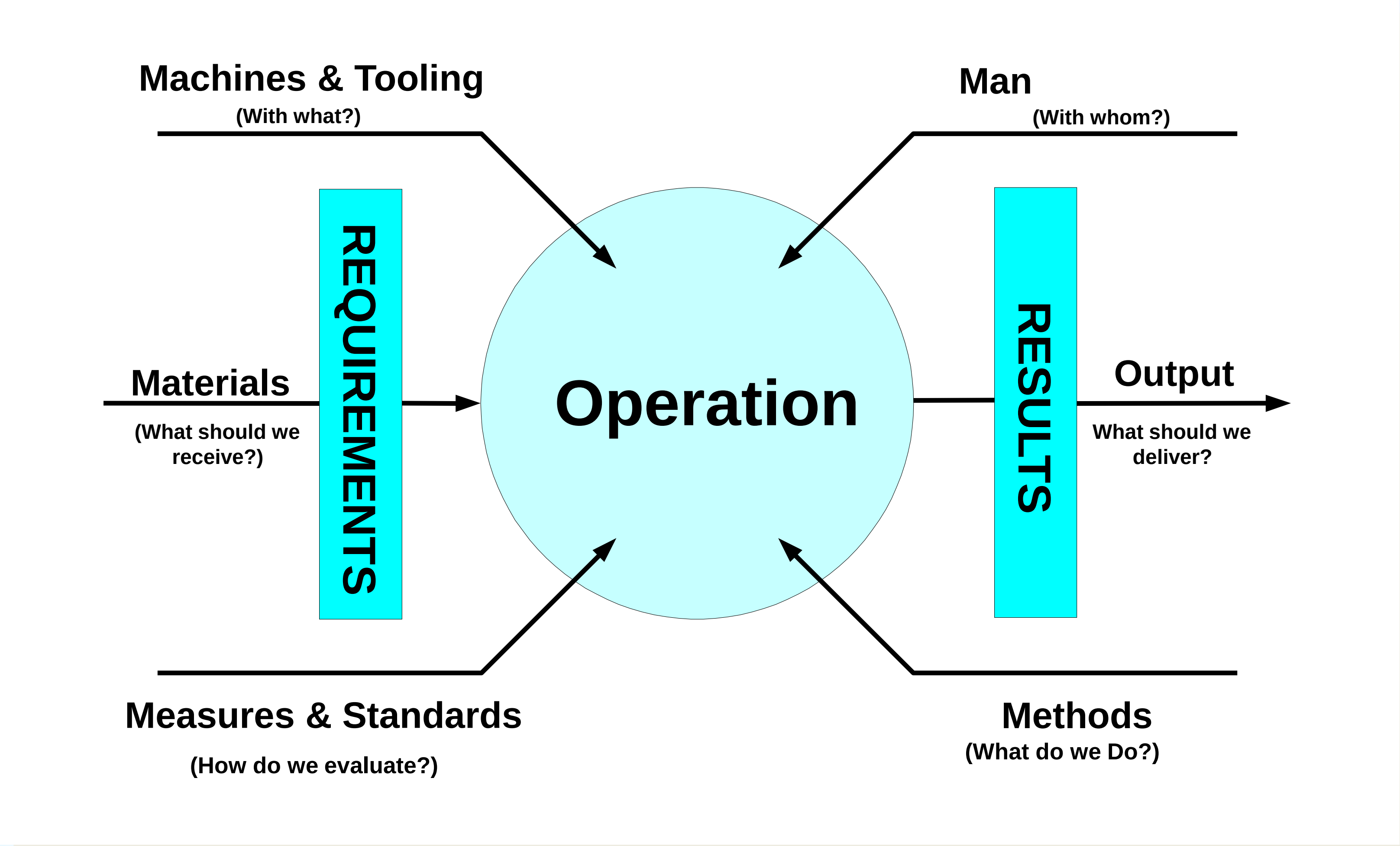
3. Study the Operations

Turtle Diagram

SIPOC + R

Turtle Diagram



Five Elements of All Operations

1. Material Needed for the Process
2. Machines Used in the Process
3. Man the Operator
4. Methods Followed to Complete the Process
5. Information Required and Followed

All mistakes and defects can be attributed to problems in one or more of these areas

Determining Sources of Defects

- **Operations can be classified on the basis of the dominant sources of influence on product quality.**
  - Machine Dominant
  - Operator Dominant
  - Component Dominant
  - Tools Dominant
  - Preventive Maintenance Dominant
  - Fixture/Pallet/Position Dominant
  - Setup Dominant
  - Environment Dominant

Operating Mistakes – Materials

1. **Parts that are Out of Specification**

2. **Parts that are not Processed Completely**

3. **Parts with Scratches, Dents, Dings, Chips, Burrs, etc.**

4. **Materials that are Out of Specification:**
   - Non-conforming chemical or physical characteristics

Operating Mistakes – Machines

1. **Missed Cycles**
2. **Broken or Worn Tooling**
3. **Excessive Variation**

Operating Mistakes – Man/Methods

1. Misidentification of Parts
2. Forgetting to Perform a Task
3. Missing a Step in the Process
4. Incorrectly Performing an Operation
5. Making Adjustment Errors
6. Making Setup Errors – Including Improperly Preparing Jigs, Tools and Fixtures
7. Careless Handling of Parts

SIPOC + R WORKSHEET

Supplier	Inputs	Requirements	Process Step	Outputs	Requirements	Customers

4. Identify the Abnormal Conditions

- **Root Cause(s) Analysis**
  - Fish with more than one pole
  - Address all possible causes
- **Brainstorming**
- **Is / Is-Not Analysis**
- **Five Why's Analysis**
- **Creative Problem Solving**

