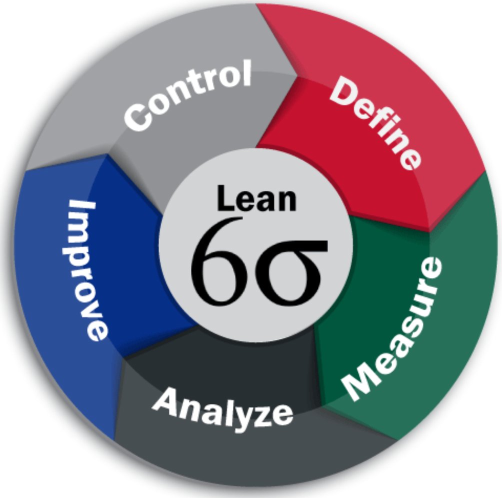


LEAN SIX SIGMA MEASURE PHASE

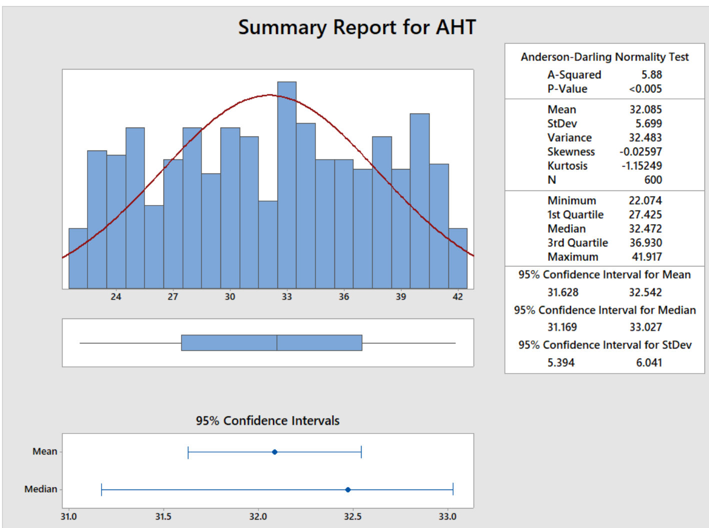
"That which cannot be measured cannot be proven" - Anthony W. Richardson

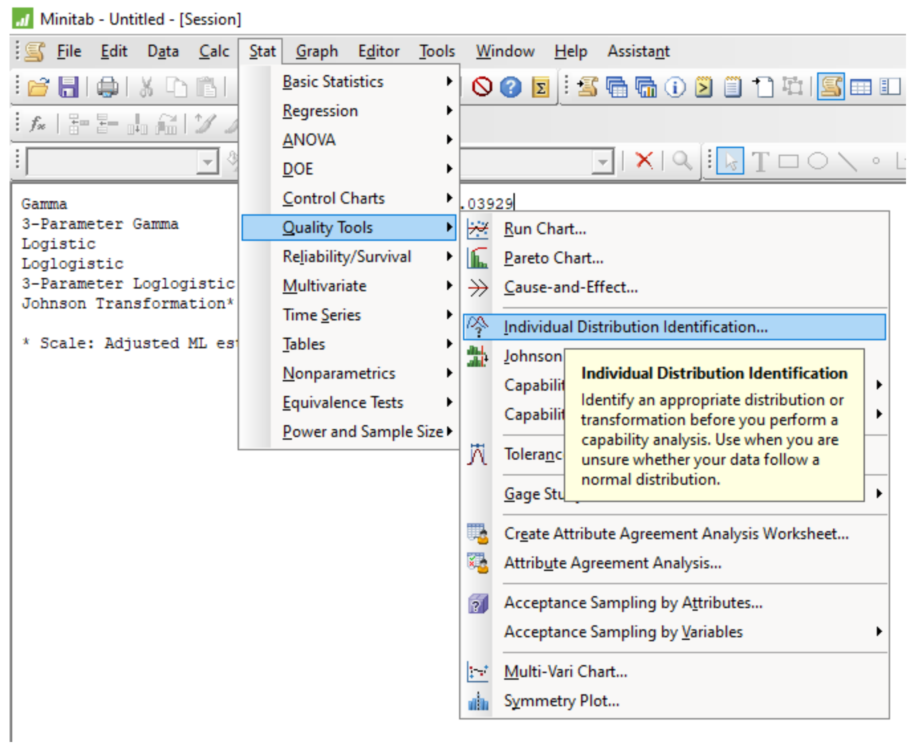
Coverage:

- Introduction to QUALITY and LEAN SIX SIGMA
    - ➢ Central limit theorem
    - ➢ Data transformation
    - ➢ Run Chart
    - ➢ MSA in minitab
    - ➢ Process Capability for non normal data

