Problem Solving

Presented by

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Six Sigma Master Black Belt

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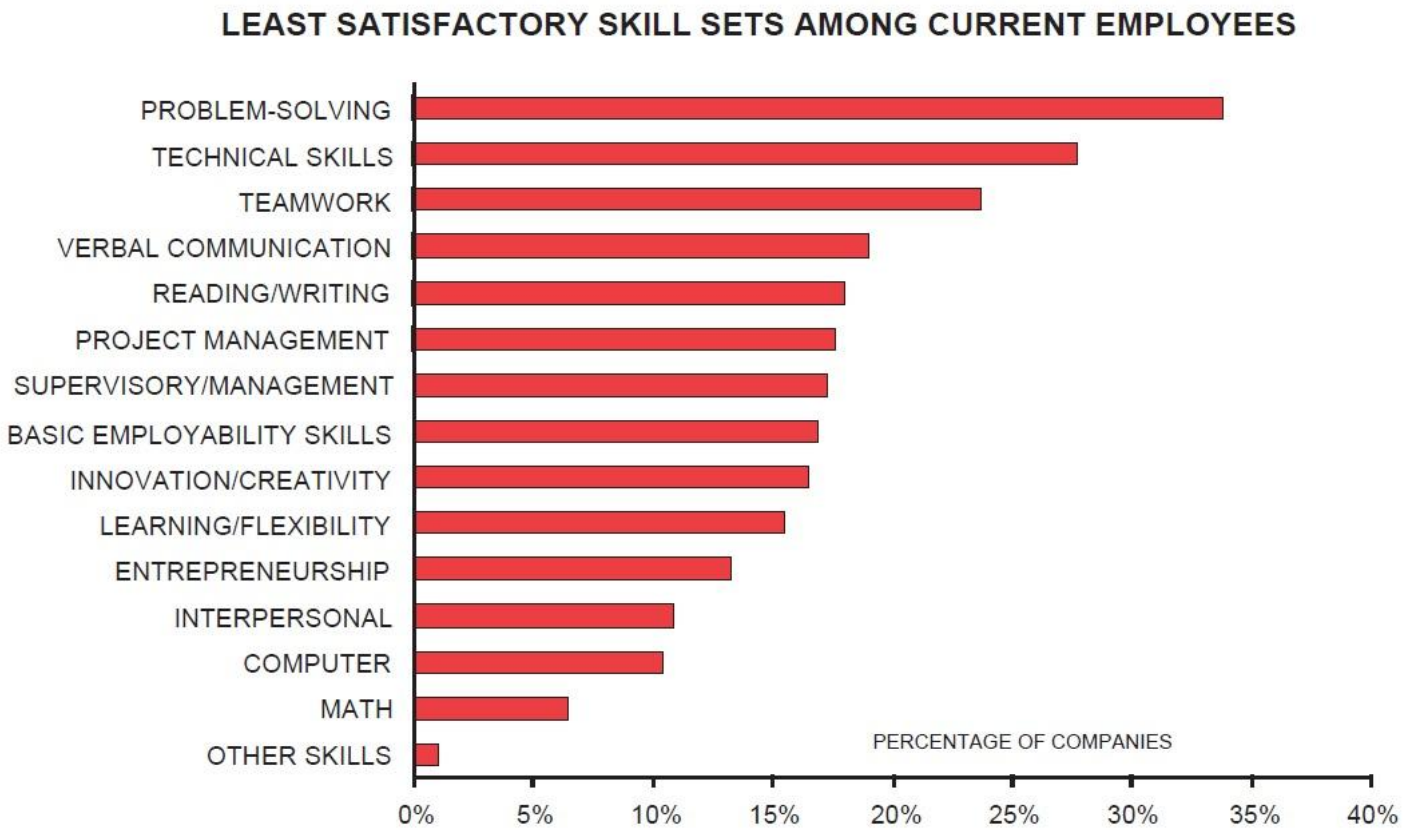
Outline

- Introduction
- Cost of Quality
- Pareto Distribution
- Chronic vs Sporadic Problems
- Variation Reduction
- Clue Generating Techniques
  - Multi Vari Studies
  - Paired Comparisons
- Human Error

From article in 20 / 20



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Cost of Quality

How much does your organization spend on Quality?

- 3% of sales?
- 5% of sales?
- 10% of sales?
- 20% of sales?

Cost of Quality

Most companies will find that their Cost of Quality, when properly evaluated, falls between 10% and 20% of total sales - not the 2% or 3% that many estimate it to be.

Most companies are involved in some quality program. Very few calculate the Cost of Quality.

Cost of Quality

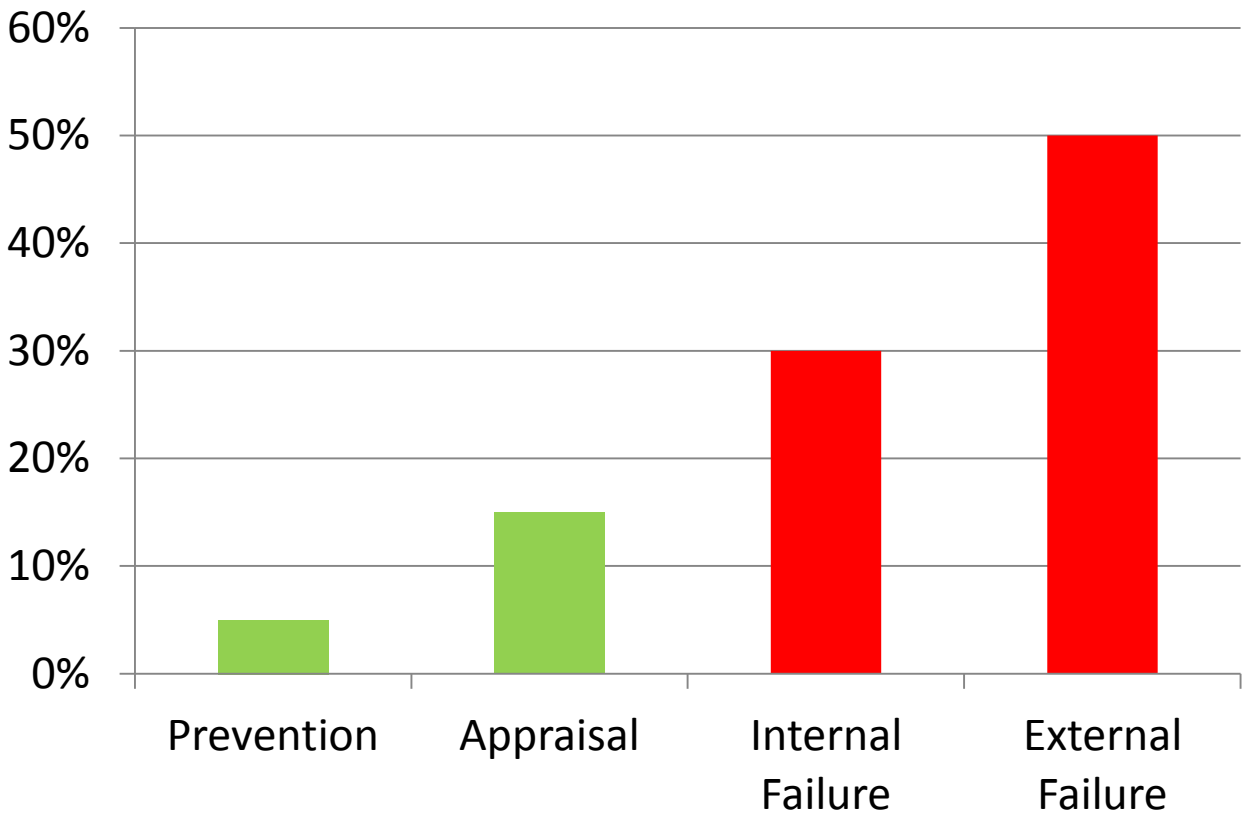
We spend money trying to make a quality product.

Prevention – planning, SPC, training etc
Appraisal – inspections, tests, measuring equipment, calibrations, audits etc.

We spend more when we fail to do so;

Internal failure – scrap, rework etc
External failure – warranty service, complaints, recalls, reputation etc

Cost of Quality



Cost of Quality

Key point in the Cost of Quality model is that approximately 16% of sales is lost due to quality problems.

Pareto Distribution

The Pareto Law is empirical. It shows up often in the distribution of results vs activities.

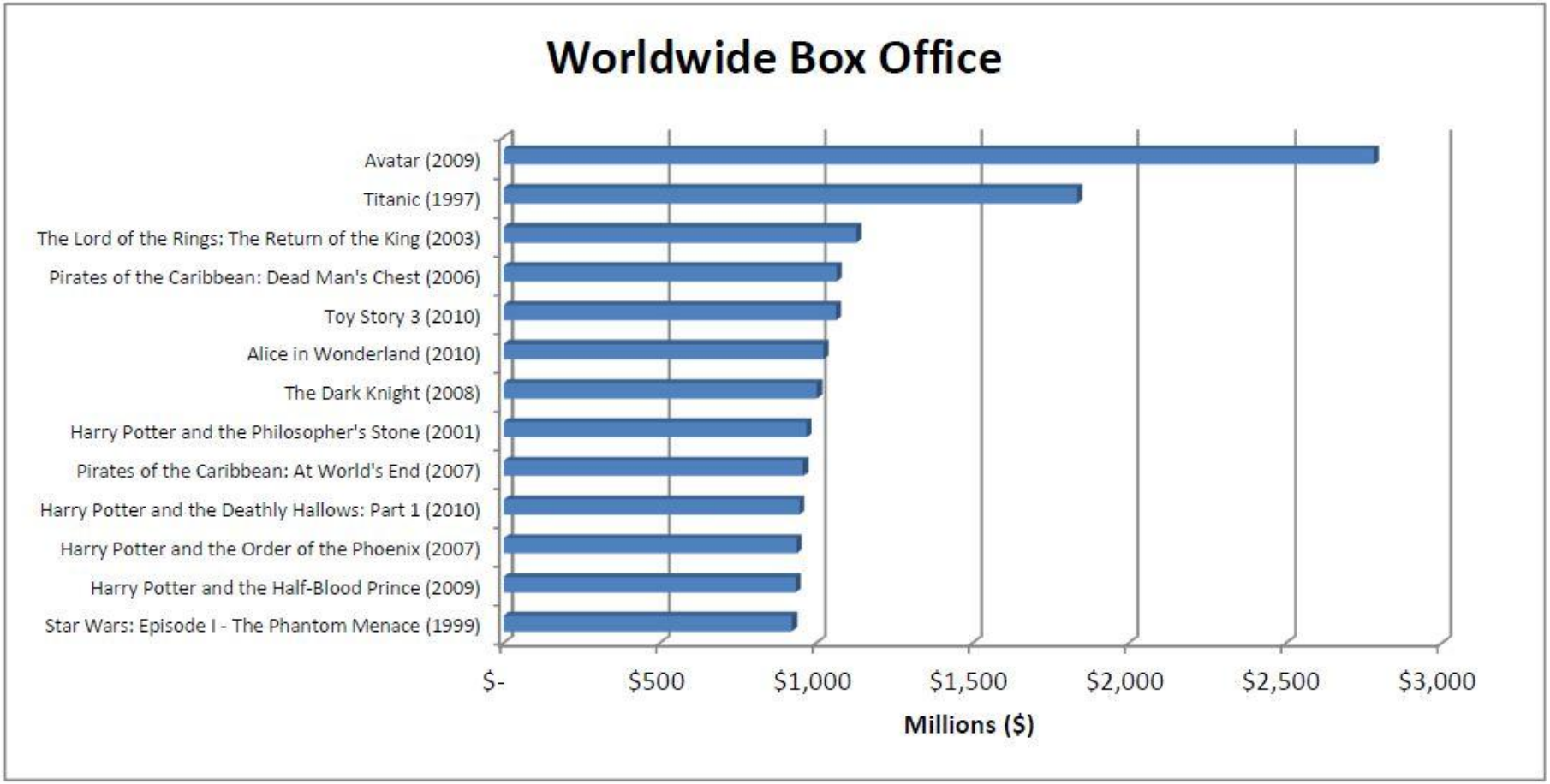
Also called the 80 / 20 rule.

