Estimating Benefits from Process Automation

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Introduction

- Project Justification Activities
- Where to Look for Benefits
- Techniques for Estimating Improvement Quantities

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Project Justification

The justification for process automation modernization is one of the most difficult steps to complete during the planning process

- Create the business case
- Obtain operational data
- Develop the benefits
- Estimate degree of improvement
- Establish the financial gain

Where to Find Benefits

Think of the Plant as a Financial Asset

Raw Material →

Net Utilities →

Operating Expenses →

Maintenance Expenses →

New Capital ↑

→ Primary Products

→ Secondary Products

→ Waste Streams

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ROIC

- Want to Increase Return on Invested Capital
- (ROIC) = Profit / Invested Capital
- Function of:
  - Profit
    - Revenue
    - Costs
  - Capital
    - Fixed
    - Working

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Increase Profit

- Increased Production
  - **Increased**
    - Equipment Capacity
  - **Reduced**
    - Batch Cycle Time
    - Grade Transition Time
    - Product Re-blends
    - Unscheduled Downtime
    - Scheduled Shutdown Duration / Frequency

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Increase Profit

- Increase Price / Sales
  - Increase Yield of Most Valuable Product(s)
  - Improve Product Quality
    - Meet Specifications
    - Consistency
    - Meet Delivery Demands
  - Ability to Increase Price
  - Ability to Increase Market Share

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Increase Profit

- Reduce Costs
  - Feedstocks
  - Energy and Utilities
  - Direct and Indirect Labor
  - Off-Spec Material
  - Abnormal Events
  - Demurrage
  - Maintenance

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Reduce Capital

- Fixed Capital
  - Fixed Assets
  - Project Capital
  - Commissioning and Start-up Costs
- Working Capital
  - Feed / Intermediate / Product Inventory
  - Warehouse / Spares
  - Financial Working Capital

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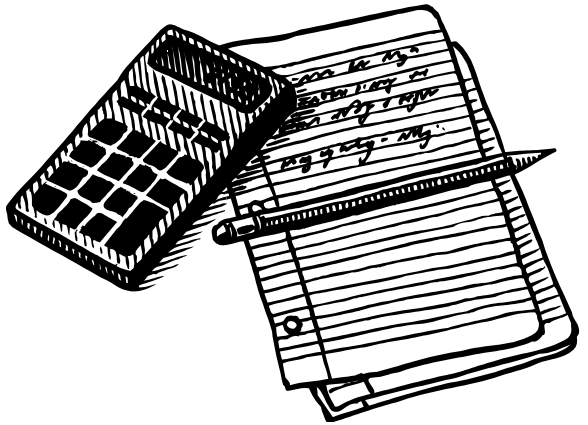
Benefit Estimation Methods

- Best Operator Method
- Data Reduction Method
- Percent Limit Violation



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Develop a Base Case

- Identify and retrieve historical data
  - Key Performance Indicators
  - Important Manipulated Variables
  - Constraint Variables
  - Material and Energy Balance Parameters
- Obtain data while plant was running at normal operating conditions
- Data sampling frequency needs to match type of data collected

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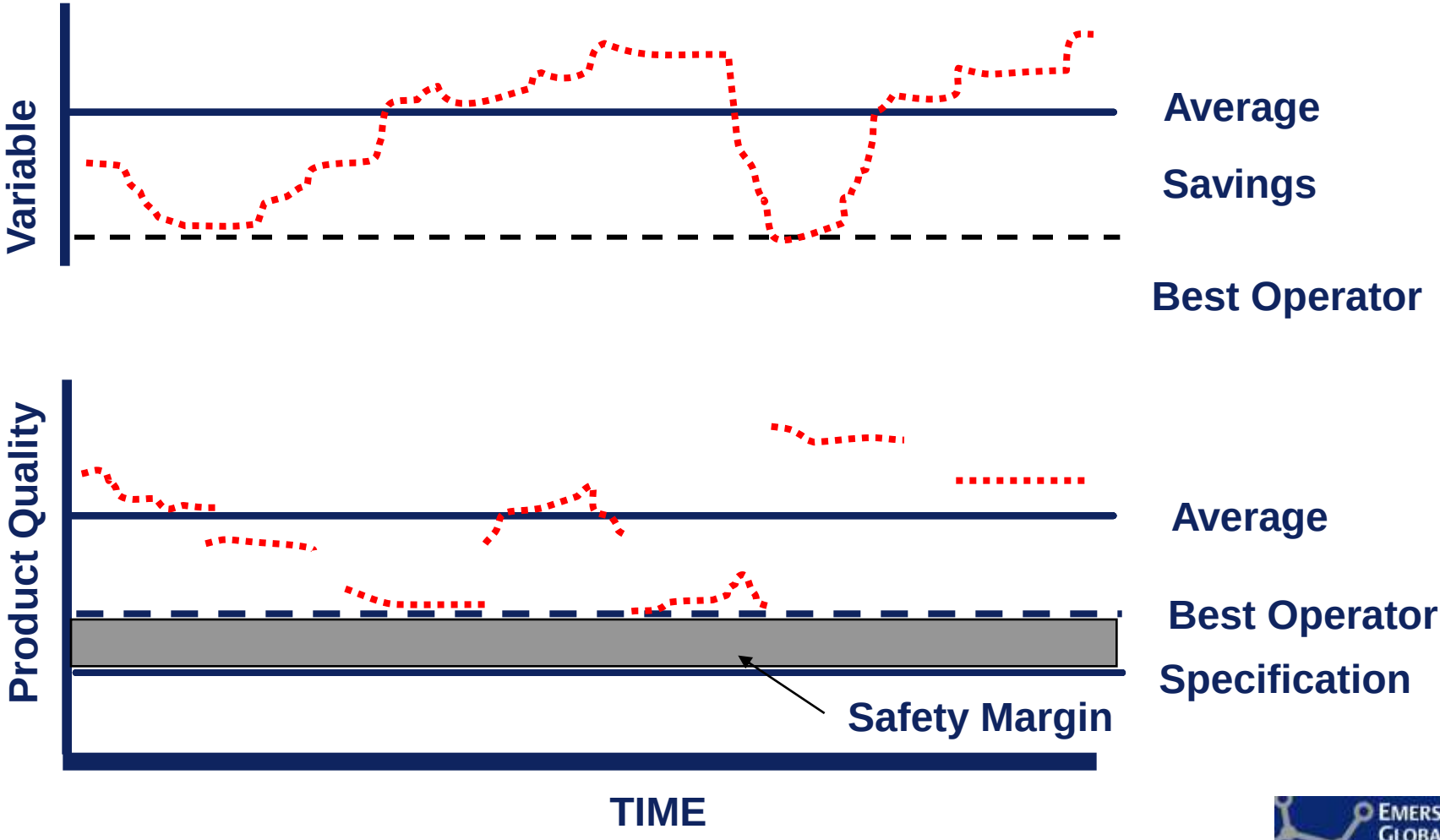
Best Operator Method



