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SPC

LESSON: History of Quality Control

Prior to 1800 and up to 1900: Operator Quality Control

- There were tradesmen, craftsmen, apprenticeships, and guilds (association of persons with similar purposes).
- A **single person** usually manufactured, built, and finalized the product; craftsmen took **pride** in their work.
- Volume was limited, but **quality** was **controlled** by craftsman
- ~1800: Americans credit Eli **Whitney** with inventing **interchangeable parts** for muskets in 1803.

Reference: http://www.uh.edu/engines/epi1252.htm

Interchangeability had to be developed before mass production of goods could begin.

Gunsmith Honoré **Blanc** (France)

- Made 1,000 **muskets** and put their parts in **separate bins**.
- Brought together politicians and militia to show them that he could assemble muskets from **randomly drawn parts** from the separate bins.
- **Thomas Jefferson** (while in France) found out about interchangeable parts from visiting Blanc's workshop.

Whitney "duplicated" Blanc's demonstration 18 years later for then President Jefferson. This difference was that Whitney had hand-crafted each part in his demonstration so that they'd fit together perfectly.

Whitney sold the government a huge contract for **4,000 muskets**.

- Took **8 years** to deliver them
- Parts were *not* interchangeable

Blanc went into business and was producing 10,000 muskets/year for Napoleon.

In 1806, the **French** government **sacked** the whole process. Why?

- Using unskilled labor, Blanc's method made **manufacturers independent of government control.**

- By 1850, the French had never even heard of it; credited America with inventing interchangeability.

Question: *Why is the use of interchangeable parts important in manufacturing?*

~1900: Foreman Quality Control, Industrial Revolution, mass production

Ford Motor Company was established. **Henry Ford** used **assembly lines** to make the automobiles.

Suggested reading: Ford's **"My Life and Work"**

- Available for free at dailylit.com/books/my-life-and-work.
- Ford's view on technology and innovation – he could be writing this book about **today's world**.
- Ford Quote: "Make the **best quality** of goods possible at the **lowest cost** possible, paying the **highest wages** possible."

Complex operations were broken down into many simple steps.

- Each step was performed by an **unskilled worker** who was taught a specific step.
- Individuals performing the same task were **grouped together** under a **foreman**.

Loss of pride in workmanship, but workers were paid **high wages**; could still buy a Ford car

Foremen were responsible for group operations and the quality of the item produced by the group.

- Foremen's real **priorities** became **meeting production deadlines**.
- Foremen were NOT necessarily checking quality.

~1920-1940: Inspector Quality Control

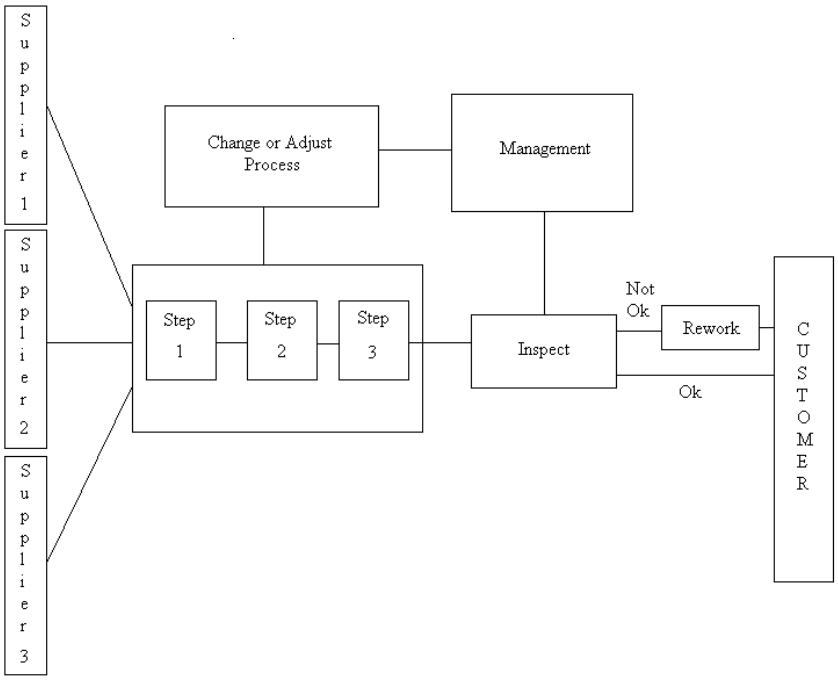
During **World War I** stringent requirements forced the employment of **full-time inspectors**.