80% of a company's revenues come from 20% of its SKUs.

80% of homes are sold by 20% of realtors.

80% of your failure costs come from 20% of your quality problems.

Pareto Distribution



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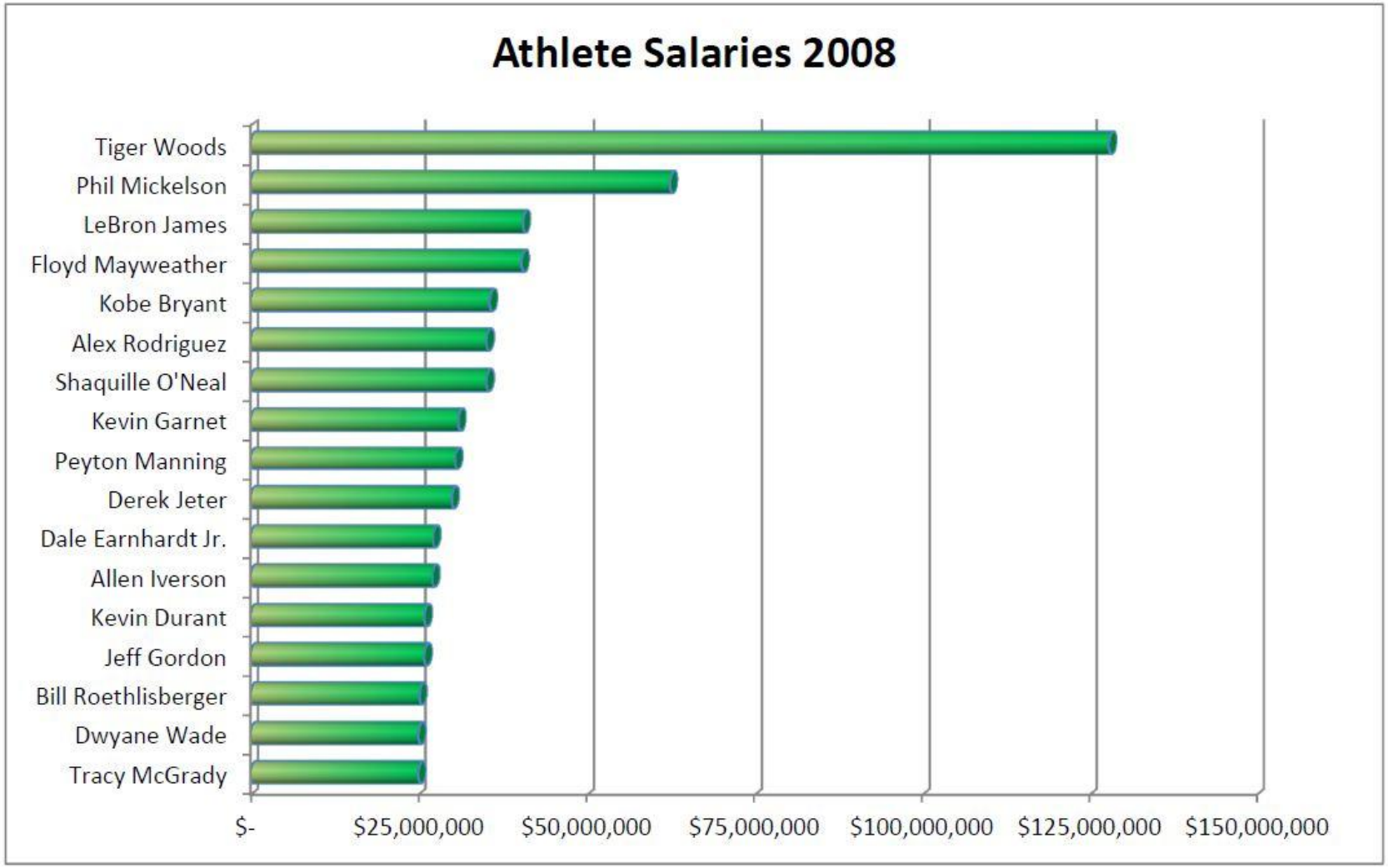
Pareto Distribution



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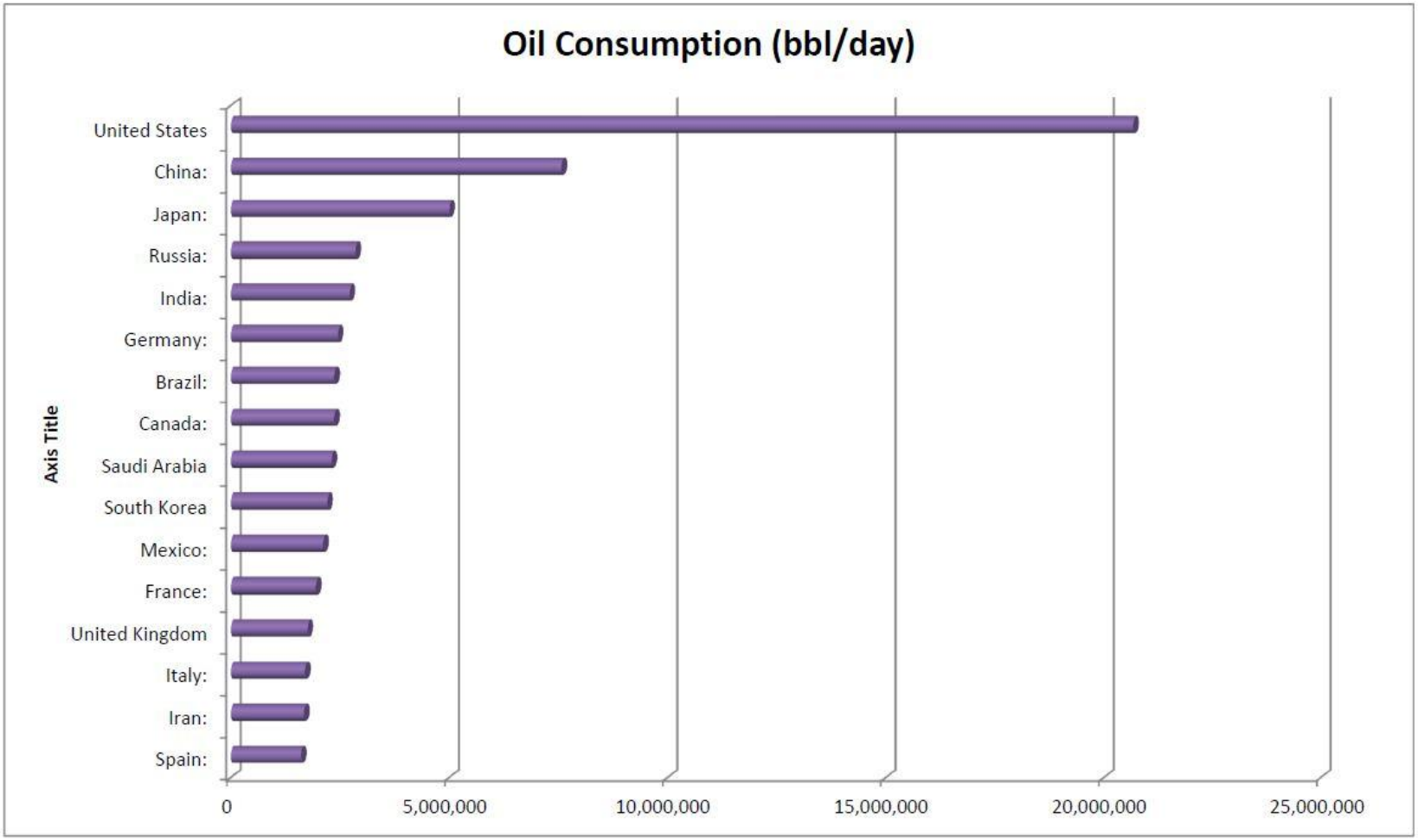