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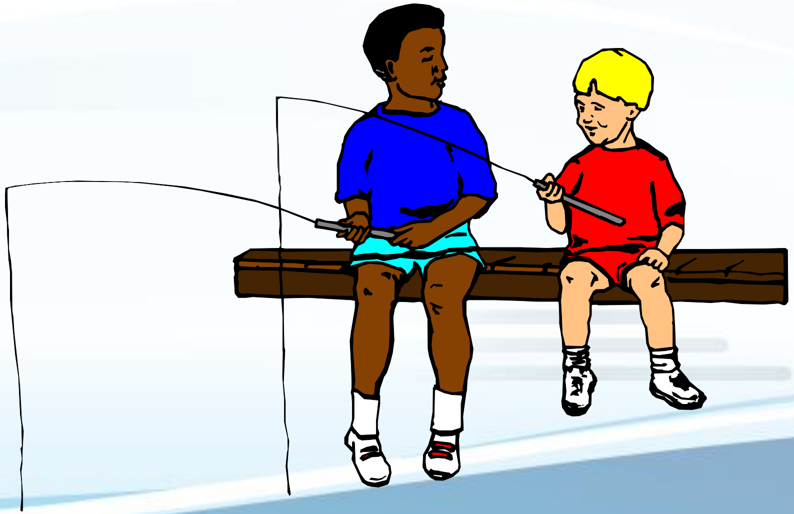
Root Cause Analysis

- **A common mistake made in planning for quality is to assume that a defect has a single cause.**
  - Most defects are the result of many causes
  - To eliminate a defect you must address each of the causes – "***fish with many poles***"



Brainstorming: Team Approach to Ideation

- **Guidelines for effective brainstorming:**
  - No evaluations, judgments or discussion permitted.
  - Relax your brain. Don’t worry about being right.
  - Quantity of ideas is most important.
  - Strive to maintain an uninterrupted stream of ideas.
  - Build on the ideas of others.
  - Reach for radical, impossible ideas.
  - Think in pictures. Use all five senses to make these pictures. Smell, feel, hear, taste, and see your ideas.
  - Build off the ideas of others use contrasts, similarities, opposites, alternatives, etc.

Creative Process

Diverge Right Brain		Converge Left Brain
Ideate	*Possibilities* *Facts* *Opinions* *Actions* *Items* *Ideas* *Things* *Criteria* *Problems* *Solutions*	**Evaluate**
No Judgement Quantity Imaginative Free Gut Child		Judgement Quality Analytical Restricted Intellect Adult

Is/ Is Not Analysis

Root causes are somewhere in the differences between "Is" and "Is not."		
Questions to ask to complete the Is/ Is not Worksheet (each question may not always apply)		
	IS	**IS NOT**
What	**What is happening?** **What is the problem?**	**What could be happening, but is not.** **What could be the problem but is not?**
Where	**Where does the problem occur?**	**Where does the problem not occur?** **Does the problem cover the entire object?**
	Where geographically was the problem observed? **Where can you first see it?**	**Where else, geographically, could the problem have been observed, but was not?**
When	**When in time was the problem first observed?**	**When in time could it have been first observed, but was not?**
	In a process flow diagram, at what step do you first see the problem.	**Where else in the process might you have observed the problem, but did not?**
	When does it recur (be specific about minutes, hours, days, weeks)?	**What other times could you have observed the problem, but did not?**
	What is the trend? Has it leveled off? Has it gone away? Is it getting worse?	**What other trends could have been observed, but were not?**
How Big	**Who is affected by the problem?**	**Who is not affected by the problem?**
	How big is the defect in terms of dollars, people, time, other resources?	**How big could the problem be, but is not?**

Five Why's Worksheet

Operation ____ - __ **Product/Service** __ - _____ **Date** ______

1) A Describe the Defect

1) B Show the Defect Rate

2) Identify the location at which the defect is:
Discovered
Made

3) Detail the current standard procedures/elements of the process step where the defect is made (one standard element per card)

4) Errors or deviations from standards where the defect is made

5) Investigate/Analyze the causes for each error/deviation

Red Flag Conditions:

Why?	Why?	Why?	Why?	Why?	Why?	Why?
Why?	Why?	Why?	Why?	Why?	Why?	Why?
Why?	Why?	Why?	Why?	Why?	Why?	Why?
Why?	Why?	Why?	Why?	Why?	Why?	Why?

Keep Asking Why

Root Cause

Root Cause							

6) Ideas to eliminate or detect the error

Check device required:
- ☐ Level 1 Eliminate cause of error at the source
- ☐ Level 2 Detect error as it is being made
- ☐ Level 3 Detect defect before it reaches next process step

Idea	Idea	Idea	Idea	Idea	Idea	Idea
Idea	Idea	Idea	Idea	Idea	Idea	Idea
Idea	Idea	Idea	Idea	Idea	Idea	Idea

7)Create a device

IMPROVEMENT		IMPROVEMENT		Team Members
Current Condition	Device	Current Condition	Device	
Cost to Install:	Time to Install:	Cost to Install:	Time to Install:	
Remarks:	Date:	Remarks:	Date:	