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Best Operator Method

- Compare Historical Operational Information
  - Compare operating data between the historical best versus average results
  - Compare normal operating results versus when engineers are running
  - Compare normal versus those obtained during continuous monitoring demanded by a process optimization or alteration
  - Comparison between two similar plants except for one having automation and the other manual control
- Conservative Method Since does not Account for Improvements

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Best Operator Method

∆Value =

(|Average Variable – Best Operator Variable|)

X Average Rate

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Best Operator Example

Raw Data

Cycle Time (Minutes)	
75	75
150	90
45	105
75	75
30	90
75	90
135	45
60	75
45	75
60	90
60	90
90	45
60	60
45	45

Data without Outliers

Cycle Time (Minutes)	
75	75
	90
45	105
75	75
	90
75	90
135	45
60	75
45	75
60	90
60	90
90	45
60	60
45	45

Average 72 Minutes
Best 45 Minutes
Delta 27 Minutes

Capacity Gain = 27 min x # of Current Batches

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Data Reduction Method

- Collect raw data over appropriate time interval
  - Hourly averages/week, shift averages/month, daily averages/year
  - Remove startup/shutdown and upset data
- Normalize the data to a production rate
- Plot in a Histogram
- Subtract the values at the median and the 15% points
- Difference indicates potential economic benefit

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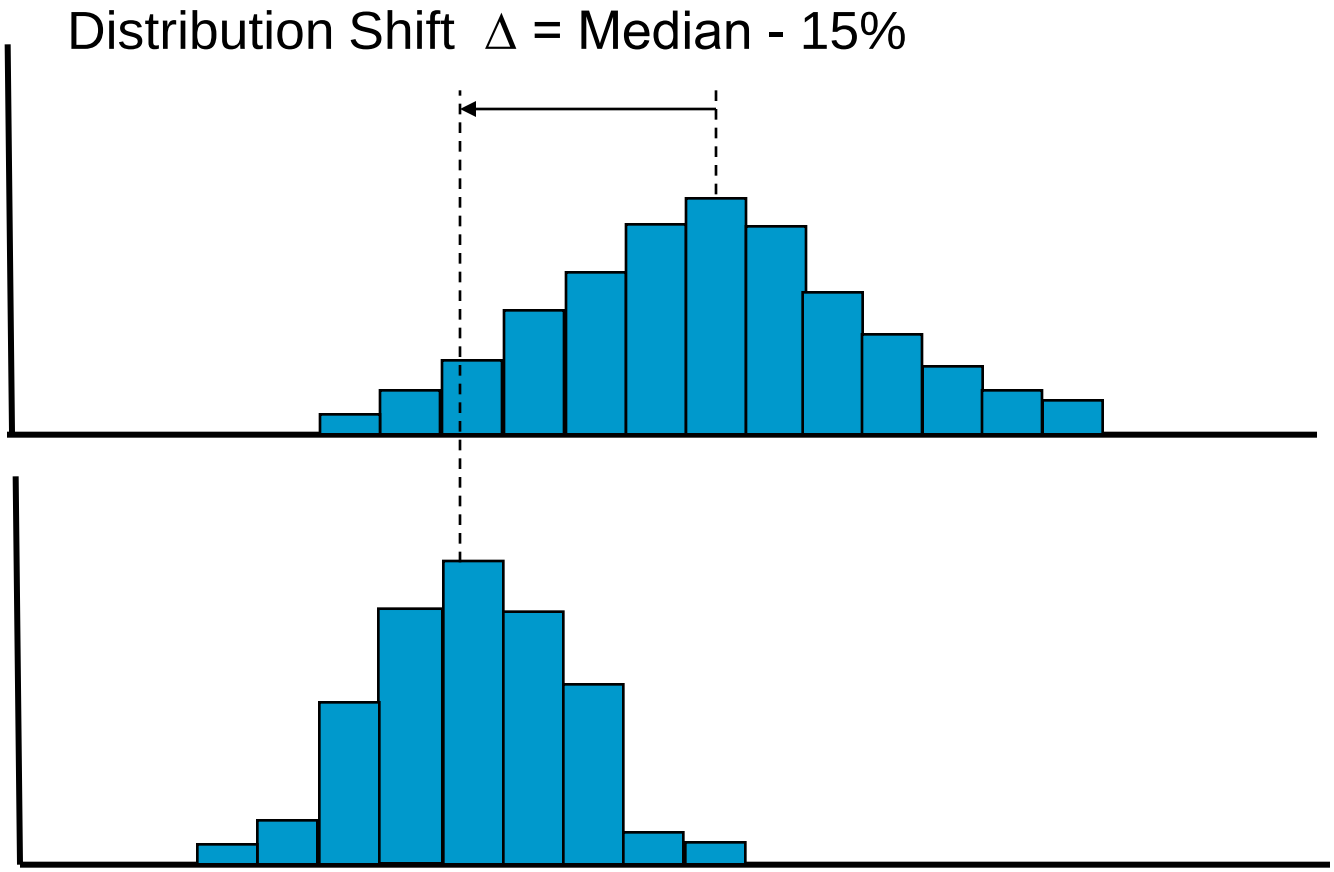
Data Reduction Method



