

MINITAB Applications in Six Sigma

Agenda

13:00-13:30 Registration

13:30-14:20 MSA-MINITAB

14:20-14:30 Break

14:30-15:20 SPC-MINITAB

15:20-15:30 Break

15:30-16:20 Case study (Healthcare & Banking)

16:20-16:30 Q&A

July 14, 2006 in Taipei

MSA-MINITAB

Application in
(Measurement Systems Analysis, MSA)

Measuring System.

What is a Measuring System?

- The measuring device (Repeatability)
- The person who is taking the measurement (Reproducibility)

Measurement Process

- The ideal measurement system produce “true” measurements every time
- Quality of the measurement system is characterized by statistical properties
- Properties
 - ◆ Must be in Statistical Control
 - ◆ Variability must be small compared to product specifications
 - ◆ Variability must be small compared process variation

Basic Model

$$\sigma_{\text{Total}}^2 = \sigma_{\text{Product}}^2 + \sigma_{\text{Measurement System}}^2$$

The Total Variation is equal to the real product variation plus the variation due to the measurement system

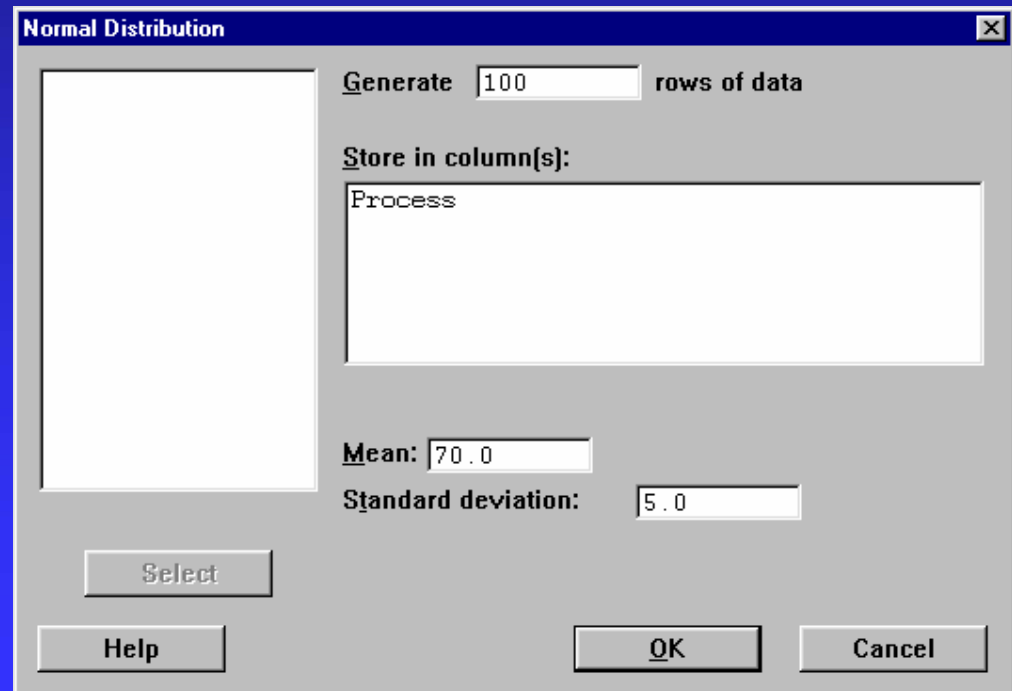
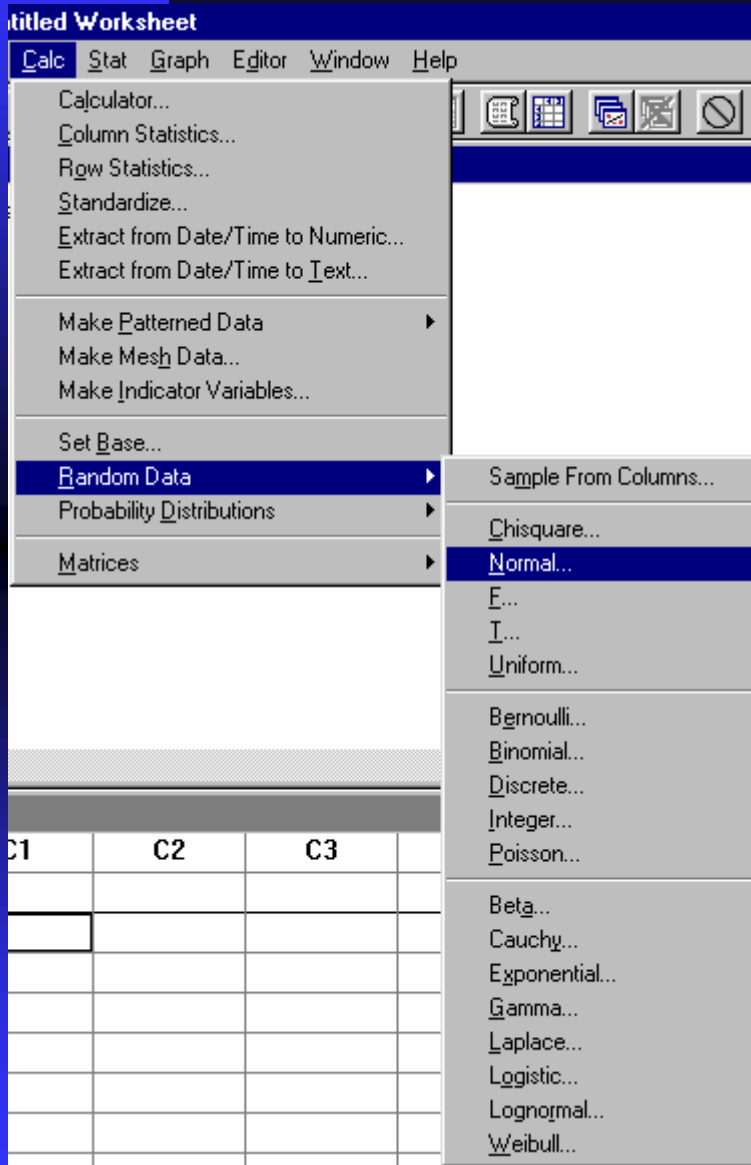
Minitab Exercise

Capability and Measurement Error

- Assume we have a process that has an actual *sigma of 5 units* and a *mean of 70 units*
- Also assume we have a measurement system that has the same measurement error as the process - *sigma of 5 units*
- Let's use Minitab to simulate the effect of measurement error on process capability

Exercise - Continued

- Follow these methods to create data to fit our process model:
Creates a random normal distribution



Exercise - Continued

Normal Distribution

Generate rows of data

Store in column(s):

Mean:

Standard deviation:

Select

Help

OK

What value should we use for the mean of the measurement error?

Calculate observed process behavior.