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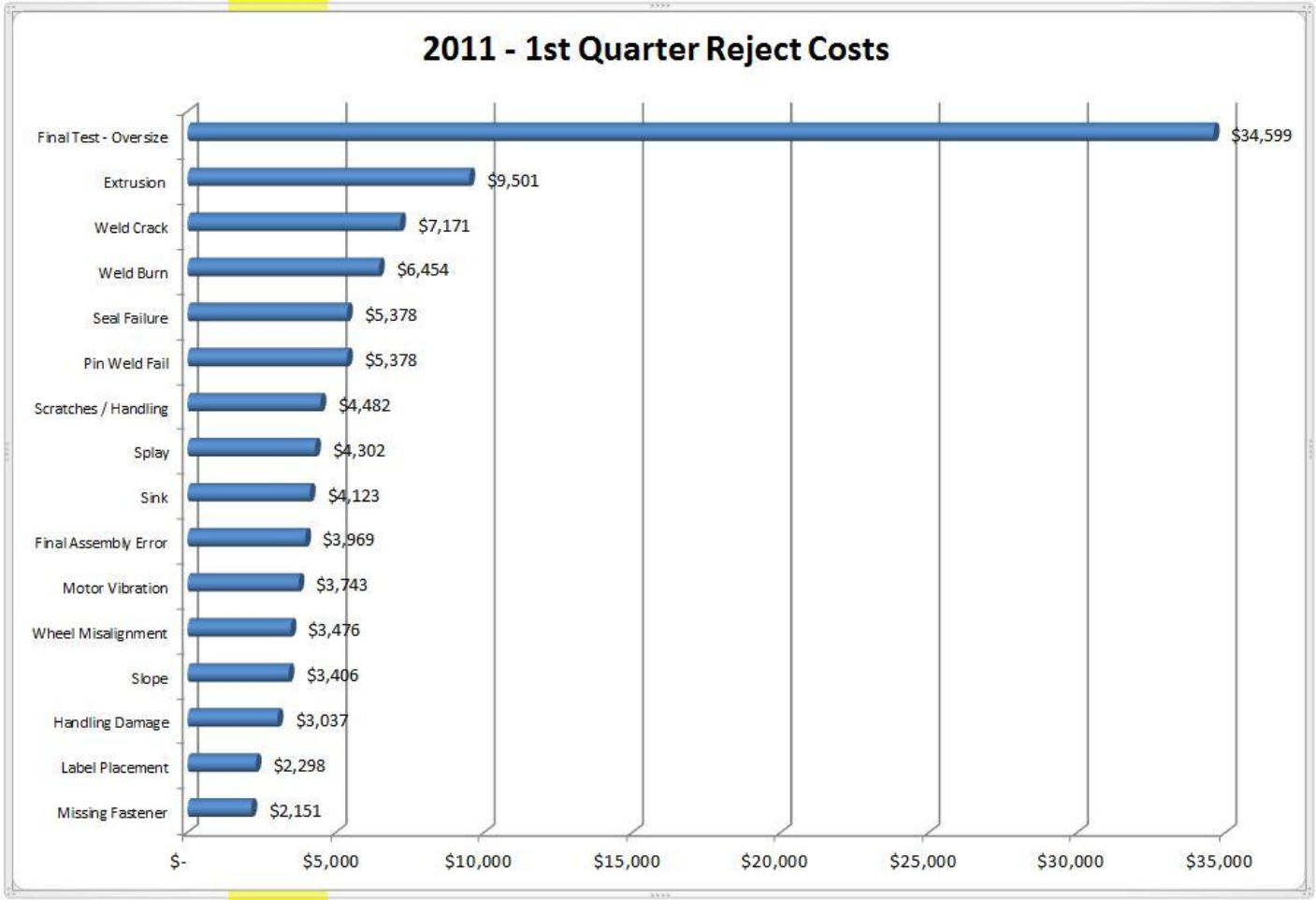

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Pareto Distribution

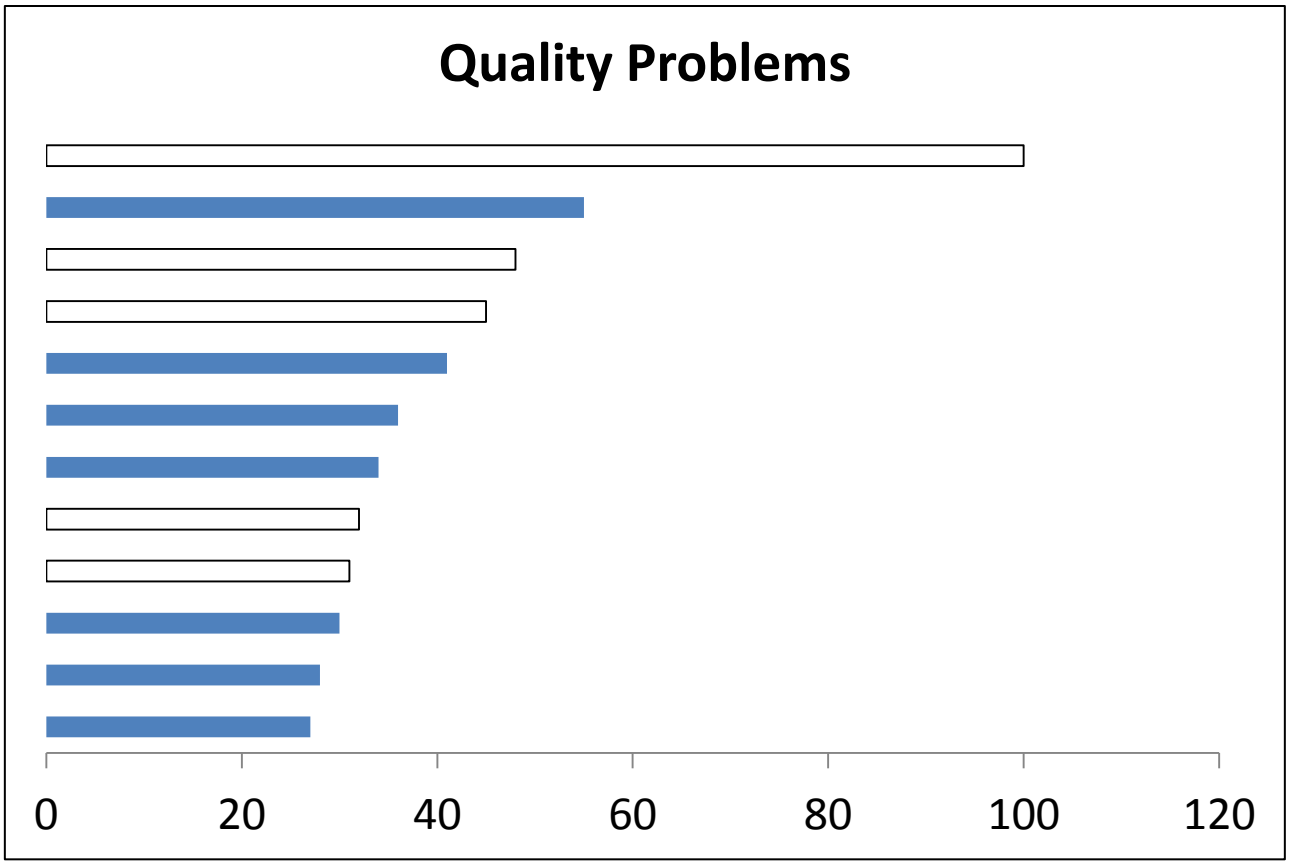
Four different Pareto distributions from very different data sets and all display the same feature. As you approach the top, the difference between successive entries grows so that the number one element is double or more the size of the second.

Pareto Distribution

What this means for Manufacturers is that your top few problems really dominate your quality costs.

The task is to identify your top few problems. Some are visible. Some require thinking and studying.

Pareto Distribution



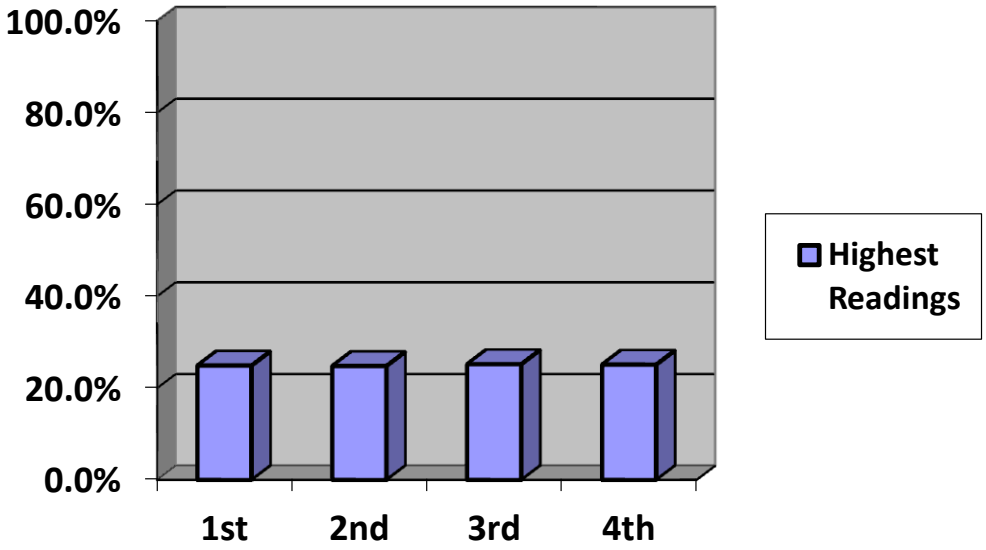
Example 1

A source of problem solving projects comes from testing our assumptions. All organizations have theories about their processes but sometimes we're wrong.

One organization required four samples tested to acquire an average value for batch approval. The first sample was to be discarded because it was considered to be always high.

Example 1

A large sample of many hundreds revealed that the largest reading out of the four was (show chart) equally distributed among the four takes. The hypothesis was not supported. This analysis reduced the cost of sampling by 25%.



Example 2

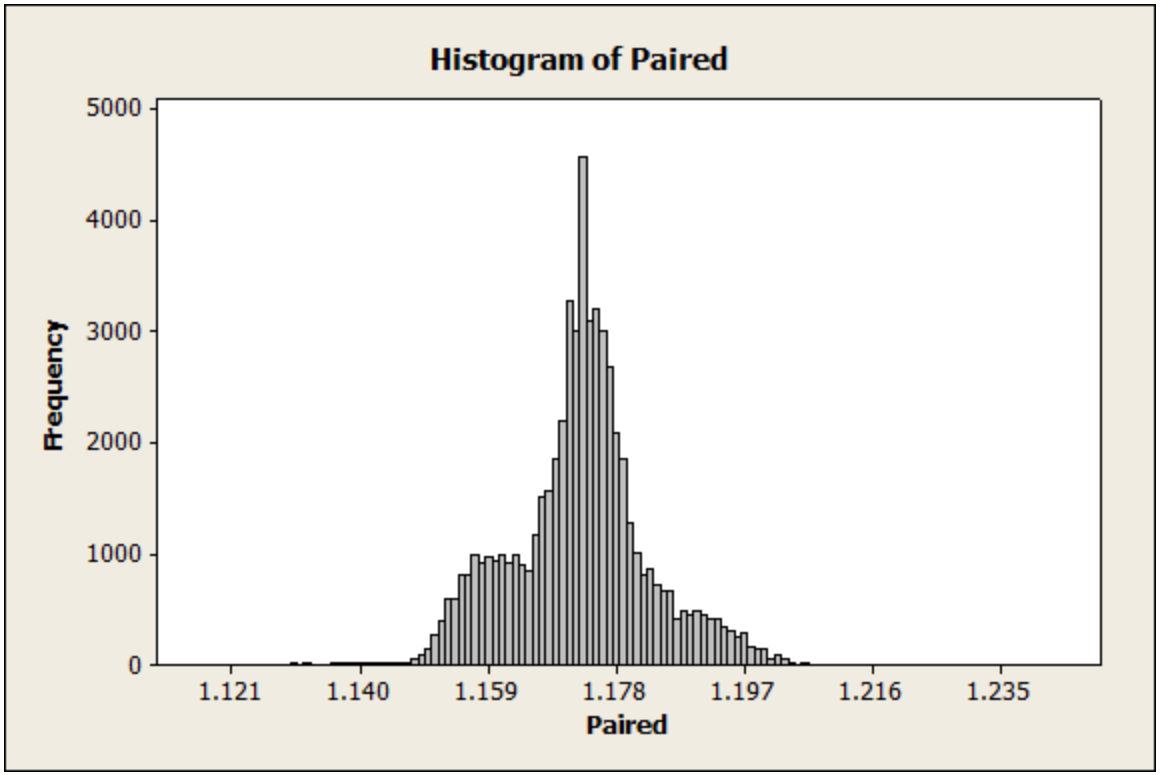
Manufacturer of widgets made left and right subcomponents that had to be paired. Here, the issue was that an improper match would cause the device to fail at final test. Pairing meant measuring every left, every right, labeling each item, inventorying the item and when they were paired, recording the match in a file. This pairing was a very expensive process - several hundred thousand dollars annually. Wasn't listed as a problem. Wasn't considered a process that needed attention.