An **inspection** of each product was instituted **at the end** of a production line.

- Used to separate the **"good" from the "bad."**
- The bad items were either **reworked or discarded**.

Productivity decreased as **quality increased** because bad items were rejected.

Old Quality Philosophy:

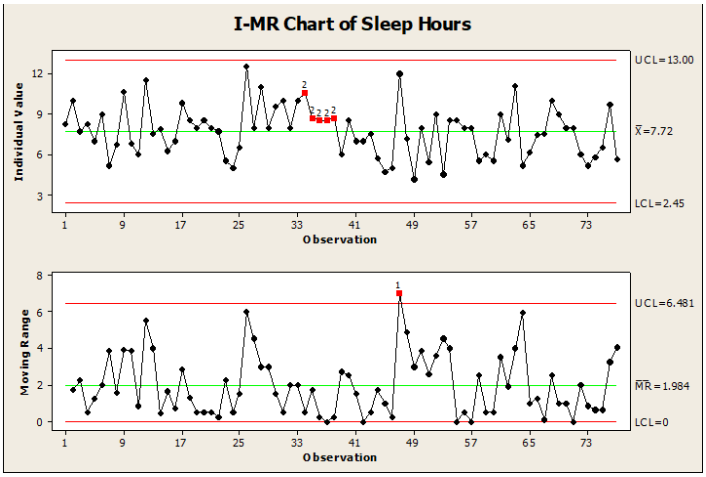


Western Electric: U.S. Electrical Engineering company – the **manufacturing arm** of Bell Telephone

- Location of many technological innovations and developments in industrial management
- In 1918, **Walter Shewhart** joined Western Electric.
- Western Electric realized the importance of **reducing variation** in a manufacturing process.
- Shewhart determined that **continual process-adjustment** in reaction to natural cause variation increased variation and degraded quality.

Simulation: Deming's funnel experiment: http://www.symphonytech.com/dfunnel.htm

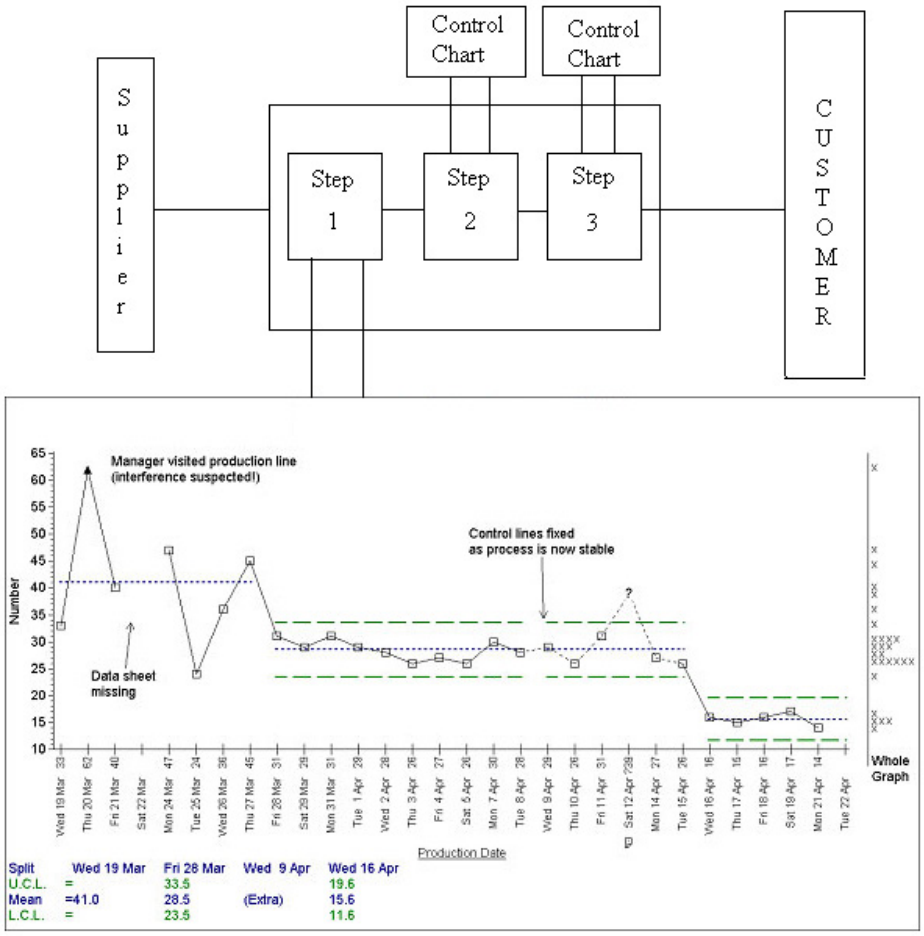
In **1924**, Shewhart framed product variation in terms of *special cause* and *common cause variation*; he introduced the **control chart** as a tool for **distinguishing** between the two. Shewhart stressed the importance of a process being in a state of **statistical control** (only common cause variation present) and keeping it in control – only then could future output be predicted.