Calculator

Store result in variable:

Expression:

7	8	9	+	=	<>
4	5	6	-	<	>
1	2	3	*	<=	>=
0	.	/	And		
		**	Or		
		[]	Not		

Functions:
All functions
Absolute value
Antilog
Arcsine
Arccosine
Arctangent
Cosine
Current time
Date (from text)

Select

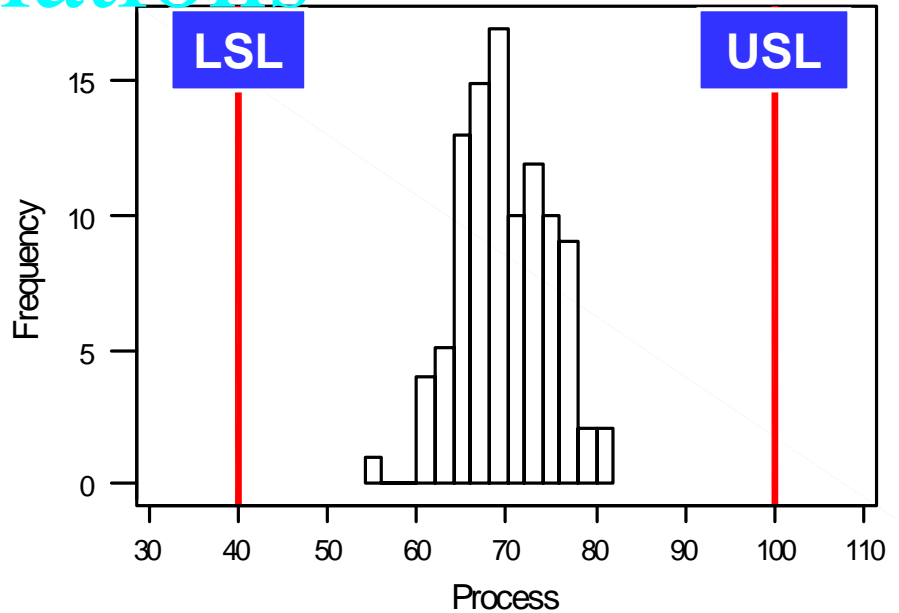
Help

OK

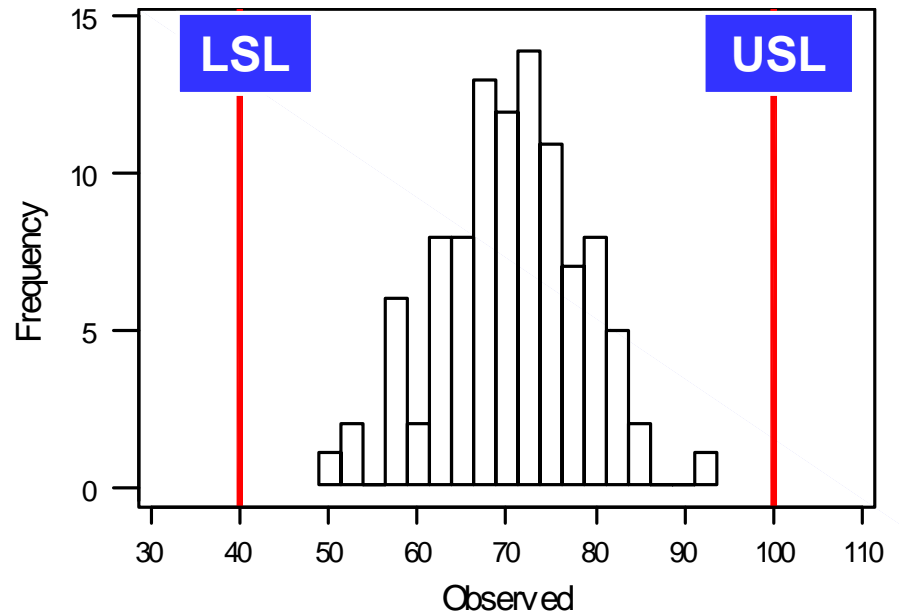
Cancel

Results of Simulations

Actual process variation -
No measurement error



Observed process
variation -
With measurement error



Effects of Measurement Error

Averages

$$\mu_{total} = \mu_{product} + \mu_{measurement}$$

Accuracy

Variability

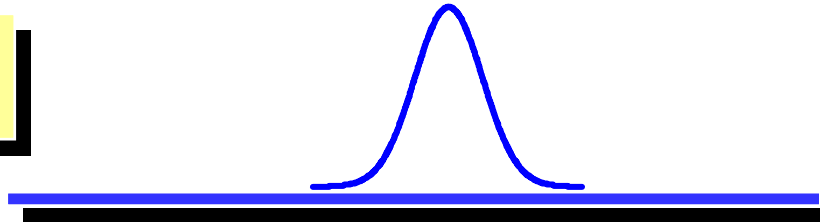
$$\sigma_{total}^2 = \sigma_{product}^2 + \sigma_{measurement}^2$$

*Measurement System
Variability - Determined
through "R&R Study"*

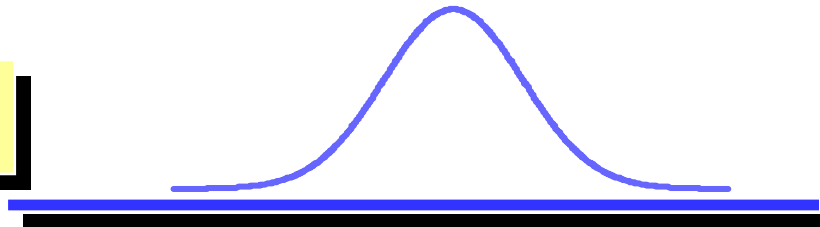
Precision

Sources of Variation

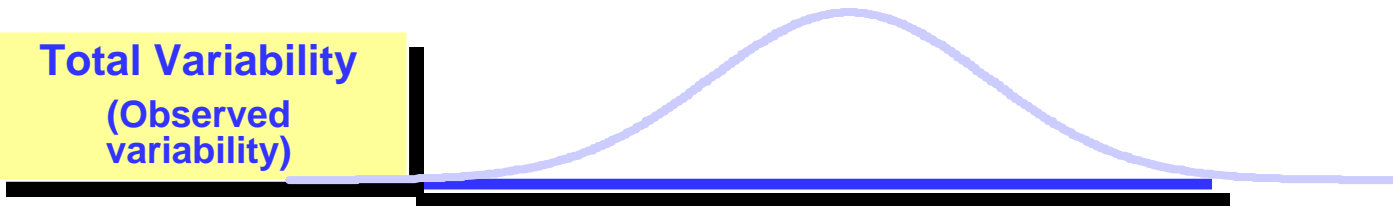
Product Variability
(Actual variability)



Measurement Variability



Total Variability
(Observed variability)



Two General Kinds of Data

ATTRIBUTE - Discrete, Counted Data

Ex: 1, 2, 3, 4 etc...
 Good/Bad, Go/NoGo, Pass/Fail
 Machine 1 , 2 , 3 ...

VARIABLES - Continuous, Measured Data

Ex: Weight = 10.2 Lbs
 Thickness = 11.211 inches

GR&R Metrics



Main Question - Is my measurement system okay to use on my project?

MSA Exercise

Part	Operator	Response
1	1	0.65
1	1	0.60
2	1	1.00
2	1	1.00
3	1	0.85
3	1	0.80
...