Example 2

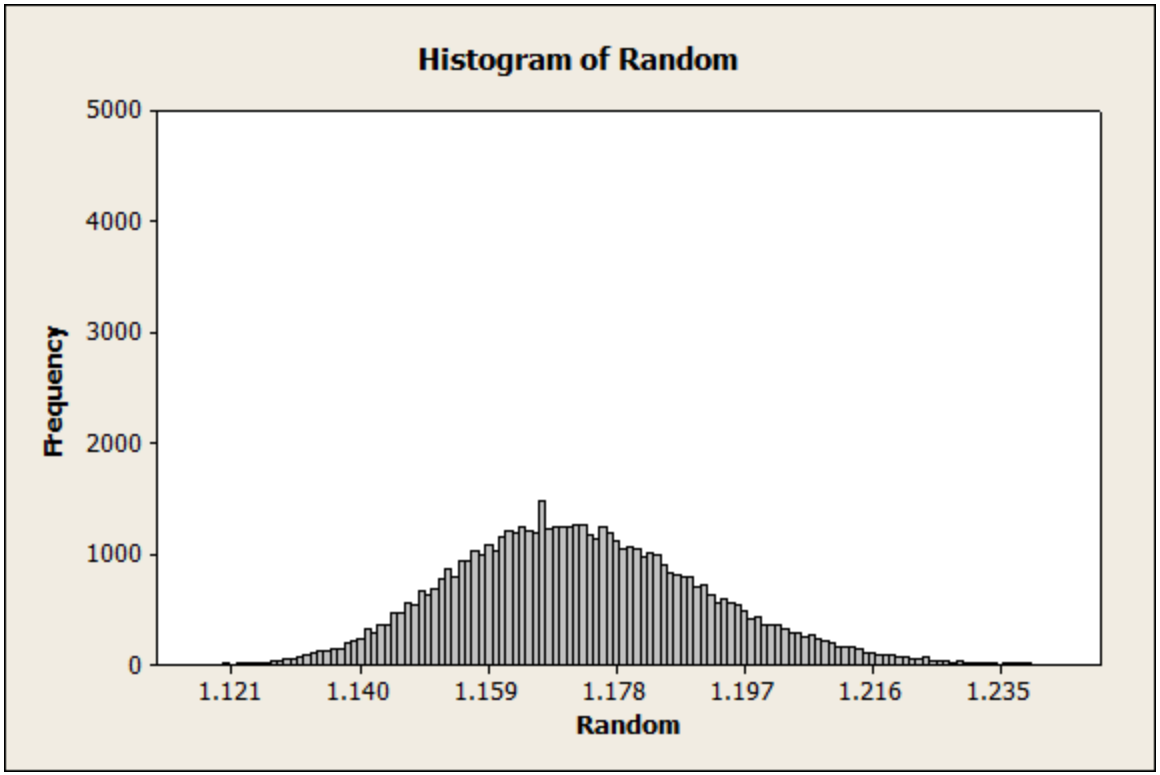
An analysis of the data revealed that if you paired randomly, you would fare almost as well in terms of product quality. In fact, a variation reduction project, perhaps two at most, and the whole pairing process could be ignored.

Lots of money!

Example 2



Example 2



Chronic vs Sporadic Problems

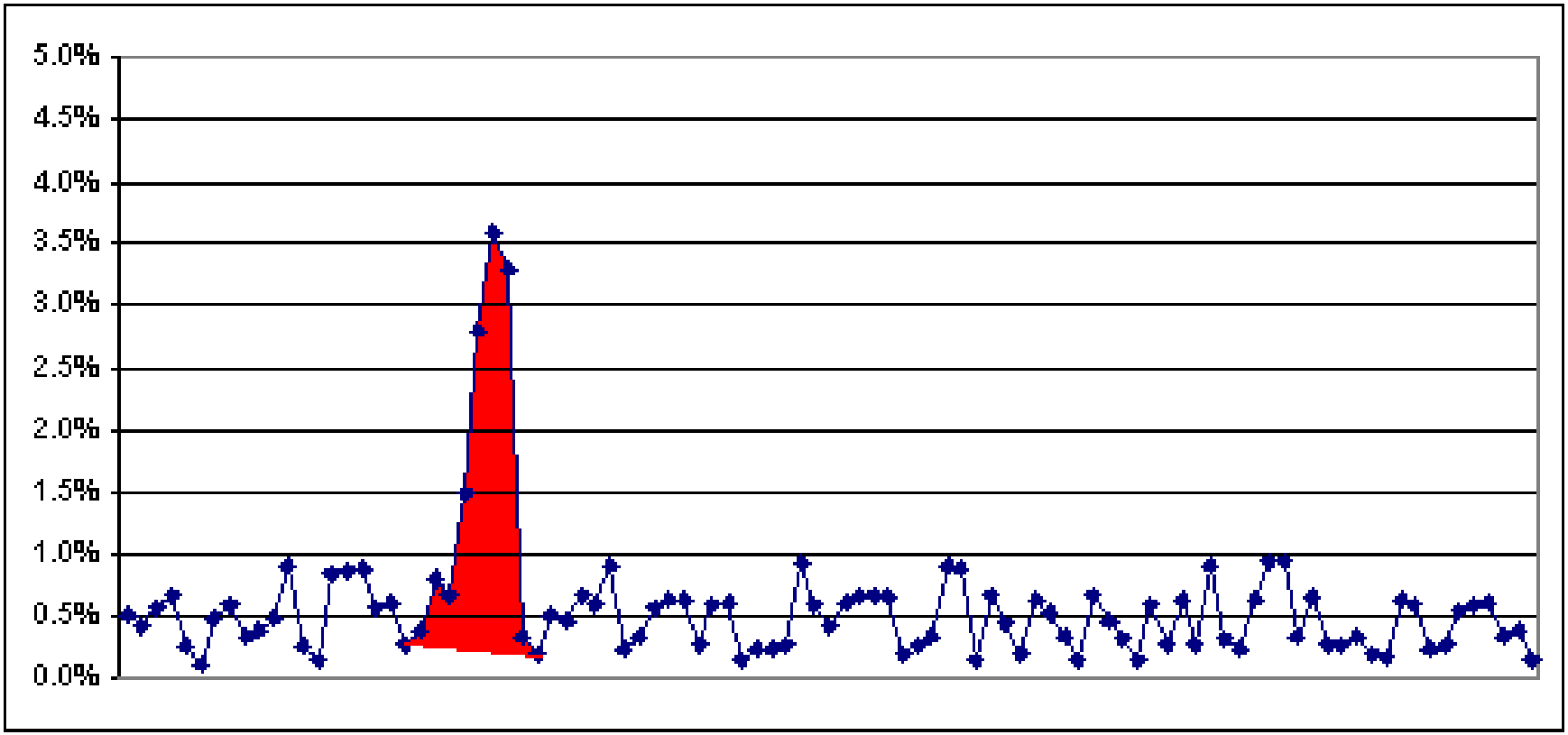
Chronic problems

- Have been around for along time
- Don’t sound alarms
- Cost a lot of money
- Your competitor may be dealing with these as well

Sporadic Problems

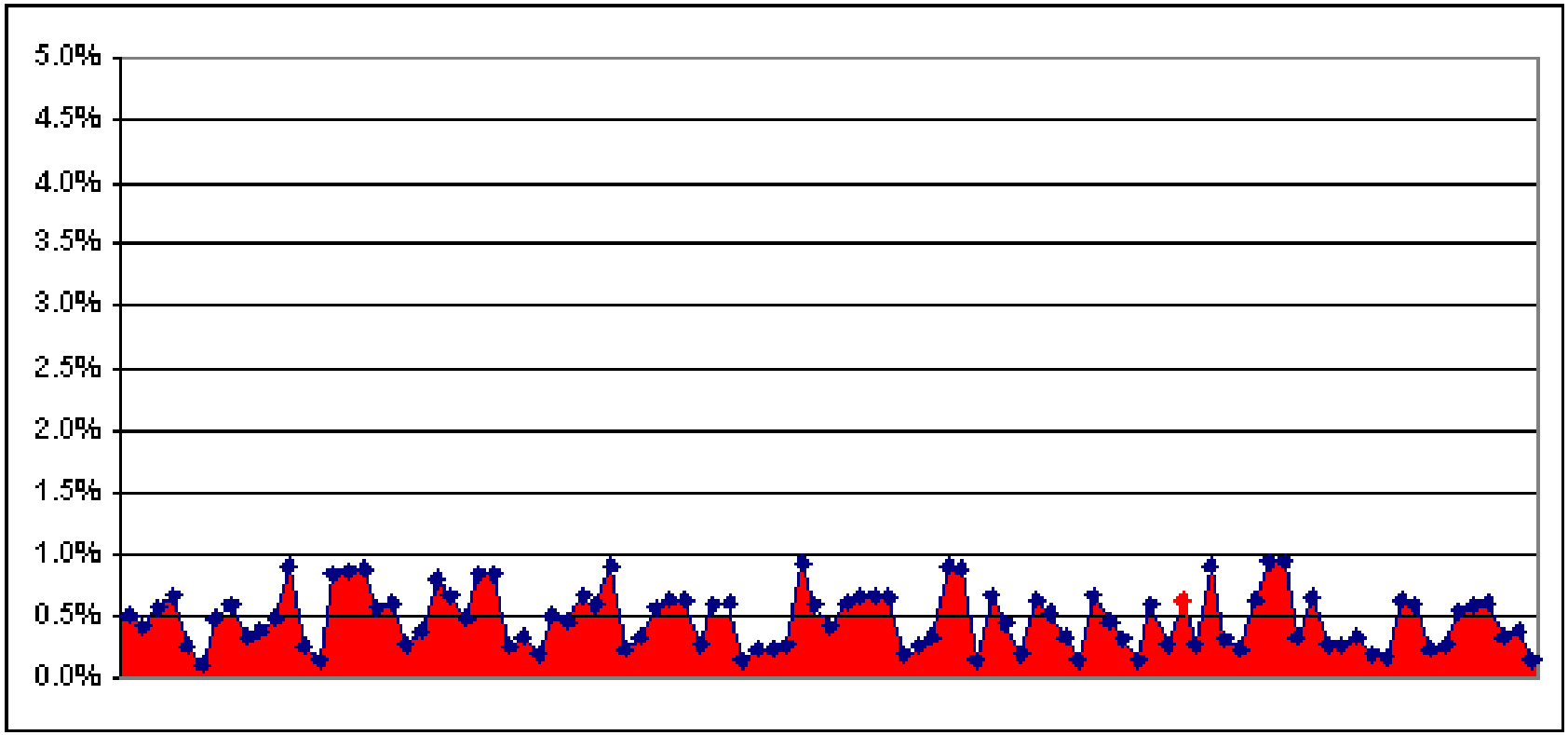
- A spike in performance
- Triggers an alarm
- Corrective action often includes adding inspection point – increase cost

Sporadic Problem



Sporadic problems stand out. They're new. Sometimes they've been resolved before you knew they existed.