Distribution identification

If Normality Test fail





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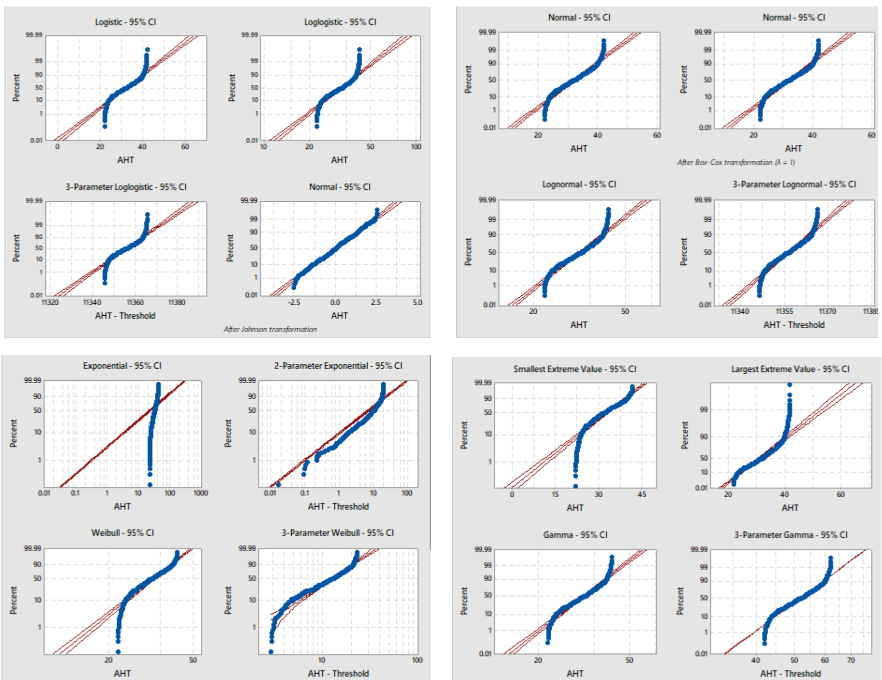
SKILLOGIC

Distribution identification

If Normality Test fail



Distribution ID Plot for AHT

Descriptive Statistics

N	N*	Mean	StDev	Median	Minimum	Maximum	Skewness	Kurtosis
600	0	32.0850	5.69935	32.4724	22.0736	41.9167	-0.0259705	-1.15249

Box-Cox transformation: λ = 1

Johnson transformation function:
-0.0291060 + 0.665296 × Ln((X - 21.6297) / (42.3626 - X))

Goodness of Fit Test

Distribution	AD	P	LRT P
Normal	5.881	<0.005	
Box-Cox Transformation	5.881	<0.005	
Lognormal	7.064	<0.005	
3-Parameter Lognormal	5.914	*	0.001
Exponential	185.691	<0.003	
2-Parameter Exponential	37.655	<0.010	0.000
Weibull	5.898	<0.010	
3-Parameter Weibull	6.385	<0.005	0.000
Smallest Extreme Value	7.932	<0.010	
Largest Extreme Value	8.719	<0.010	
Gamma	6.423	<0.005	
3-Parameter Gamma	6.120	*	0.173
Logistic	6.466	<0.005	
Loglogistic	7.291	<0.005	
3-Parameter Loglogistic	6.469	*	0.005
Johnson Transformation	0.419	0.326	

Central limit theorem

The central limit theorem states that if you have a population with mean µ and standard deviation σ and take sufficiently large random samples from the population with replacement , then the distribution of the sample means will be approximately normally distributed

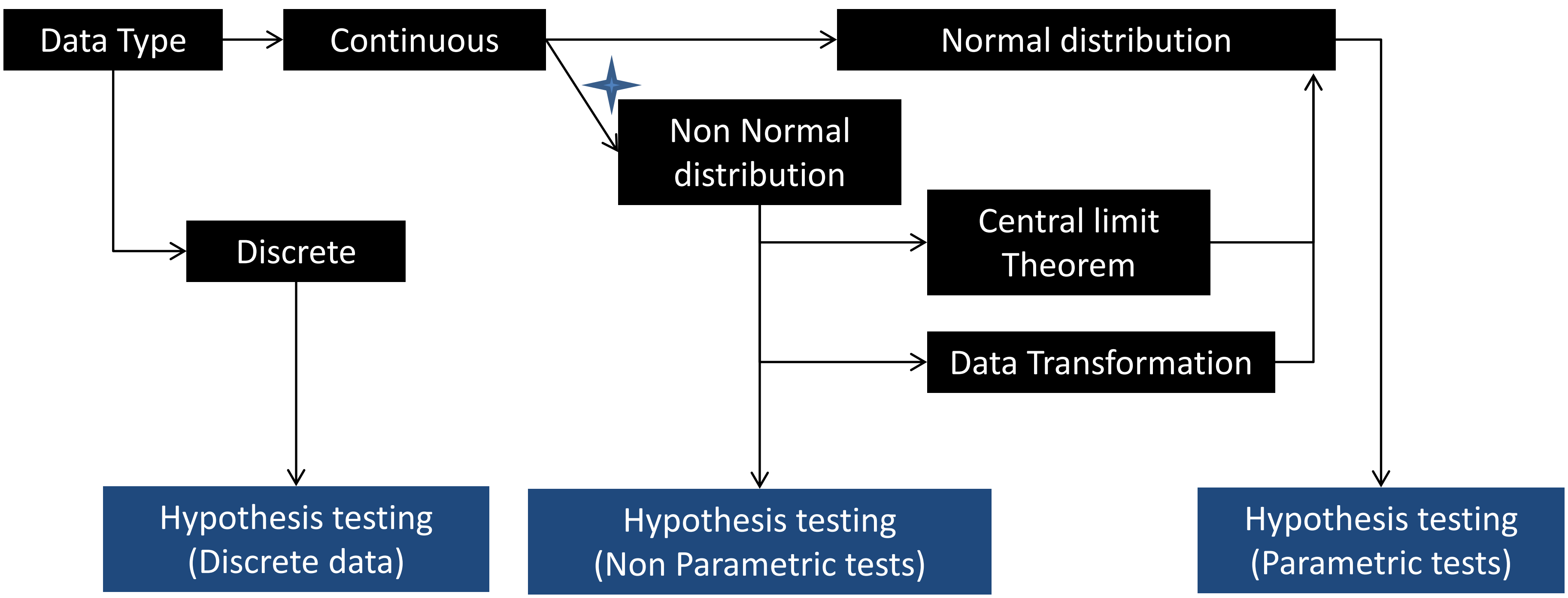
Key take away : Even if the original variables themselves are not normally distributed.. when independent random variables are added, their properly normalized sum tends toward a normal distribution