Lbs Steam / Lbs Product

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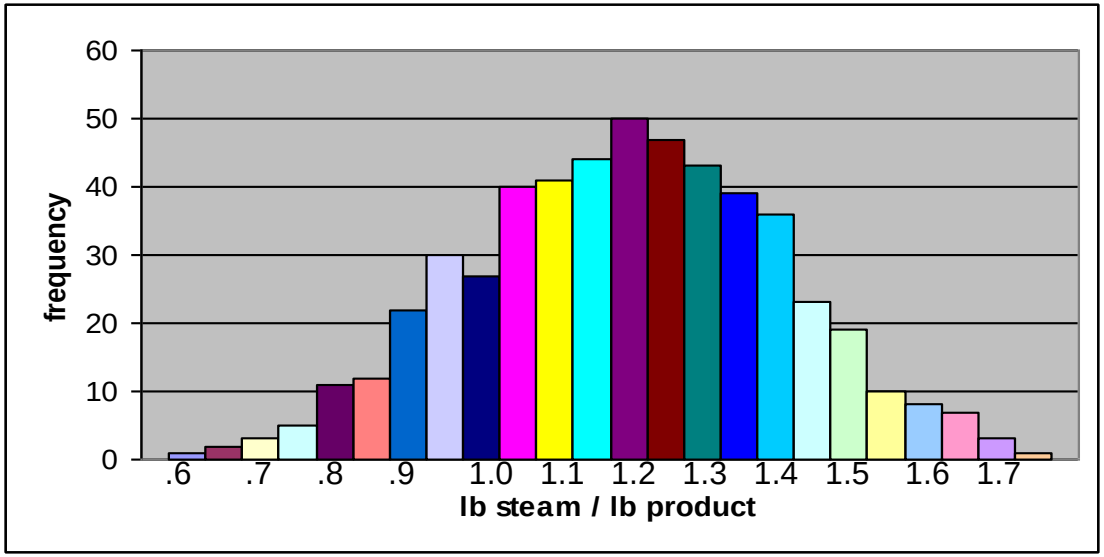
Data Reduction Method Example

Lb Steam/ Lb Product	Frequency	Lb Steam/ Lb Product	Frequency
0.6	1	1.2	50
0.65	2	1.25	47
0.7	3	1.3	43
0.75	5	1.35	39
0.8	11	1.4	36
0.85	12	1.45	23
0.9	22	1.5	19
0.95	30	1.55	10
1	27	1.6	8
1.05	40	1.65	7
1.1	41	1.7	3
1.15	44	1.75	1