Chapter Five

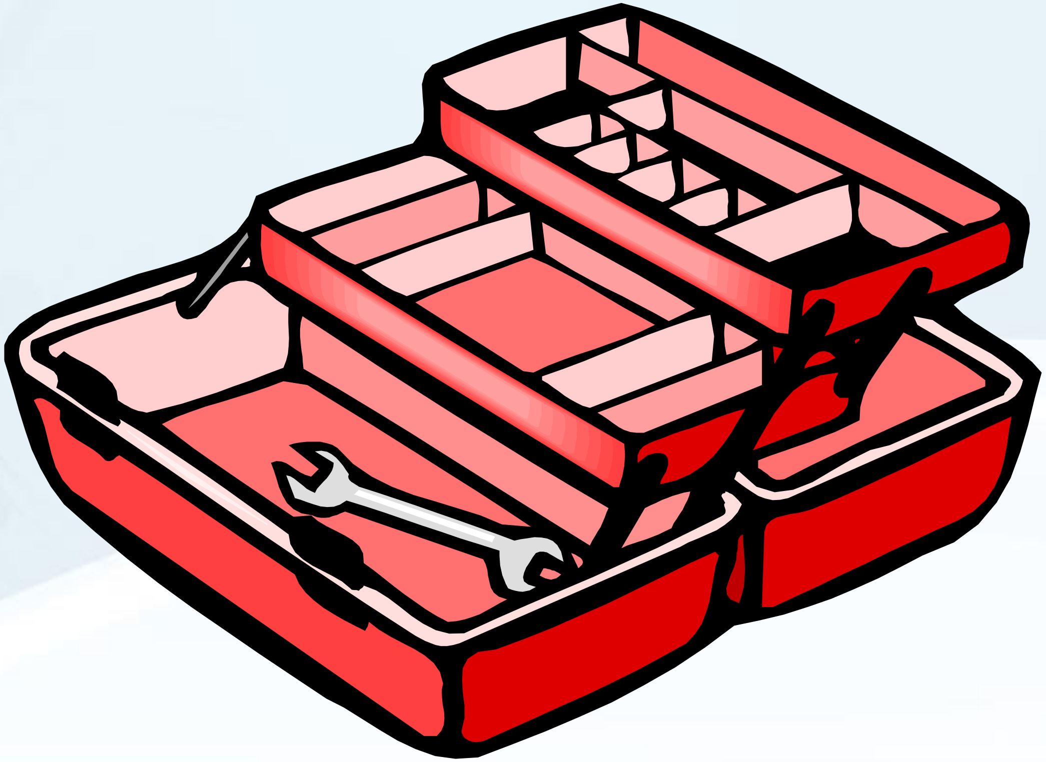
Poka-yoke Devices

Poka-yoke Devices

- **ZQC uses poka-yoke devices designed into the product or process to do 100% inspections and provide immediate feedback for corrective actions.**
- **Rather than rely on operators or assemblers to catch their own mistakes, ZQC uses poka-yoke devices to detect the mistakes people might have missed – mistake detection.**
- **Poka-yoke devices can also be used to detect abnormal conditions (*mistakes*) before they result in mistakes – mistake prevention.**

Design, Develop and Deploy Devices to Prevent the Mistakes from Affecting Customers

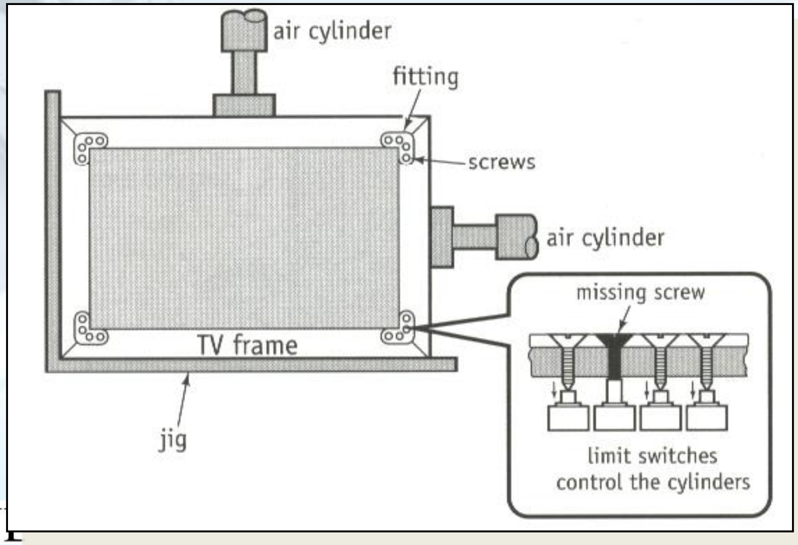
Mistake Proofing Tool Box



Contact Type of Poka-yoke Devices

1. Contact Methods:

- Work by detecting whether a product makes physical or energy contact with a sensing device.
- Takes advantage of shape in the product's design.
- Can include passive methods such as guide pins, as well as sensors such as limit switches.

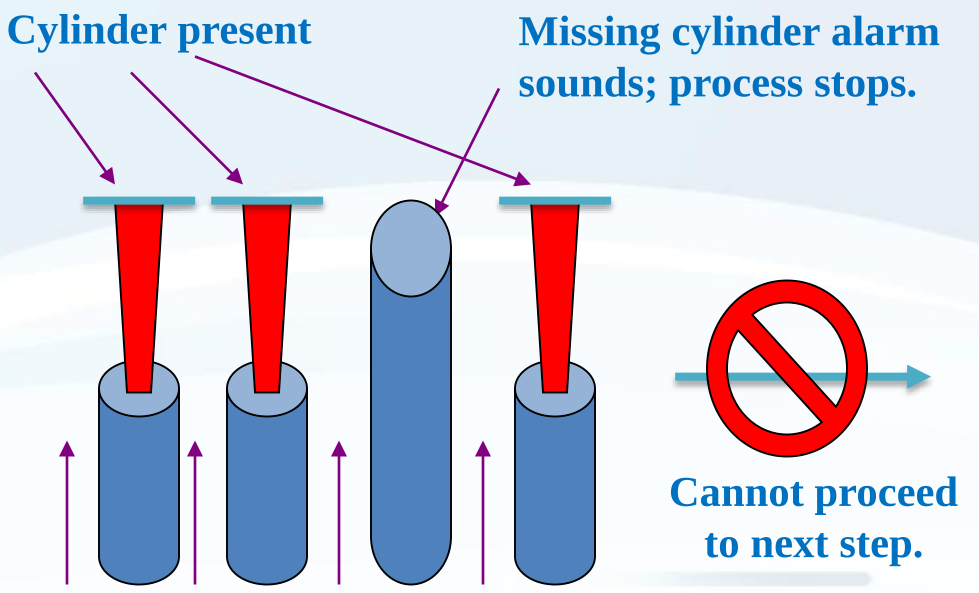


This method can be used with either control systems or warning systems

Contact Methods

- A contact method functions by detecting whether a sensing device makes ***contact*** with a part or object within the process.

