Six Sigma Tools

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Six Sigma® Simplified Tools

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Any Six Sigma Book can be customized to reflect a company's improvement process. For information, call, write, or e-mail to the address above.

Also by Jay Arthur:
The Six Sigma Simplified (2nd), Greenbelt Training Made Easy, LifeStar, 2001
The Six Sigma Instructor's Guide (2nd), Greenbelt Training Made Easy, LifeStar, 2003
Improving Software Quality, John Wiley & Sons, 1993, 287 pages, ISBN 0-471-57804-5

Phone, Fax, or E-mail support: Contact Jay Arthur at the phone, fax or e-mail address above for any questions you have about Six Sigma or using this book.

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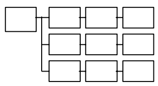
Laser-Focused Improvement

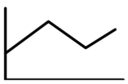
Step 1 - Focus

Factory
Fix-it: **Defects + Delay = Cost**
Main: **Quality + Speed = Profit**

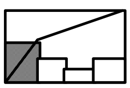
Tools

Tree Diagram


What's important?

Line Graph


What's broken?

Pareto Chart
4-50 Rule


Where's the "Mother Lode"

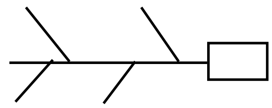
Cost of Quality

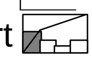
Step 2 - Improve

Quality

Root Cause Analysis (Why, Why, Why?)

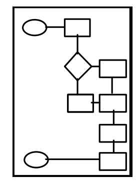
Tools

Fishbone (Ishikawa)


Countermeasures
Verify Root Causes
Line Graph 
Pareto Chart 

Speed

Value-added Analysis (Where?)
Hint: It's the Arrows

Flow Chart


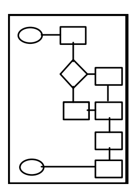
Value-Added Worksheet

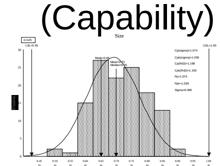
F I
H S

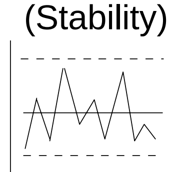
Step 3 - Sustain

Monitor and Sustain New Levels of Performance in Mission Critical Systems

Tools

Flow Chart


Histogram (Capability)


Control Charts (Stability)


Attribute	Variable
np, p	XmR
c,u	XbarR
	XbarS

Step 4 - Honor

Recognize, Review, Refocus

What did we do right?

Where else can we apply what we've learned?

What's next?

Histogram

Why?

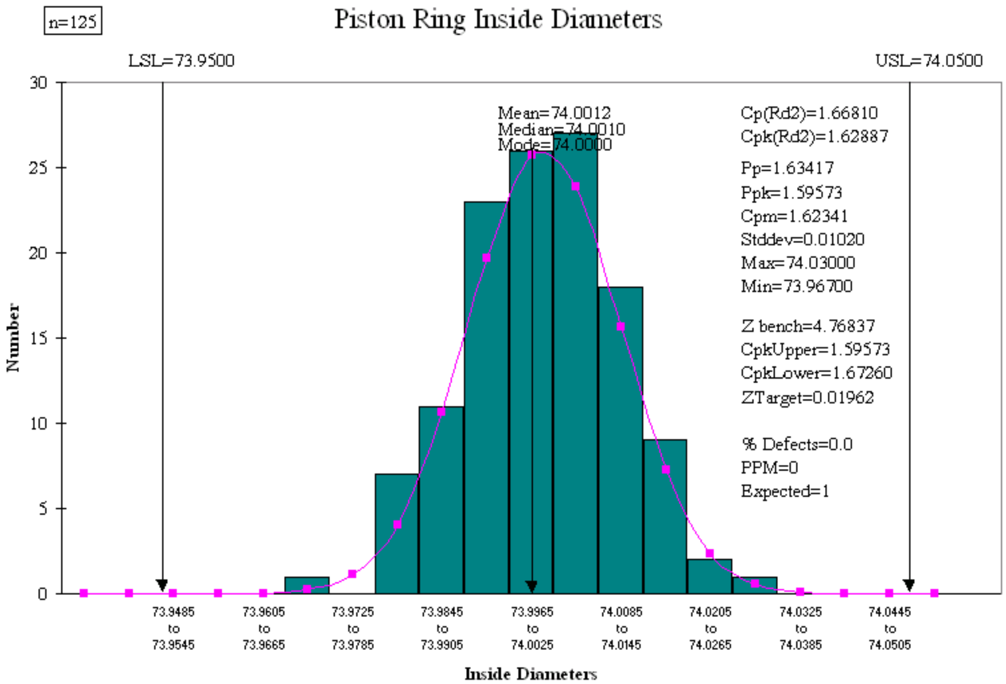
Evaluate the capability of a process to meet customer's specifications using **measured** (i.e., variable) data like time, money, age, length, width, and weight.