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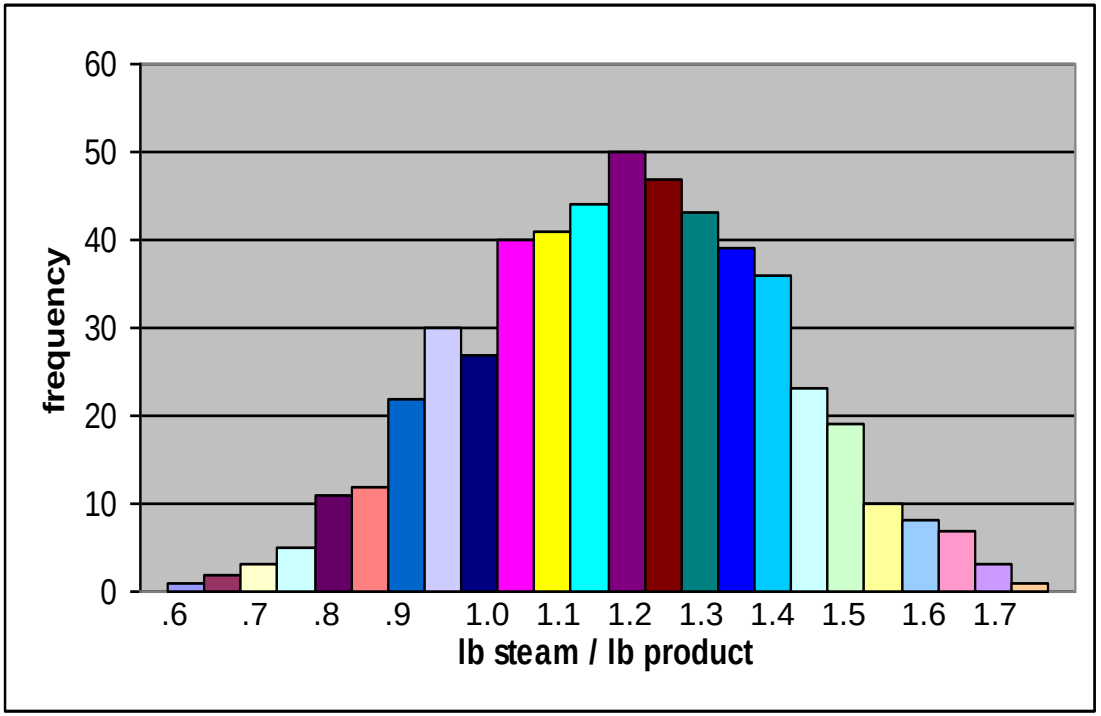
Data Reduction Method Example

Midpoint	1.2
Low End	0.6
High End	1.75
Range	1.15
15% Point	0.8

Improvement:

1.2 – 0.8 = 0.4



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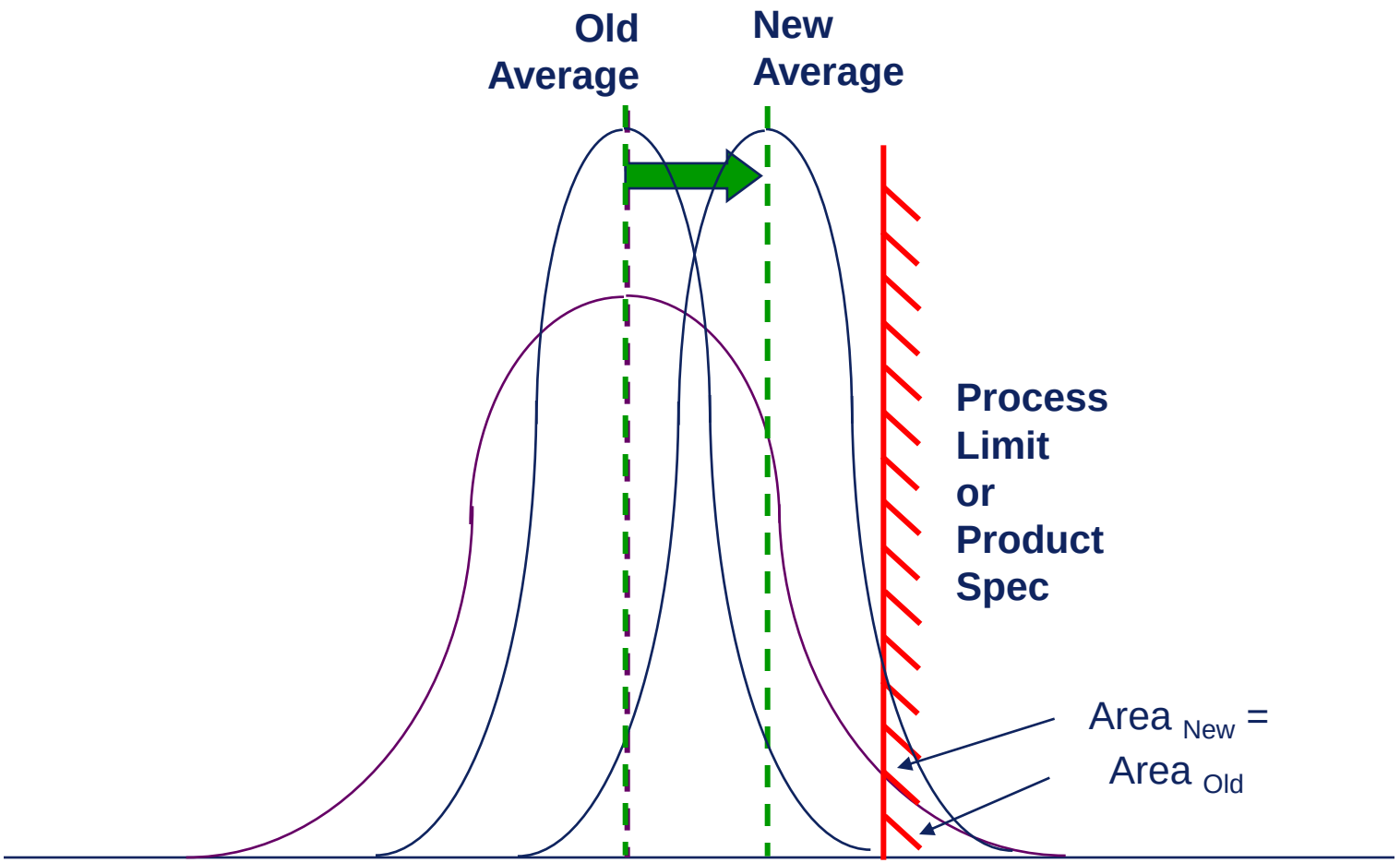
Limit Violation Methods