Minitab exercise

Refer : Data distribution

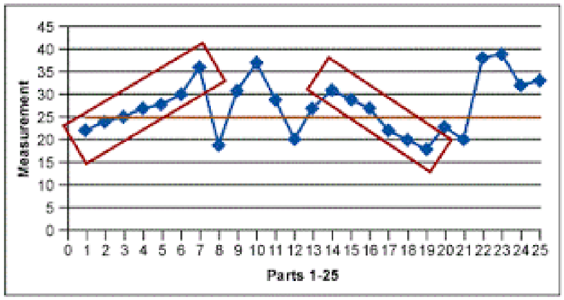
Normal (Vs) Non normal distribution

When data type is Continuous then the distribution can be broadly classified as Normal distribution or Non Normal distribution and if the data is non normally distributed then we may follow three different approach while performing hypothesis testing

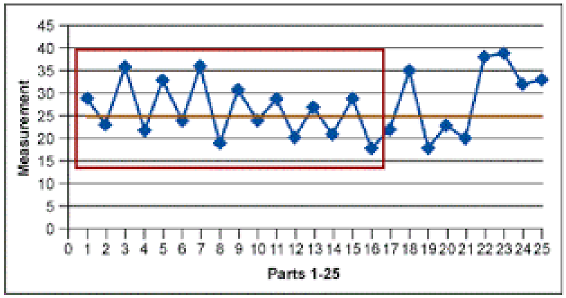


RUN CHART

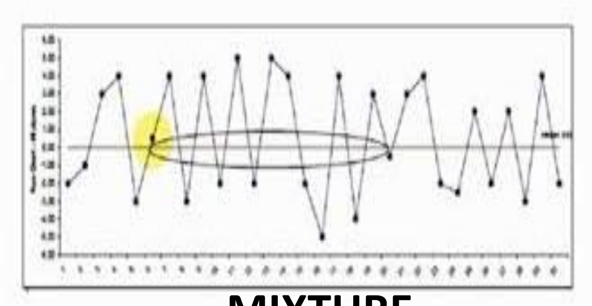
A **run chart** is **used to** study collected data for trends or patterns over a specific period of time. A **run chart** will help you: Monitor data over time to detect trends, shifts, or cycles. Compare a measure before and after the implementation of solution to measure impact.



