PROCESS PERFORMANCE ANALYSIS

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ASQ – Boulder Section

What Do You Do When ?…..

- You are handed an issue with a product characteristic that isn't meeting a customer requirement (VOC).
- You are "given" more data than you can evaluate (VOP).
- You don't know where to start in process improvements (VOP).

- You conduct a Process Performance Analysis!
- A what?
- A Process Performance Analysis is a tool to determine what part of a process is causing you not to meet the customer's (internal or external) requirements.

PPA Uses

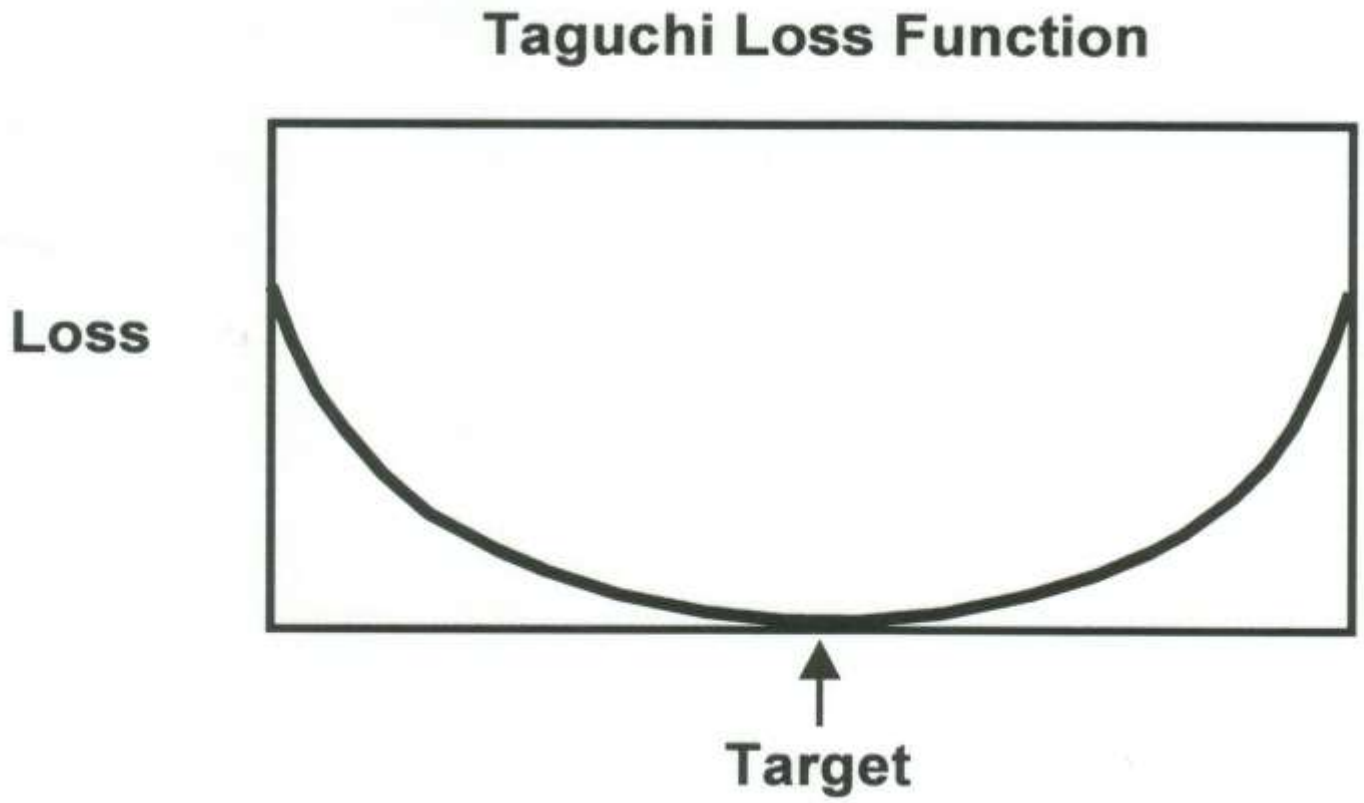
- Assess the process before statistical control is achieved.
- Determine the sources of process loss.
- Determine improvement priorities.
- Assess the results of process improvement efforts.

- Useful in presenting results to management and team members.
  - Great for the number-phobic folks

Things to Consider

- This really applies to high-volume processes.
- This is useful when the customer cannot distinguish parts off of different stations or tools.
- What about the customer specification?
  - Is it any “good”?
- What is a good process capability goal?
  - 1.33?
  - 2.00?
- What about the capability of the measurement system?
- This is a “rear view mirror” analysis.

Premise



Performance Definitions

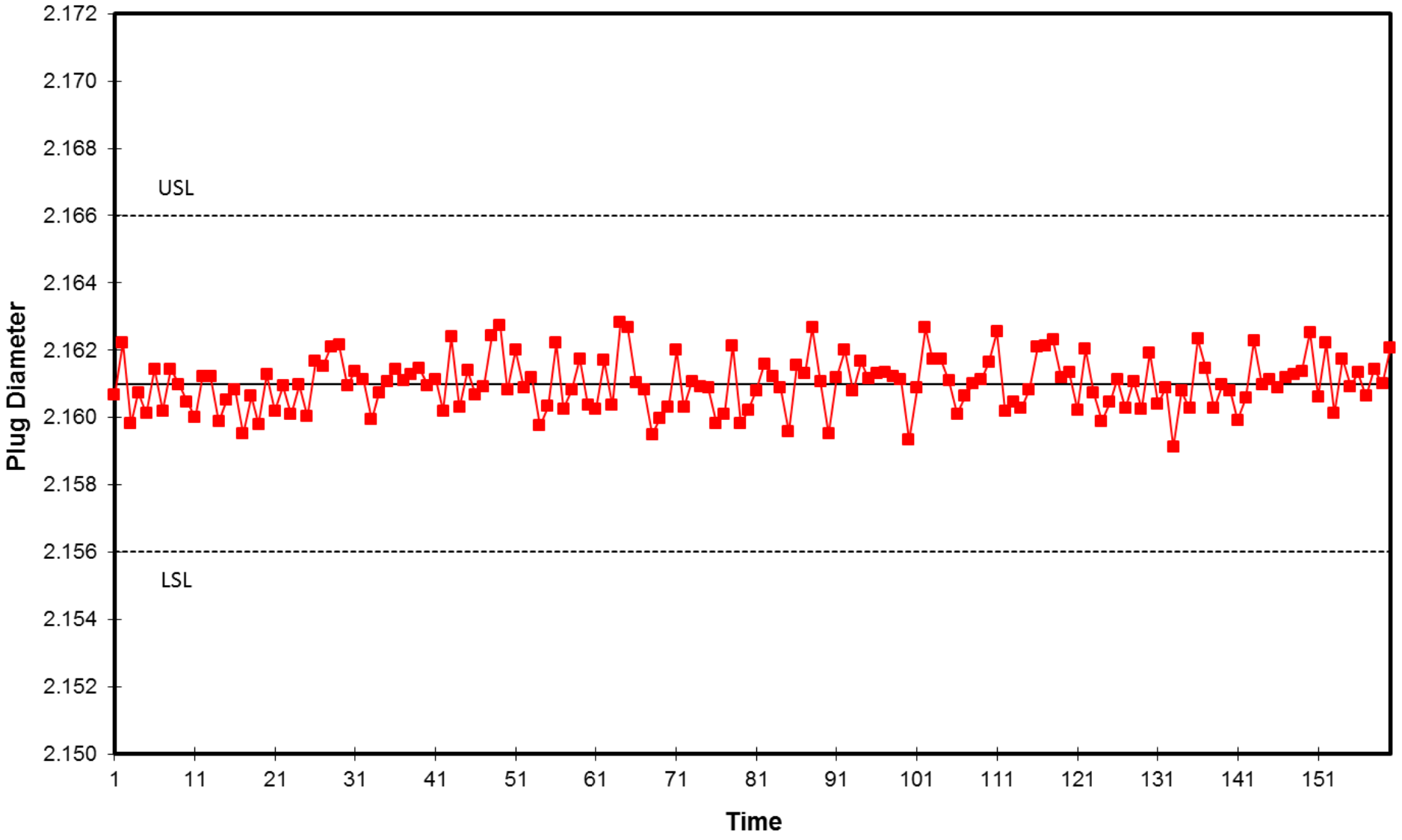
- $Cp_{(pot)}$ (aka $Cp_{(potential)}$) is the potential process capability where you **could** be if the process had no process stream differences, was in statisitical control and was on target.
- $Pp_{(tool)}$ (aka $Pp_{(tool\text{-}to\text{-}tool)}$ and $Pp_{(process\ stream)}$) is process performance that would occur if no tool-to-tool or process stream variation existed and the overall process fell on target but there was a loss of statistical control.
- Pp is the process performance that would occur if the overall process average fell on target but there was a loss of statistical control and process stream variation existed.
- Ppm is the **actual** process performance and considers overall variation in the process and deviation from target.