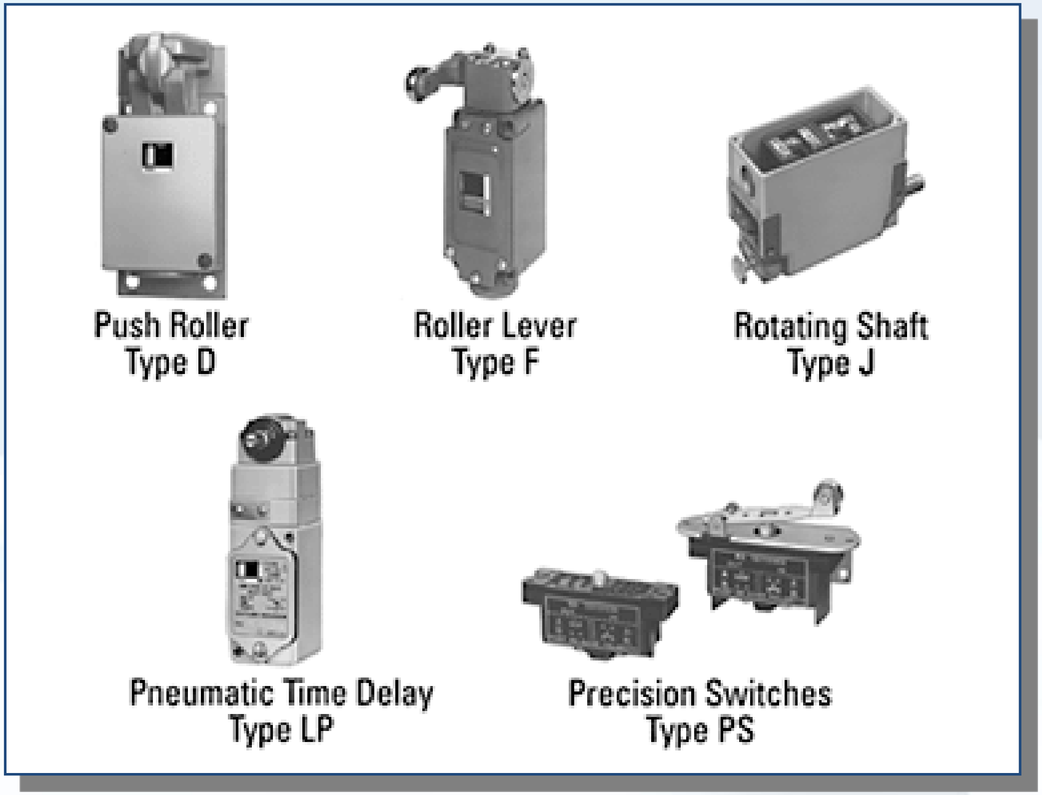
- Limit switches are pressed when cylinders are driven into a piston. The switches are connected to pistons that hold the part in place. In this example, a cylinder is missing and the part is not released to the next process.



Contact Method using limit switches identifies missing cylinder.

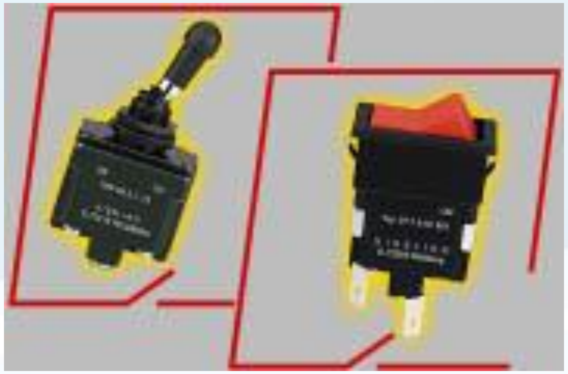
Physical Contact Sensors

- These devices work by physically touching something. This can be a machine tool or a piece being produced.
- These devices send an electronic signal when they are touched. Depending on the process, this signal can shut down the operation or give the operator a warning signal.



