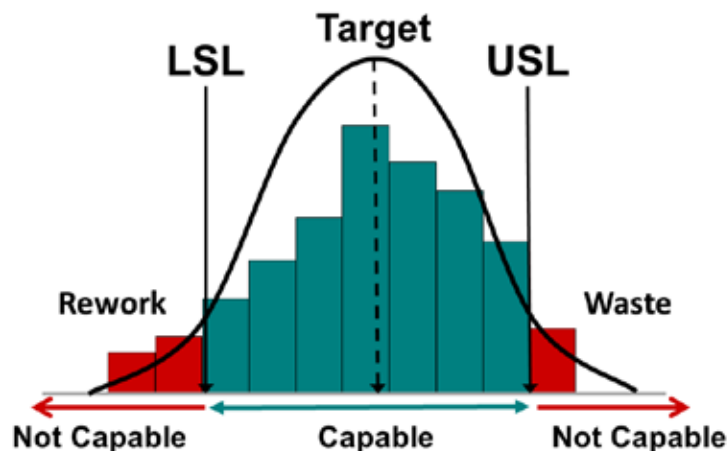


# Histogram - Process Capability Analysis Cheat Sheet

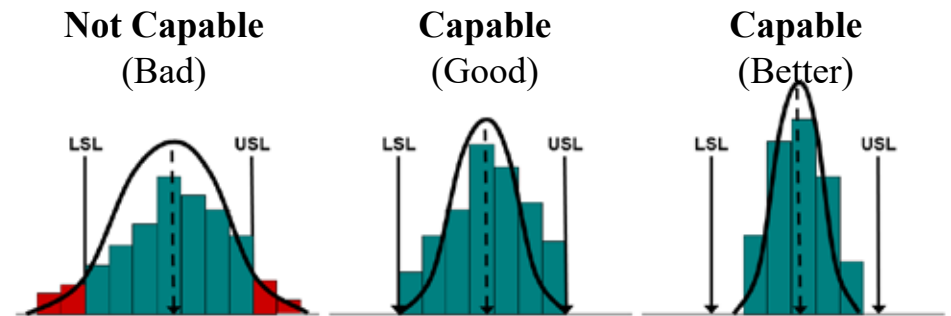
## Key Concepts

- ◇ Histograms show the spread or dispersion of variable (measured) data.
- ◇ Upper and lower specification limits (USL/LSL) define customer requirements.
- ◇ Think of specification limits like goal posts on a football field.
- ◇ Data points within the spec limits meet customer requirements.
- ◇ Data points outside of the spec limits do NOT meet customer requirements.
- ◇ Process capability metrics Cp and Cpk measure how well a process fits within the specification limits.
- ◇ Cp Cpk should be calculated on data listed in the order measurements were taken. **Warning:** Do not sort your data before calculating Cp Cpk.
- ◇ A process has to be stable before it can be tested for capability.

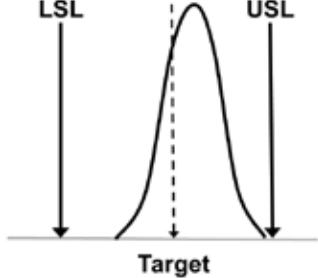
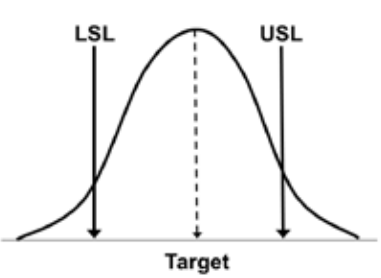
## Histogram Example



## Process Capability Examples



## Process Capability Metrics

Cp - Capability Index	Cpk - Capability Centering Index
Measure of how well the data fits between the LSL and USL.	Measure of how well the data is centered between the LSL and USL.
Fits, but not centered $Cp \geq 1$ and $Cpk \leq Cp$	Centered, but does not fit $Cp \leq 1$ and $Cpk \leq 1$
	

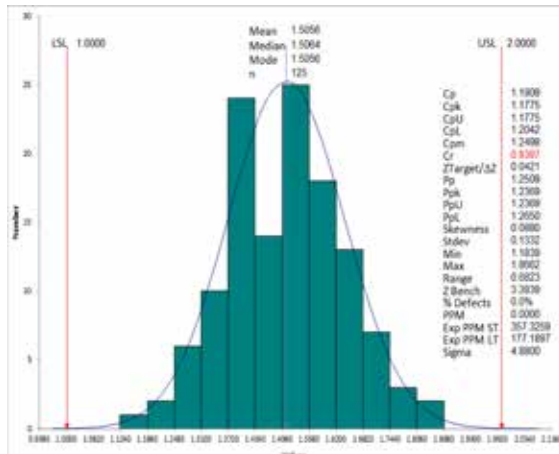
## Cp Cpk vs Pp Ppk

Cp Cpk - Capability Indices	Pp Ppk - Performance Indices
Use with a sample when testing the capability of a process.	Use with the total population when testing the performance of a process.
Cp Cpk use sigma estimator.	Pp Ppk use standard deviation.
$\bar{R}/d_2$ $\bar{S}/c_4$ Pooled SD	