Chronic Problem



Chronic problems don't attract much attention – they are mostly caused by excessive variation in a process.

Variation Reduction

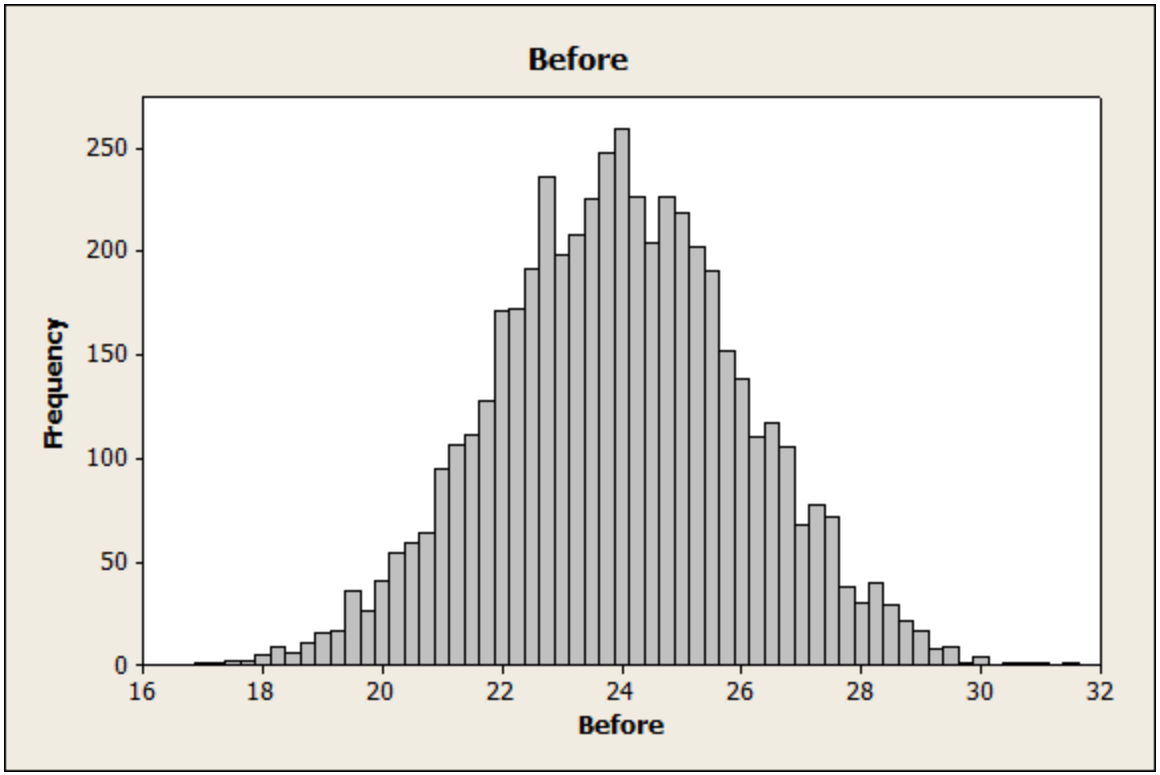
Chronic problems are typically your most expensive and yet they get the least attention.

Chronic problems are often the result of excessive process variation.

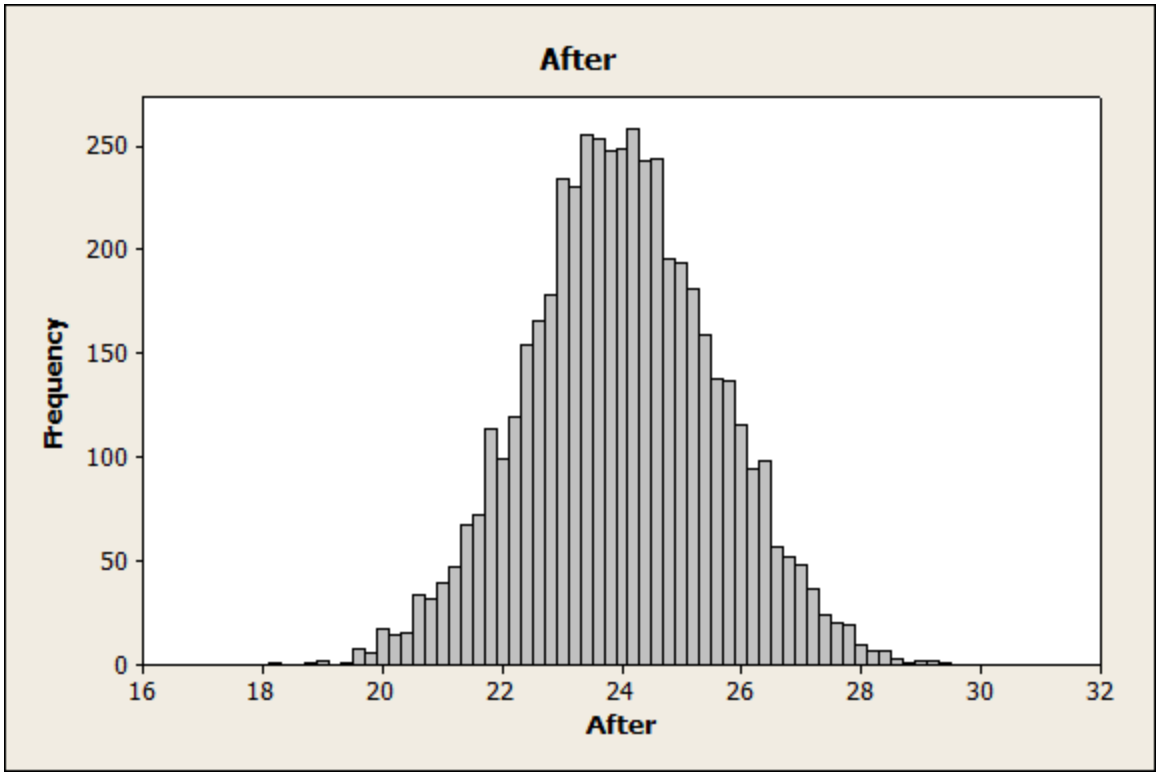
The key to reducing variation in process output is to determine the dominant source and work on that.

There are several / many sources of variation in a process that affect the output. But they are not distributed evenly. There is a dominant source – they also follow the Pareto principle.

Variation Reduction



Variation Reduction



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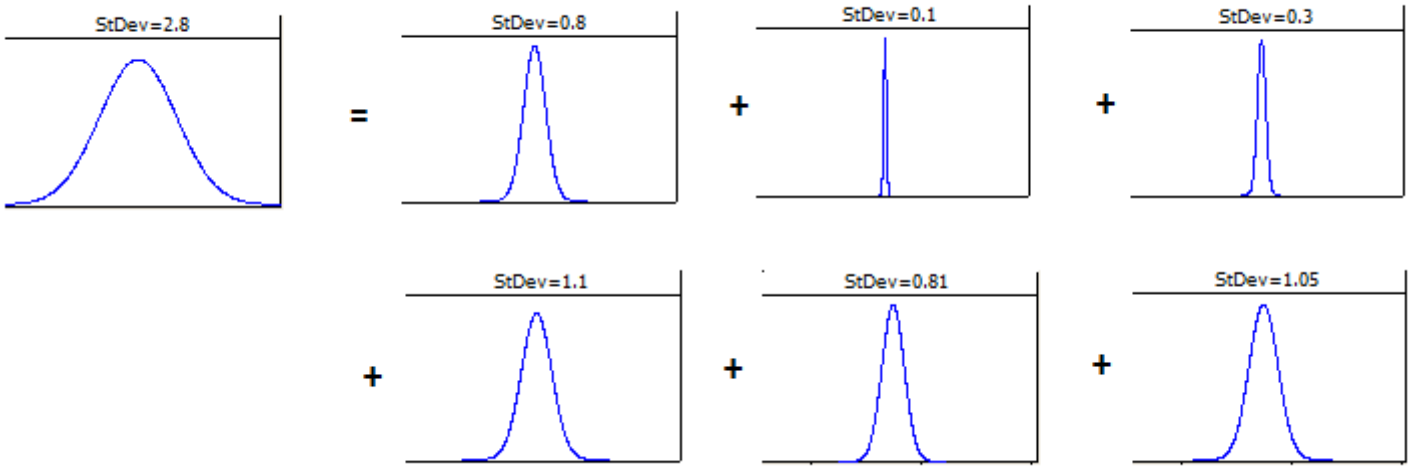
Variation Reduction