Minitab - Gage R&R Studies

The screenshot shows the Minitab menu bar with 'Stat', 'Graph', 'Editor', 'Window', and 'Help'. The 'Stat' menu is open, showing a list of statistical tools. The 'Quality Tools' submenu is also open, listing various quality control methods. The 'Gage R&R Study (Crossed)...' option is highlighted in blue.

44	
45	
46	
47	
48	
49	
50	
51	
52	
53	

The 'Gage R&R Study (Crossed)' dialog box is shown. It contains a table of variables, fields for 'Part numbers', 'Operators', and 'Measurement data', and radio buttons for 'Method of Analysis'. The 'ANOVA' radio button is selected and circled in blue. The 'Gage Info...' and 'Options...' buttons are also circled in blue.

C1	Part
C2	Operator
C3	Response

Part numbers: Part
Operators: Operator
Measurement data: Response

Method of Analysis
 ANOVA
 Xbar and R

Select Help Gage Info... Options... OK Cancel

Minitab - Gage R&R Studies

Gage R&R Study (Crossed) - Gage Info

Gage name:

Date of study:

Reported by:

Gage Tolerance:

Miscellaneous:

Help OK Cancel

General Info
On Your Study

GAGE Options

If There Is A
Tolerance For
This Part -
Put It Here

Gage R&R Study (Crossed) - Options

Study variation: (number of standard deviations)

Process tolerance:

Historical sigma:

Do not display percent contribution

Do not display percent study variation

Draw plots on separate pages, one plot per page

Title:

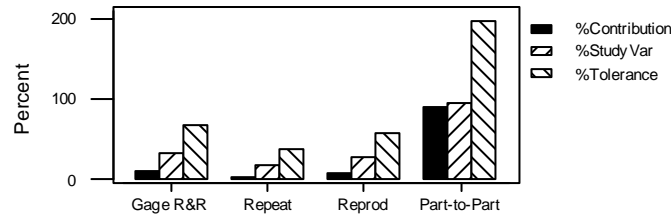
Help OK Cancel

Minitab - Output

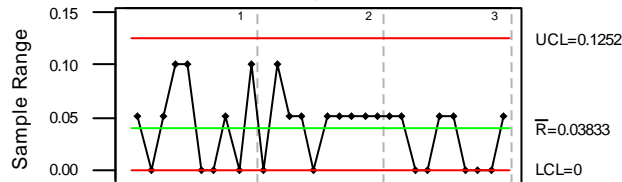
Gage R&R (ANOVA) for Response

Gage name:
Date of study:
Reported by:
Tolerance:
Misc:

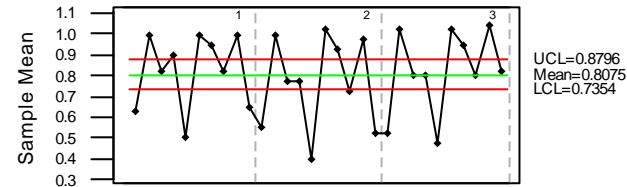
Components of Variation



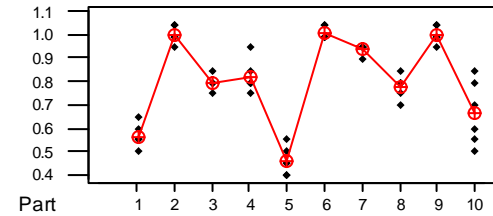
R Chart by Operator



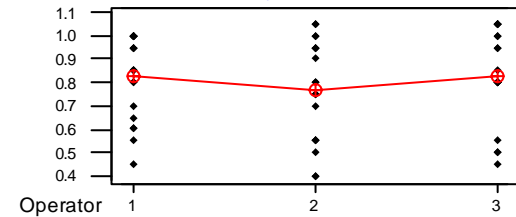
Xbar Chart by Operator



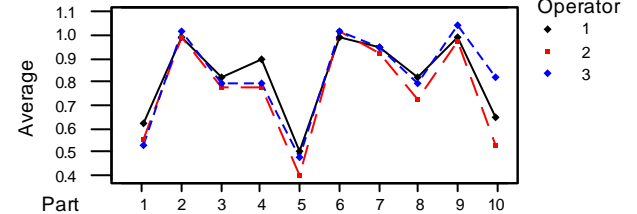
By Part



By Operator



Operator*Part Interaction



%R&R &
P/T Ratios

Gives Us The 1st
Look At
Discrimination

Expected To
Be Out of Control

Graphical View
Of Results

Minitab - Output

Gage R&R

	StdDev	Study Var	% R&R	%P/T
Source	(SD)	(5.15*SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.066615	0.34306	32.66	68.61
Repeatability	0.035940	0.18509	17.62	37.02
Reproducibility	0.056088	0.28885	27.50	57.77
Operator	0.030200	0.15553	14.81	31.11
Operator*Part	0.047263	0.24340	23.17	48.68
Part-To-Part	0.192781	0.99282	94.52	198.56
Total Variation	0.203965	1.05042	100.00	210.08

Number of Distinct Categories = 4

What decision do we make?