Physical Contact Devices – Examples

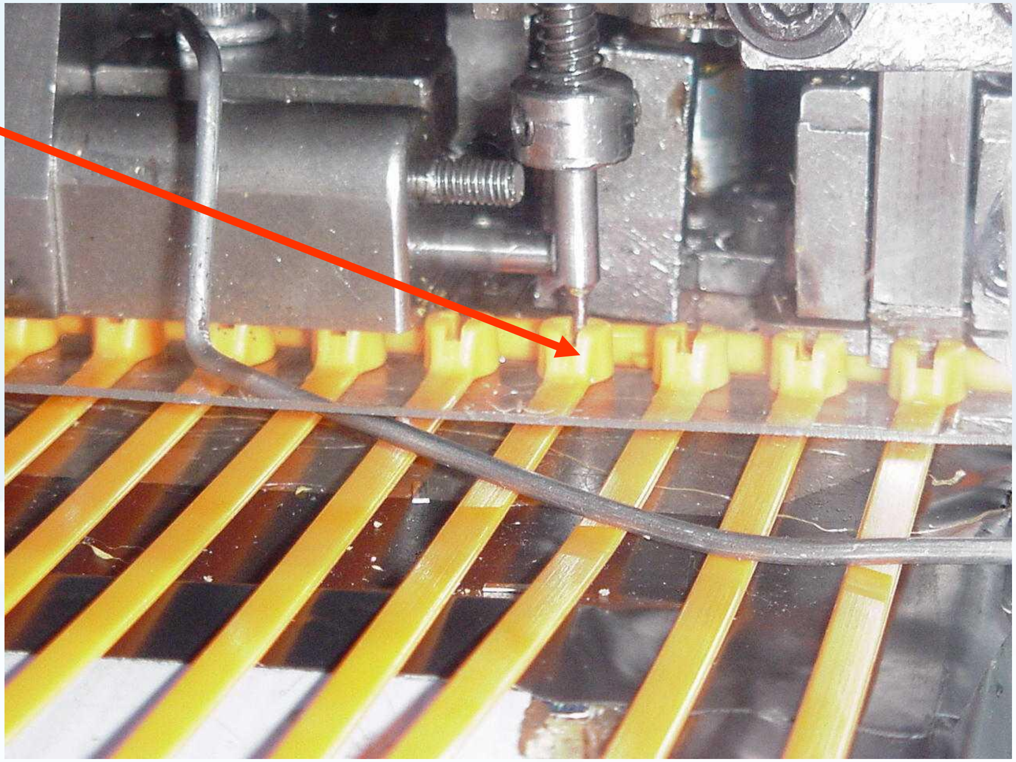
Limit Switches



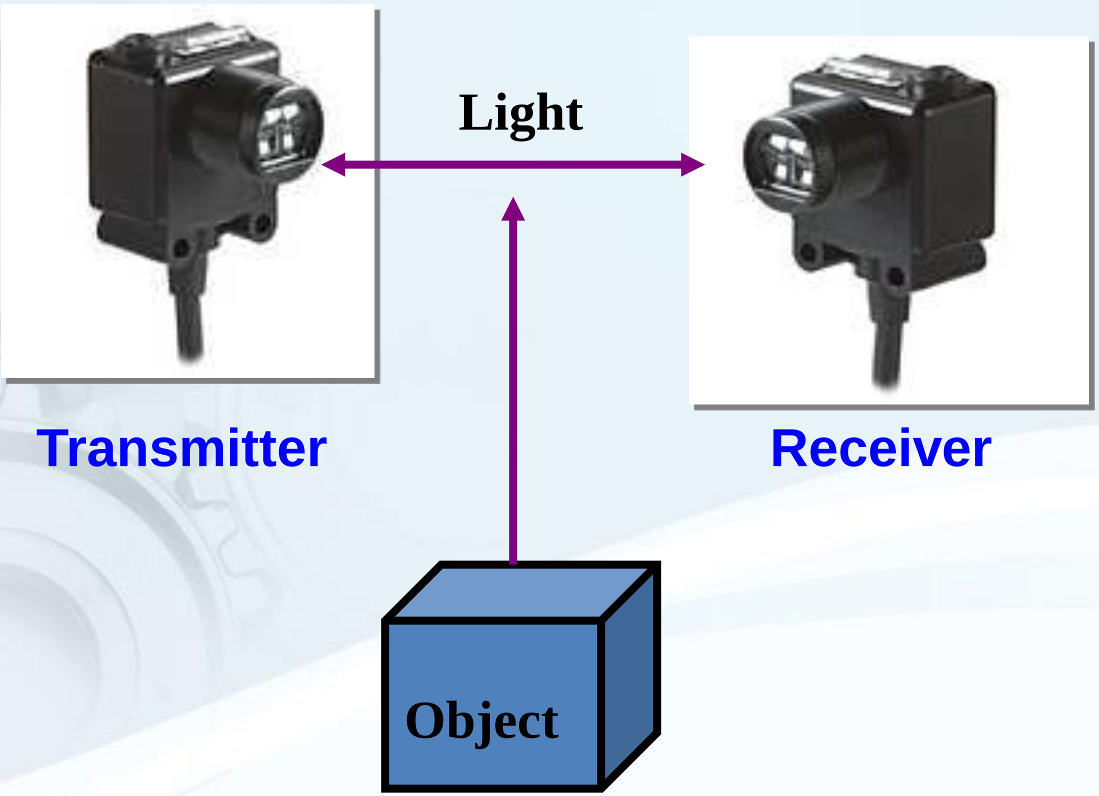
Toggle Switches

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.**



Energy Contact Devices



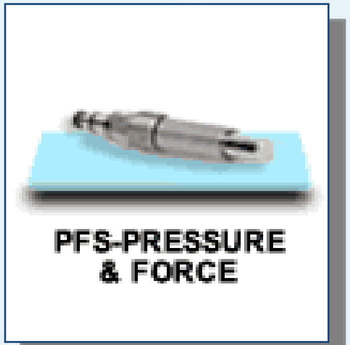
- **Photoelectric switches can be used to detect the presence or absence of a characteristic depending upon the need.**
- ***Transmission method:*** **two units, one to transmit light, the other to receive.**
- ***Reflecting method:*** **sensor responds to light reflected from object to detect presence or absence.**