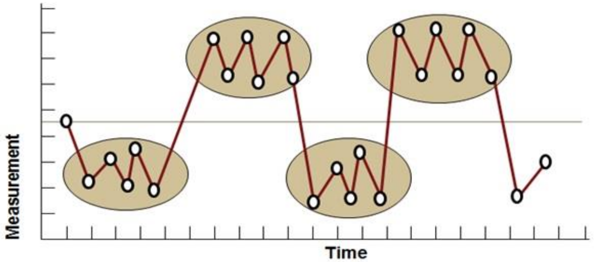
TREND



OSCILLATION

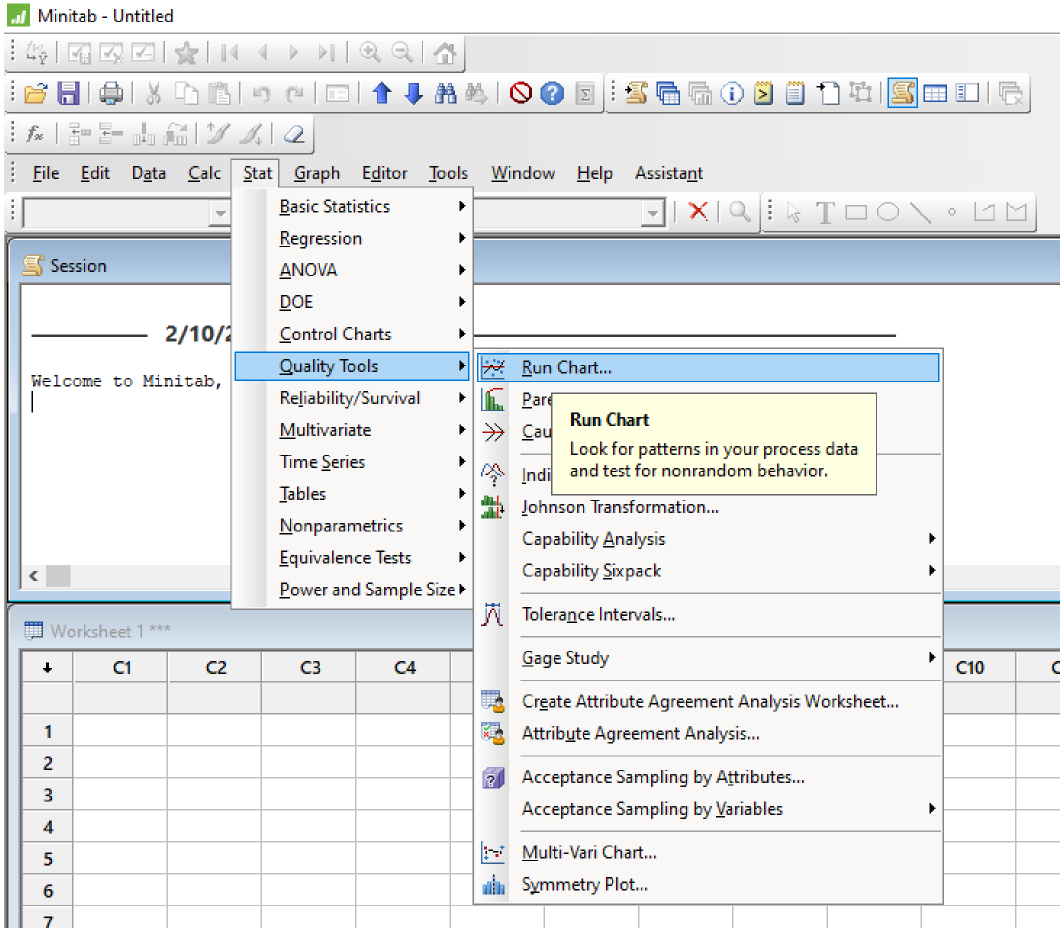


MIXTURE



CLUSTER

RUN CHART



Drawing a **Run chart** in minitab 17

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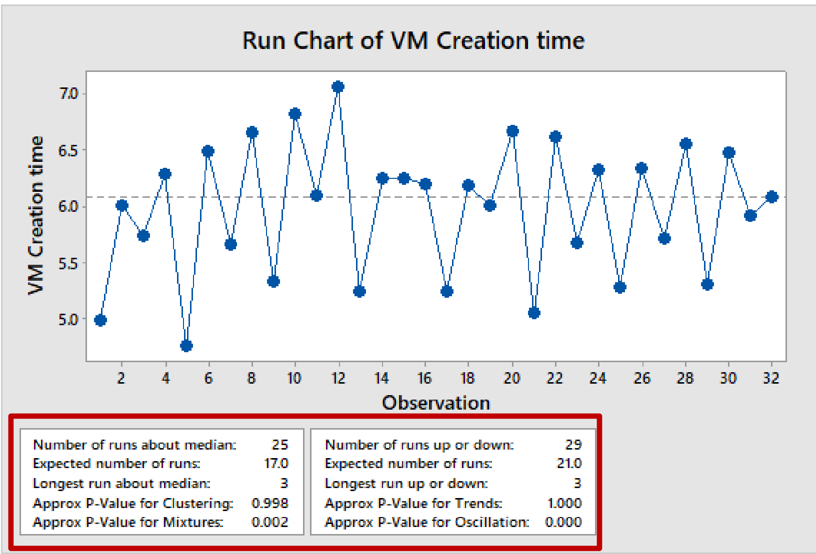
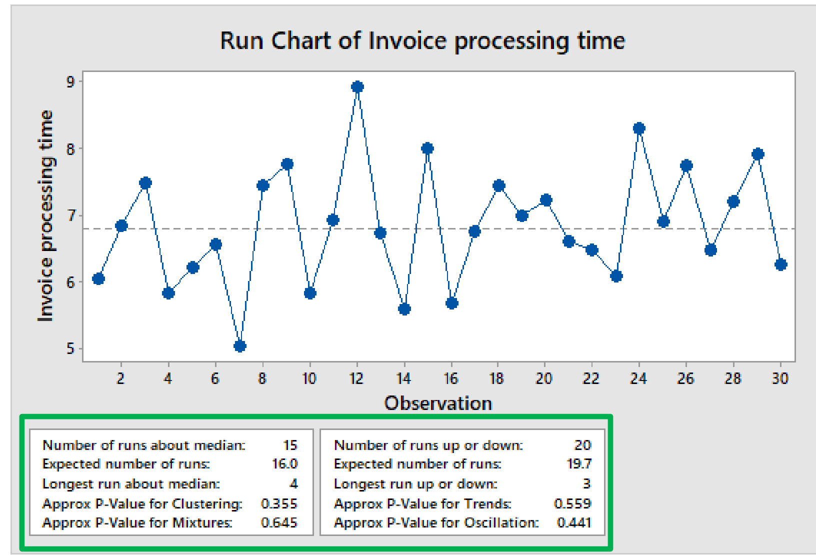
RUN CHART





P-value of any of the special cause less than 0.05 indicate existence of special cause

Minitab exercise

Refer : Data distribution

MSA

A measurement system must detect meaningful differences between parts in a process. A gage R&R study can help you decide if your measurement system can identify meaningful differences.