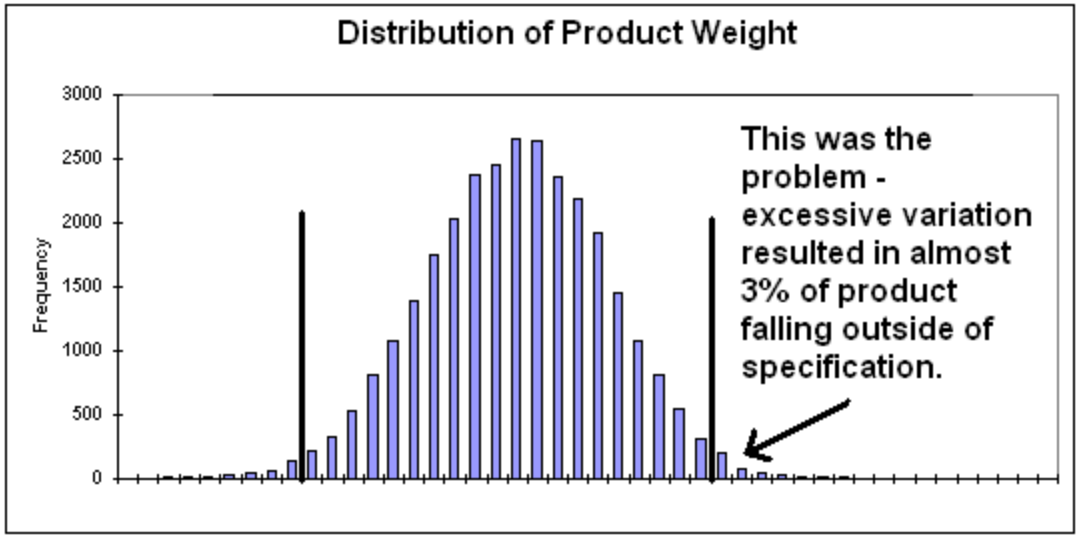


Example 3

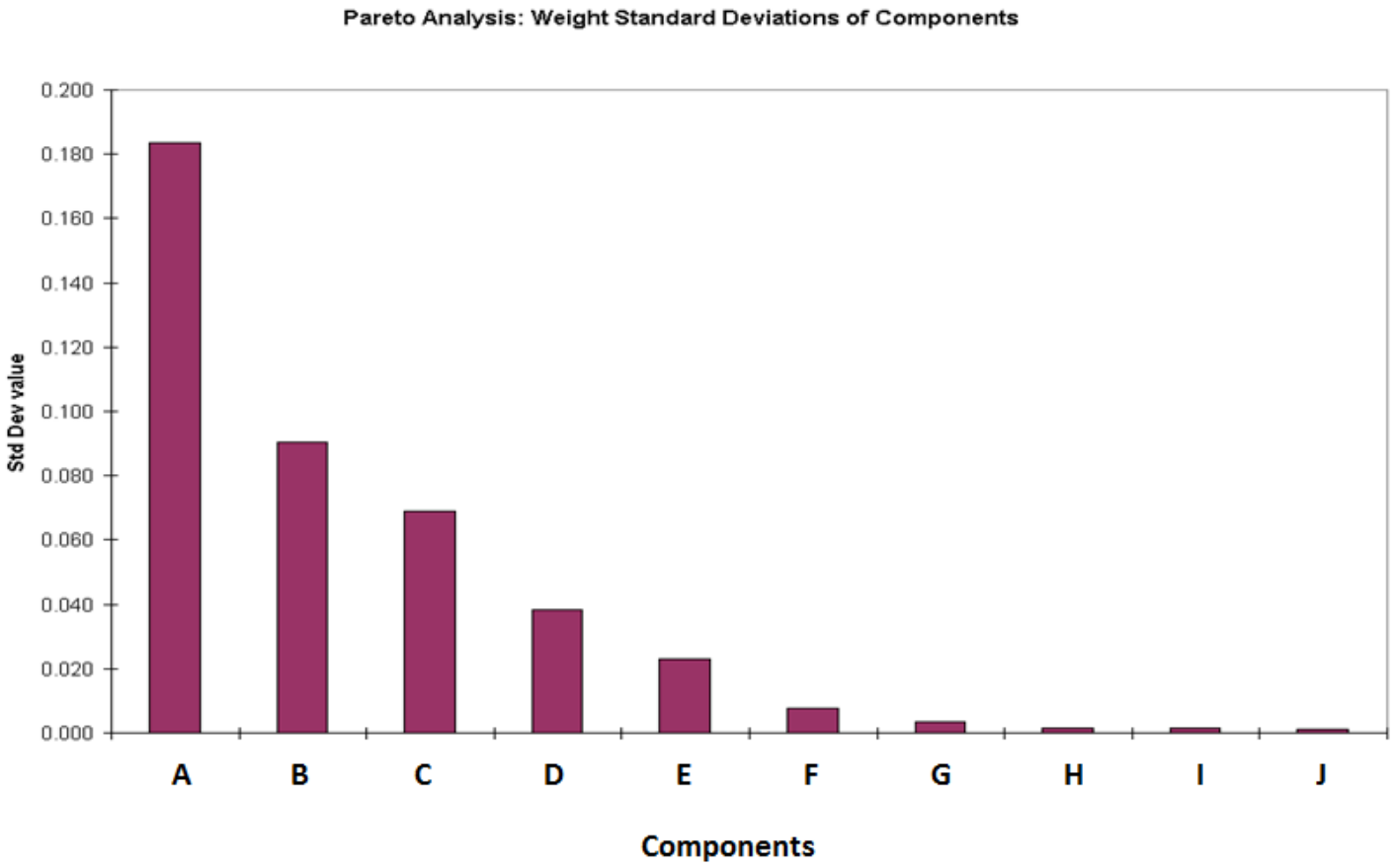
Manufacturer was rejecting ~3% of final product due to over/under weight. Product was an assembly of 17 components.

$\sigma^2_{Total} = \sigma^2_a + \sigma^2_b + \sigma^2_c + \sigma^2_d + \ldots$

Example 3



Example 3



Quote

“If I had to reduce my message for management to just a few words, I’d say it all has to do with reducing variation.”

Dr. W. Edwards Deming

“Between 70 and 80 percent of quality issues can be resolved by reducing variation in the process as opposed to redesigning the product.”

Don Mitchell, Director of Warranty Improvements, General Motors

Clue Generators

Solving quality problems is like solving a crime. You want to gather clues that steer you in the right direction. Clues come from the scene of the crime.

Like solving a crime, solving a quality problem is much more accurate when you acquire data, show evidence. Listening and buying into a theory isn't successful enough to make it a strategic approach.

Clue Generators

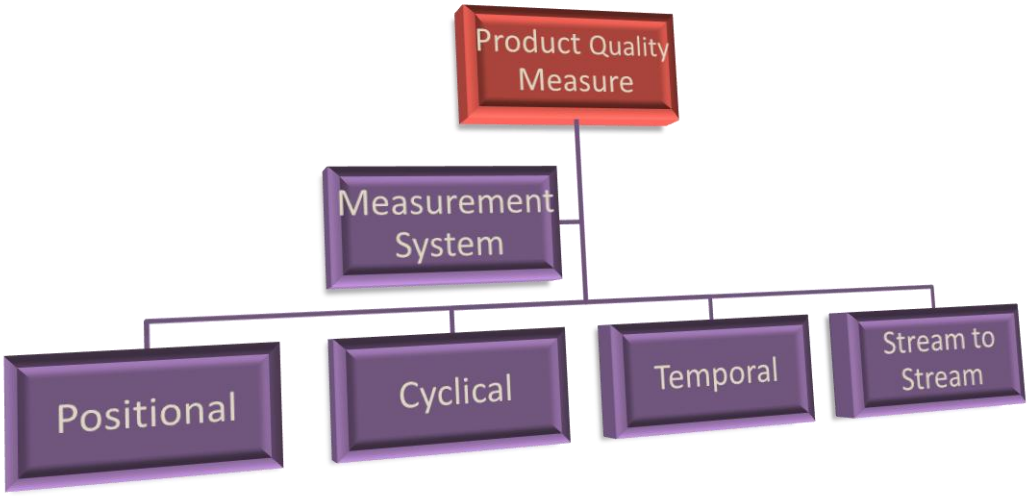
- Multi vari analysis
- Paired comparisons

Multi Vari Analysis

Which factors contribute the most to overall variation?

The purpose of the study is to narrow down the large list of potential causes to a small number which includes the dominant cause.

Multi Vari Analysis



Multi Vari Analysis

Positional - variations within the unit such as several measures of diameter on a ball bearing.

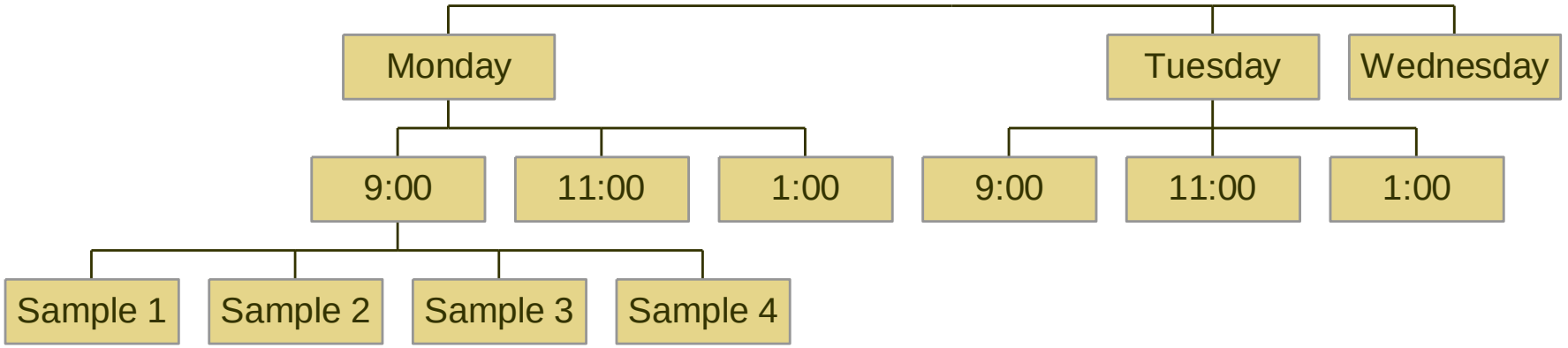
Cyclical - one after another. Differences between consecutive units drawn from a process. Could also be batch-to-batch.

Temporal - time. Variations from hour-to-hour, day-to-day, etc.

Stream-to-Stream - cavity-to-cavity variation. Machine-to-machine, operator-to-operator.

Multi Vari Analysis

Sampling plan for a multi vari study.



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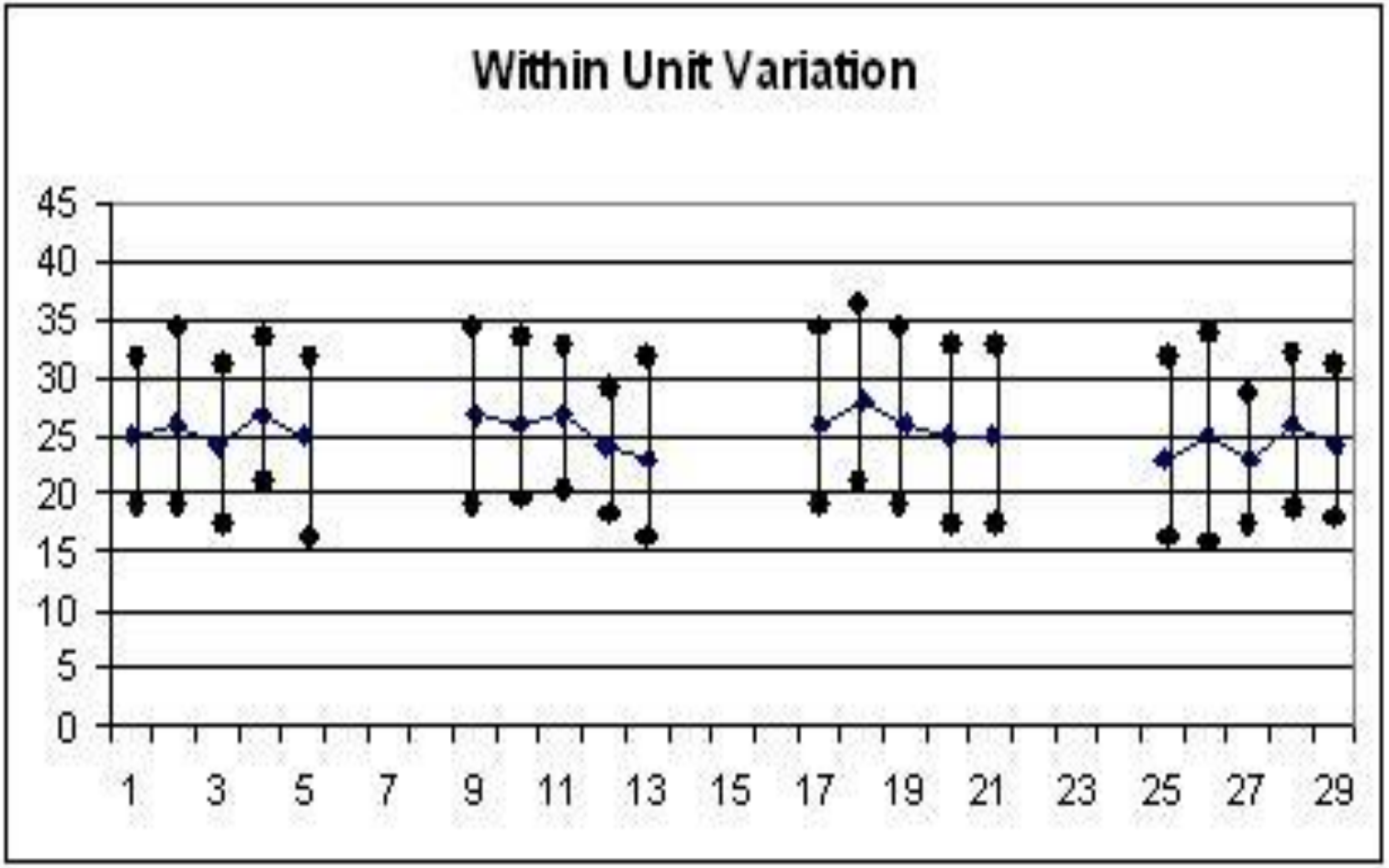