Process Performance Measures Formula

Measure	Specification Type		
	Two-Sided with Target	One-Sided with Target	One-Sided without Targets
Cp(potential)	$\frac{USL-LSL}{6\left(\frac{\tilde{MR}_{(within-tool)}}{\tilde{d}_2}\right)}$	$\frac{\lvert T-SL\rvert}{3\left(\frac{\tilde{MR}_{(within-tool)}}{\tilde{d}_2}\right)}$	$\frac{\lvert \bar{X}-SL\rvert}{3\left(\frac{\tilde{MR}_{(within-tool)}}{\tilde{d}_2}\right)}$
Pp(process stream)	$\frac{USL-LSL}{6\left(\bar{S}_{within-tool}\right)}$	$\frac{\lvert T-SL\rvert}{3\left(\bar{S}_{within-tool}\right)}$	$\frac{\lvert \bar{X}-SL\rvert}{3\left(\bar{S}_{within-tool}\right)}$
Pp / Ppk	$\frac{USL-LSL}{6(s)}$	$\frac{\lvert T-SL\rvert}{3(s)}$	$\frac{\lvert \bar{X}-SL\rvert}{3(s)}$
Ppm / Ppk	$\frac{USL-LSL}{6\sqrt{s^2+\left(\bar{X}-T\right)^2}}$	$\frac{\lvert T-SL\rvert}{3\sqrt{s^2+\left(\bar{X}-T\right)^2}}$	$\frac{\lvert \bar{X}-SL\rvert}{3(s)}$

Example

- Assume you have a single-tooled process that exhibits stability and the overall average is at target.
- We'll call this "AGAIG" (As Good As It Gets)
  - Plot the points over time
  - Create a histogram
  - Calculate the four capability indices


Plug Diameter Over Time
Plug Diameter
2.172
2.170
2.168
2.166
2.164
2.162
2.160
2.158
2.156
2.154
2.152
2.150
USL
LSL
1
11
21
31
41
51
61
71
81
91
101
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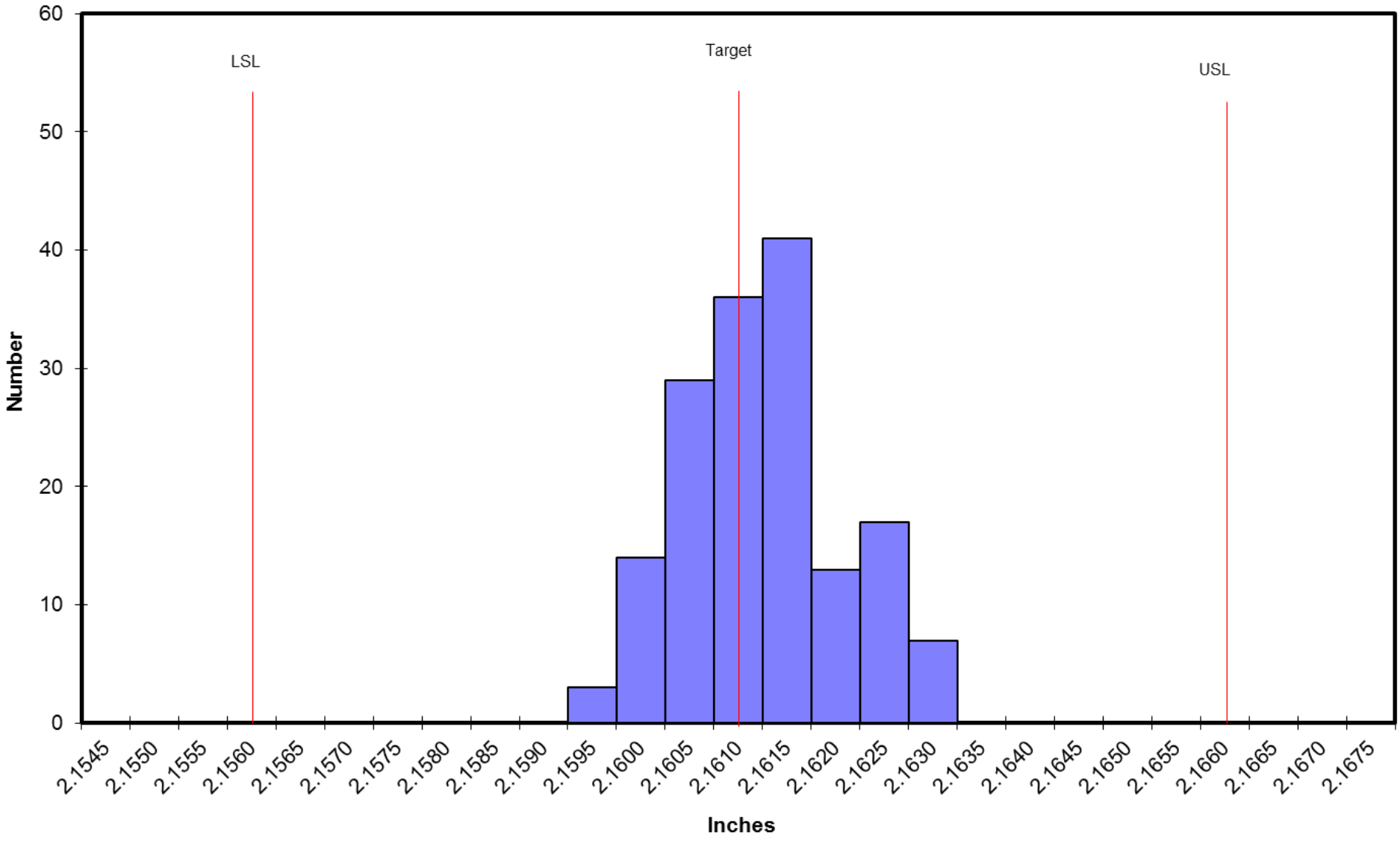
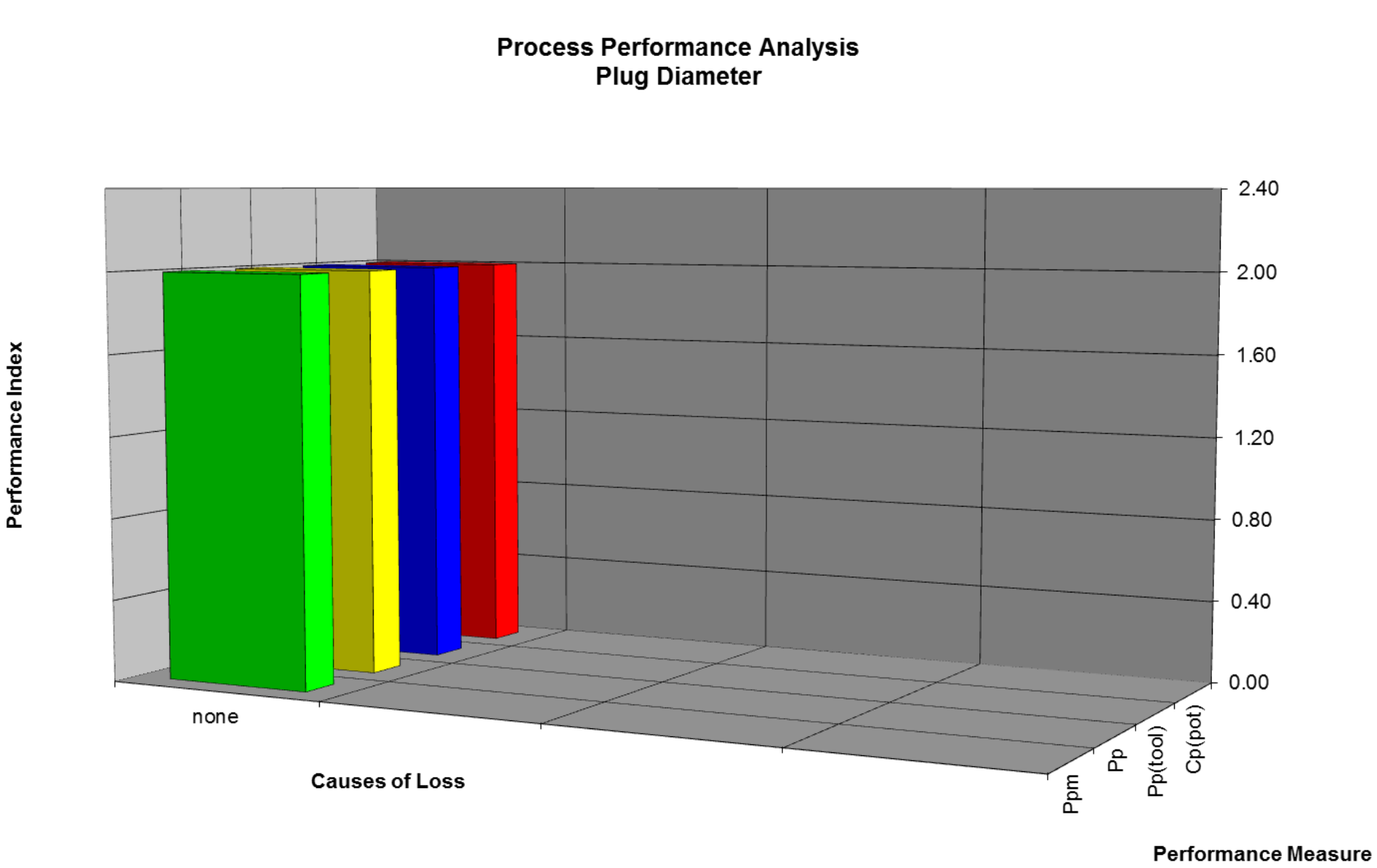
121
131
141
151
Time