You can use a gage R&R study to determine whether your measurement tools are consistent, a prerequisite for reliable data

A gage R&R study can help you identify operator differences or environmental conditions that can influence measurements and that may warrant more operator training or stricter measuring guidelines.

MSA

Your measurement data must be numeric and continuous. For example:

Weight of potatoes in pounds

Length of an automotive part in inches

Diameter of piston rings in centimeters

You also need a part name or number column. Optionally, you can include a column for the operators. Parts and operators can be text or numbers. For example:

Parts A, B, C, and D and operators 1, 2, 3

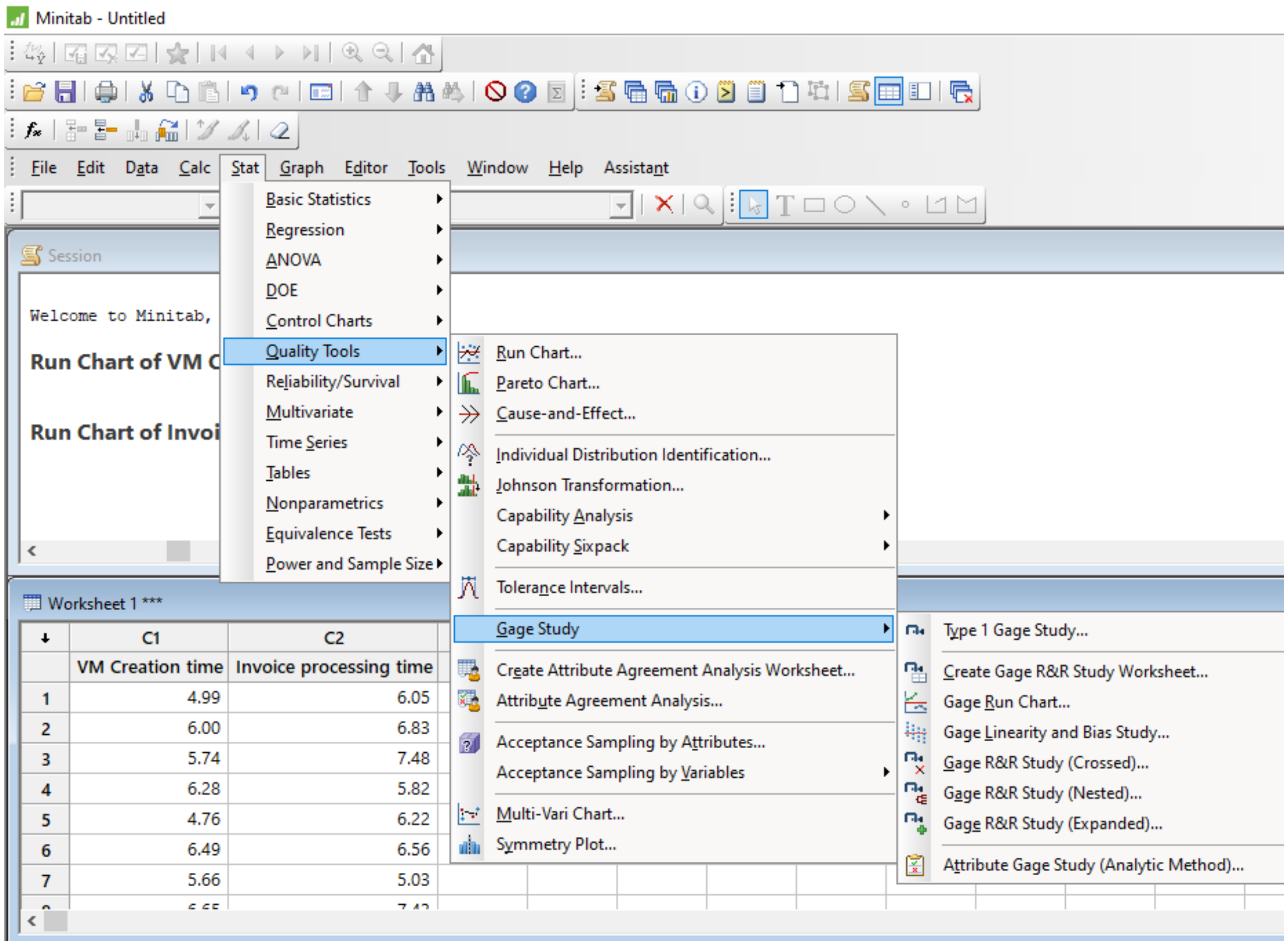
Parts 111, 117, and 119 and operators Sam and Laura

A Gage R&R study requires balanced designs (equal numbers of observations per cell) and replicate measurements. Select parts that represent the actual or expected range of process variation.