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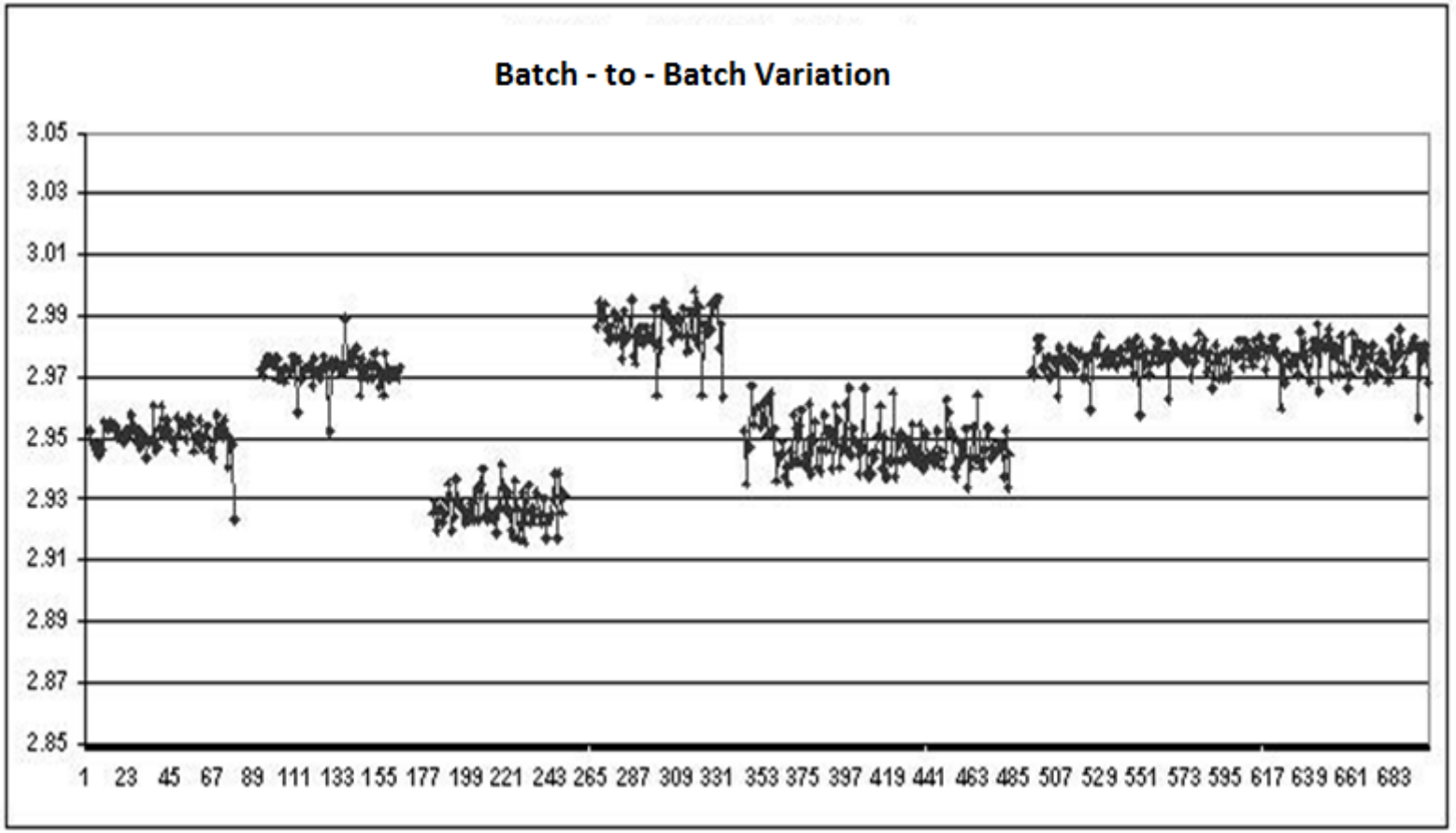


Example 4

Company was rejecting 3% of final product.

Multi vari study showed dominant source was between batches.

Process was not sequential therefore the structure in the data was lost.

Had to link batches to upstream process steps.

All batches were heated in an oven so all batches were given a label identifying which oven and which shelf/position in the oven.

Example 4

93% of all rejects were heated on the bottom two shelves of the oven!

Paired Comparisons

Called the Tukey-Duckworth Sum, this method provides confidence in linking cause and effect.

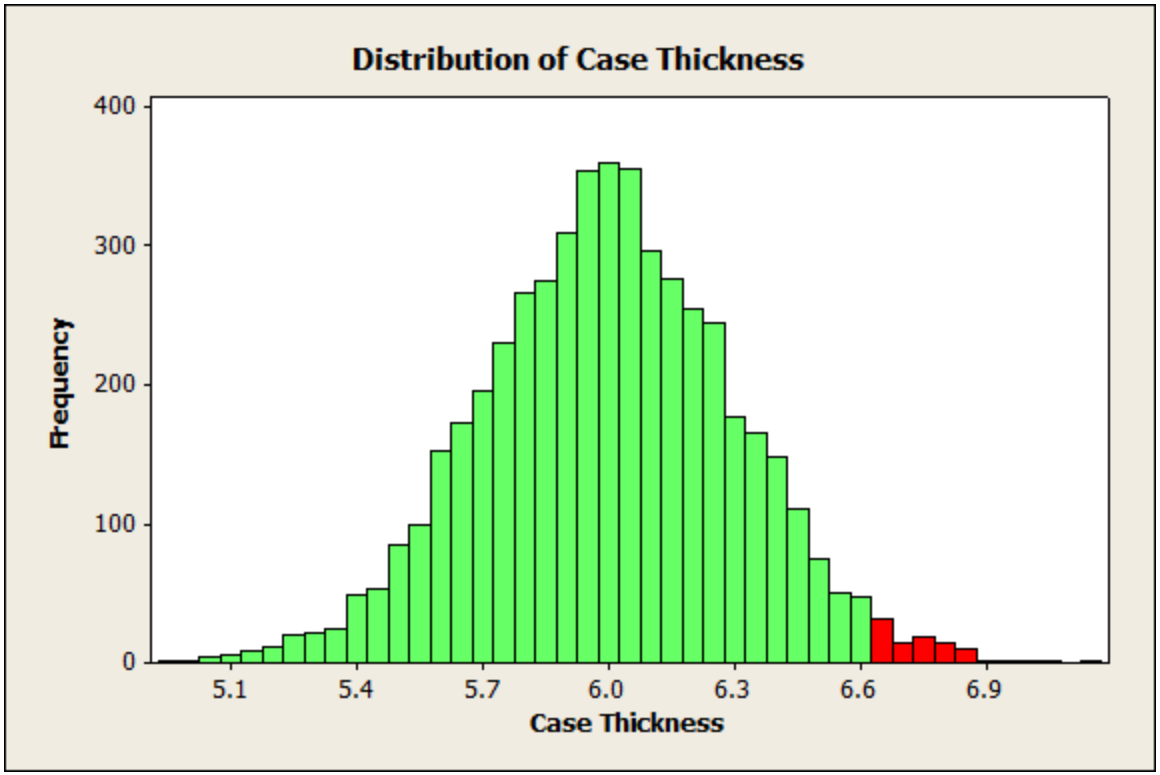
You are interested to learn why parts coming off the same process are very different.

Start by determining the distribution of these parts – measure a large sample and plot the data.

Take 6 to 8 good parts and 6 to 8 bad parts and label them.

Now measure a list of things about these parts that could affect the critical dimension.

Paired Comparisons



Paired Comparisons

- a nonparametric test
- data is organized by rank - not absolute value
- order by rank the 12 to 16 readings
- designate each reading as a good or bad part
- from top, count all the bad parts up to the first change to good (or vice-versa)
- from bottom, count all the good parts up to the first change to bad (or vice-versa)
- sum the end counts

Paired Comparisons

Part weight			Position of Crimp	
13.33	Good		6.50	Good
14.06	Good		6.51	Good
14.25	Bad		6.62	Good
14.27	Good		6.82	Good
14.37	Bad		6.83	Good
14.95	Good		6.84	Good
15.03	Good		6.89	Good
15.10	Bad		6.92	Bad
15.29	Good		7.20	Good
15.34	Bad		7.21	Bad
15.34	Bad		7.24	Bad
15.70	Good		7.27	Bad
15.94	Bad		7.28	Bad
15.96	Good		7.31	Bad
16.02	Bad		7.68	Bad
16.40	Bad		7.79	Bad

Paired Comparisons

Total End Count	Confidence
6	90%
7	95%
10	99%
13	99.9%

Example 5

New product had failures at final test. Fourteen failed out of 318 tested.

A showstopper.

Brainstorming highlighted several potential issues. Costly investigation. Design mods were implemented.

New products built to the new design and 30 units were submitted for testing. Zero failures.

There was much rejoicing.

Example 5

But let's do the math on this.

Original fail rate was 14 / 318 = 4.4%

The probability of having zero failures in 30 tests is 26%.

That's too high to be comfortable.

It turned out that the problem was still there and showed up after a few more samples were tested.