%P/T

Best case: 10% Acceptable: 30%

% R&R

As a target, look for %R&R < 30%

Reducing recruiting costs

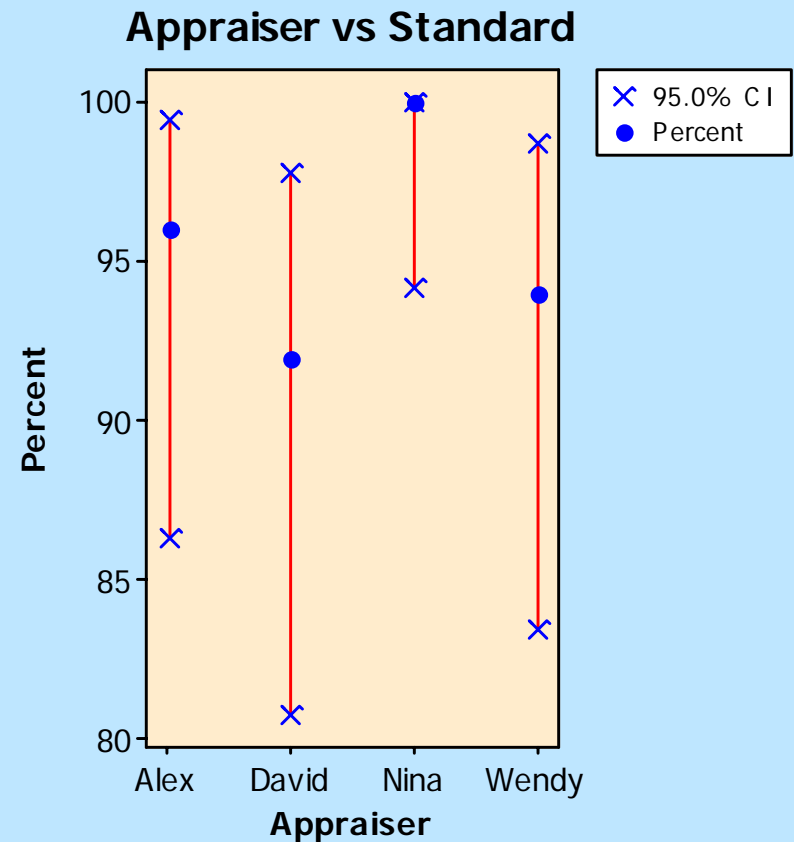
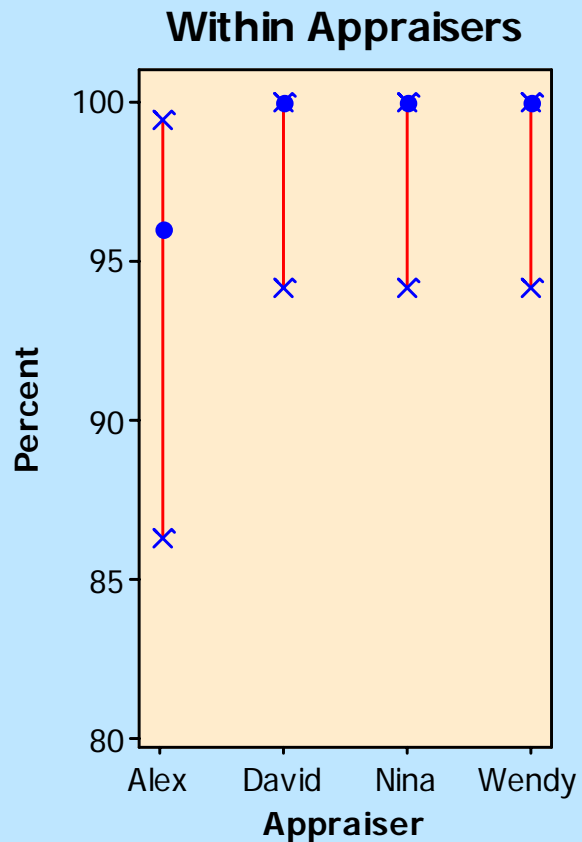
- Due to high costs and significant time needed to screen resumes submitted electronically, the team decides to evaluate the screening process for resumes submitted via the web.
- Think about the response. Resumes are evaluated by team members- what type of data is this?

Attribute Agreement Analysis

- **Binary response- Pass/Fail.**
- **A resume either proceeds to the next level or not.**
- **4 people are responsible for screening resumes. Each is presented with 50 resumes, randomly selected and already judged to be either a pass or fail.**

Attribute Agreement Analysis

Assessment Agreement



MSA - Summary

- Introduce *Measurement Systems Analysis*
- Define basic measurement terms
- Outline procedure for performing a Gage Study (Measurement Systems Analysis)

SPC-MINITAB

Application in
(Statistical Process Control, SPC)

The Way We Manage Data - Today

SPC

S = Statistical techniques used to examine process variation

P = Process, ANY Process

C = Controlling the process through active management

Control Chart Methods

Where Did It Come From ?

- 1920's - Western Electric / Dr. Walter Shewhart
- Used to identify Controlled & Uncontrolled Variation
 - ◆ Controlled: Common Cause or Inherent Variation
 - ◆ Uncontrolled: Special Cause or Assignable Variation
- Uses Control Charts as main tool

Types of Variation

“Common vs. Special”

COMMON CAUSE

- Is present in every process
- Is produced by the process itself (the way we do business)
- Can be removed and/or lessened but requires a fundamental change in the process

*A process is **Stable, Predictable, and In-Control** when only Common Cause Variation exists in the process*

Types of Variation

“Common vs. Special”

SPECIAL CAUSE

- Unpredictable
- Typically large in comparison to Common Cause variation
- Caused by unique disturbances or a series of them
- Can be removed/lessened by basic process control and monitoring

*A process exhibiting Special Cause variation is said to be **Out-of-Control** and **Unstable***

Minitab - Control Charts

Stat Graph Editor Window Help Six Sigma

Fit Intercept

- Basic Statistics
- Regression
- ANOVA
- DOE
- Control Charts**
- Quality Tools
- Reliability/Survival
- Multivariate
- Time Series
- Tables
- Nonparametrics
- EDA

Define Tests...

Box-Cox Transformation...

Xbar-R...

Xbar-S...

I-MR...

Z-MR...

Xbar...

R...

S...

Individuals...

Moving Range...

EWMA...

Moving Average...

CUSUM...

Zone...

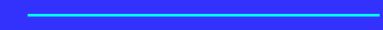
P...

NP...

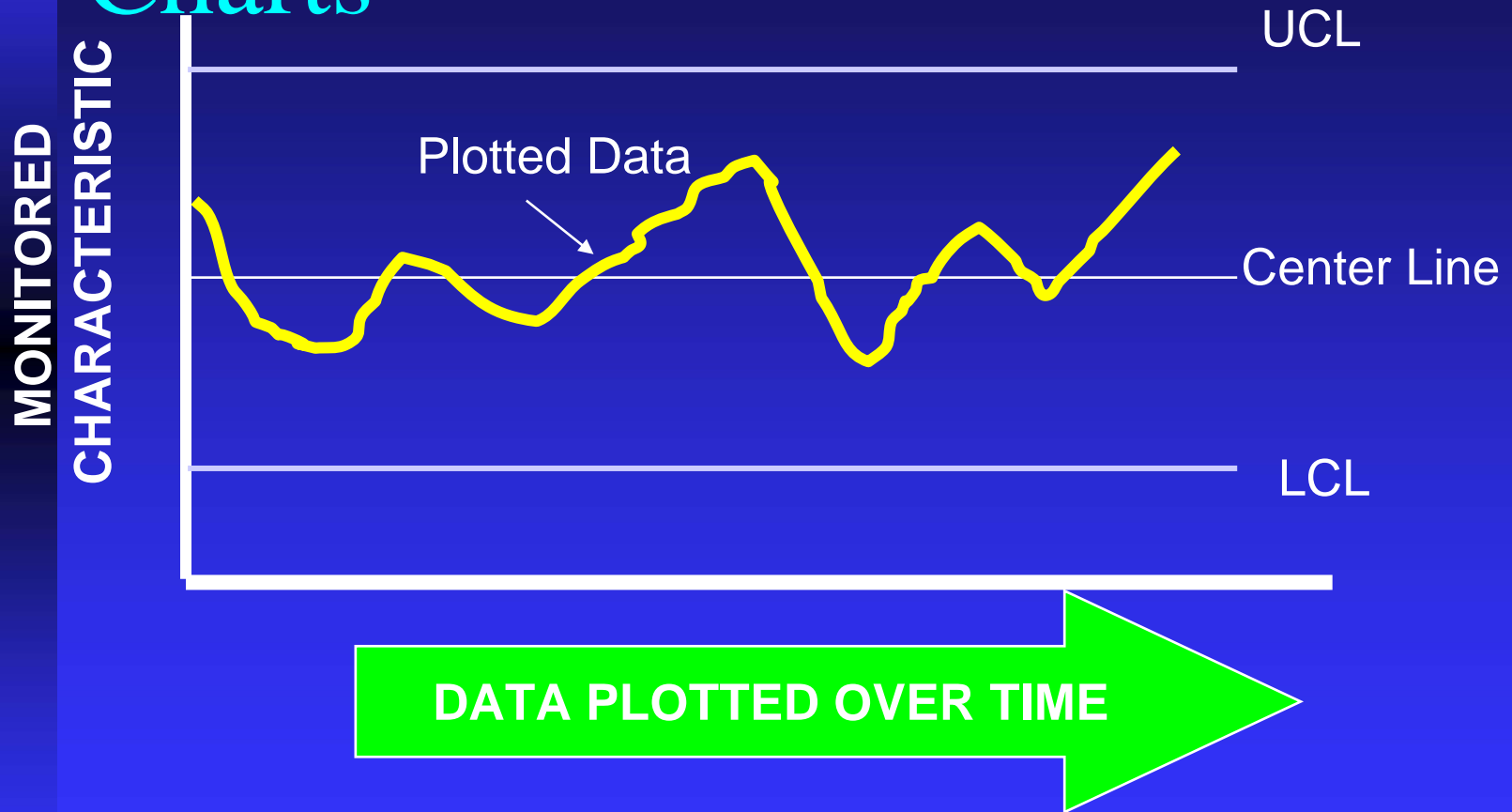
C...