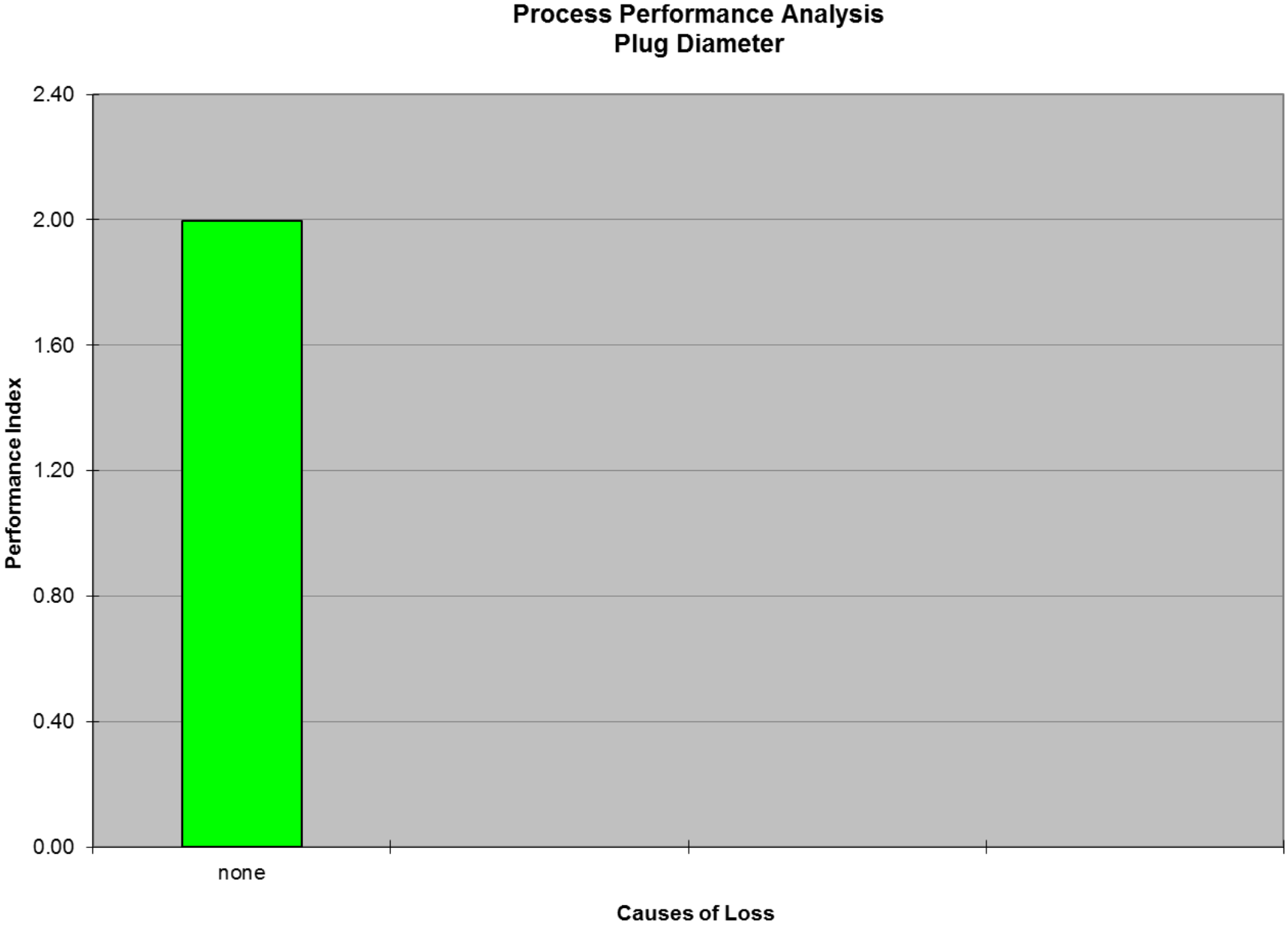
Plug Diameter



The AGAIG Numbers

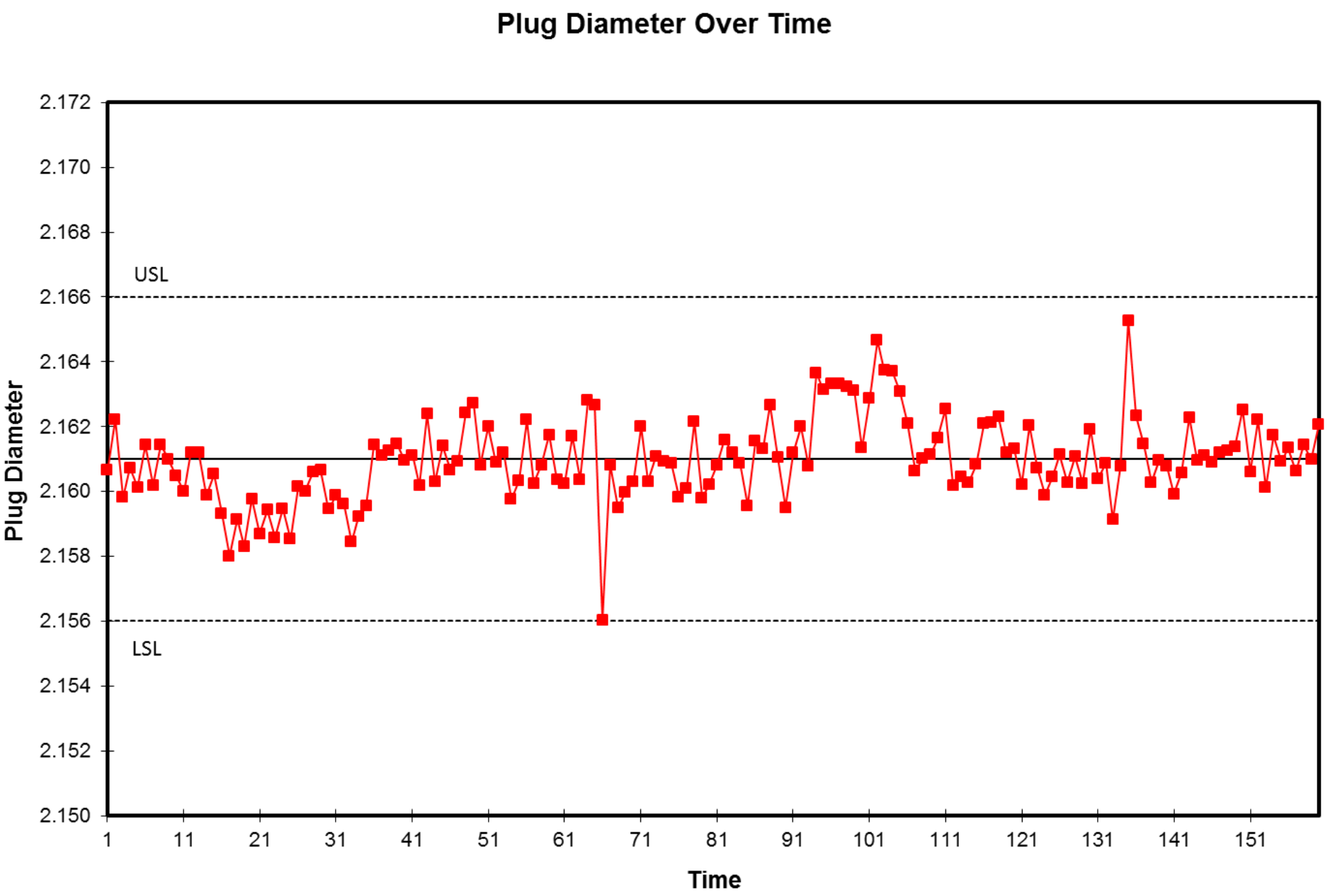
	AGAIG
$Cp_{(pot)}$	1.998
$Pp_{(tool)}$	1.998
Pp	1.998
Ppm	1.998


Process Performance Analysis
Plug Diameter
Performance Index
2.40
2.00
1.60
1.20
0.80
0.40
0.00
none
Causes of Loss
Ppm
Pp
Pp(tool)
Cp(pot)
Performance Measure


Process Performance Analysis
Plug Diameter
2.40
2.00
1.60
1.20
0.80
0.40
0.00
Performance Index
none
Causes of Loss

Example

- Now we add some process instability.
- We'll call this "OOC" (Out of Control)
  - Plot the points over time
  - Create a histogram
  - Calculate the four capability indices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Plug Diameter
2.172
2.170
2.168
2.166
2.164
2.162
2.160
2.158
2.156
2.154
2.152
2.150
USL
LSL
1
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21
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41
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81
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111
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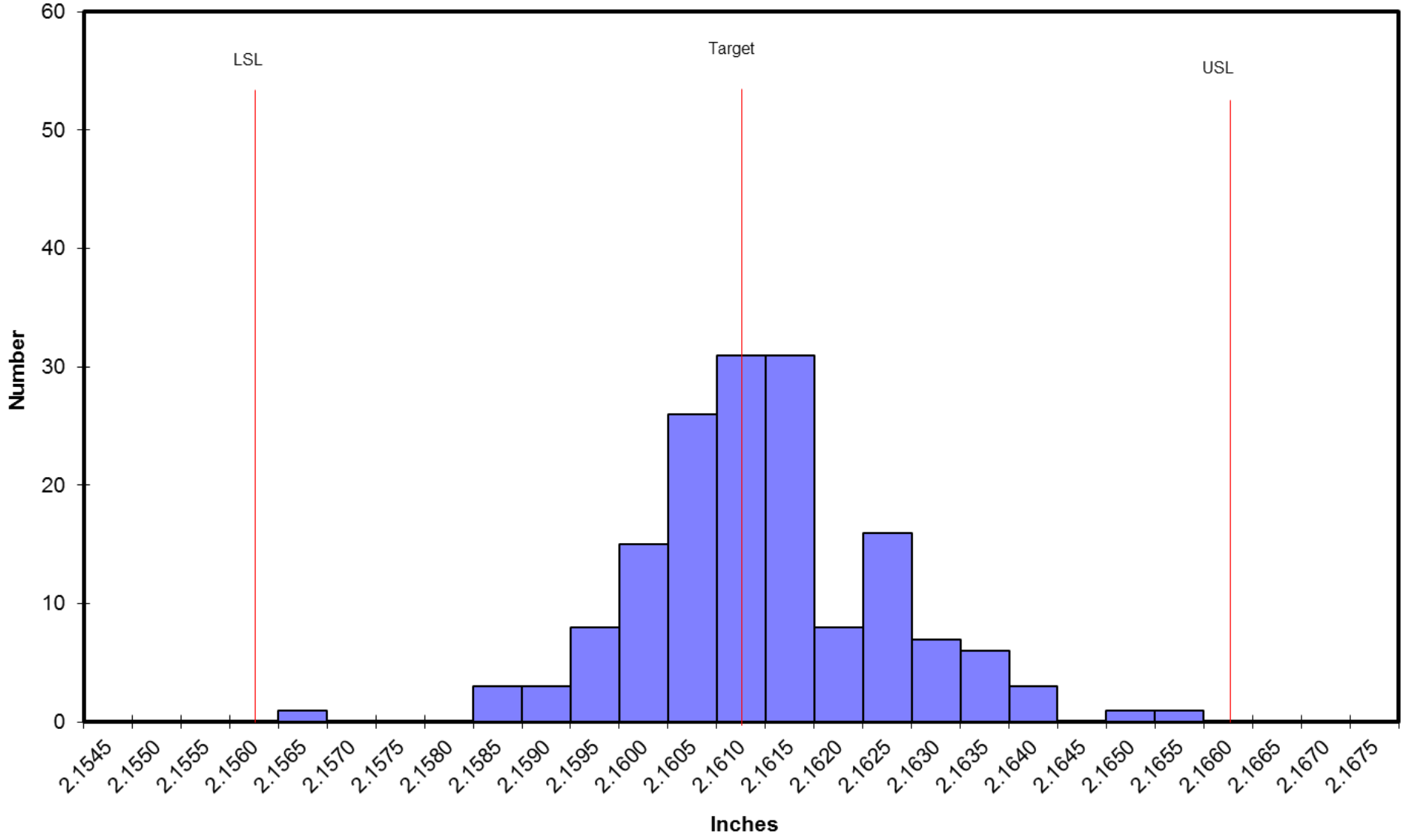
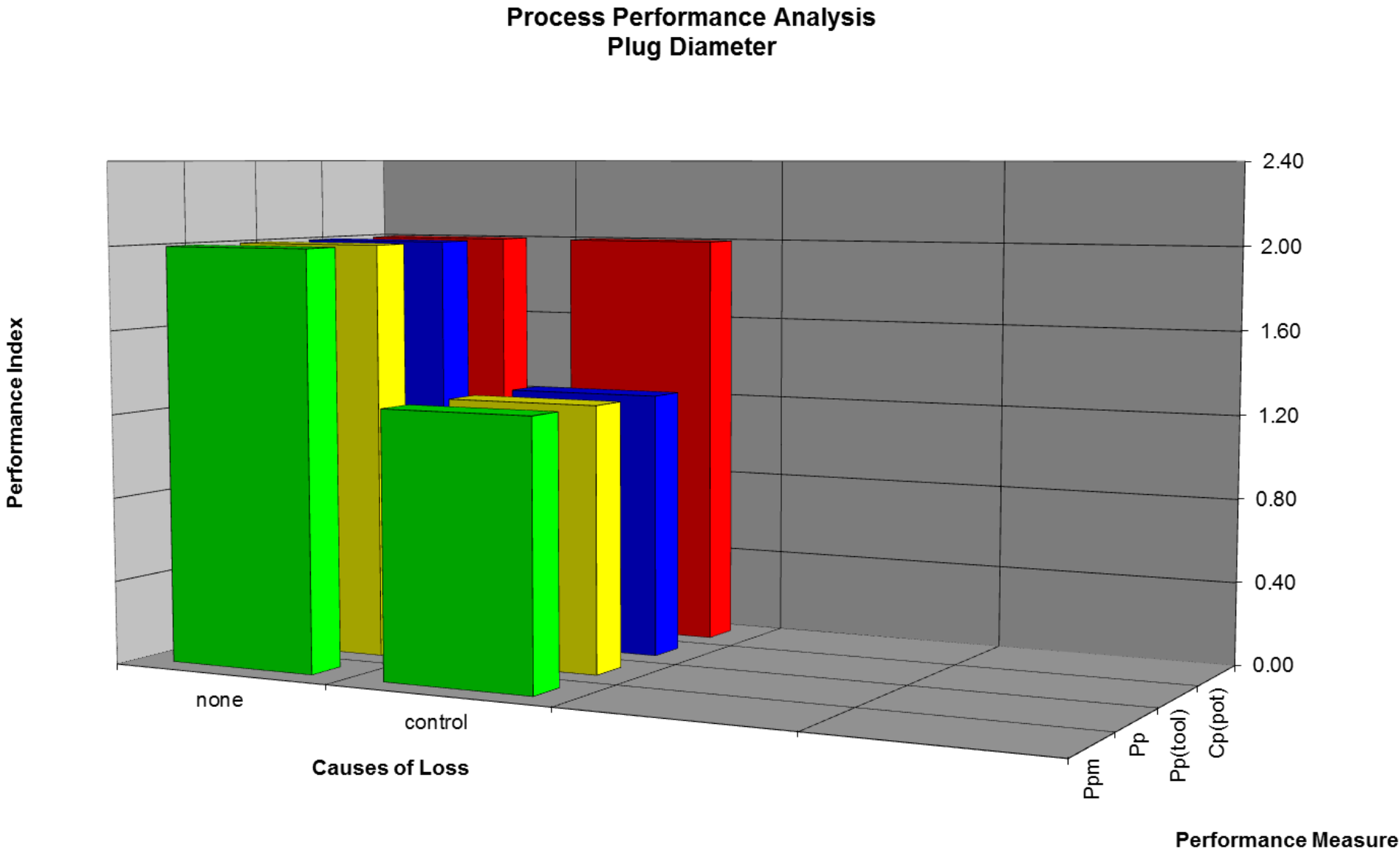
131
141
151
Time