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

Energy Sensors

Vibration

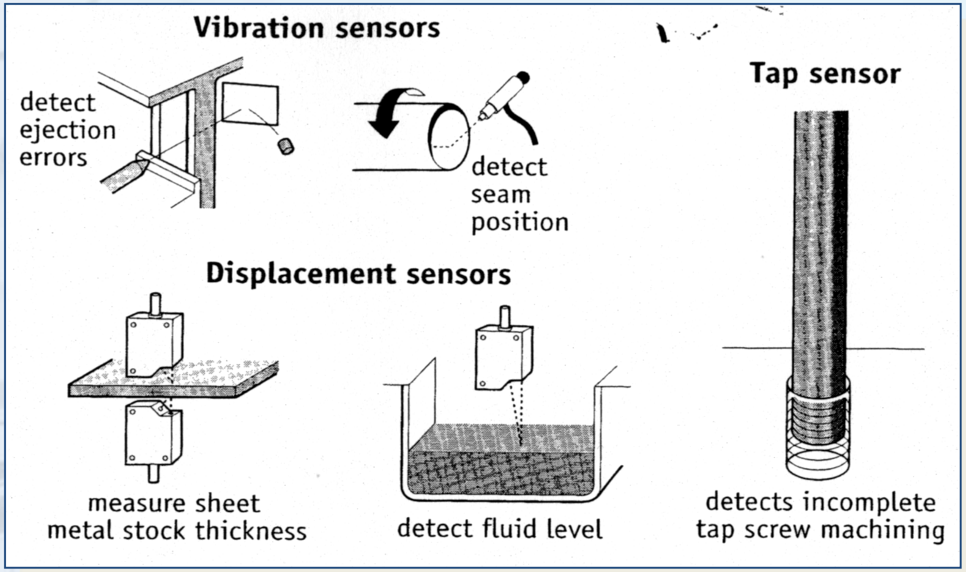
Photoelectric

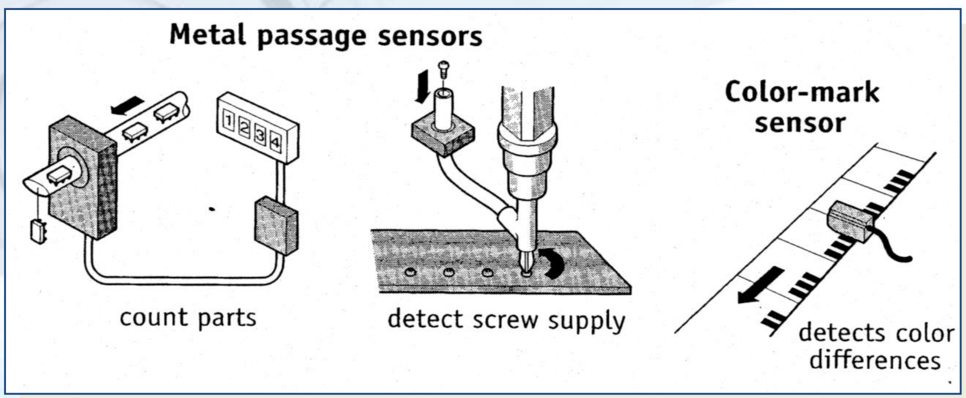


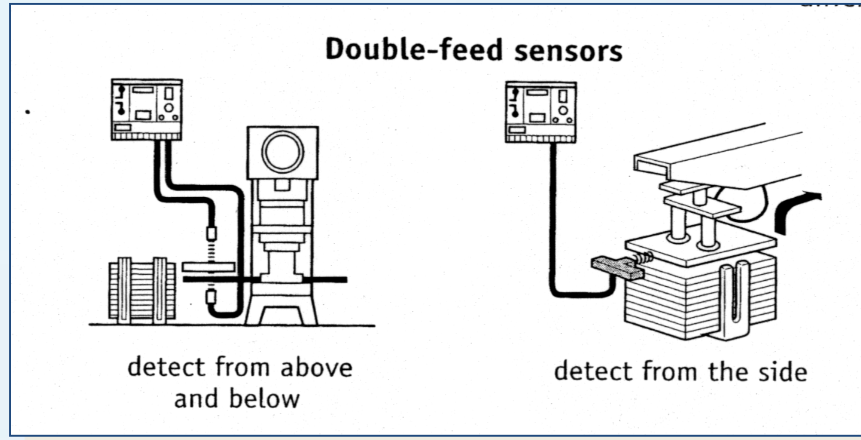
Fiber optic

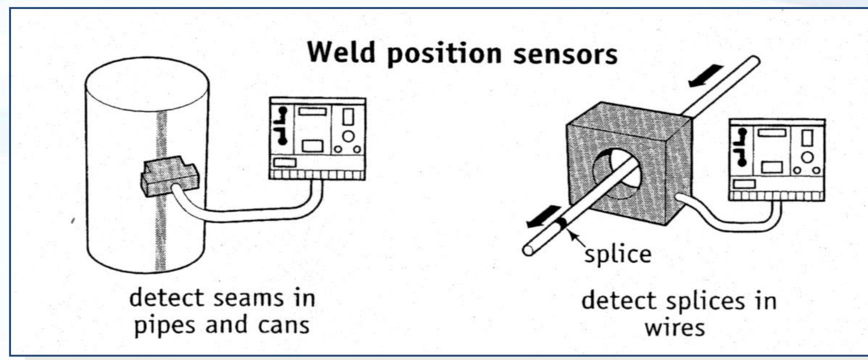
These devices use energy to detect normal and abnormal conditions.

More Examples of Energy Sensing Devices









Sensors that Detect Changes in Physical Conditions

Three categories:

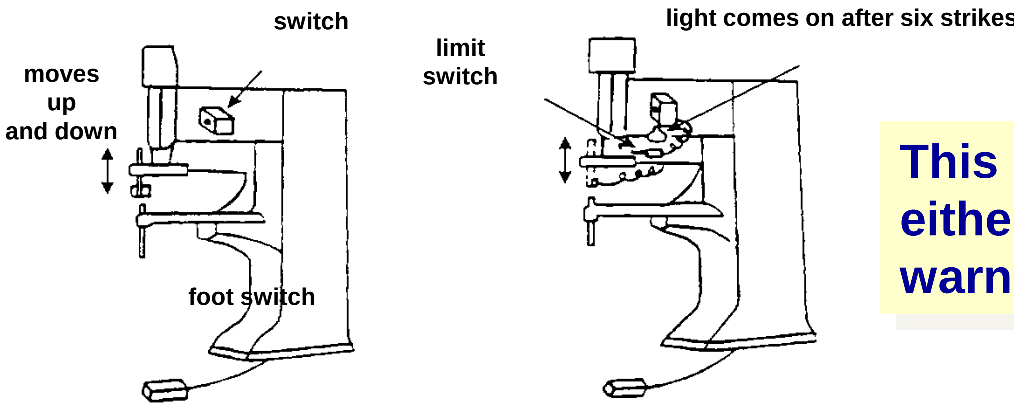
- **Pressure** – pressure changes can be detected by pressure gages and pressure-sensitive switches
- **Temperature** – temperature changes can be detected through heat-activated devices such as thermometers, thermostats, thermistors, etc.
- **Electrical Current** – changes in electrical current flow include meter relays, which can detect material defects by detecting occurrence or non-occurrence of electrical currents

Fixed Value Type of Poka-yoke Devices

2. Fixed-value Method:

– Counts the number of times something is done and signals or releases the product only when the required number is reached

Before Improvement | **After Improvement**



Only a foot switch is attached to a stationary welding machine. Number of strikes controlled only by operator.

1. A limit switch on the upper electrode pole turns on a light after six operations.
2. The light does not come on if product is missing.

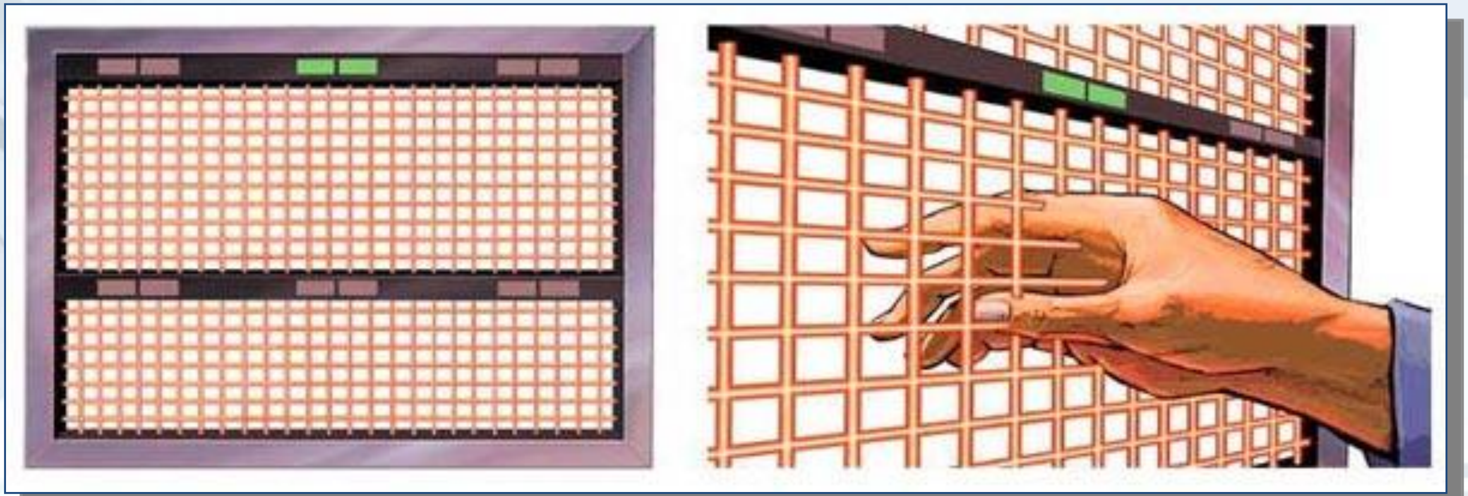
This method can be used with either control systems or warning systems