U...

	C2	C3
	Age	Mon
	19	
L	19	
L	20	
L	23	
L	29	
B	19	



Key Component - Control Charts



UCL = Upper Control Limit / LCL = Lower Control Limit

Process Control Tests

A set of standard tests have been created to help identify **SPECIAL CAUSE** events in our processes

We use the phrase “Out of Control” when a test (or rule) has been broken.

The tests we suggest:

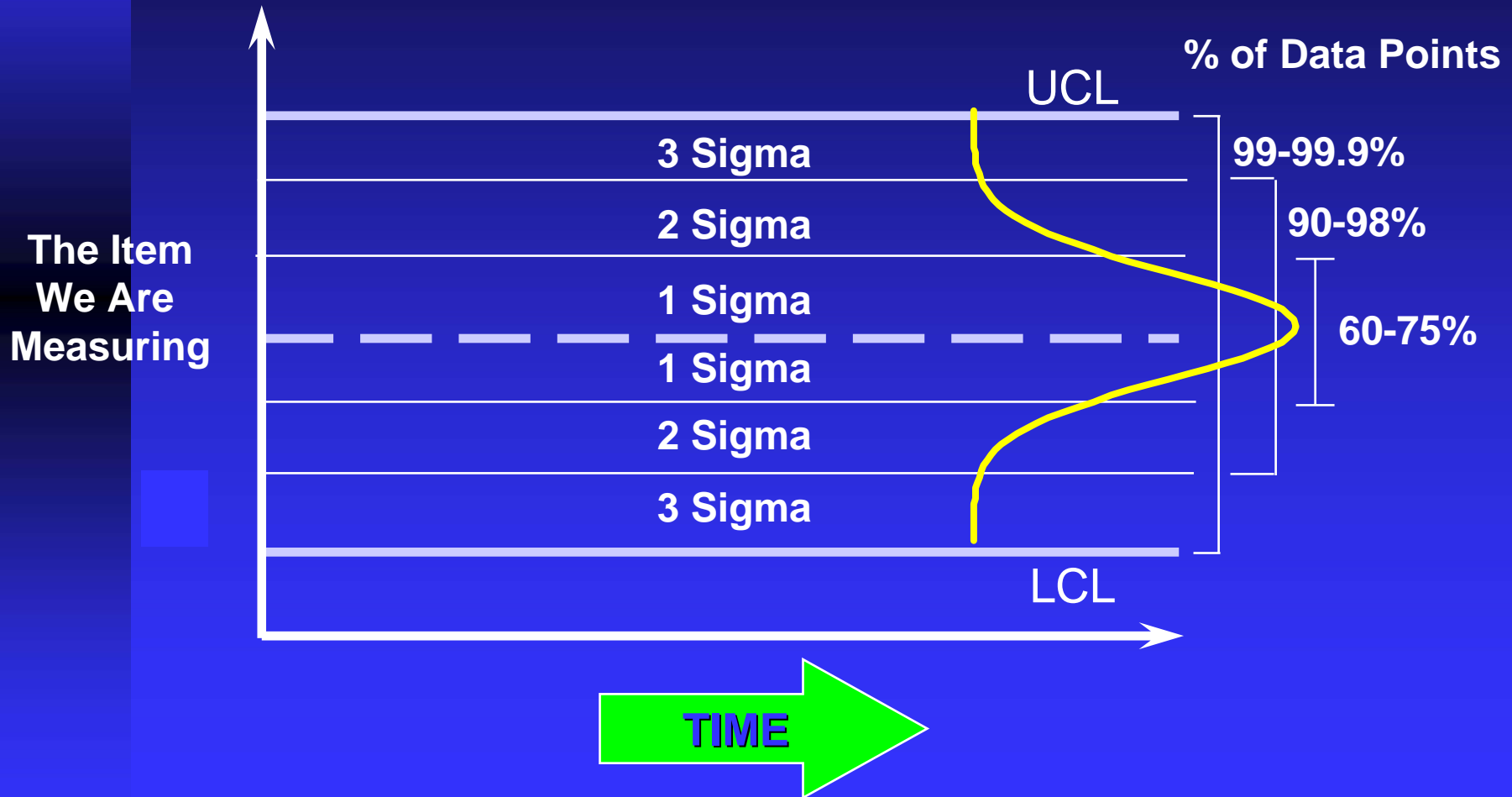
-**Pattern rule:** If you see a pattern, the process is out of control

This means something “**unusual**” has happened -

Go check it out!!

Rules of Standard Deviation

“Where should the data lie?”



Minitab Tests

Individuals Chart

Variable:

Historical mean: (optional)

Historical sigma: (optional)

Tests...

Estimate...

S Limits...

Stamp...

Options...

Select

Help

4		
5		
6		
7		
8		

Tests

Tests For Special Causes (default definitions)

- One point more than 3 sigmas from center line **Test #1**
- Nine points in a row on same side of center line **Test #2**
- Six points in a row, all increasing or all decreasing
- Fourteen points in a row, alternating up and down
- Two out of three points more than 2 sigmas from center line (same side)
- Four out of five points more than 1 sigma from center line (same side)
- Fifteen points in a row within 1 sigma of center line (either side)
- Eight points in a row more than 1 sigma from center line (either side)