Plug Diameter



The OOC Numbers

	OOC
$Cp_{(pot)}$	1.998
$Pp_{(tool)}$	1.270
Pp	1.270
Ppm	1.270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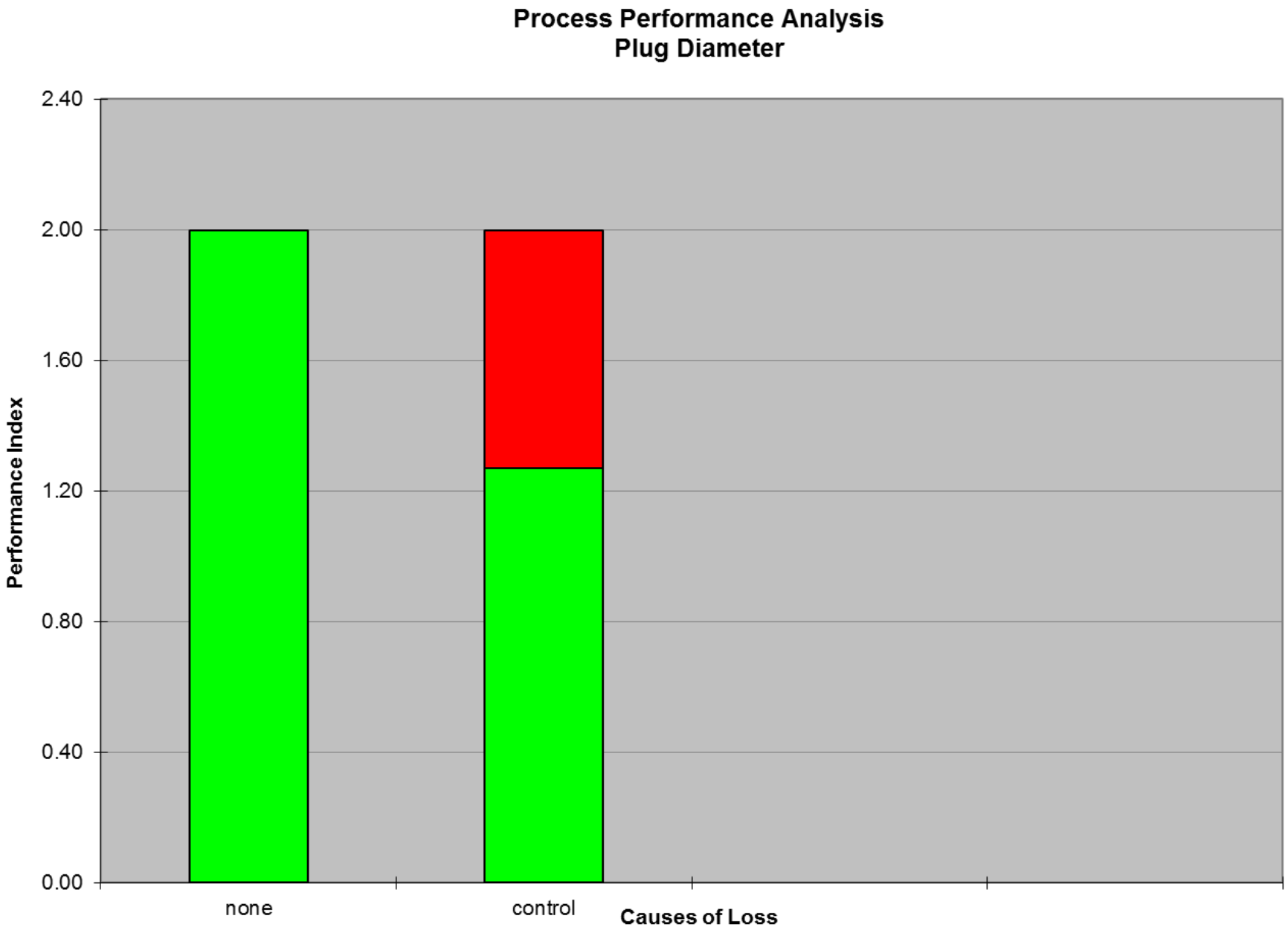
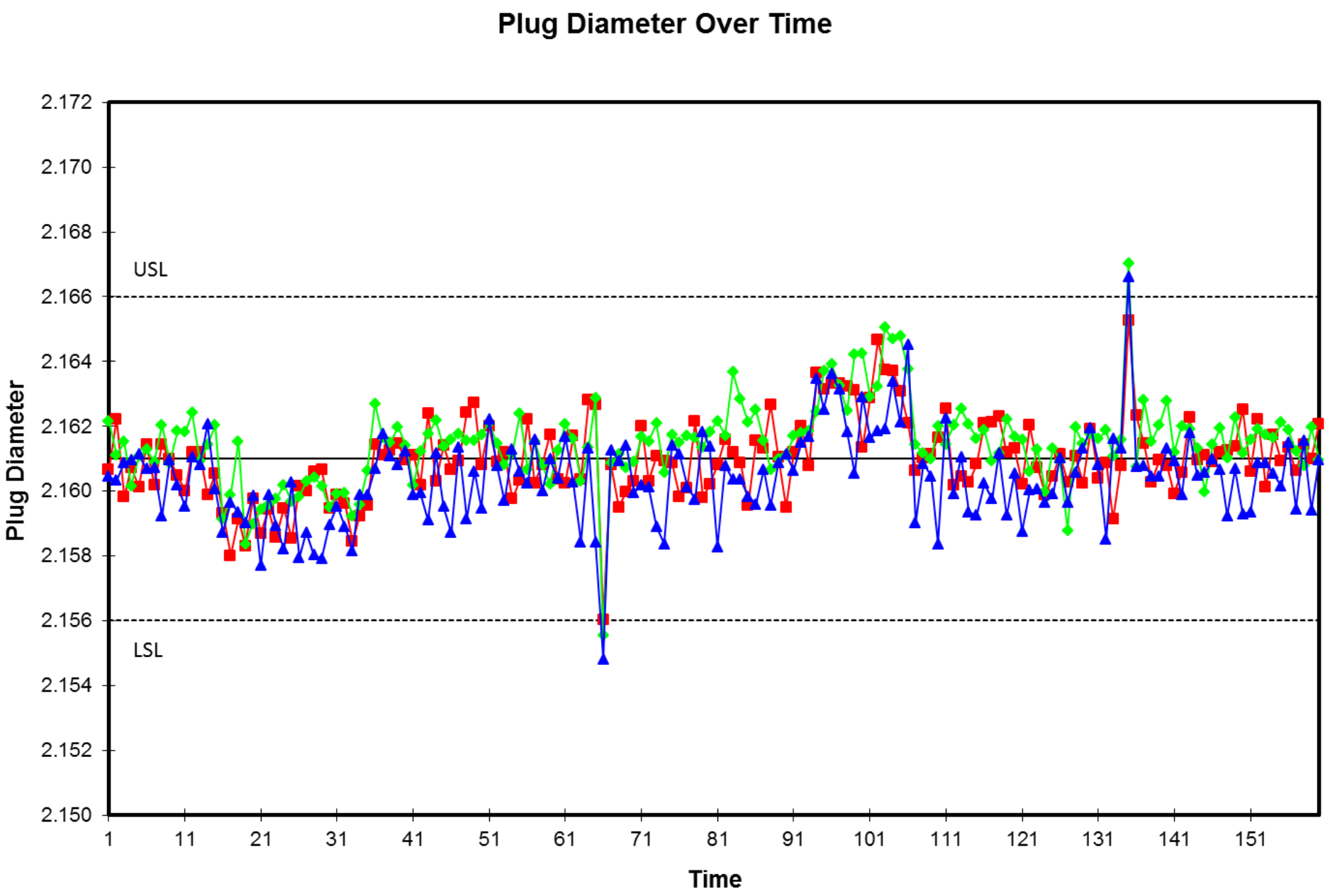
Plug Diameter
Performance Index
2.40
2.00
1.60
1.20
0.80
0.40
0.00
none
control
Causes of Loss
Ppm
Pp
Pp(tool)
Cp(pot)
Performance Measure