I chart: Individual Chart: This student's sleep hours are plotted each day over Winter Quarter.

MR chart: Moving Range Chart: The absolute value of the difference in this student's sleep hours between two consecutive days are plotted each day over Winter Quarter

New Quality Philosophy: The **WORKERS monitor** and adjust the process, but only when signaled to adjust by the **statistical control chart**:



Dodge and Romig at Bell Telephone doing **Acceptance Sampling**

Reference: http://www.itl.nist.gov/div898/handbook/pmc/section2/pmc21.htm

Original application: The testing of **bullets** by the U.S. military during **World War II**.

- If *every bullet was tested* in advance, no bullets would be left to ship.
- If *none were tested*, malfunctions might occur in the battlefield with potentially disastrous results.

What is **acceptance sampling**?

- A sample is chosen at random from a lot, and based on the information obtained from the sample, a decision is made regarding the lot – typically, accept or reject the lot.
- It is "**the middle of the road**" approach between no inspection and 100% inspection.

The **main** purpose of acceptance sampling is to decide whether the lot is likely to be acceptable, not to estimate the quality of the lot.

Question: In what situations is acceptance sampling particularly useful?

~1940-1960: Statistical Quality Control

During World War II, the U.S. needed greater production and high quality, which led to the use of **Statistical Quality Control**, which eliminated the need for inspection at the end of a process.

Many **MIL-SPEC** documents and sampling inspection plans were developed by the U.S. military.

- Used to **help achieve standardization** objectives by the U.S. Department of Defense.
- **Standardization** is beneficial in achieving **interoperability**, ensuring products meet certain requirements, commonality, reliability, total cost, compatibility with logistics systems, etc.

Example: In World War II American screws and bolts did not fit British equipment properly and were **not fully interchangeable** due to differences in dimensional tolerances between the U.S. and Britain.

1946: The **American Society for Quality Control** (http://www.asq.org/) was founded; our local chapter is the oldest chapter in the state of Indiana

As World War II ended, most **U.S. companies** viewed **quality** as just a **wartime** effort. U.S. felt that it could sell everything it made and didn't worry about quality.

v. 1946-1950: **W. Edwards Deming** tried to convince U.S. managers to go back to statistical quality control.

