Statistical Quality Control

and the Rise of International Manufacturing Competition

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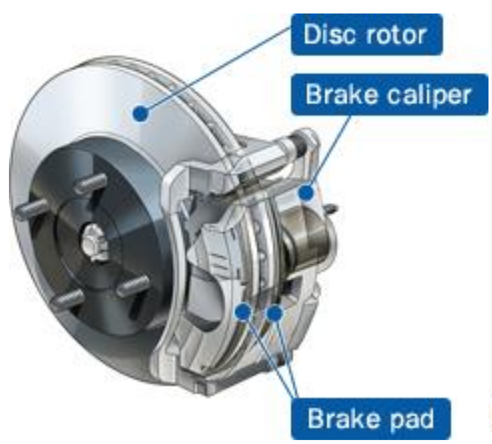
Basics as shown illustrated by the piston of a brake caliper

Variable data

Design spec, tolerance

Brake caliper, power supply, . . . you name it. Measure! Length, voltage, temperature, weight . . . inexpensive digital tools available.



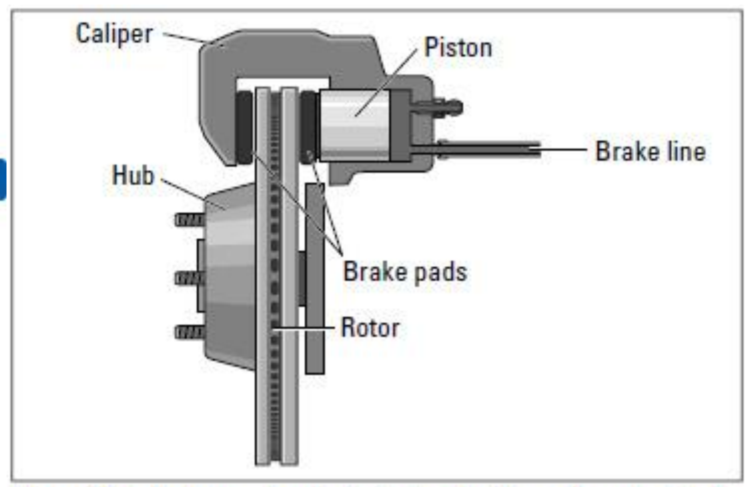


Figure 14-9: Anatomy of a single-piston, floating-caliper disc brake.

Mass Production

Make **hundreds of thousands** of pistons perhaps

Volume and *quality* both goals

Lack of quality has many downsides

Recalls, wasted money, lawsuits, lost customers . . .

What does quality mean here?

Item within specification

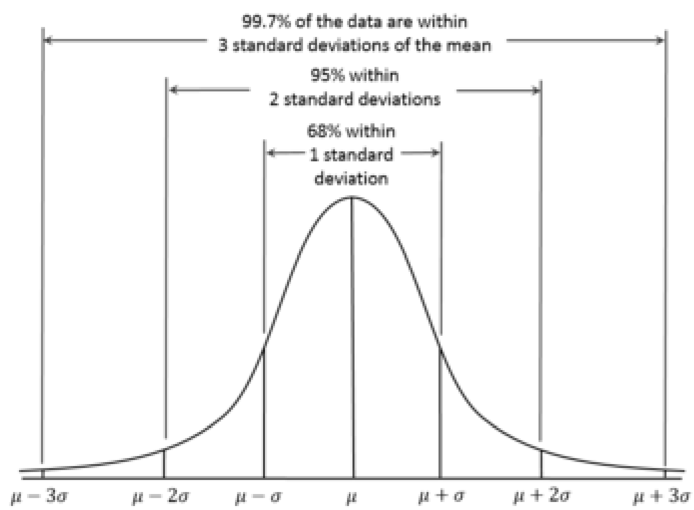
Typically: diameter +/- tolerance. Here **1.510 +/- .005"**

Metric #1 : **#defects per million items** **dpm**

Reality:

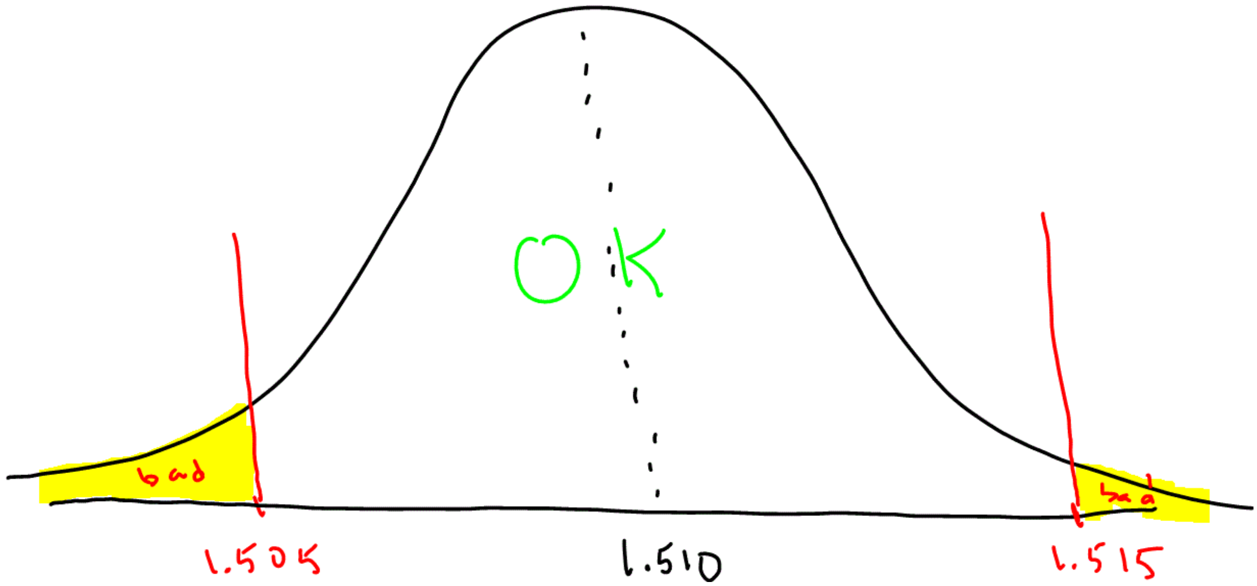
Measure all diameters of all pistons.

A *Normal Distribution* results



all the time. **There is *always* variation. (key point).** For my piston assume the average is **1.510" = μ** and the standard deviation **σ = .0025**

How does quality relate to this news?



The area in yellow, in the tails is equal to approximately **.0458** . This means of course that **95.42%** of the items are being manufactured correctly. Or an equivalent defect rate of **45,800** per million. . . . hmmm.

Background: history of US Mass production

Ford assembly line for Model T

https://safeshare.tv/x/ShbgvwazCZ

Electrical industry 1920s, 30s

AT&T Western Electric

Wire!

Walter Shewart, W. Edwards Deming

Sampling *as a way to measure quality*

Central Limit Theorem an important underlying fact

Increasing quality as a goal

Management philosophies tied to statistical methods. Eventually

Deming's 14 points of Management

WWII manufacturing capacity a key element in eventual victory

Postwar

Volume!

By the late 1960s, Hal Spierlach, an accountant working for Lee Iaccoca at Ford, estimated the cost of nonconformance was 20-40% of revenues", perhaps $2500 per car. Lessons forgotten.

Meanwhile**, Japanese industrial capability grew post WWII**. Deming taken very seriously. Became global players in electronics and cars thanks in part to sound management practices that included Deming's philosophies. Meanwhile Ford was losing millions per day by the early 80s. And *market share* it would never regain.

The Shewart Cycle

Collect data samples regularly in the factory
Study, conjecture possible paths to improvement
Carefully implement changes
Collect more data, evaluate

Also:

Study *failures* methodically

Fishbone diagrams

Control Charts - Everyday Statistics on the Assembly Line

Two charts: $\bar{x}$, R charts for samples relating to **mean** and **standard deviation** of the process

Take samples daily (shift if possible). Often just 5.

Compute averages, plot

Watch the plot. Holler if key events observed

Trends, drifts, outstanding events

If needed, stop the line!

A visual, intuitive understanding of statistics is involved

Back to our pistons

We would like to lower the defect rate. This can be achieved by **lowering variation** σ which will decrease the area in the tails and hence the defect rate.

Suppose thru communication, training, analysis and feedback we decrease σ to .0016. Then the area in the tails is now about .002 so **99.8%** of our pistons are acceptable and **.2%** defective, which translates into **2000 defects per million**, about 1/22 nd of what we had! This came about by reducing variation from .0025 to .0016. Consistency is worth something!!

A process is often described by its *sigma level*. This is defined as **how many units of standard deviation lie in between the design specs, over 2.**

In our case, since the design specs are 1.505 to 1.1515 and σ to .0016. So the sigma level is about **3.1** (.005/.0016)

The higher the sigma level the better.

In the 1990s, Motorola , a major manufacturer of computer chips, was said to have achieved a **6 sigma** level. This corresponded to only a few defects per *bilslion*.

Who This Material Appeals To

Measuring, sampling, variation, control charts: manufacturing personnel

Underlying mathematics of Control Charts: statistics students

The mathematics of normal distributions: AP Calc students (see reference below)

Strategies for improving quality: management students

Conclusion

Statistical Quality Control has, and will continue to play an important role in manufacturing, which in turn plays an important role in the economy of a region or country. Different aspects of it can interest and challenge a variety of students and allow them to relate their mathematical studies. The notions of *sampling* and *variation* are important, in one way or another, to almost everyone.

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(General Motors plant in Freemont CA which became the home of the joint Toyota-GM project)