Process Performance Analysis
Plug Diameter
2.40
2.00
1.60
1.20
0.80
0.40
0.00
Performance Index
none
control
Causes of Loss

Example

- And now we add the fact that this product is produced on three different tools or stations on the same production line.
  - All the product is combined into one shipping bin or pallet.
- We'll call this "T^3" (Tool-to-Tool)
  - Plot the points over time
  - Create a histogram
  - Calculate the four capability indices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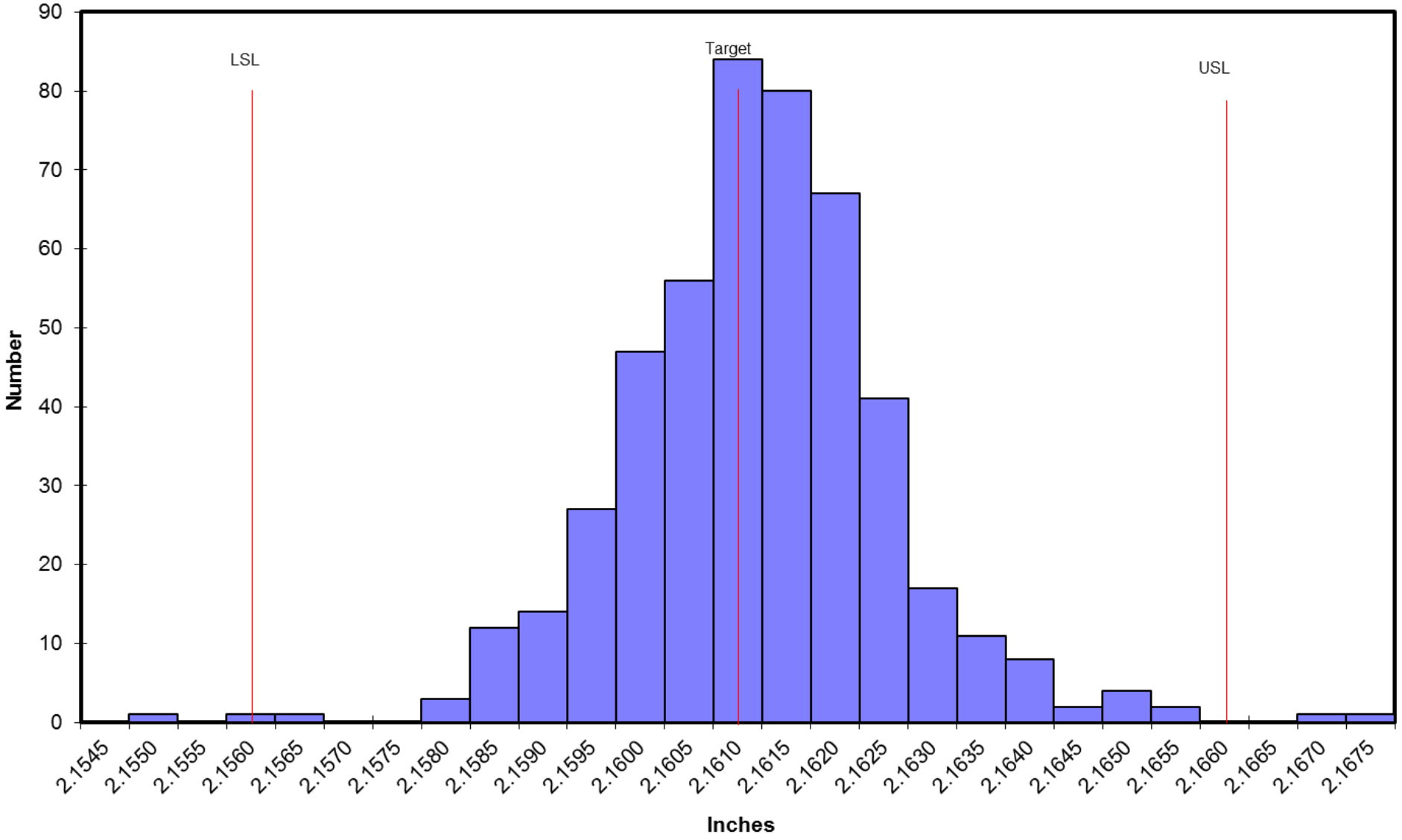
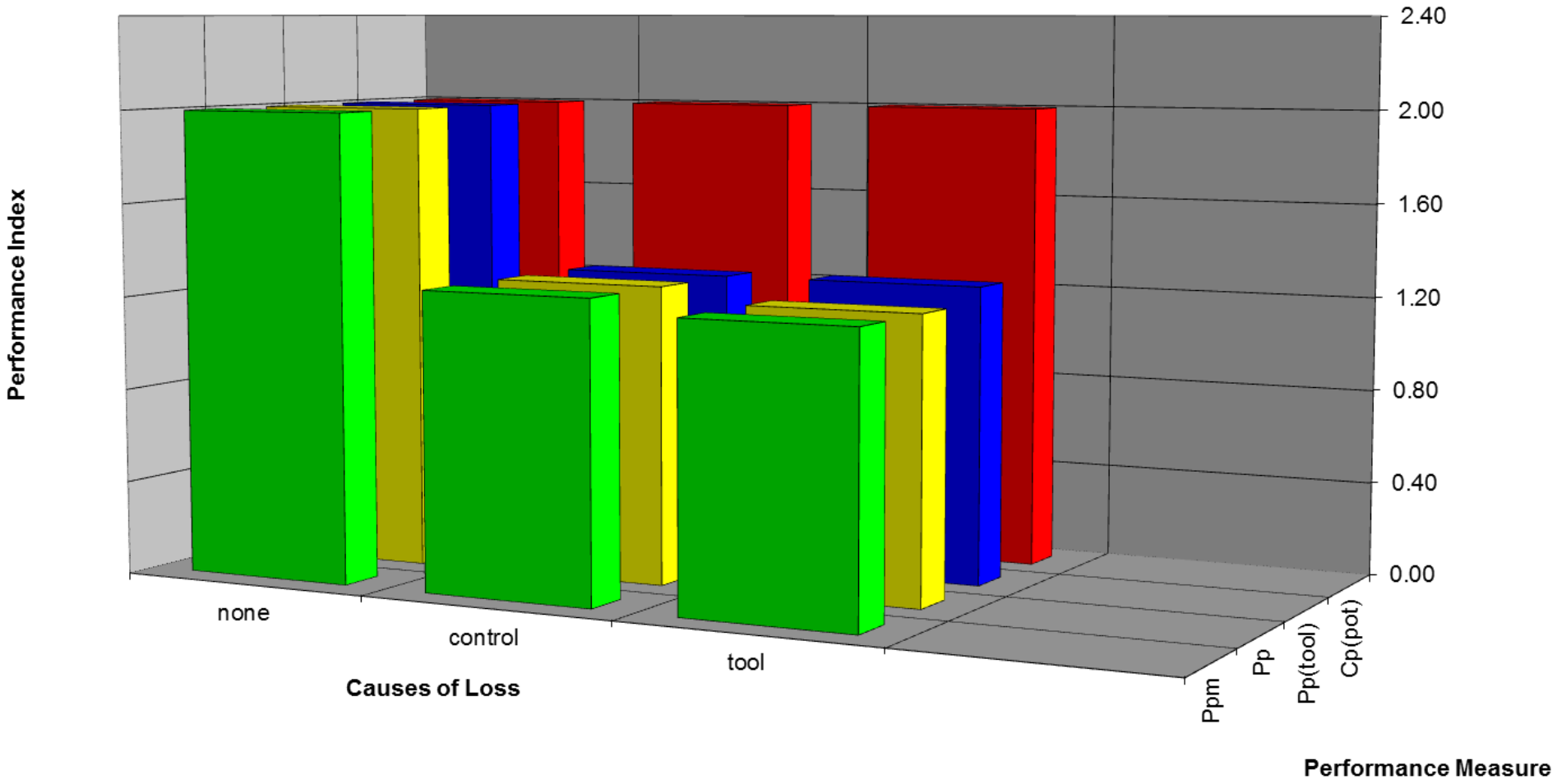
151
Time