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Same Percent Limit Violation

Calculate the Average

Calculate the Standard Deviation

$$Z = (L - Avg_O)/SD_O$$

Standard Normal Distribution Function	
Z	F(Z)
0.00	0.5000
1.00	0.8413
1.50	0.9332
1.65	0.9505
2.00	0.9772
2.05	0.9797
2.33	0.9901

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Same Percent Limit Violation

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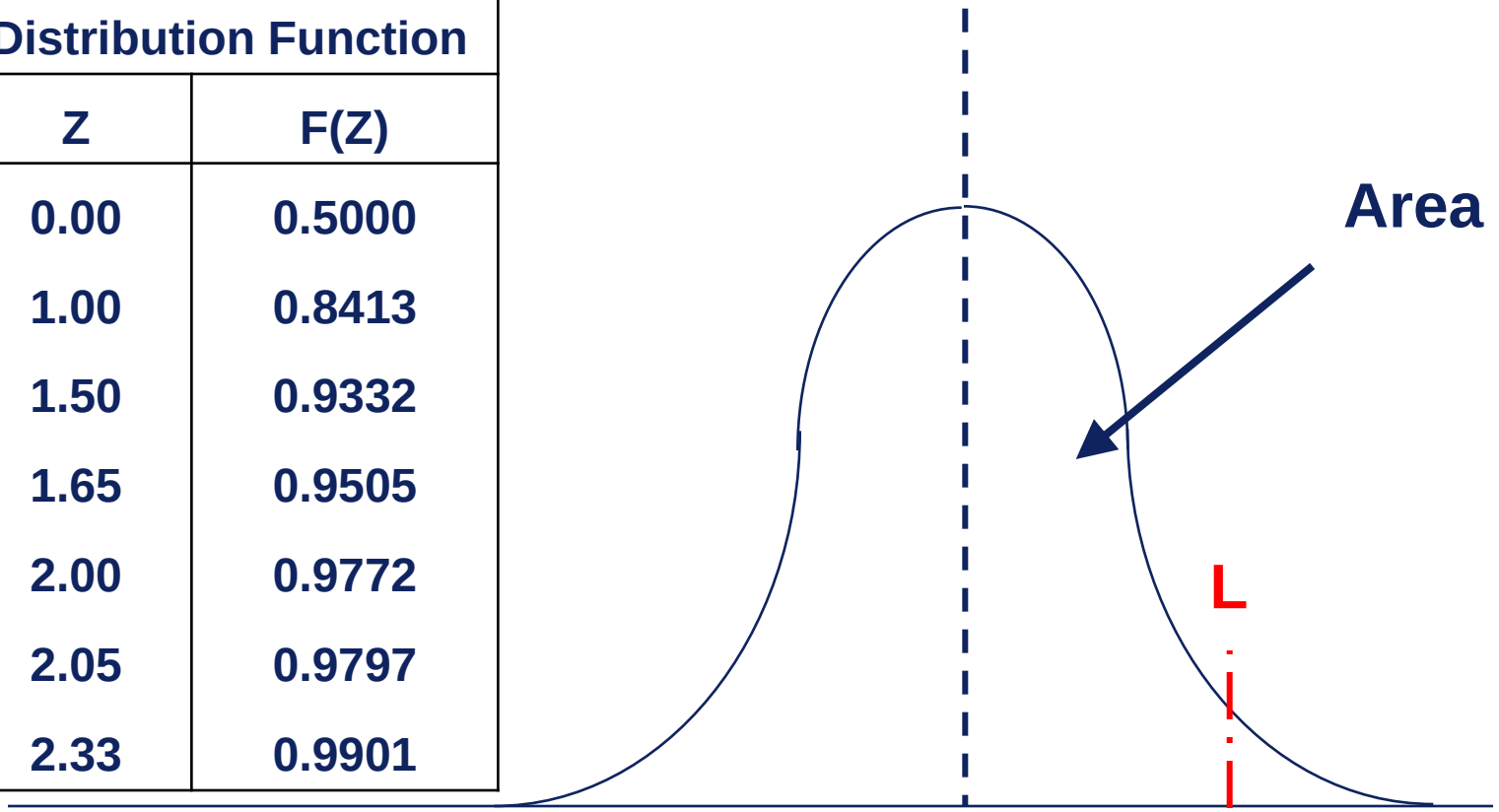
Z = (L -Avg)/SD



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Same Percent Limit Violation