In a crossed study, every part is measured by more than one operator. If only one operator measures each part, analyze the data using a Gage R&R Study

COURSE CONTENT

MEASURE



Gage R&R Study (Crossed)

Assess the variation in your measurement system when every operator measures every part in the study.

Gage R&R Study (Nested)

Assess the variation in your measurement system when you can measure each part only once, such as with destructive testing.

Gage R&R Study (Expanded)

Assess the variation in your measurement system when it is affected by factors in addition to part and operator, such as temperature and location.

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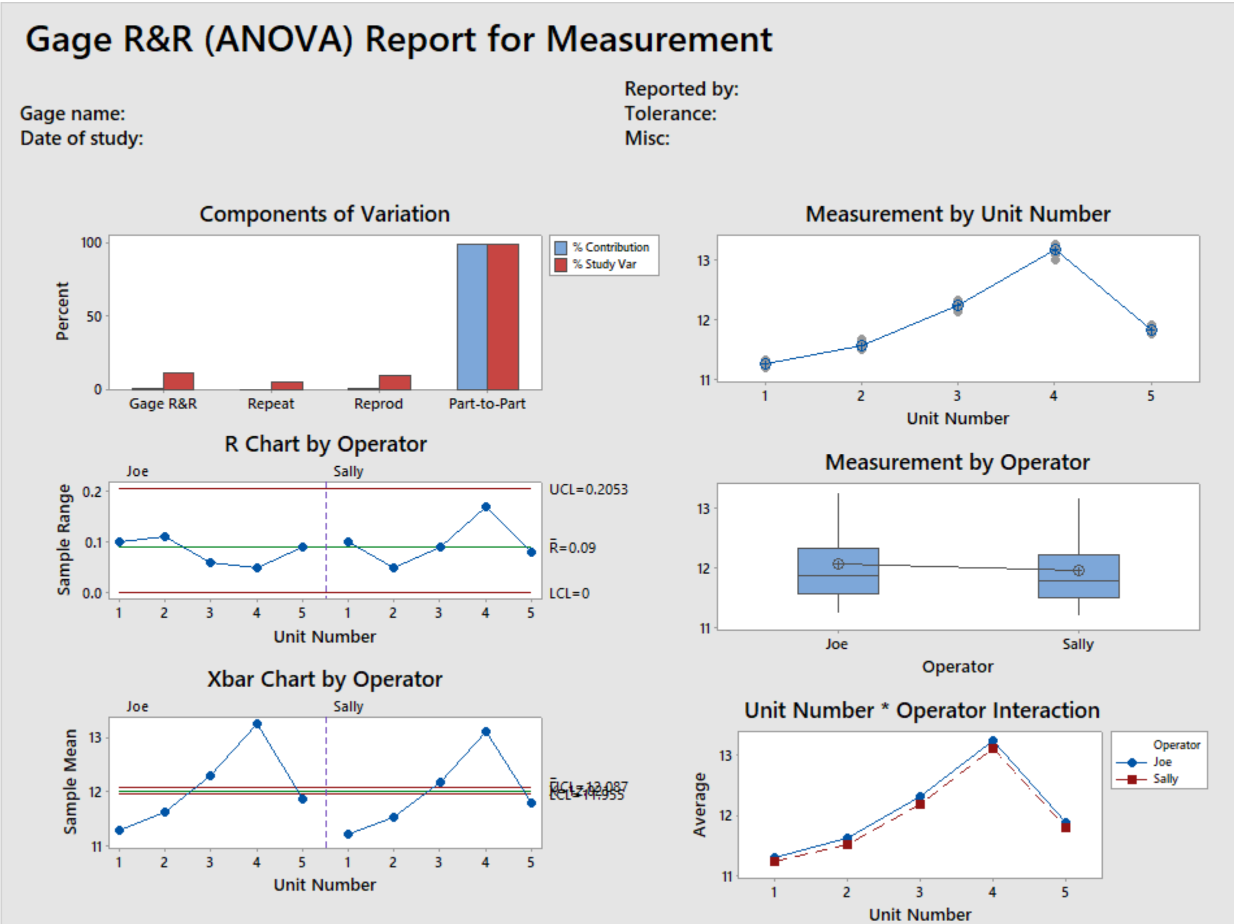
MSA



MSA – Charts will explain the variation operator wise, Part wise

MSA

Gage R&R Study - ANOVA Method

Two-Way ANOVA Table With Interaction

Source	DF	SS	MS	F	P
Unit Number	4	17.6209	4.40522	2005.79	0.000
Operator	1	0.1061	0.10609	48.31	0.002
Unit Number * Operator	4	0.0088	0.00220	1.23	0.319
Repeatability	30	0.0536	0.00179		
Total	39	17.7894			

α to remove interaction term = 0.05

Two-Way ANOVA Table Without Interaction

Source	DF	SS	MS	F	P
Unit Number	4	17.6209	4.40522	2400.86	0.000
Operator	1	0.1061	0.10609	57.82	0.000
Repeatability	34	0.0624	0.00183		
Total	39	17.7894			