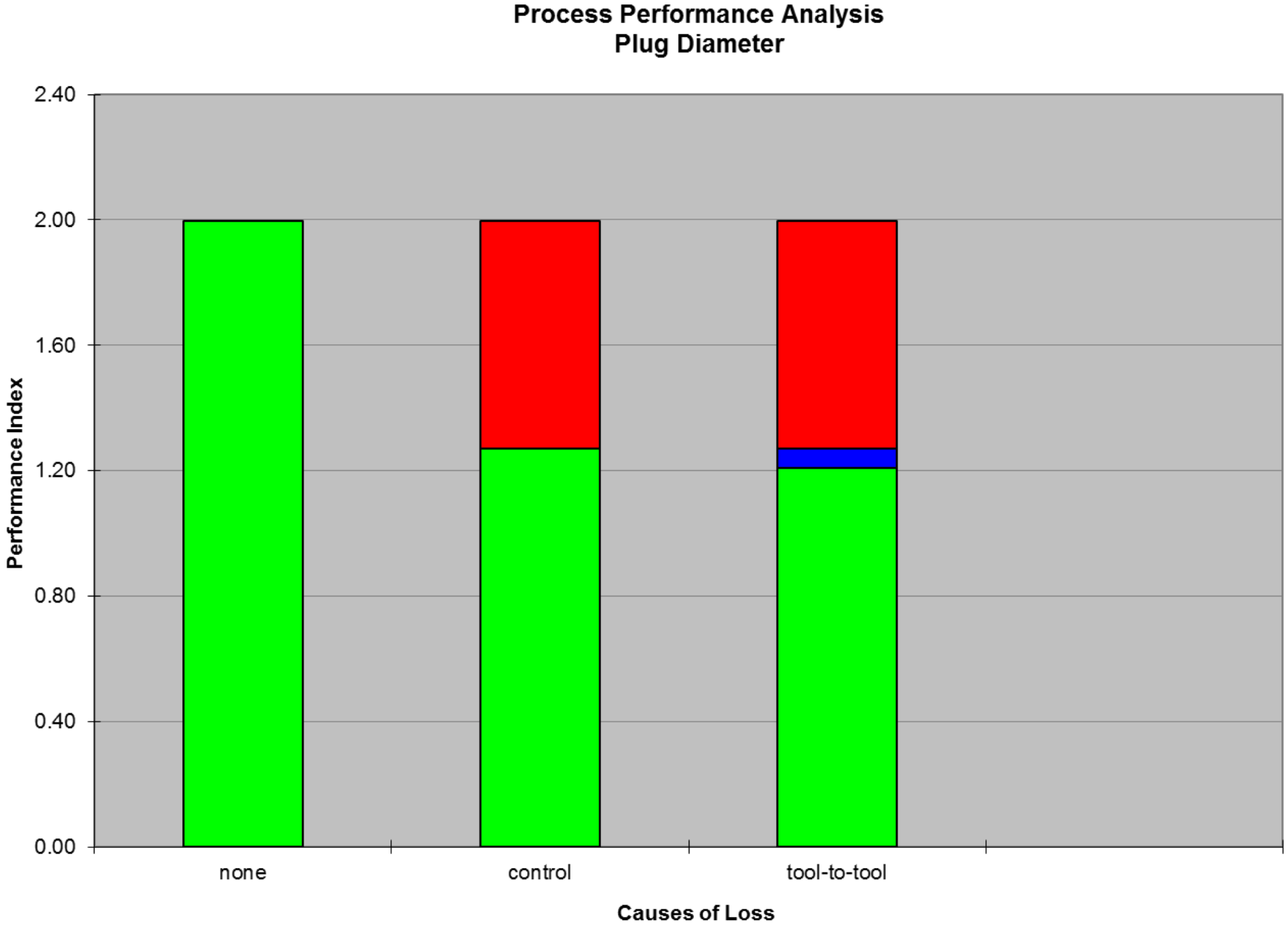
Plug Diameter



The T^3 Numbers

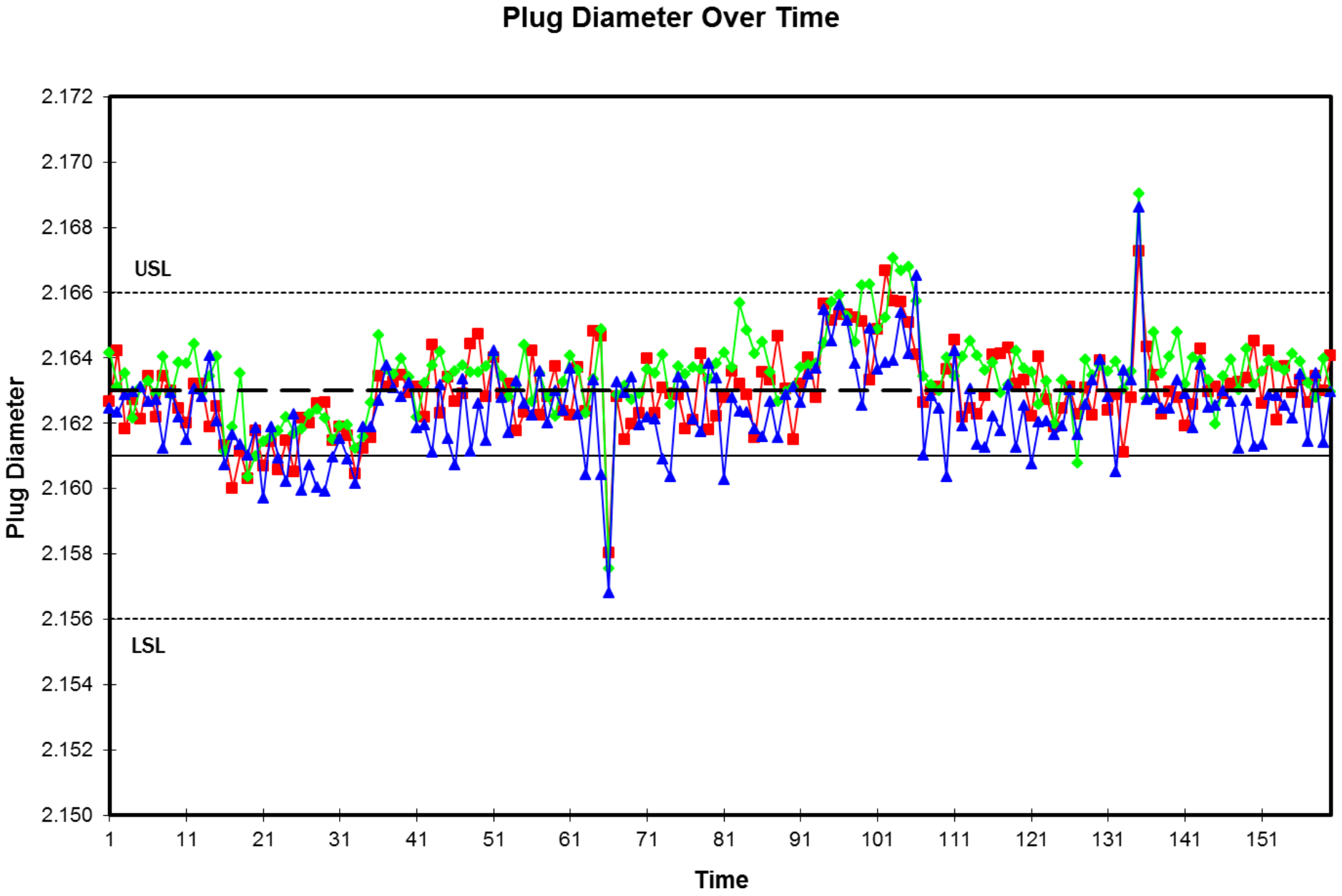
	T^3
$Cp_{(pot)}$	1.998
$Pp_{(tool)}$	1.270
Pp	1.208
Ppm	1.208


Process Performance Analysis
Plug Diameter
Performance Index
2.40
2.00
1.60
1.20
0.80
0.40
0.00
none
control
tool
Causes of Loss
Ppm
Pp
Pp(tool)
Cp(pot)
Performance Measure

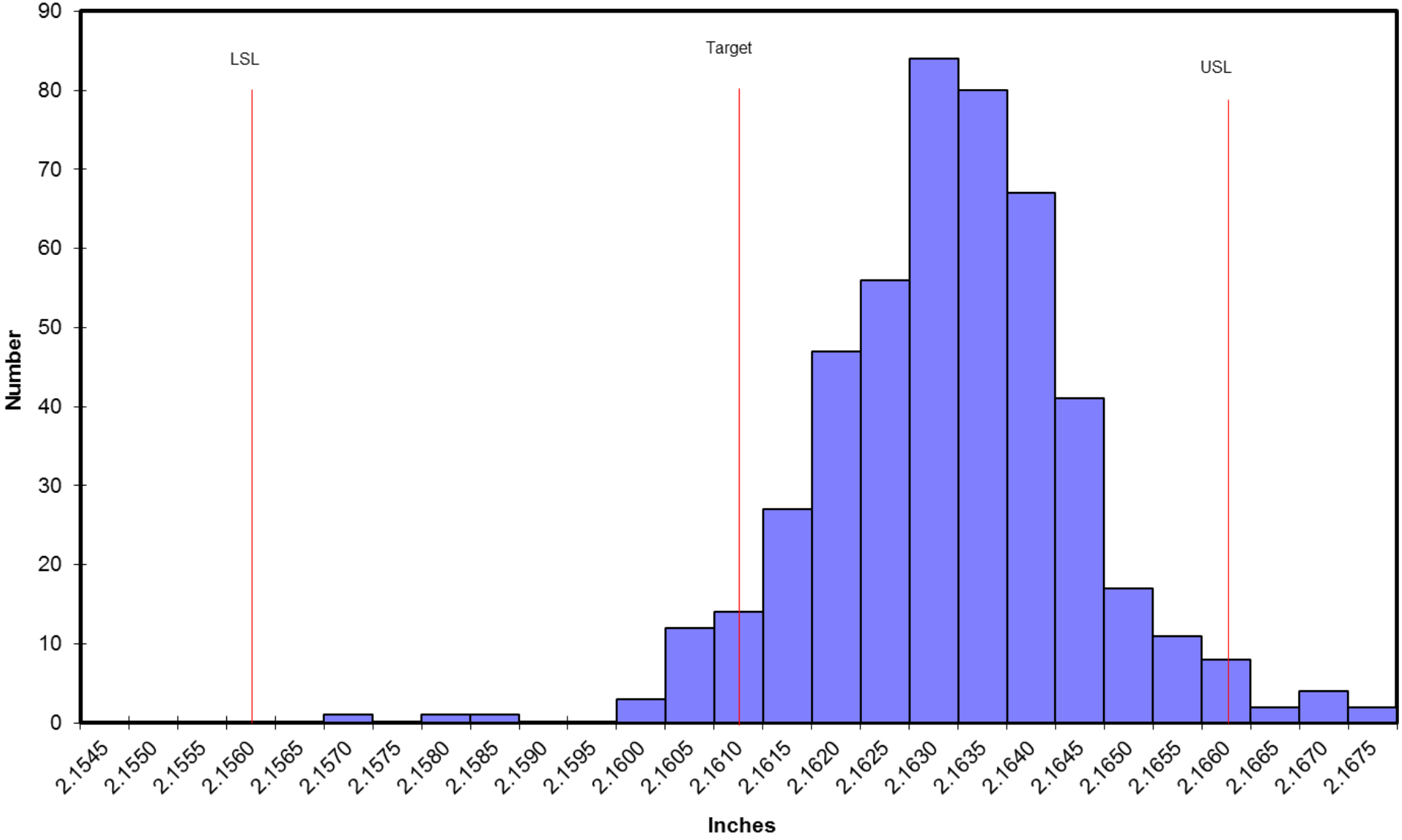

Process Performance Analysis
Plug Diameter
2.40
2.00
1.60
1.20
0.80
0.40
0.00
Performance Index
none
control
tool-to-tool
Causes of Loss