Calculate the Average

Calculate the Standard Deviation

$$Z = (L - Avg_O)/SD_O$$

$$Z = (L - Avg_N)/SD_N$$

$$(L - Avg_N)/SD_N = (L - Avg_O)/SD_O$$

$$Avg_N = L - SD_N/SD_O \times (L - Avg_O)$$

Standard Normal Distribution Function	
Z	F(Z)
0.00	0.5000
1.00	0.8413
1.50	0.9332
1.65	0.9505
2.00	0.9772
2.05	0.9797
2.33	0.9901

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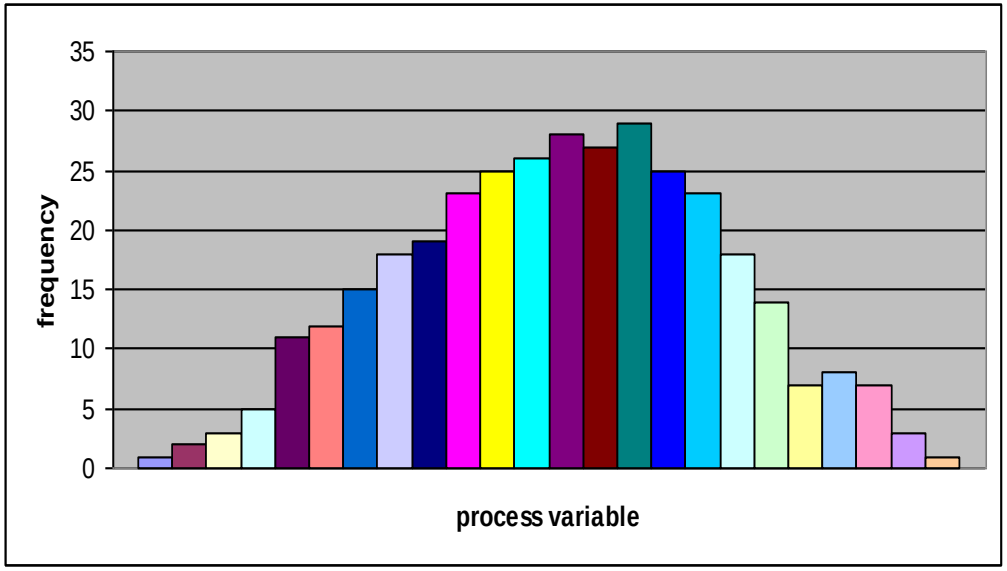
Same Percent Limit Violation Example

Lbs Steam/hr	Frequency	Lbs Steam/hr	Frequency
1460	1	2420	28
1540	2	2500	27
1620	3	2580	29
1700	5	2660	25
1780	11	2740	23
1860	12	2820	18
1940	15	2900	14
2020	18	2980	7
2100	19	3060	8
2180	23	3140	7
2260	25	3220	3
2340	26	3300	1



Same Percent Limit Violation Example

Existing Average:	2411 Lbs/hour
Existing Standard Deviation:	372 Lbs/hour
Limit:	1650 Lbs/hour
Z=(Limit-Average)/Std Dev :	2.045
Limit Violation:	~2%

$$Avg_N = L - SD_N/SD_O\ (L - Avg_O)$$

New Average: 2030 Lbs/hr

Theoretically can reduce average steam usage by 381 Lbs/hr

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Same Percent Violation of 5% Limit

From Table: @ F(Z) = .95; Z = 1.65

$Z_O = Z_N = 1.65$

$(L - Avg_O)/SD_O = 1.65$

$(L - Avg_N)/SD_N = 1.65$

$\Delta Avg = 1.65(SD_O - SD_N)$

Standard Normal Distribution Factor	
Z	F(Z)
0.00	0.5000
1.00	0.8413
1.50	0.9332
1.65	0.9505
2.00	0.9772
2.05	0.9797
2.33	0.9901