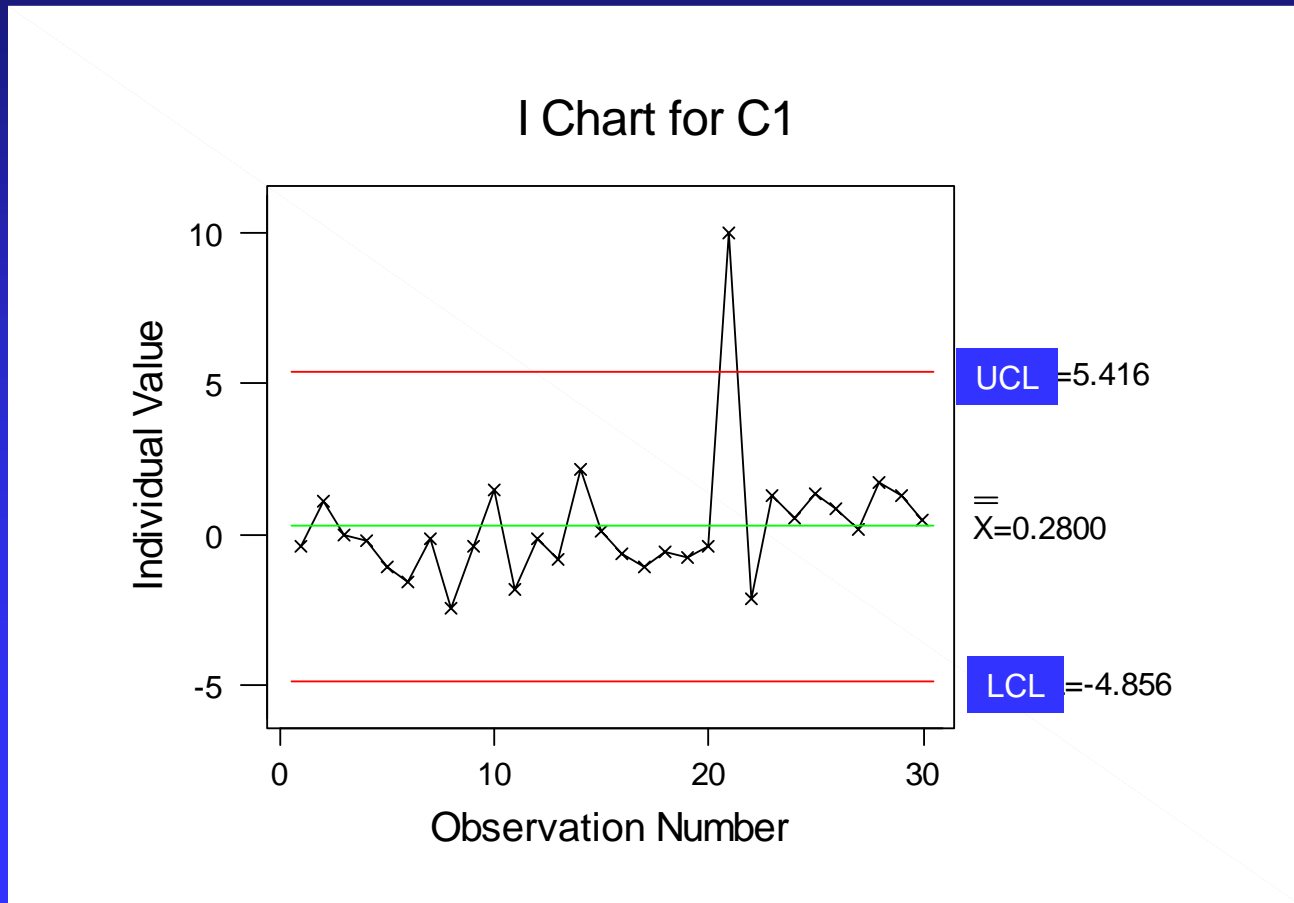
Help

OK

Cancel

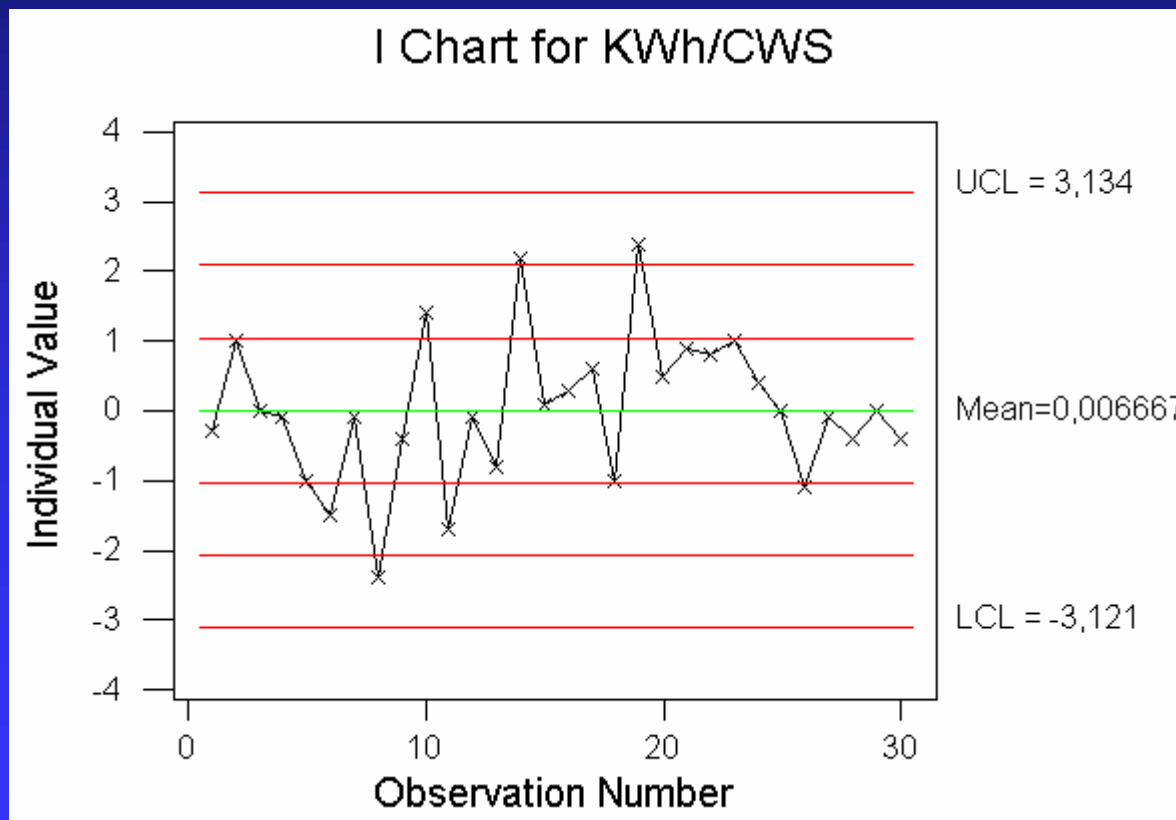
In Control or Out of Control ? _____

If out of Control, which rule(s) is broken or condition(s) is present?