Example

- And finally we see that this process is “pushed” off-target by some unforeseen force.
- We’ll call this “OT” (Off-Target)
  - Plot the points over time
  - Create a histogram
  - Calculate the four capability indices

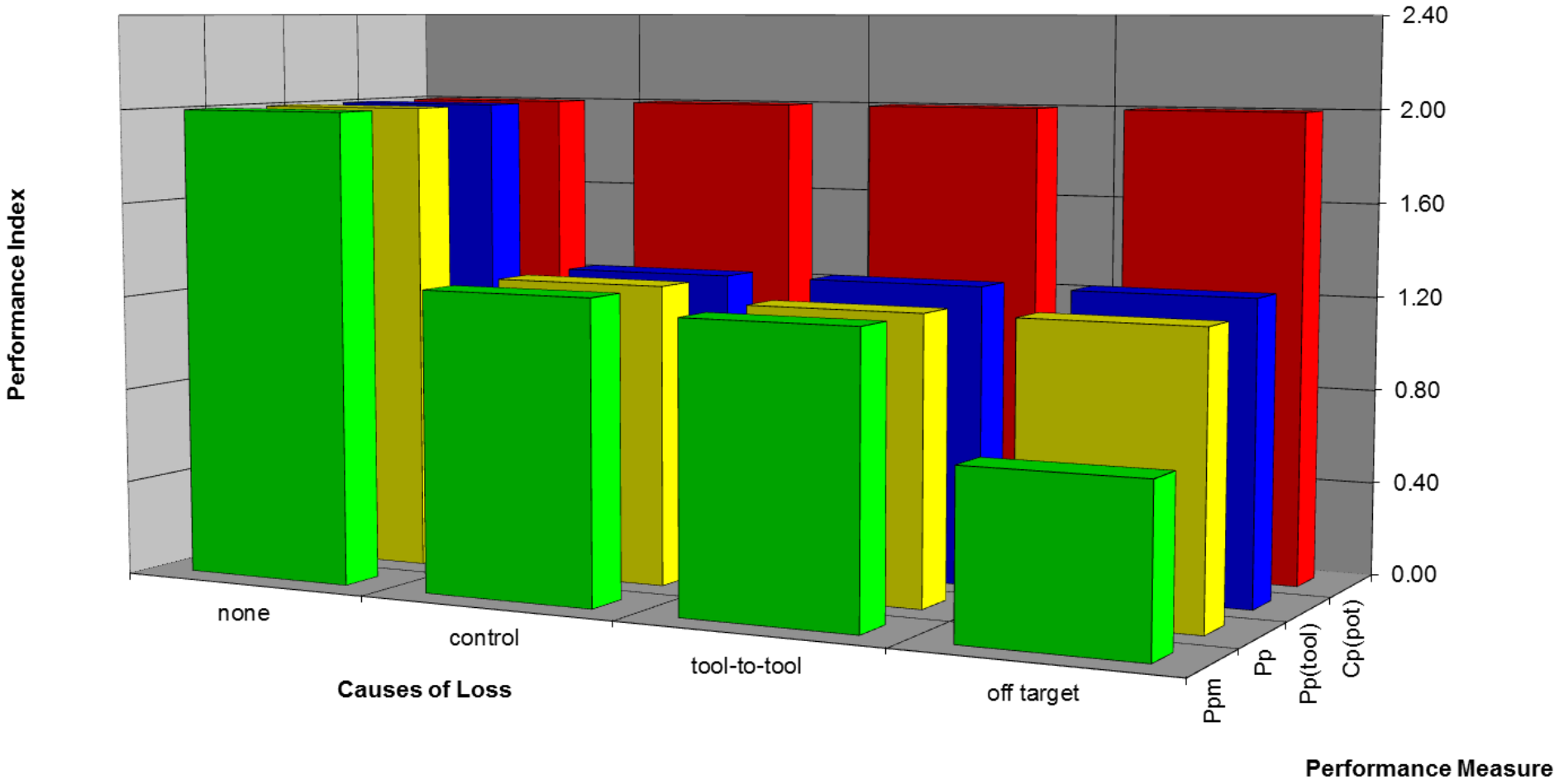

Plug Diameter Over Time
2.172
2.170
2.168
2.166
2.164
2.162
2.160
2.158
2.156
2.154
2.152
2.150
USL
LSL
Plug Diameter
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
Time

Plug Diameter



The OT Numbers

	OT
$Cp_{(pot)}$	1.998
$Pp_{(tool)}$	1.270
Pp	1.208
Ppm	0.696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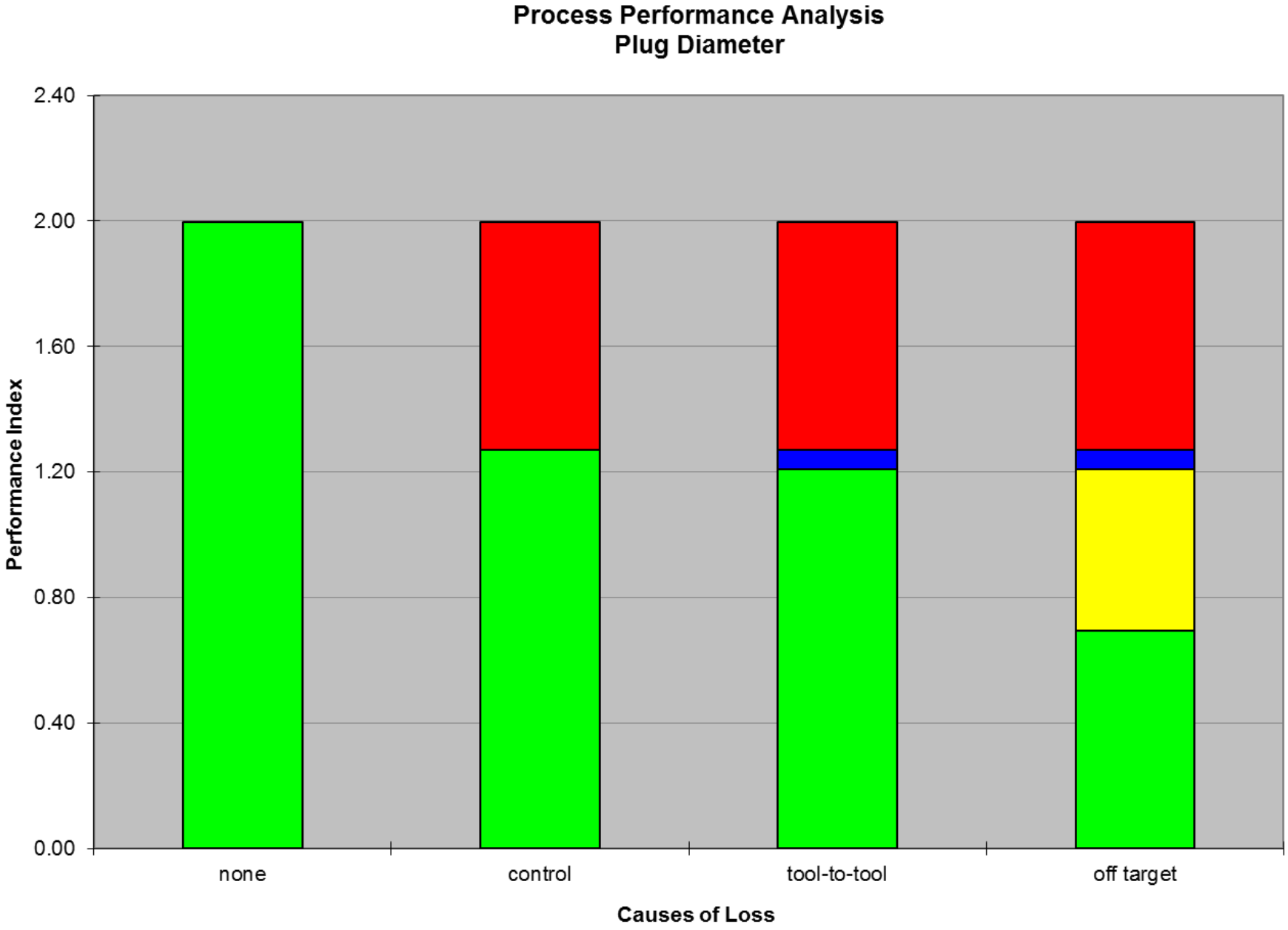
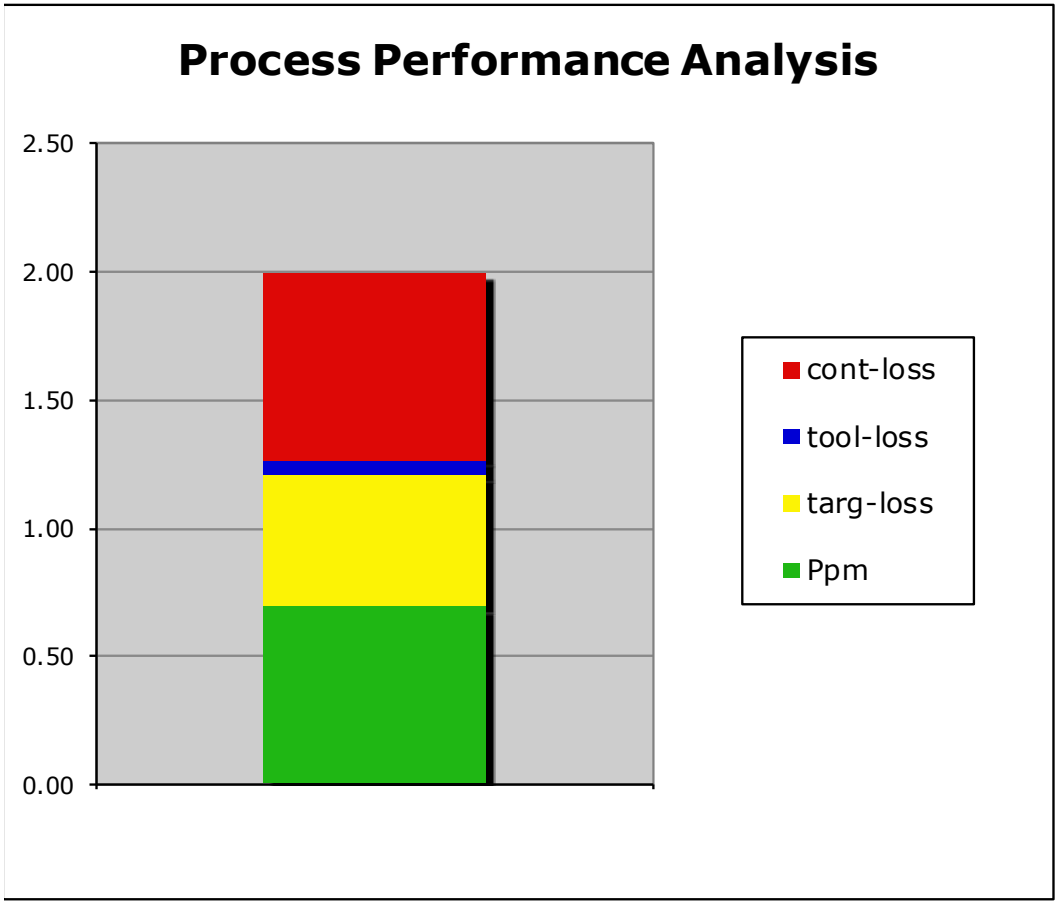
Plug Diameter
Performance Index
2.40
2.00
1.60
1.20
0.80
0.40
0.00
none
control
tool-to-tool
off target
Causes of Loss
Ppm
Pp
Pp(tool)
Cp(pot)
Performance Measure