Example 5

Using the paired comparison approach we had eight good and eight bad units.

Cut them open to see what was different. Something was causing the parts to fail and maybe it would be evident.

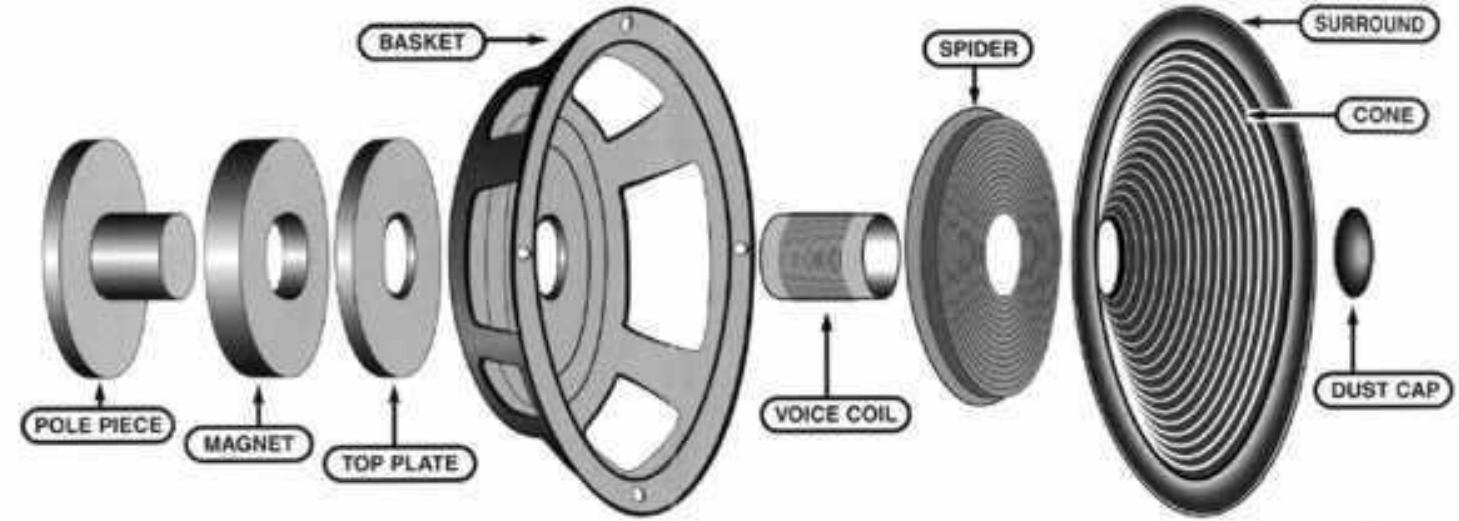
The root cause was obvious when you saw the parts lined up.

It wasn’t on any list because it was new information.

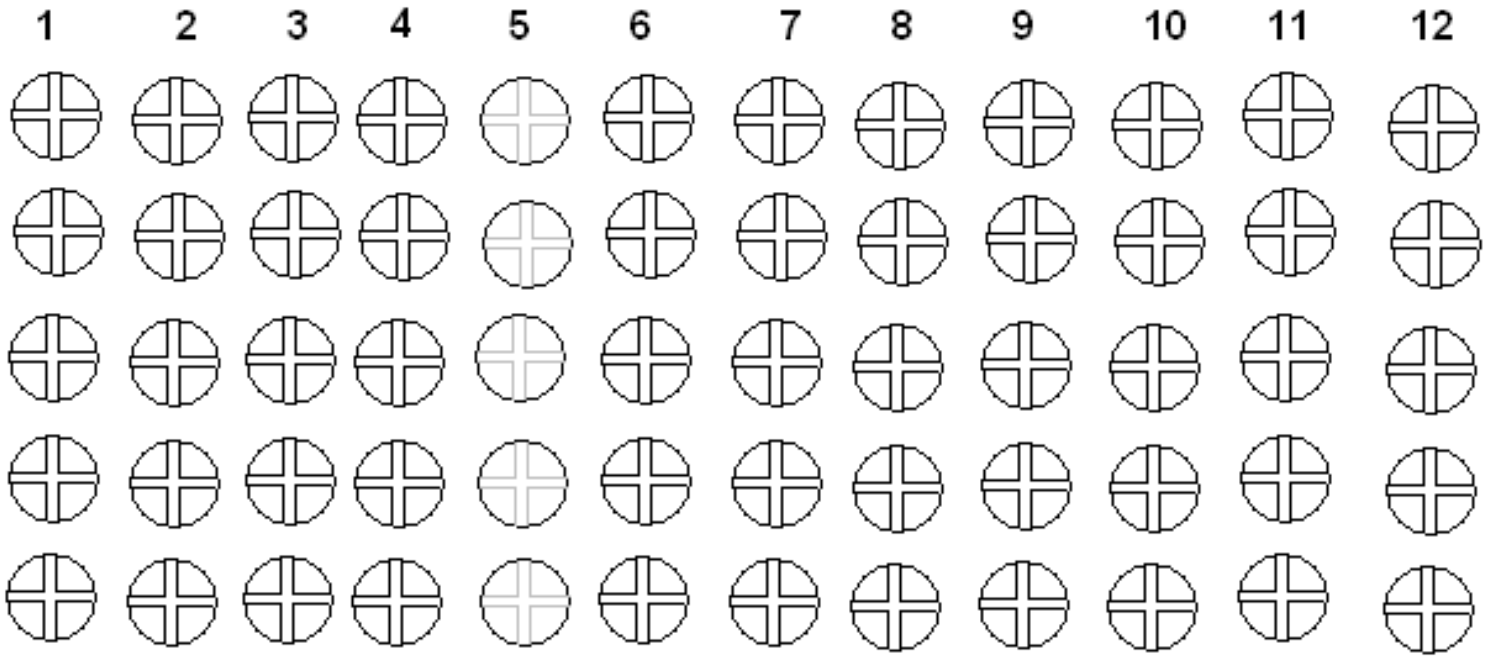
Example 6

Speakers were failing final test at a high rate ~8%.

Example 6



Example 6



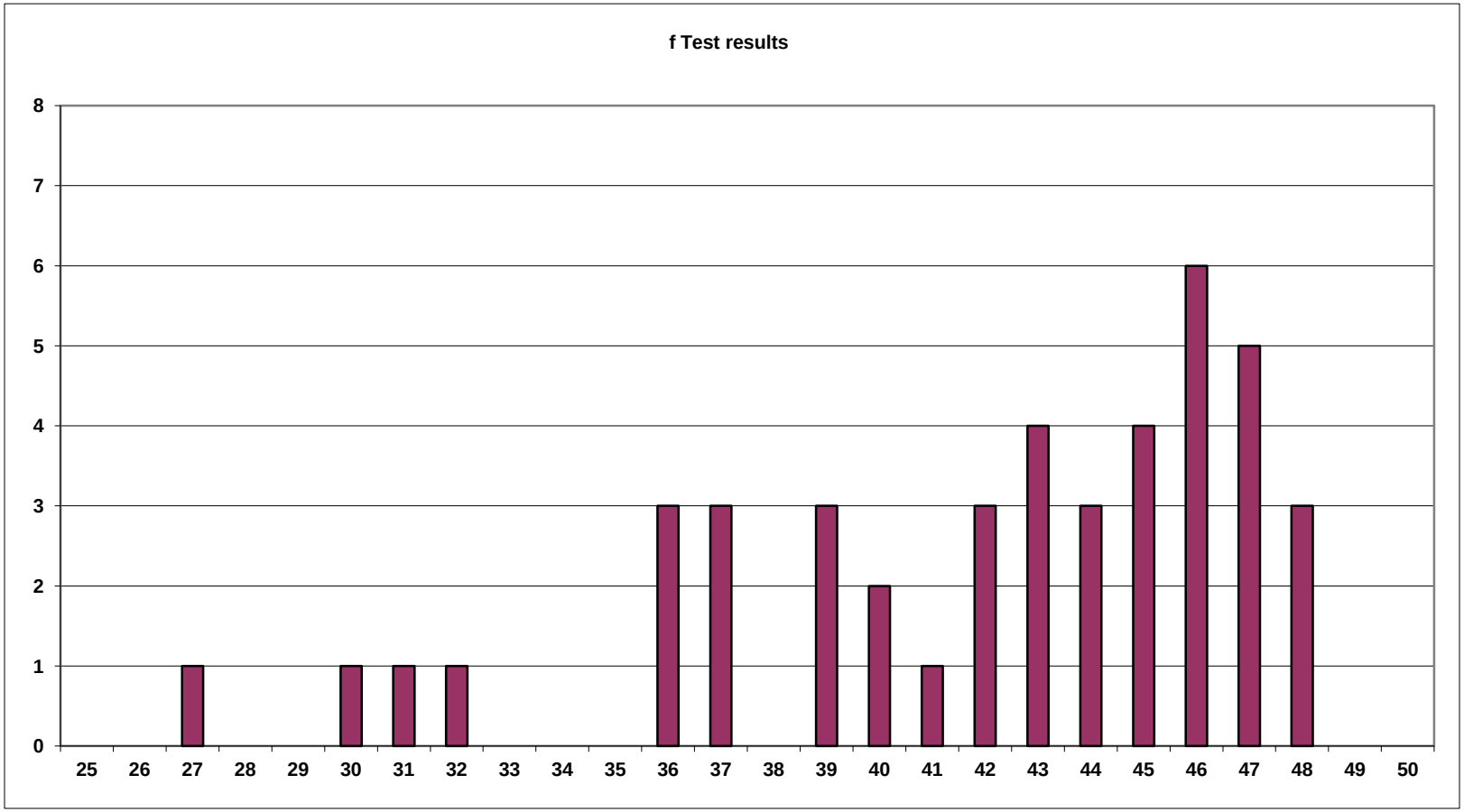
Human Error

Human error is a dominant source of quality problems in many organizations.

Human Error

The necessity of training farm hands for first class farms in the fatherly handling of farm livestock is foremost in the minds of effective farm owners. Since the forefathers of the farm owners trained the farm hands for first class farms in the fatherly handling of farm livestock, the farm owners feel they should carry on with the former family tradition of training farmhands of first class farms in the effective fatherly handling of farm live stock, however futile, because of their belief that it forms the basis of effective farm management efforts.

Human Error



Human Error

We are all wired to make mistakes.

We are likely to make mistakes more often than we realize.

Most mistakes are trivial, some are not (we need to eliminate these).

Human error rates are subject to many conditions but for mechanical tasks, the error rate is 1 in 200

Human Error

Human error is unavoidable

1 in 200

There are things we can do to reduce the error rates.

Changing what we do and how we do it.

Adding redundancy by using inspection.

Mistake-proofing

Simplifying processes

Human Error

Problem Solving

Cost of Quality model tells us our quality problems are eating our profits.

Pareto distribution tells us there are some really big problems and may be hidden.

There are techniques for generating clues that lead to solving problems.