# Histogram Process Capability Analysis Cheat Sheet

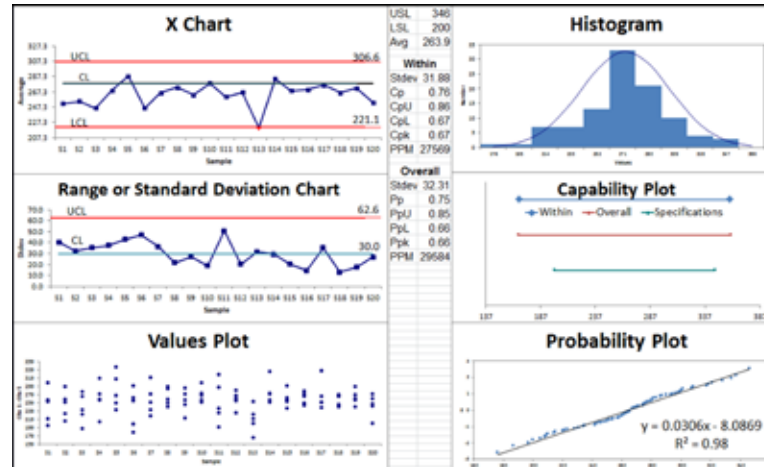
## Examples of Tools included in QI Macros for Excel

### Histogram with Cp Cpk



Histograms: normal data  
Histogram Weibull: non-normal data  
Frequency Histograms

### Capability Suite of Six Charts



X chart  
Range chart  
Values plot

Histogram  
Capability plot  
Probability plot

### Cp Cpk Template

Characteristic	S 1	S 2	S 3	S 4	S 5
Target	1.500	1.500	1.500	1.500	1.500
+ Tol	0.250	0.250	0.250	0.250	0.250
- Tol	0.250	0.250	0.250	0.250	0.250
USL	1.750	1.750	1.750	1.750	1.750
LSL	1.250	1.250	1.250	1.250	1.250
AVE	1.488	1.487	1.524	1.466	1.564
MAX	1.711	1.767	1.837	1.646	1.866
MIN	1.285	1.274	1.236	1.184	1.193
USL-LSL	0.500	0.500	0.500	0.500	0.500
σ	0.111	0.137	0.137	0.122	0.145
σest	0.099	0.131	0.132	0.114	0.152
Cp	0.840	0.634	0.630	0.728	0.548
Cpk	0.798	0.601	0.570	0.629	0.409
CpU	0.881	0.667	0.570	0.827	0.409
CpL	0.798	0.601	0.689	0.629	0.688
Cr	1.191	1.577	1.588	1.374	1.823
σZ	0.112	0.095	0.173	0.279	0.440
Cpm	0.748	0.607	0.600	0.659	0.526
Pp	0.753	0.609	0.609	0.684	0.575
Ppk	0.716	0.578	0.551	0.591	0.429
PpU	0.791	0.641	0.551	0.777	0.429
PpL	0.716	0.578	0.666	0.591	0.722
Sample #	S 1	S 2	S 3	S 4	S 5
1	1.324	1.413	1.674	1.457	1.691
2	1.431	1.359	1.608	1.467	1.611
3	1.428	1.487	1.483	1.432	1.667

Up to 35 characteristics with 100 data pts.  
Cp Cpk True Position  
MMC Cpk True Position

## Advantages of Using QI Macros Histogram Maker

- Just select your data and the tool you want from the QI Macros menu.
- QI Macros does all of the calculations and draws the charts for you.
- Easily change spec limits to determine impact on Cp Cpk.
- Easily change bin/bar width and number of bars.
- Calculates unilateral or one-sided spec limits.
- Works with PC and Mac. Excel 2010 - 2019 and Office 365.
- Reduce risk of manual calculations.
- Saves Time!

## Cp Cpk to Sigma Estimator

Cp Cpk	Equivalent to
1.00	3 Sigma
1.33	4 Sigma
1.67	5 Sigma
2.00	6 Sigma