Assessing Capability from an $\overline{X}$ & R Chart

Data Science for Quality Management: Process Capability

with **Wendy Martin**

Learning objective:

Assess capability from an Xbar and R chart for data that is normally distributed

Capability of the Cartridge Bearing Production Process: Assess the Potential Capability of the Process

$$C_p = \frac{USL - LSL}{NT} = \frac{0.012}{0.01965} = 0.61085$$

Where: $NT' = 6\sigma$

```
# Calculate Cp using sig_est
spcxbar.r$capability[1,1:4] = 0.61085
```

Capability of the Cartridge Bearing Production Process: Assess the Potential Capability of the Process to Produce within Specification

$$C_{pk}U = \frac{USL - \mu}{3\sigma}$$

$$C_{pk}U = 0.61163$$

$$C_{pk}L = \frac{\mu - LSL}{3\sigma}$$

$$C_{pk}L = 0.61007$$

$$C_{pk} = \min\left(C_{pk}U, C_{pk}L\right)$$

$$C_{pk} = 0.61007$$

```
# Calculate Cp using sig_est
spcxbar.r$capability[2,1:4] = 0.61007
```

Capability of the Cartridge Bearing Production Process: Assess the Potential Capability of the Process to Produce within Specification

$$C_{pm} = \frac{USL - LSL}{6\sqrt{\sigma^2 + (\mu - Nominal)^2}}$$

$$\mathrm{C_{pm}} = 0.61085$$

```
# Calculate Cp using sig_est
spcxbar.r$capability[3,1:4] = 0.61085
```

Standard Deviation (s)

- When we use the overall s,
  - Cp -> Pp
  - Cpk -> Ppk
  - Cpm -> Ppm

Standard Deviation Overall

```
# Calculate overall standard deviation
s<-sd(bearing$diameter)
= 0.003302562
```

Natural Tolerance using s

```
# Calculate the natural tolerance
# If normally distributed, this is 6*s
nt_s<-6*s = 0.01981537
```

Performance Measures - Pp

```
# Calculate Pp using s
spcxbar.r$capability[4,1:4]
= 0.60559
```

Performance Measures - Ppk

```
# Calculate Ppk using s
spcxbar.r$capability[5,1:4]
= 0.60481
```

Performance Measures - Ppm

```
# Calculate Ppm using s
spcxbar.r$capability[6,1:4]
= 0.60559
```

Generating Capability & Performance Indices

statistic	eq	n	value
Cp	=		0.61085
Cpk	=		0.61007
Cpm	=		0.61085
Pp	=		0.60559
Ppk	=		0.60481
Ppm	=		0.60559
Obs. n / PPM (lower)	=	4	30769.00000
Obs. n / PPM (upper)	=	1	7692.00000
Obs. n / PPM (total)	=	5	38461.00000
Pot. PPM (lower)	=		33610.00000
Pot. PPM (upper)	=		33260.00000
Pot. PPM (total)	=		66870.00000

Conclusions About the Bearing Cartridge Diameter Process

- The process is in control
- The process average is on target
- The target is centered between the specifications
- The process is not capable
- The capability problem is one of spread (dispersion), not location (central tendency)

Why Might the Dispersion Be Too Great?

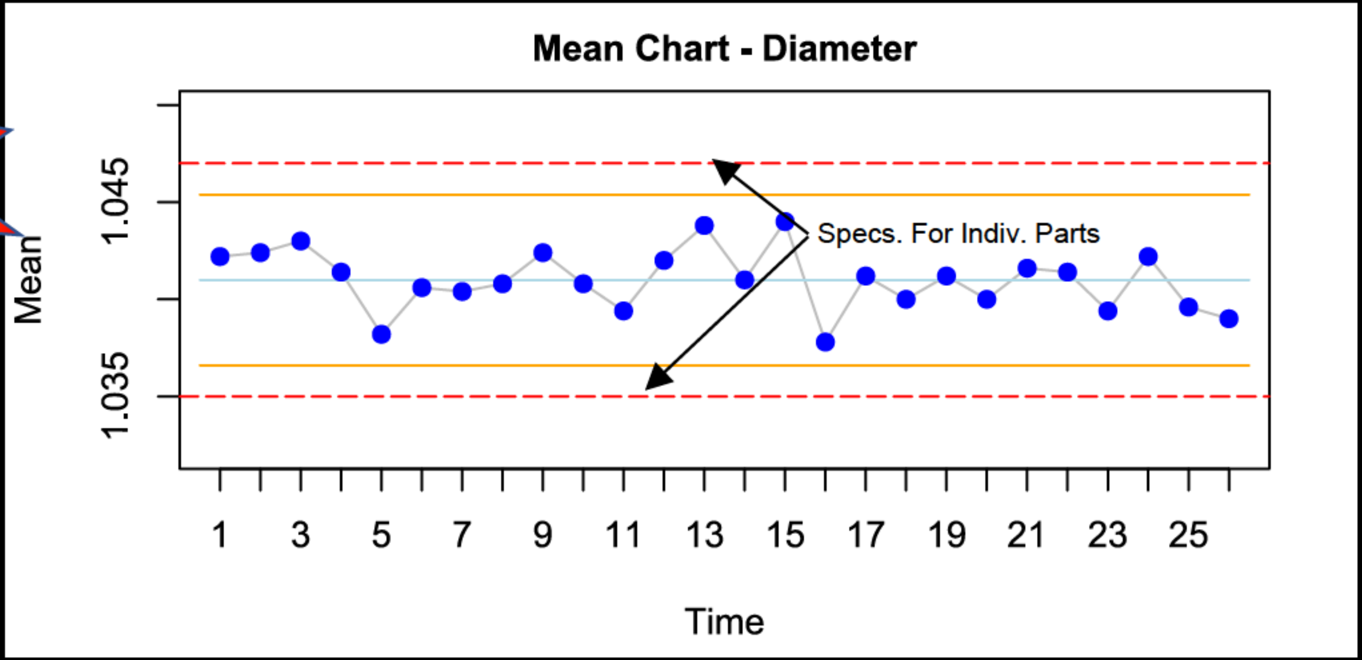
- Will ordering the operating crew to reduce the piece-to-piece variability accomplish anything?