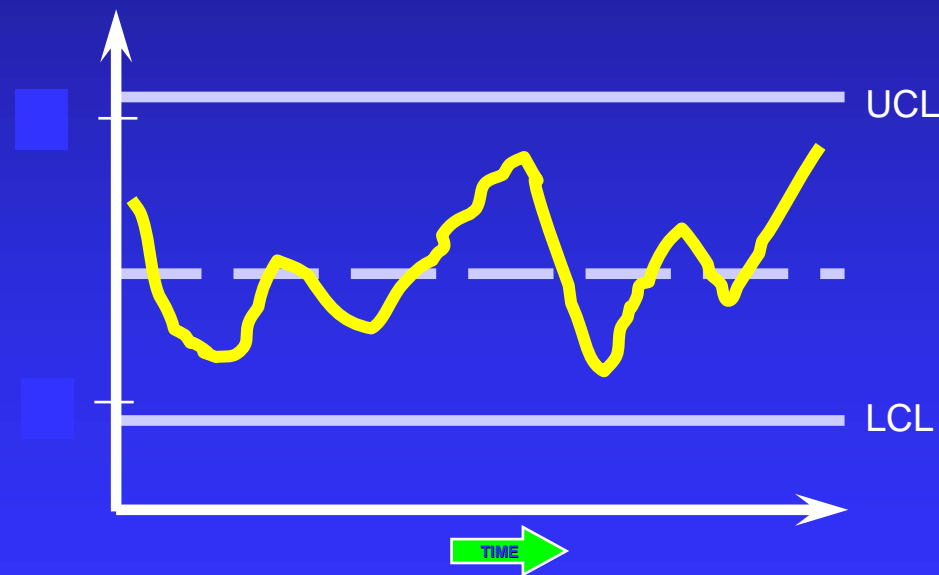
In Control or Out of Control ? _____

If out of Control, which rule(s) is broken or condition(s) is present?



Control Limits vs. Specification Limits

If a point falls beyond the upper or lower control limit does this mean we are making a defect for the customer?



Control Limits vs. Specification Limits

- Process Control Limits are calculated based on data from the process itself
- They are based on $\pm 3\sigma$ (*99.73% of the process variation is expected to fall between these limits*)
- Product Specification Limits ARE NOT found on the control chart
- Understanding how the process matches up against customer requirements IS important to know

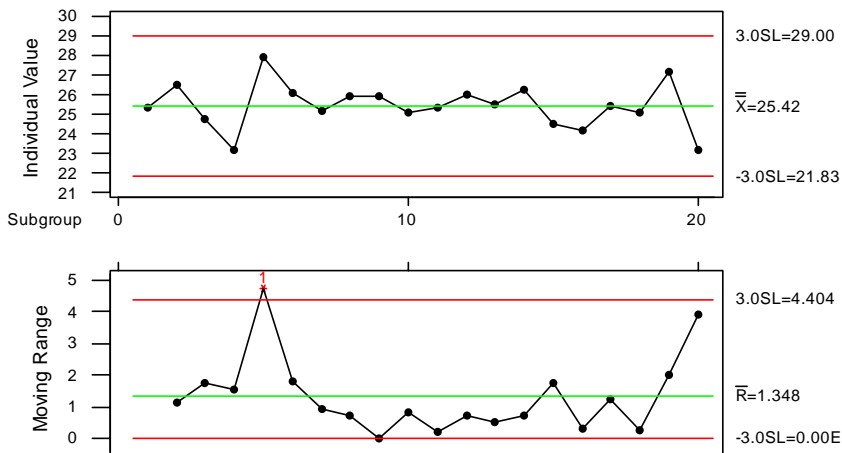
To determine how the process performs to Customer Expectations, a Process Capability Study is required