Fixed-Value (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 component is used or a work element is completed and releases the part only when the right count is reached.**

Counting Fixed Value Devices

- Gate, Bin and Rack Counters can be used to detect the number of moves an operator makes within a given Work Cycle. Photoelectric eyes can detect that the correct number of motions were performed.

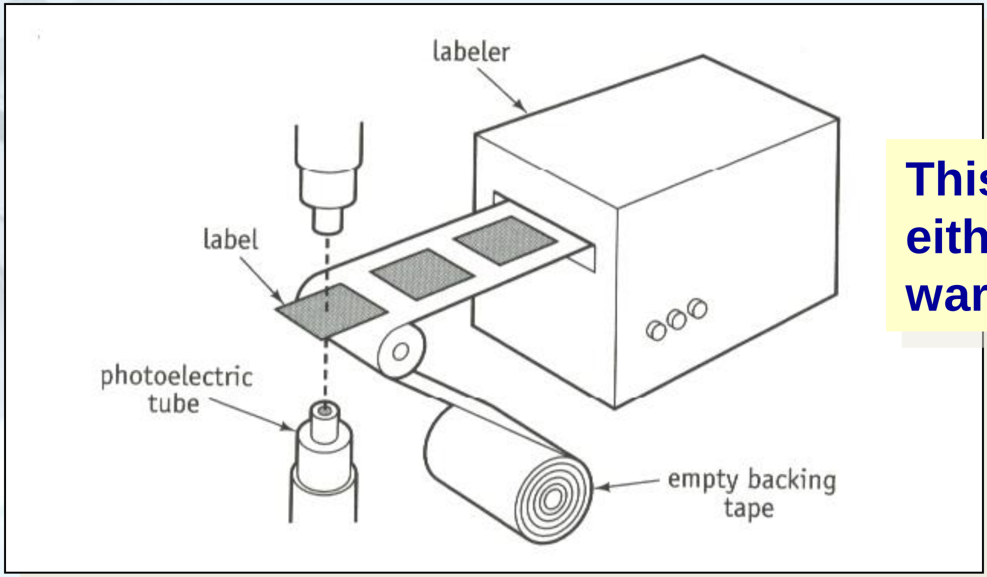


Source: Speastech Inc., www.speastech.com

Motion Step Type of Poka-yoke Devices

3. Motion-Step Method:

– Senses whether a predetermined motion or step in the process has been carried out within a certain expected time, such as a machine's cycle time, or within certain sequence.



This method can be used with either control systems or warning systems

Motion-Step 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 sensor activates a shut-off 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.

Source: Speastech Inc., www.speastech.com

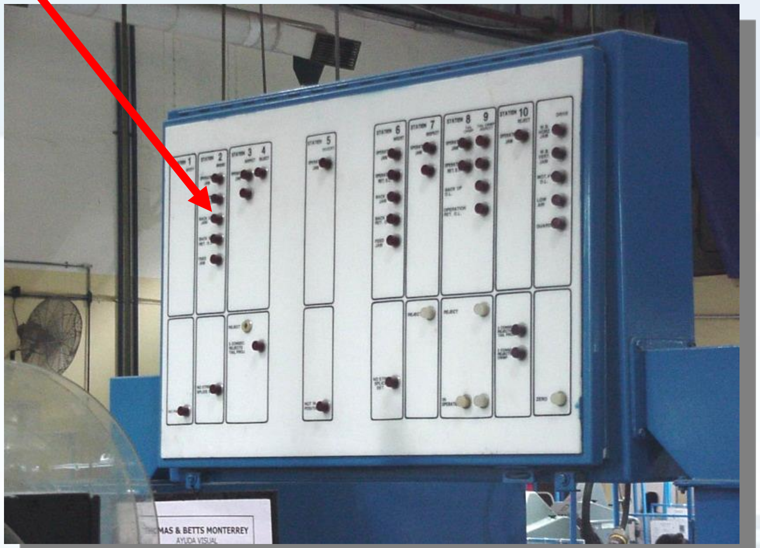
Motion Step Devices

This device will detect the operator's hand motions and the sequence of those motions to assure that the right moves were made in the right order.

Source: Speastech Inc., www.speastech.com

Motion-Step Method – Example

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 warning light for that step will be turned on and the machine will stop.



Source: Speastech Inc., www.speastech.com

Five Best *Poka-yoke* Devices for Manufacturing

1. Guide pins of different sizes.
2. Warning alarms, bells, lights, etc.
3. Limit switches
4. Counters
5. Checklists

Guide Pins

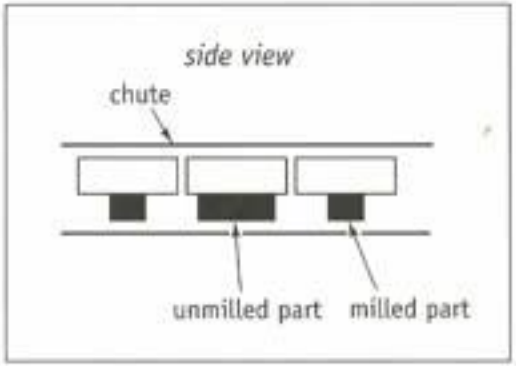
- **Guide pins, narrow chutes, go/no-go checking can be used to detect non-conforming products during production.**
- **Inexpensive to deploy.**
- **Typically function to stop the operation and/or remove defective product.**
  - Example on following slide.