- U.S. ignored him.
- In 1950, Japan's "mark of quality" = junk
- Deming was asked by the Japanese Union of Scientists & Engineers to speak to Japanese industrialists. They wanted to:
- Rebuild Japanese industry, and break into foreign markets and increase sales
- Improve their reputation of producing poor quality goods
- From 1950-1960, Deming's management methods were **embraced** by the **Japanese**. The change in 2-5 years was dramatic! https://www.youtube.com/watch?v=GHvnIm9UEoQ (2:30)
- In 1951, the Japanese established the Deming Prize – Silver medal engraved with Dr. Deming's profile awarded to individuals and companies for accomplishments using his statistical applications.

vi. **Joseph Juran** is also credited as helping to rebuild Japan after WWII – he focused on **managing** for quality

~1960: Total Quality Control

Department of Defense (DOD) developed the **Quality Control and Reliability Handbook H-107,** which dealt with sampling plans and tables for inspection of attributes.

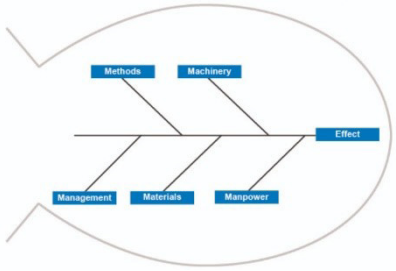
Other departments and management personnel became part of the quality control process – quality was no longer just the responsibility of the QC department.

The term **"zero defects" (Philip Crosby)** became prevalent – achieving productivity through worker involvement; this was for production of critical parts and assemblies, such as missiles and rockets.

Quality circles arose in Japan, thanks to Kaoru **Ishikawa**

~1970-80s: Total Quality Control Organizational Phase

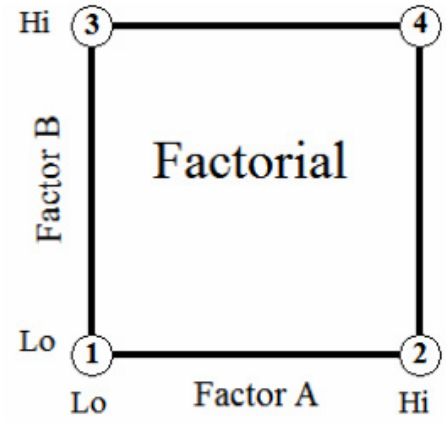
Quality was associated with every person – "total quality system"

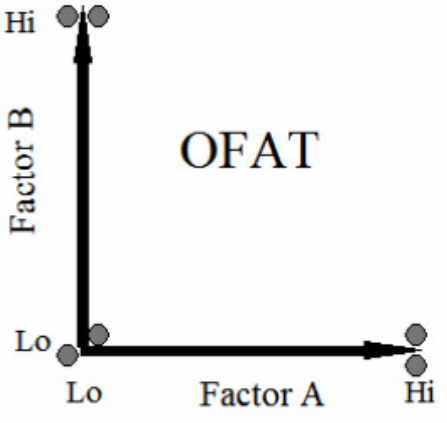


In Japan, a new popular diagram was introduced to help determine why a process went out of control; it is called the **Cause-and-Effect diagram**, Ishikawa diagram, or fishbone diagram

Genichi **Taguchi** introduced how to design an experiment

- **Design of Experiment (DOE)** focuses on a wide range of key inputs to determine their optimal output
- DOE is probably one of the **most powerful tools** in the statistics toolbox
- Key advantage of DOE over OFAT (One Factor at a Time): It reveals **interactions** of multiple factors – the experimenter can change more than one factor at a time