Different Variables Control Charts

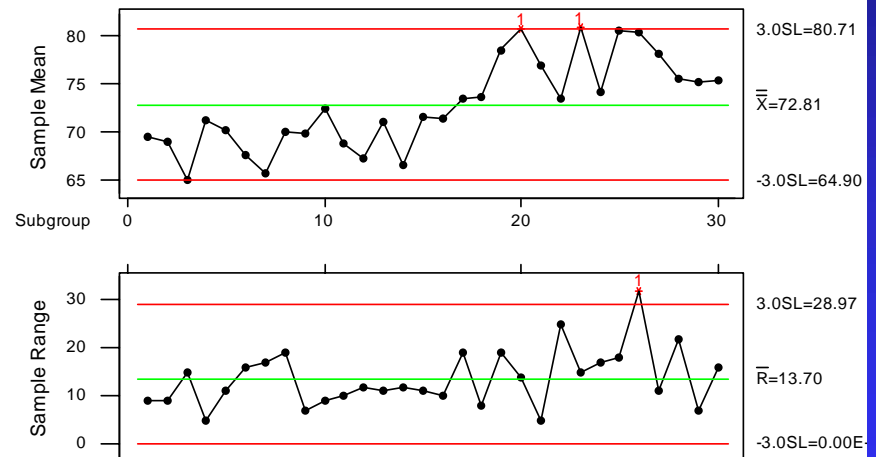
I-MR Individuals - Moving Range

X-Bar-R Average -Range Chart

I and MR Chart for C1



Xbar/R Chart for Output

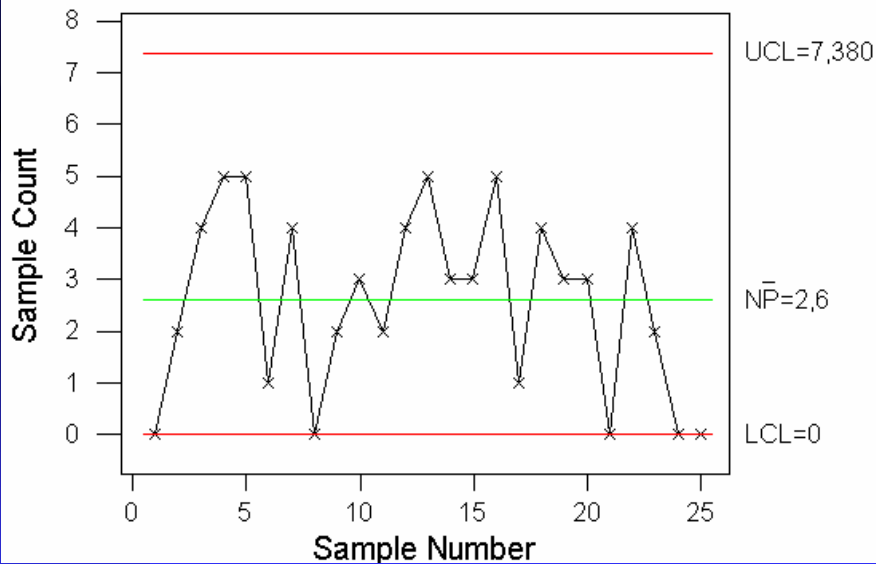


Different Attribute Control Charts: Defectives

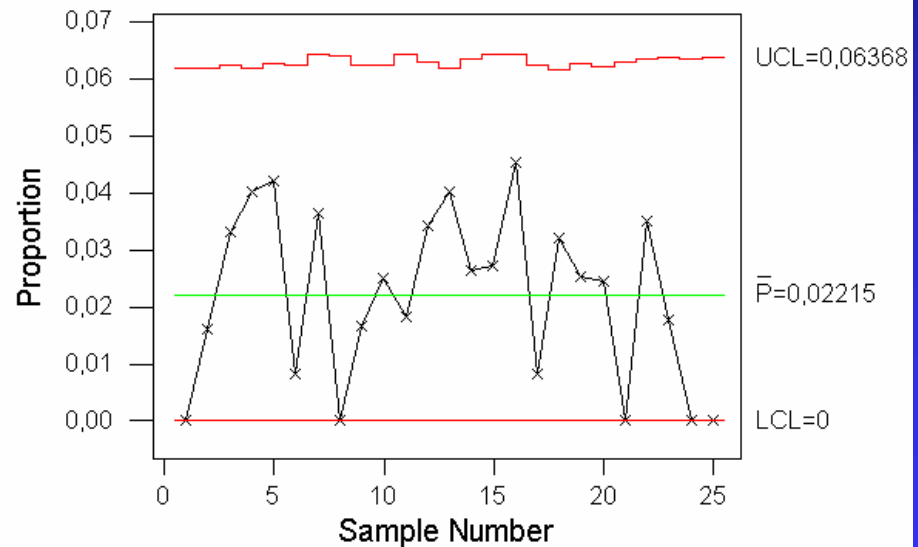
NP Number of non-conforming units

P Proportion of non-conforming units

NP Chart for NPChart



P Chart for PChart

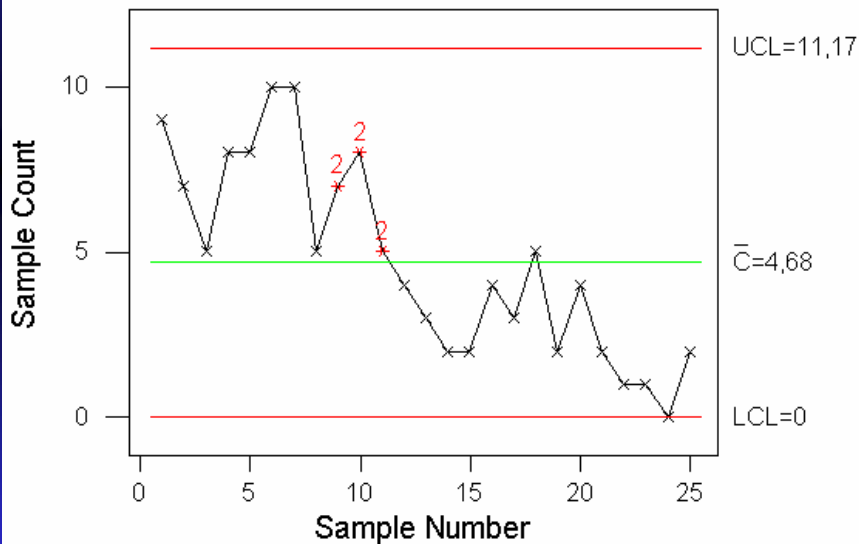


Different Attribute Control Charts : Defects

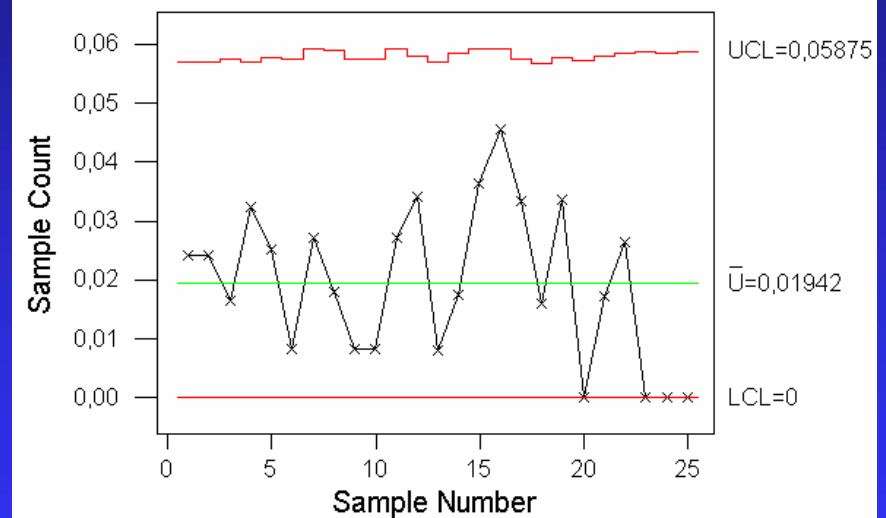
C Number of defects

U Number of defects per “unit”

C Chart for Failures



U Chart for % Errors



Exercise: What Type of Control Chart?

1. # of typos per sales contract (C,U)
2. Number of notebooks with defects in monthly production (P)
3. % of defective vehicles in monthly production (I-MR,P)
4. Per accounts receivable, amount of time it takes to close it (I-MR_)
5. Number of transmissions with defects per 100 built (NP)

Requirements for Effective Use of Control Charts

- Management **MUST** establish and support an environment that promotes proper action and support to the information collected on the control charts
- Control Charts are implemented **ONLY** on Key Processes on which improvement will bring benefit to the organization and/or the customer
- Data collected from the process is validated through the use of a **CAPABLE** measurement system

SPC - Summary

- ☞ Linked Control Chart Methods to the DMAIC roadmap
- ☞ Discussed different types of variation
- ☞ Introduced various Control Chart types
- ☞ Discussed the interpretation of Control Charts

Case study (Healthcare & Banking)

Healthcare industry

- MD Anderson Cancer Center (TX, USA)
 - ◆ 1998-2000
 - ◆ CT process re-arranged
 - ◆ Service capacity increased 28%

Healthcare industry _ City hospital of Taipei

- X-ray transparency delivery time < 30 mins
- KPIVs
 - ◆ No dedicated delivery personnel
 - ◆ No specific process
- MSA
 - ◆ Attribute data
- SPC
 - ◆ Control charts

Healthcare industry_

Local hospital in Taichung

- TQIP
- Unexpected return rate within 15 days-
<1.8%
- MSA
 - ◆ Attribute data
- SPC
 - ◆ Control charts

Banking

1. Customer waiting time <12 mins
 2. Money transfer process improvement
- Minitab tools used
 - ◆ Control Charts
 - ◆ MSA

Summary

- Process oriented
- Data driven with Minitab
- Innovation required
- Common language in project management

Q& A

Thank you

Control charts

- For data in subgroups:
 - ◆ subgroup means, \bar{X} \bar{X} Chart
 - ◆ subgroup ranges, r R Chart
 - ◆ subgroup standard deviations, s S Chart
 - ◆ \bar{X} and r on same screen \bar{X} and R
 - ◆ \bar{X} and s on same screen \bar{X} and S
 - ◆ I chart, MR chart, and R chart for subgroups on the same screen $I-MR-R/S$
(Between/Within)
- For individual observations:
 - ◆ individual observations I Individuals
 - ◆ moving ranges MR Moving Range
 - ◆ individual observations and moving ranges on same screen $I-MR$
- For subgroup combinations:
 - ◆ exponentially weighted moving averages $EWMA$
 - ◆ moving averages MA Moving Average
 - ◆ cumulative sums $CUSUM$
 - ◆ individual observations or subgroup means according to their distance from the center line Z Zone
- For short runs:
 - ◆ standardized individual observations and moving ranges from short run processes $Z-MR$
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