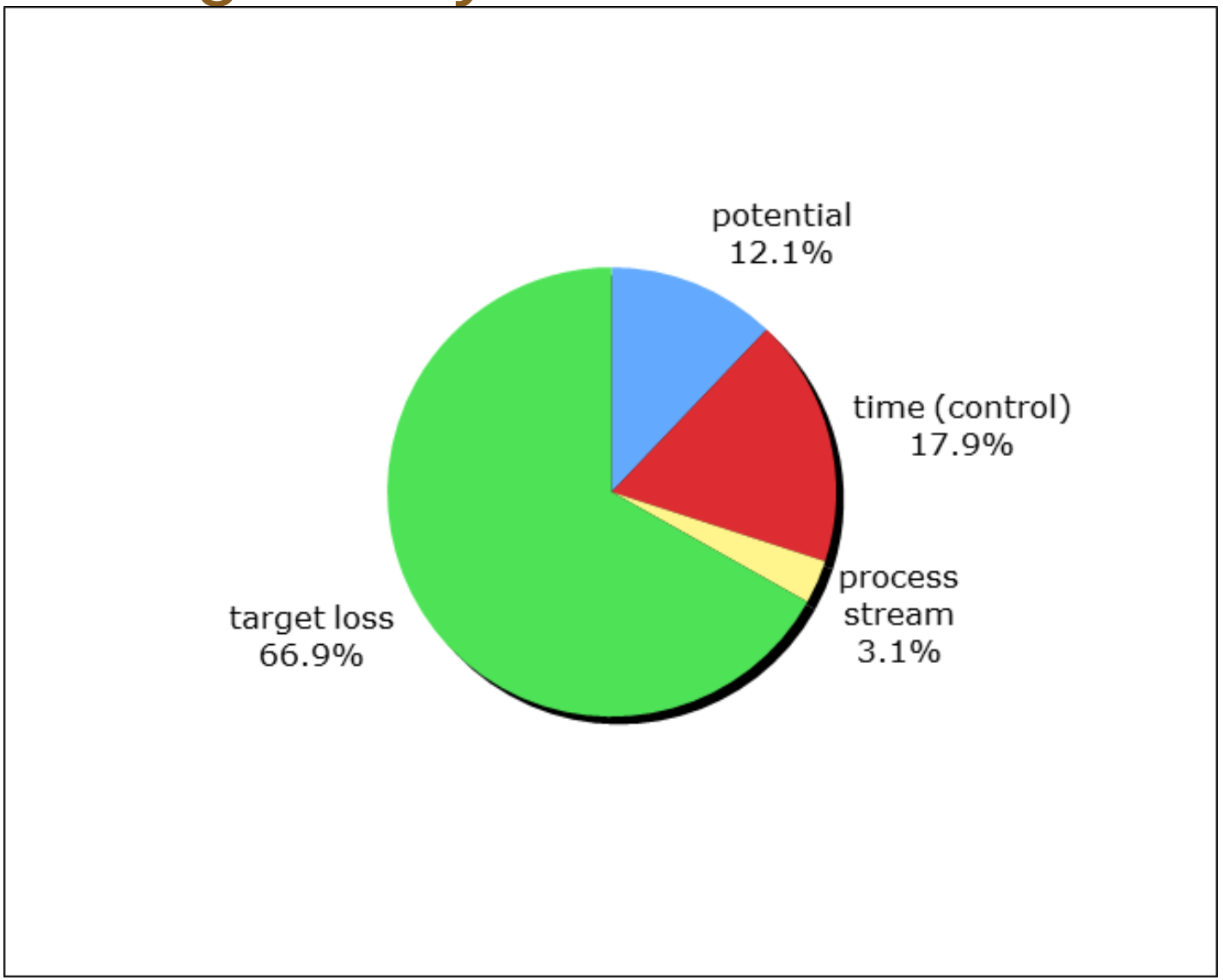

Process Performance Analysis
Plug Diameter
2.40
2.00
1.60
1.20
0.80
0.40
0.00
Performance Index
none
control
tool-to-tool
off target
Causes of Loss

Reporting Your Analysis



Cp(pot)	2.00
Pp(tool)	1.27
Pp	1.21
Ppm	0.70
Mean	2.1630
Stdev	0.0014
Number	480
ppm	20,833

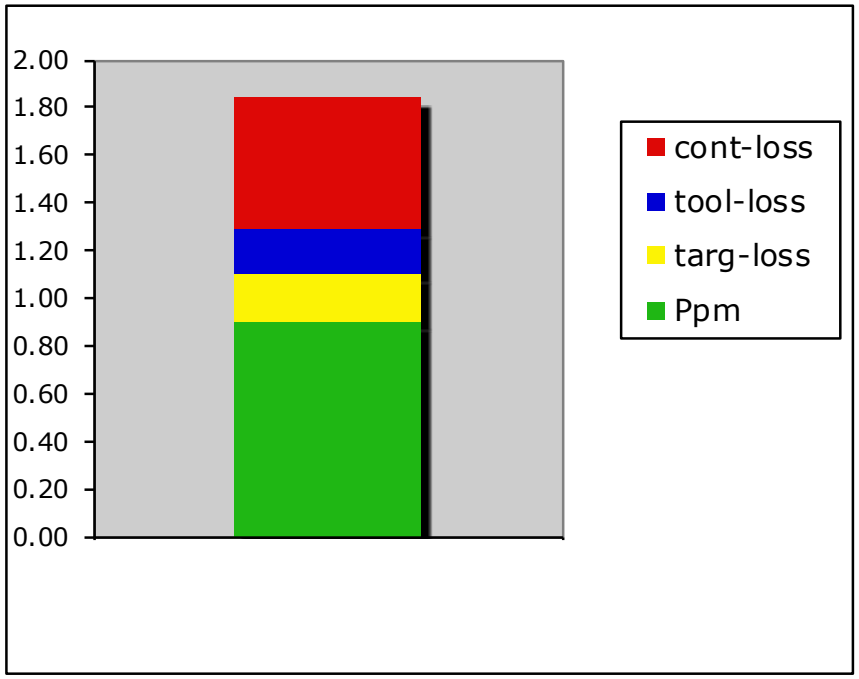
Percentage Analysis of Sources of Loss



What About Multiple Measurements on the Same Part?

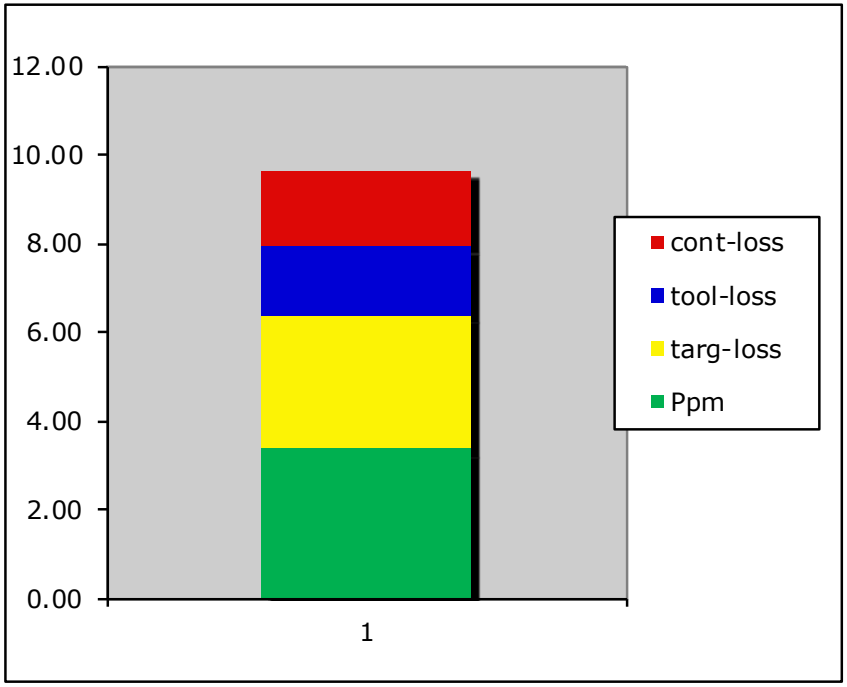
- There is a within-part, or range, component to consider
- The same concepts apply however;
  - The specification is usually
    - $LSL_R = 0$
    - $Target_R = 0$
    - USL_R = Tolerance range (USL-LSL)
  - If one measurement on the part is out of tolerance, the part is defective
- What does it look like?

Parameter Value Bar Chart



Cp(pot)	1.838
Pp(tool)	1.288
Pp	1.097
Ppm	0.902
Mean	20.42
Stdev	0.608
Number	810
ppm	1,235

Range Bar Chart



Cp(pot)	9.641
Pp(tool)	7.935
Pp	6.391
Ppm	3.356
Mean	0.07
Stdev	0.042
Number	810
ppm	0