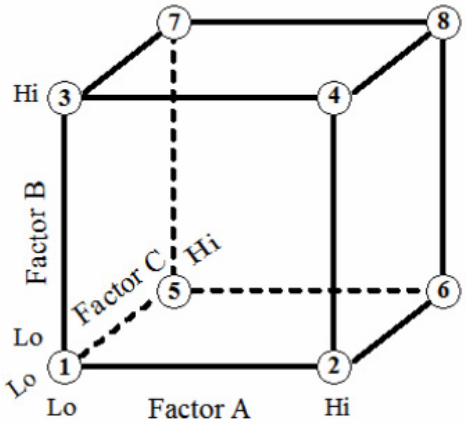


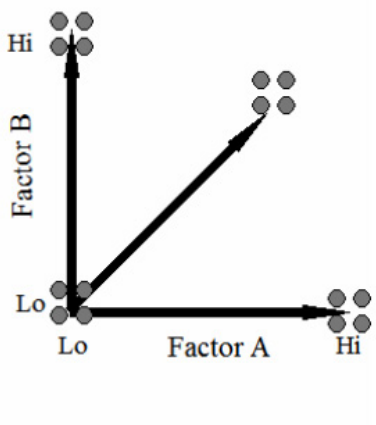


Example: Popping Popcorn: Two factors: Time and Power Level

Genichi **Taguchi** introduced how to design an experiment (continued)

- The advantage of DOE over OFAT is more evident as more factors are added to the experiment.





Example. Effect**: Gas Mileage;** Factors**: Speed, Gas Octane Rating, Tire Pressure**

OFAT design

Speed	Octane	Tire Pressure	Y = MPG
55	85	30	23
60	85	30	24
55	90	30	22
55	85	35	20

Full Factorial Design (with OFAT runs highlighted)

Speed	Octane	Tire Pressure	Y = MPG
55	85	30	23
60	85	30	24
55	90	30	22
60	90	30	28
55	85	35	20
60	85	35	21
55	90	35	27
60	90	35	25

After the 1970's when Japan had made enormous gains in markets once dominated by the U.S. – the U.S. decided it needed to focus again on quality

- **Ford lost 1 billion dollars in 1980**
  - Deming was brought into Ford in 1981
  - Ford and other U.S. companies became interested in Deming after viewing **"If Japan Can ... Why Can't We?"** – it was a 1980 NBC Special Report; it is free to watch online
- Deming at Ford: https://www.youtube.com/watch?v=YQpY3InIjBE -- ~first 5 minutes

In 1984, a list was compiled at Harvard University of "industries that the **U.S. worldwide** has had its marketing share **slip by at least 50%** in the last 10 years"

- Automobiles, Cameras, Medical equipment, TVs, Hand tools, Tires, Motors, Food processors, Microwaves, Athletic equipment, Computer chips and P.C.'s, Industrial robots, Electron microscopes, Machine tools, ...

New-new quality philosophy – **Design IN quality** or robustness from the start of production

1980's to present ...

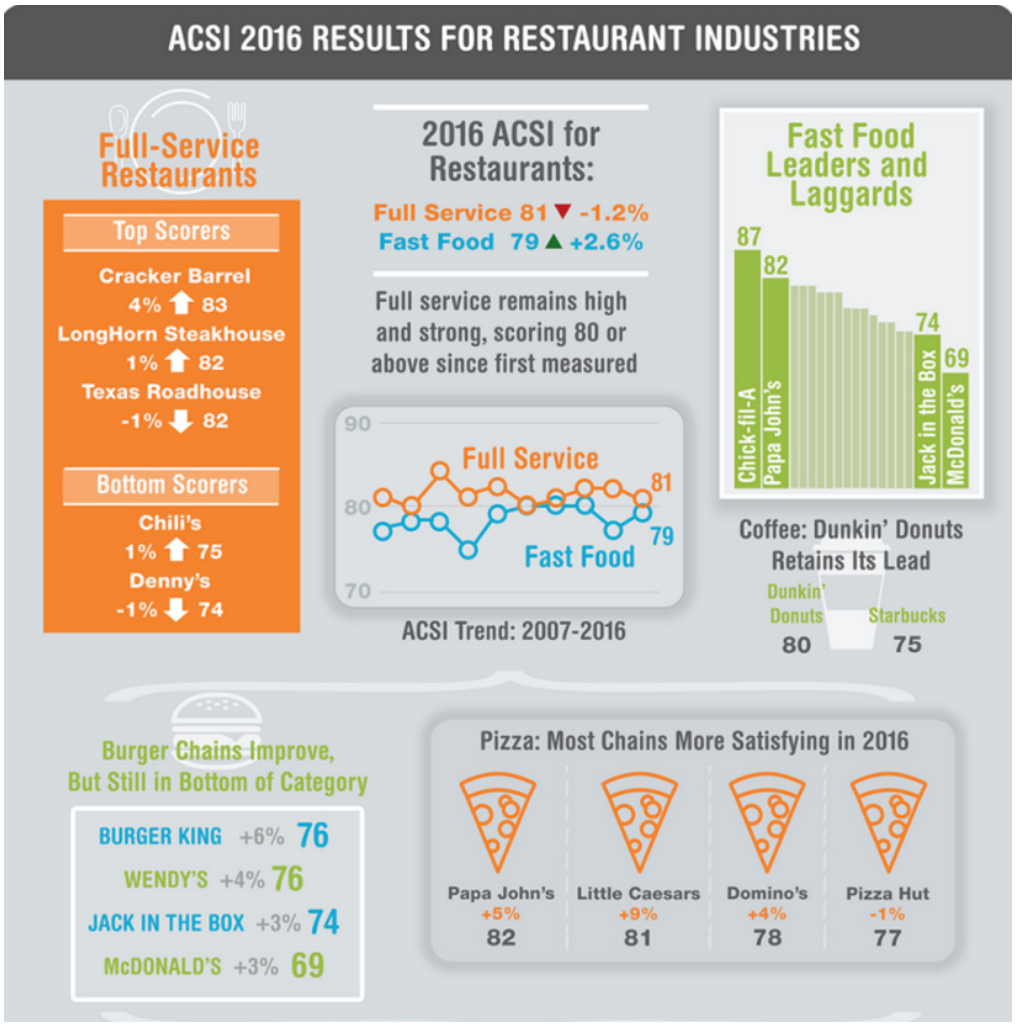
Ford and other companies demanded the use of **statistical process control from its vendors**