When?

Analyze capability of the process,

How?

1. Run the Histogram
3. Evaluate central tendency, distribution, and capability of your process.



Data

Diameters

A	B	C	D	E	F
Sample	1	2	3	4	5
6/8 8am	0.65	0.7	0.65	0.65	0.85
10am	0.75	0.85	0.75	0.85	0.65
12pm	0.75	0.8	0.8	0.7	0.75
2pm	0.6	0.7	0.7	0.75	0.65
6/9 8am	0.7	0.75	0.65	0.85	0.8
10am	0.6	0.75	0.75	0.85	0.7
12pm	0.75	0.8	0.65	0.75	0.7
2pm	0.6	0.7	0.8	0.75	0.75

Cp, Cpk

Sigma	Cp/Cpk
3	1.0
4	1.33
5	1.67
6	2.0

What can you learn?

Cp > 1 - Process is capable (products fall between upper and lower specification limits), and between 3-4 Sigma (Cp=1.0-to-1.33). Process could be improved by reducing variation and tightening up the production around a target (e.g., 0.7).

Cpk > 1 - Process is capable and centered. Because Cp ~ Cpk, process is *centered* between LSL and USL, not shifted either direction. (Don't need to shift the process mean, just reduce variation.)

Normal - If you look at the chart you can see that the bars are closely aligned to the normal curve: you have a *normal* distribution, but there's a gap in the data. Does this mean there are two different populations in the data (e.g., combining heights or weights of men and women into one chart will produce two peaks)?

c Chart

Attribute Data (defects), Sample Size Constant

Why?

Monitor defects when the opportunity is large compared to the actual number of defects (e.g., patient falls, injuries, etc.) The c chart is useful when it's easy to count the number of defects and the opportunity is large but chance is small (e.g., injuries/month).

When?

Monitor process with multiple defects per sample over a given period.

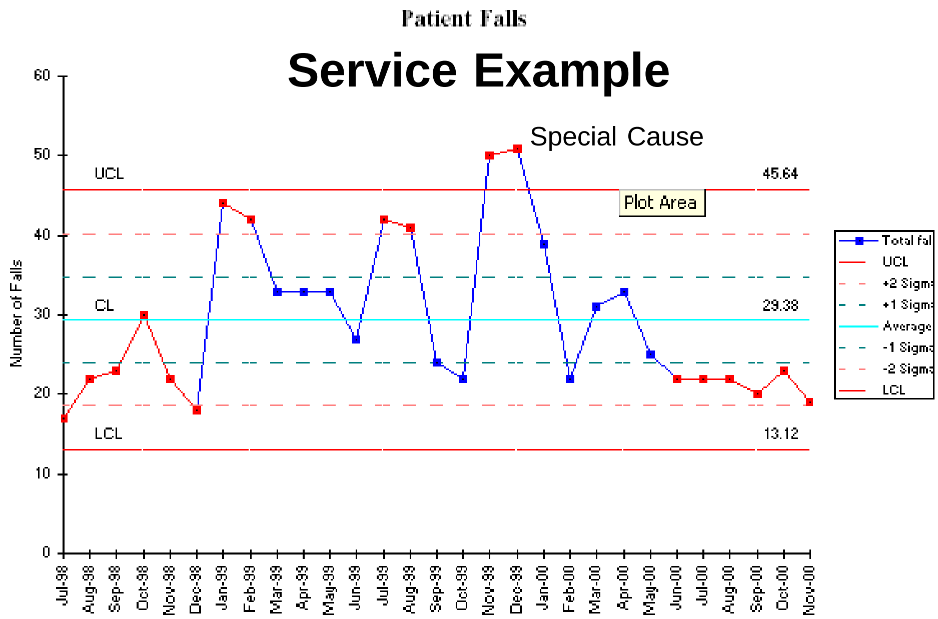
How?