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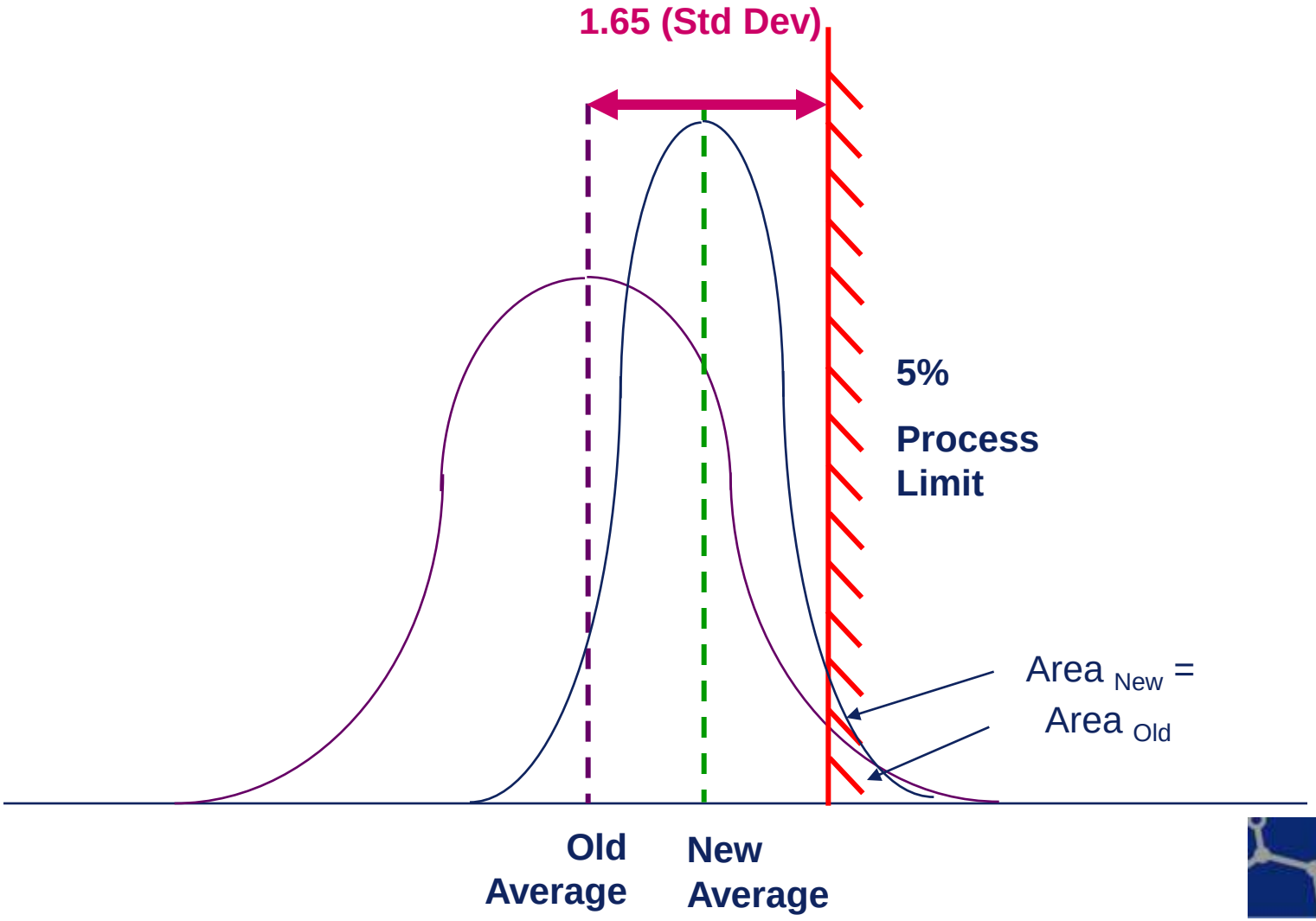
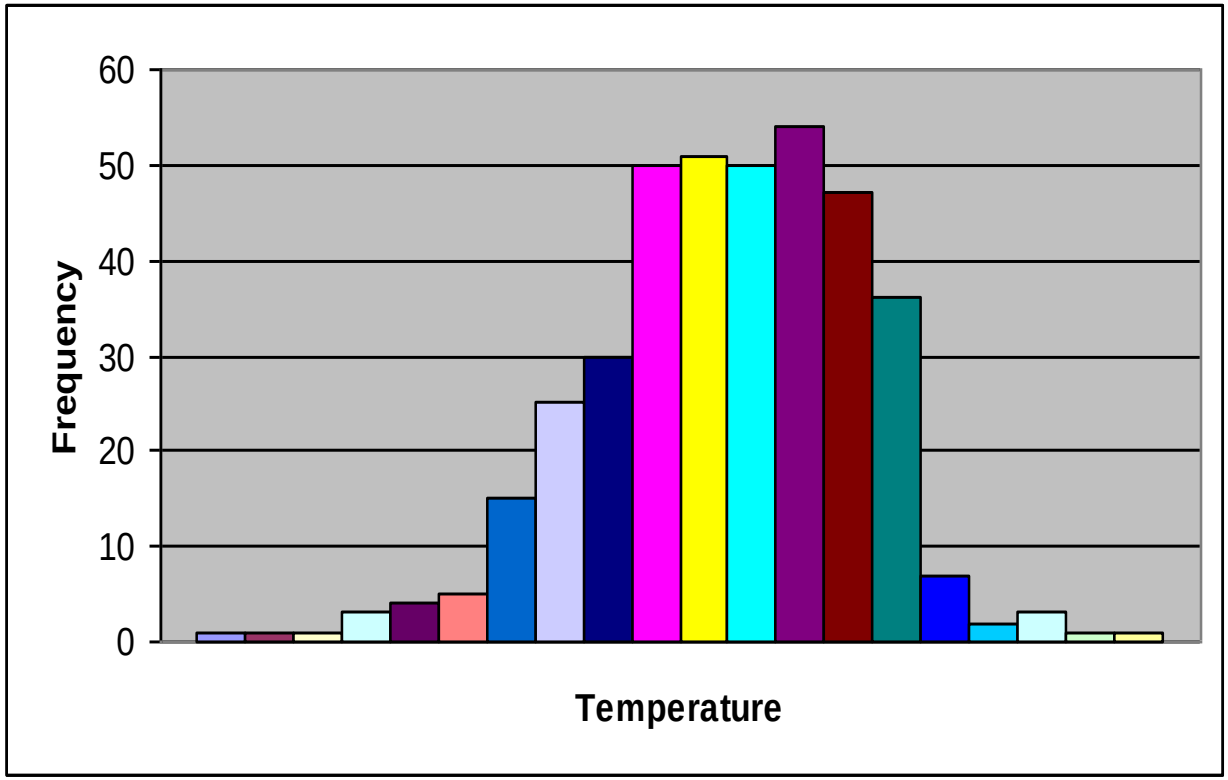
Same Percent Violation of 5% Limit