Gage R&R

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.007048	1.26
Repeatability	0.001835	0.33
Reproducibility	0.005213	0.94
Operator	0.005213	0.94
Part-To-Part	0.550423	98.74
Total Variation	0.557471	100.00

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	0.083950	0.50370	11.24
Repeatability	0.042835	0.25701	5.74
Reproducibility	0.072199	0.43320	9.67
Operator	0.072199	0.43320	9.67
Part-To-Part	0.741905	4.45143	99.37
Total Variation	0.746640	4.47984	100.00

Number of Distinct Categories = 12

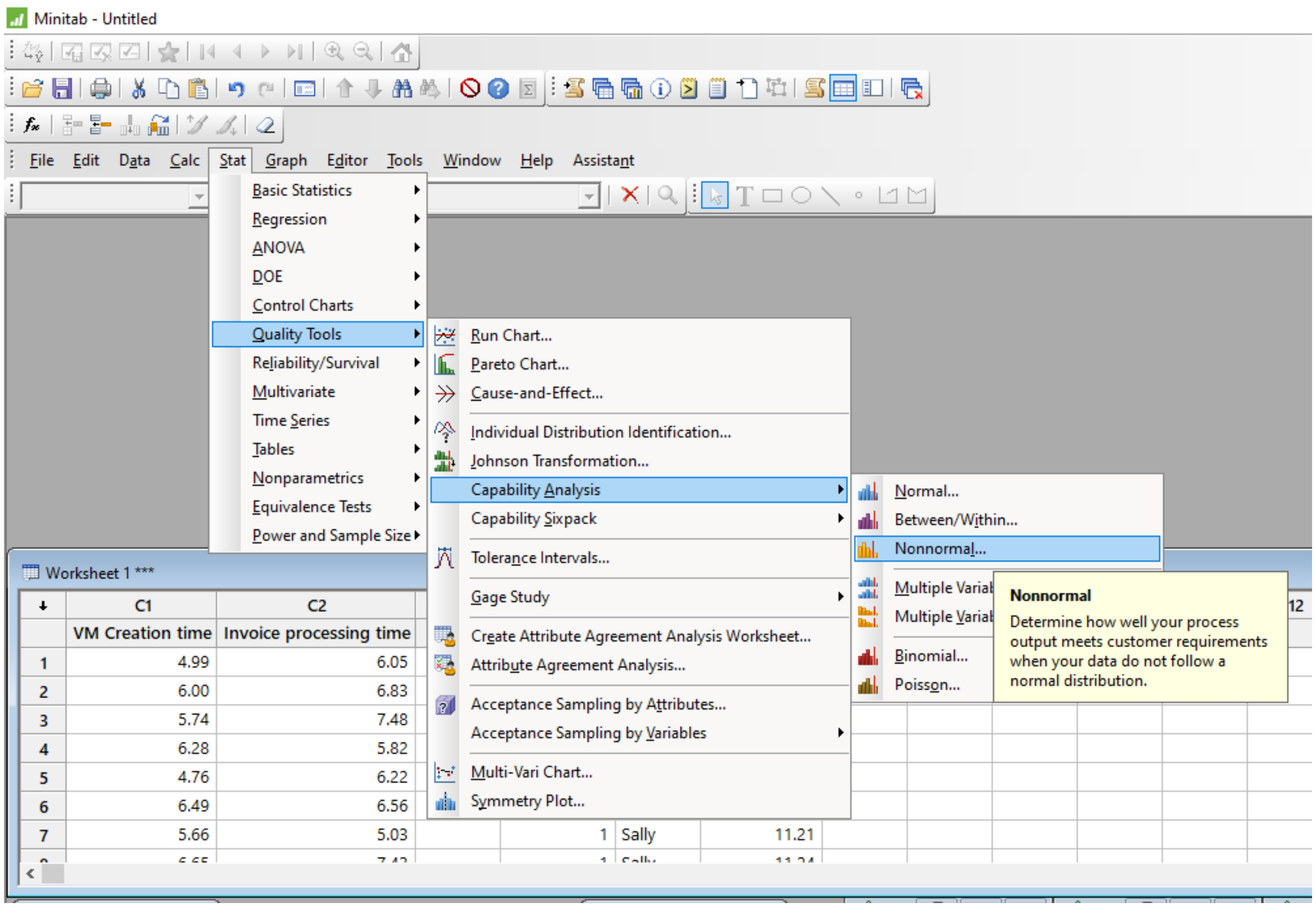
Gage R&R for Measurement

Process capability for non normal data

With **non-normal data**, it is wrong to calculate a Cpk based on the raw **data**. A better approach is to determine what **distribution** best fits your **process** and **data** and then use the **non-normal** Ppk approach. The equations for Ppk are different for **non-normal data** than for **normally distributed data**.