1. Select the labels and data.
2. Run the c Chart
3. Evaluate the c chart. Analyze special causes of any instabilities.

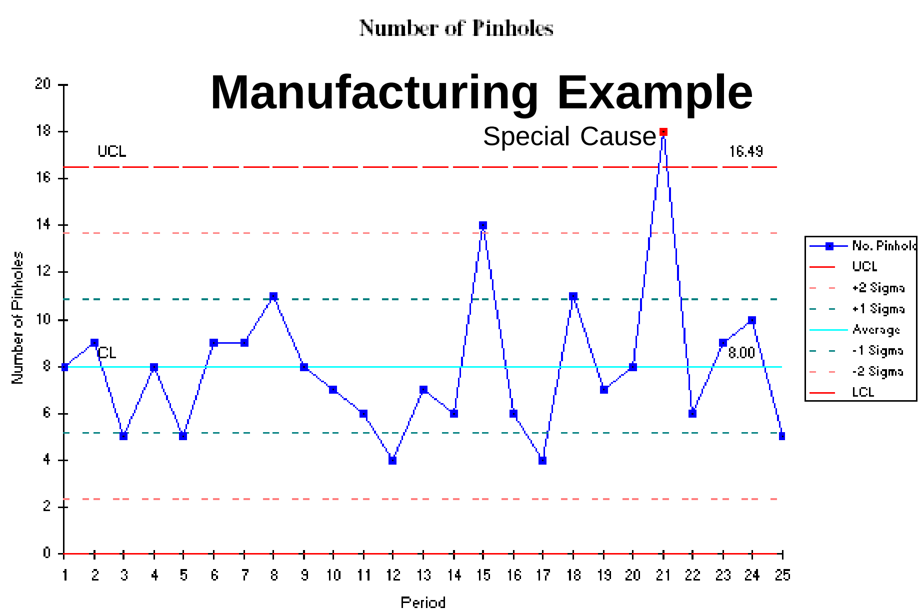
Data

Patient Falls

	A	B
1	Month	Total falls
2	Jul-98	17
3	Aug-98	22
4	Sep-98	23
5	Oct-98	30
6	Nov-98	22



	A	B	C
2		No. Pinholes	
3	1	8	
4	2	9	
5	3	5	
6	4	8	
7	5	5	



	c Chart
UCL:	$\bar{c}$ + 3*sqrt($\bar{c}$)
CL:	$\bar{c}$ = Σci/n
LCL:	$\bar{c}$ - 3*sqrt($\bar{c}$)

Six Sigma Templates

To automate all of your improvement documentation, get *The QI Macros For Microsoft Excel.*

Design of Experiments

Why?

The purpose of DOE is to quickly and efficiently discover the optimum conditions that produce top quality. Trial-and-error is the slowest method of discovering these optimal conditions and usually misses the effects of various interactions. DOE significantly reduces the time and trials necessary to discover the best combination of factors to produce the desired level of quality and robustness.

When?

After problem solving to identify plan for implementing changes.

How?

1. Determine objectives, potential causes, and factors (usually 2,3,or 4 factors).

2. Select experimental factors, identify potential interactions, and levels (+/-,high/low)

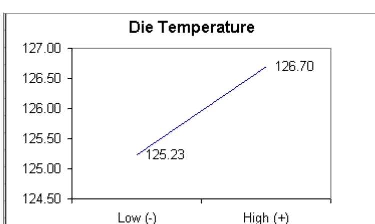
3. Choose appropriate design (4, 8, or 16 trials) and randomize sequence of trials

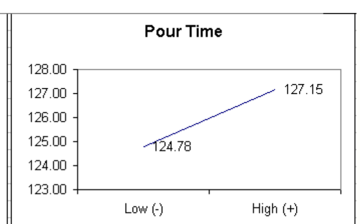
4. Run the experiment

5. Analyze the data to determine interactions and best factor levels

6. Verify results

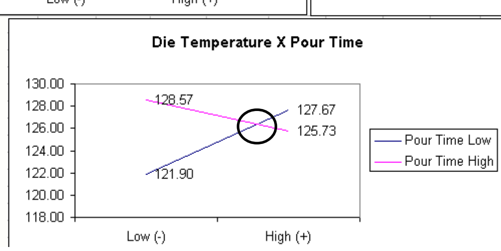
	A	B	C	D	E	F	G	H	I	J
1	Design of Experiments				L4					
2	Factor	Factor Name			Level 1		Level 2			
3	A	Die Temperature			Room temp		200 degrees			
4	B	Pour Time			6 sec		12 sec			
5	AB	Die Temperature X Pour Time								
6										
7	Design	Factors				Trial Responses				
8	Trial	A	B	AB	1	2	3	Average		
9	1	-	-	+	122.3	121.5	121.9	121.90		
10	2	-	+	-	128.5	129	128.2	128.57		
11	3	+	-	-	127.3	127.9	127.8	127.67		
12	4	+	+	+	125.8	125.2	126.2	125.73		
13				Average	125.98	125.90	126.03	125.97		
14		(1)	3	2						
15	Interactions		(2)	1						
16				(3)						
17				Pour Time Low	Pour Time High					
18	Low (-)	125.23	124.78	121.90	128.57					
19	High (+)	126.70	127.15	127.67	125.73					
20										
21	Anova	Factor			df	SS	MS	F	Effect	Contrast
22	Source	Die Temperature			1	6.45	6.45333	37.9608	1.5	8.80
23		Pour Time			1	16.80	16.8033	98.8431	2.4	14.20
24		Die Temperature X Pour Time			1	55.47	55.47	326.294	-4.3	-25.80
25		Error			8	1.36	0.170			
26		Total			11	80.09				





Slope of line shows there is an effect caused by both factors.

(Flat line = no effect.)



Optimal solution lies at intersection of "confounding" factors (e.g., higher temp, longer pour time).