Same Percent Violation of 5% Limit Example

Temperature	Frequency
332	1
333	1
334	1
335	3
336	4
337	5
338	15
339	25
340	30
341	50
342	51
343	50
344	54
345	47
346	36
347	7
348	2
349	3
350	1
351	1



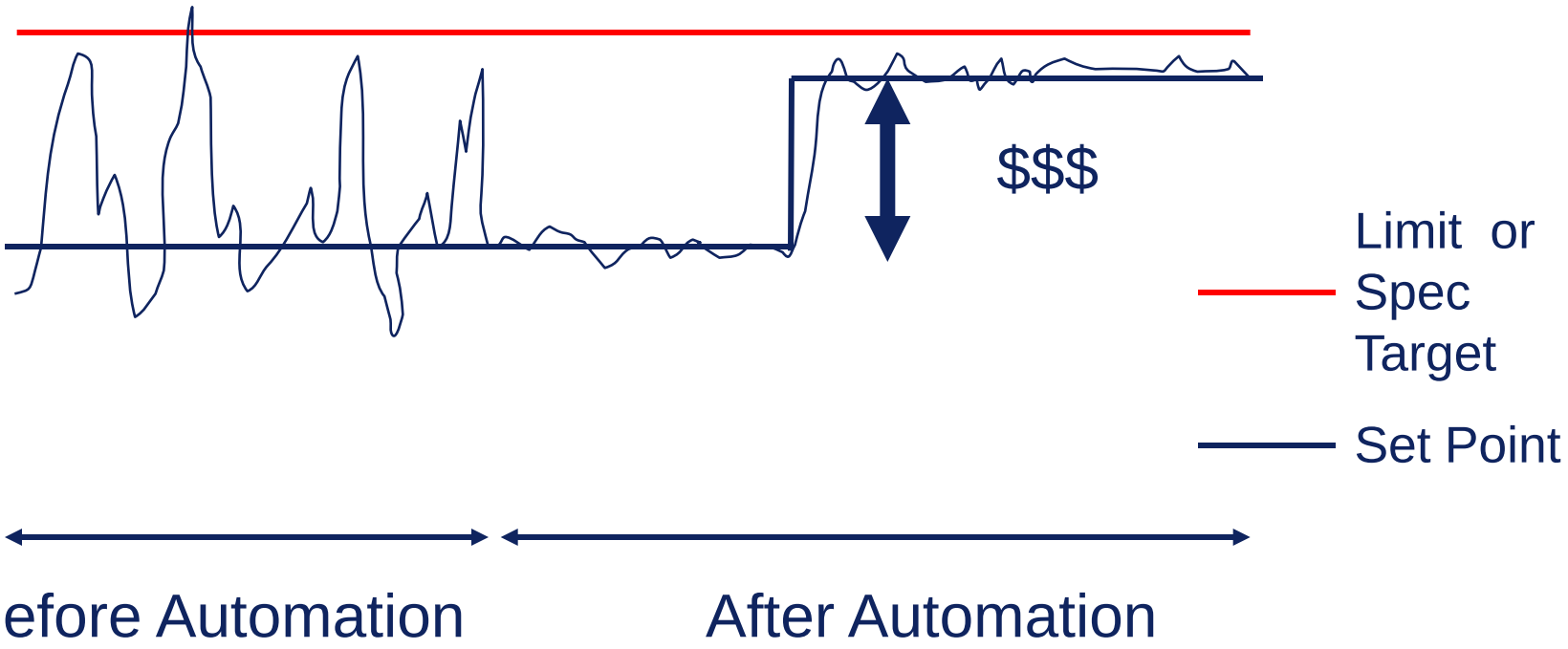
Same Percent Violation of 5% Limit Example

Existing Average:	342.5 deg F
Existing Standard Deviation:	2.8 deg F

$$\Delta \text{ Avg} = 1.65(SD_O - SD_N)$$

Increase in Average Temperature:	3.1 deg F
New Average Temperature:	345.6 deg F

Improved Control – Run Closer to Limits



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Summary

- Justification is difficult, but necessary to receive approval for automation projects
- Historical Data Collection is vital
- Build a base case
- Some “Prediction” of results is necessary

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Where To Get More Information

- "Estimating Benefits from Advanced Control" by P.L. Latour, J.H. Sharpe, M.C. Delaney (ISA)
- "Estimating Savings from Upgrading Process Control" by Herman Bozenhardt and Martin Dybeck (Chemical Engineering Magazine, 2/3/1986)
- "Calculating ROI for Automation Projects" by Doug White (Emerson Process Management Website, Advanced Automation Services Whitepaper)

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Estimating Benefits from Process Automation

Questions ?