Refer slide no 4 for identifying individual distribution

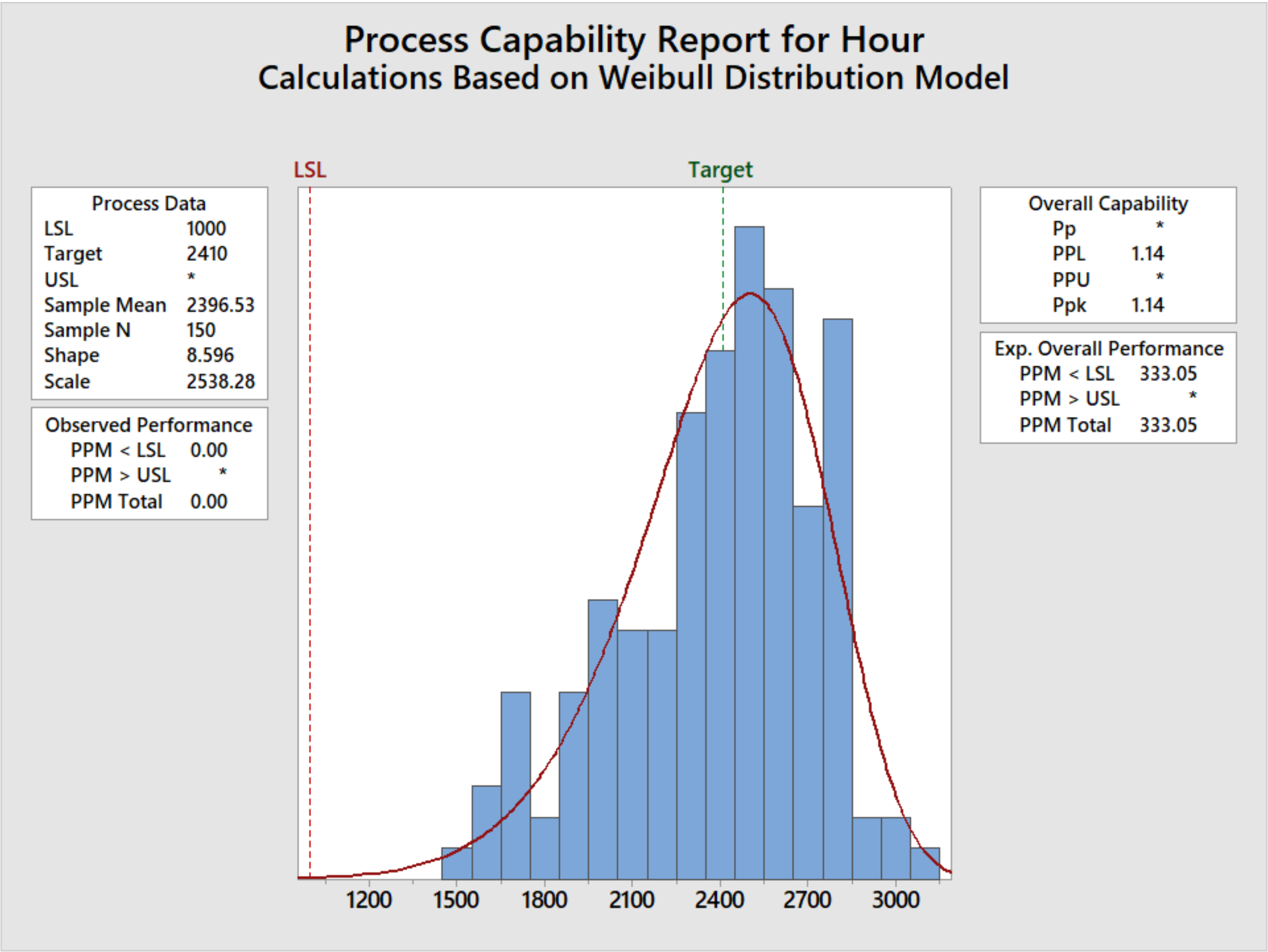
Process capability for non normal data



Process capability for non normal data

Choose the appropriate analysis	
Because this process data follows a Weibull (nonnormal) distribution, it is appropriate to use a nonnormal capability analysis.	1. Open the worksheet ELECTRONICS.MTW. 2. Choose **Stat** > **Quality Tools** > **Capability Analysis** > **Nonnormal**.
Enter your data	
This worksheet has a single column of measurements.	1. In **Single column**, enter *Hour*.
Select a fit for your data	
Specify a nonnormal distribution that fits your data.	1. Under **Fit distribution**, choose **Weibull**.
Set your specifications	
You must enter at least one specification limit. The measurements of battery life hours have a lower specification limit of 1000.	1. In **Lower spec**, type *1000*.
Specify a target and other options	
This example uses a target value, specified in the **Options** subdialog box. There, you could also change the process tolerance, request different capability indices, or add a title to the results. Use the **Estimate** subdialog box to change the estimation method for distribution parameters. Use the **Storage** subdialog box to store process parameters.	1. Click **Options**. In **Target**, type *2410*. 2. Click **OK** in each dialog box.

Process capability for non normal data



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Without Data,
you are just another person
with an Opinion.

Data is absolutely useless.
It's what you do with it that matters.

SKILLOGIC