Malcolm Baldrige Award, ISO 9000-9004, **Six Sigma**, American Customer Satisfaction Index (ACSI), ...

- We will discuss each of the above in more detail in the next two weeks.
- **ISO 9000-9004 certification** – like **ABET** (Accreditation Board for Engineering and Technology) accreditation for universities: we do what we say we do
- ABET: Non-governmental organization that **accredits** post-secondary education **programs/**

majors in applied and natural science, computing, engineering, and technology.

- **American Customer Satisfaction Index** example: Looks at trends in consumer satisfaction



ACSI: Limited-Service Restaurants

Company	2015	2016	% Change
Limited-Service Restaurants	**77**	**79**	**2.6%**
Chick-fil-A	86	87	1%
Papa John's	78	82	5%
All Others	81	81	0%
Little Caesars	74	81	9%
Panera Bread	80	81	1%
Arby's	74	80	8%
Dunkin' Donuts	78	80	3%
Subway	77	80	4%
Chipotle Mexican Grill	83	78	-6%
Domino's	75	78	4%
KFC (Yum! Brands)	73	78	7%
Pizza Hut (Yum! Brands)	78	77	-1%
Burger King	72	76	6%
Wendy's	73	76	4%
Starbucks	74	75	1%
Taco Bell (Yum! Brands)	72	75	4%
Jack in the Box	72	74	3%
McDonald's	67	69	3%

	16	17	18	19	Previous Year % Change
Chick-fil-A	87	87	87	86	-1.1
All Others	81	82	82	82	0.0
Panera Bread	81	82	81	81	0.0
Papa John's	82	82	80	80	0.0
Arby's (Inspire Brands)	80	80	79	80	1.3
Chipotle Mexican Grill	78	79	79	80	1.3
Pizza Hut (Yum! Brands)	77	76	80	80	0.0
Subway	80	81	80	79	-1.3
Domino's	78	78	79	79	0.0
Starbucks	75	77	78	79	1.3
Limited-Service Restaurants	**79**	**79**	**80**	**79**	**-1.3**
KFC (Yum! Brands)	78	78	77	78	1.3
Dunkin'	80	79	78	78	0.0
Wendy's	76	76	77	77	0.0
Little Caesars	81	78	77	77	0.0
Burger King	76	77	76	76	0.0