Guide Pin Example

Contact Method: Detecting Unprocessed Parts in a Chute

Before Improvement

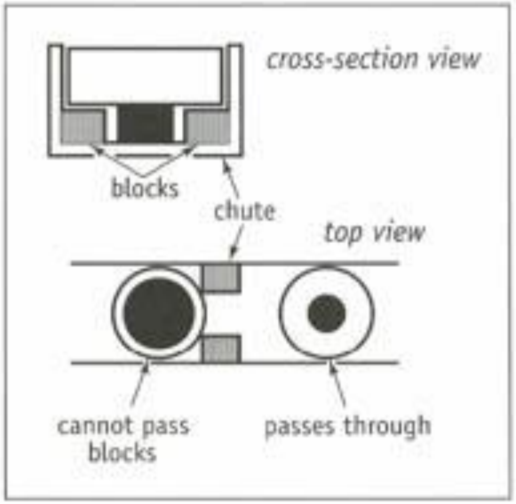
Molded parts are milled in an automatic machine, then fed to the next process by way of a chute. Sometimes a processing error allows an unmilled part to leave the milling machine and come down the chute. When an unmilled part enters the machine for the next process, it stops the machine and sometimes damages it.



What would you do to prevent this mistake?

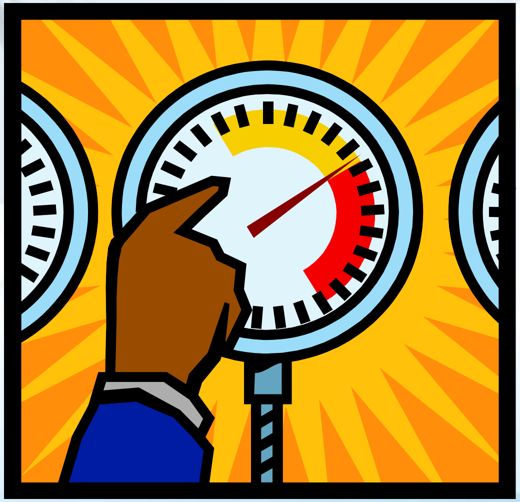
After Improvement

A method was devised to use the shape of the unmilled parts to stop them in the chute before they reached the machine. This involves placing two small blocks in the chute in such a way that the thin "stem" of the milled parts can pass through, but the thicker "stem" of an unmilled part catches on the blocks and doesn't go any further. The operator then removes the unmilled part and restores the flow of milled parts into the machine.



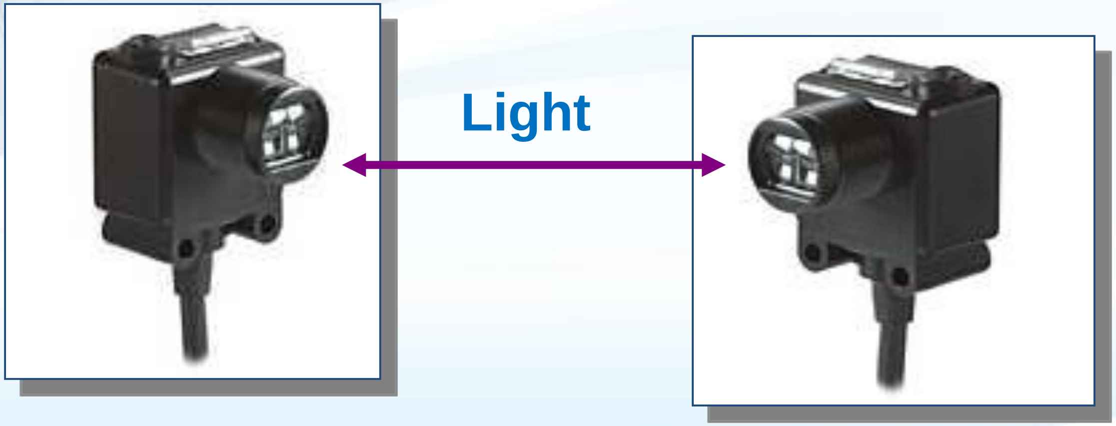
Lights, Alarms, Bells

- Used to signal the detection of abnormal conditions.
- They require a detection device with an electric output to trigger the signal.
- They require intervention/actions by an operator to correct the abnormal condition detected.



Photoelectric Switches (Photoelectric Eyes)

- **Used to check the presence or absence of a characteristic.**
  - **Transmitting** – requires a transmitter and receiver.
  - **Reflecting** – a sensor responds to light reflected off an object.



Limit Switches

- Used to confirm the presence and/or position of objects and to detect broken or missing tools.
- Switches are activated by a light touch on their probe. Limit switches can be used to detect presence, position, breakage and to evaluate dimensions with high sensitivity.

Limit Switches

Counters

- **Manual and automatic counters are used to assure that a specified number of objects have been used or that a specified number of motions have been completed during an operation.**
- **Counters can detect the number of reaches an operator makes as well as the sequence of those reaches.**
- **Counters can detect the number of machine cycles completed.**
- **Counters can detect the number of components or fasteners used.**

Checklists

- **Used to remind us not to forget:**
  - Airline pilots use checklists prior to take-off.
  - Scrub nurses use checklists prior to surgery.
- **Checklists can be used to remind us to perform all of the tasks that complete an operation.**
  - The more complex the operation, the more likely is the need for checklists.

Review from Day One

- **Mistake Proofing is a PREVENTION System for Quality Control.**
- **ZQC Requires 100% inspections.**
- **Source Inspections (Check – Do) are preferable to Judgment Inspections (Check – Sort).**
- **Mistake Proofing in Design versus MP in Process Improvement / Problem Solving.**
- **Mistake Proofing Tool Box**
  - Contact Type
  - Fixed – Value (counting) Type
  - Motion Step (count & sequence) Type

Thank You!

Questions?

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