Control Limits and Specifications

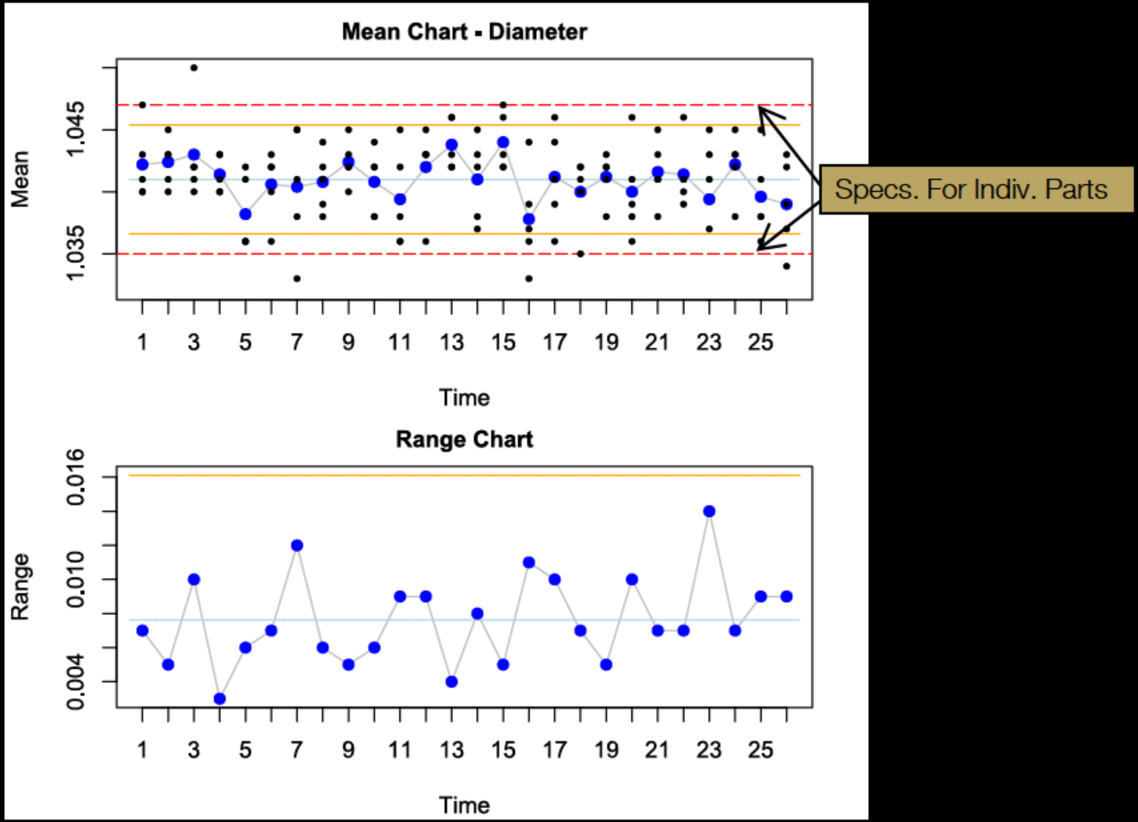
Repeat after me . . .

"I will never draw specification limits on a control chart unless we are plotting individual values."

Specifications versus Control Limits on a Mean Chart



Specifications versus Control Limits on a Mean Chart with Individuals



Sources

The material used in the PowerPoint presentations associated with this course was drawn from a number of sources. Specifically, much of the content included was adopted or adapted from the following previously-published material:

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