

Mean and Range Charts

**Data Science for Quality Management:
Xbar and R / Xbar and S charts /
X and MR charts
with Wendy Martin**

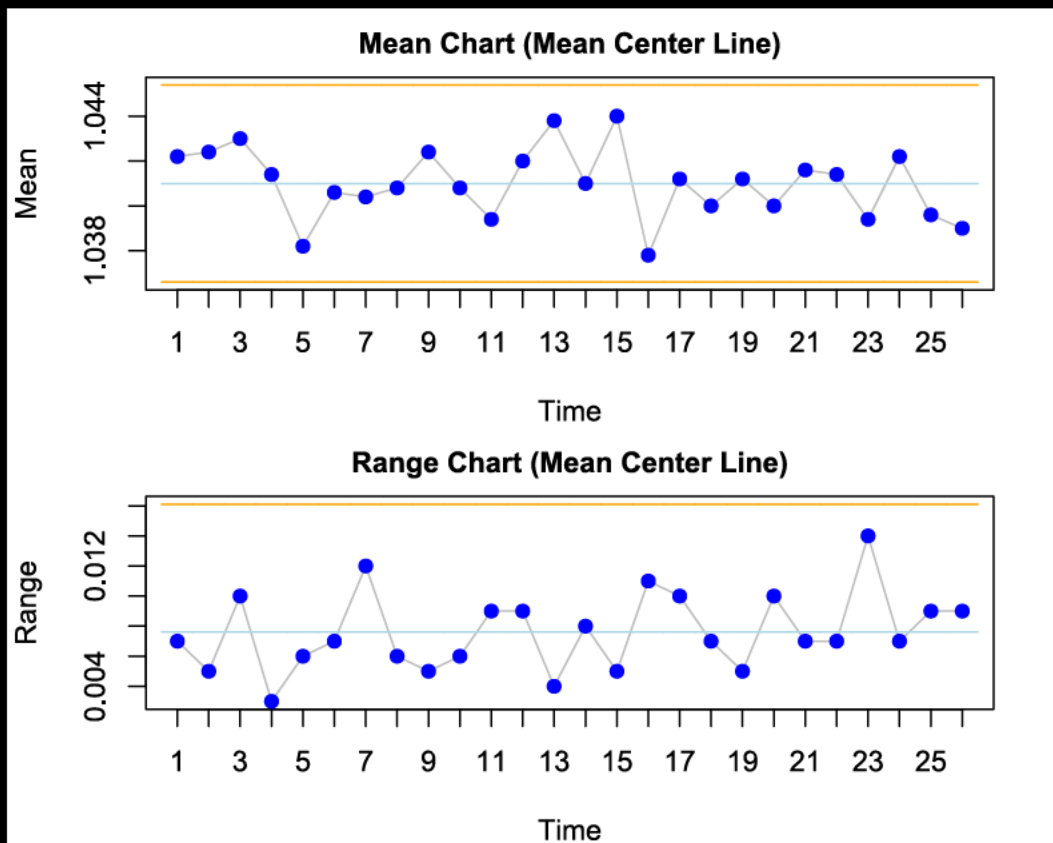
Learning objective:

Create centerlines and control limits for the X Bar and R Chart

Mean and Range Charts

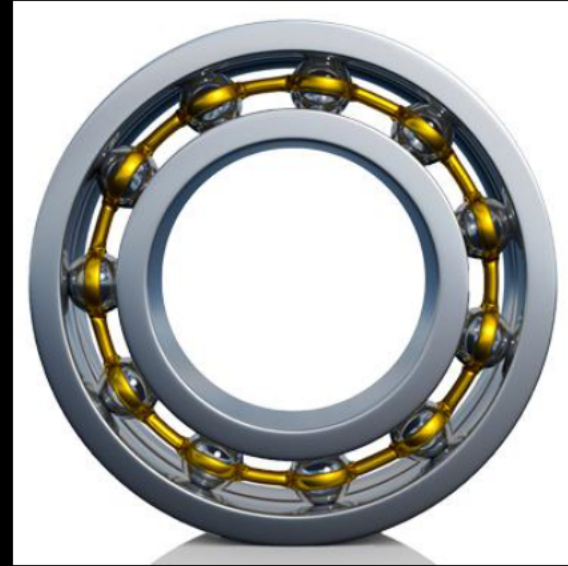
- Used with variables data
- Monitors location (central tendency) and spread (dispersion, or variability)
- Allows for the use of small sample sizes
- Simple to construct
- Easy to interpret

\bar{X} and R Chart



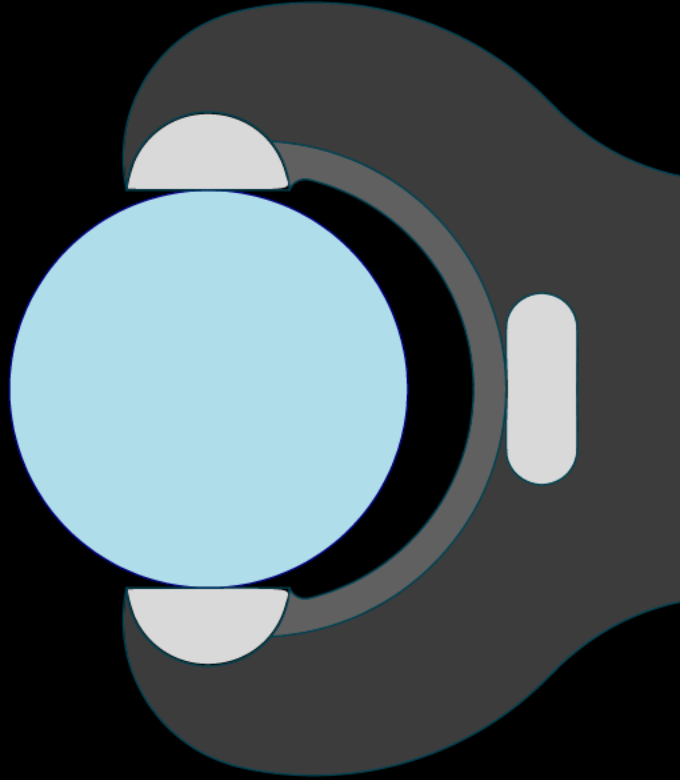
The Case of the Cartridge Bearing

Consider a forming operation in which the outside ring of a cartridge bearing is heat treated, then ground to customer specifications of $1.041'' \pm 0.006''$.



Step 1: Select the Characteristic to be Evaluated

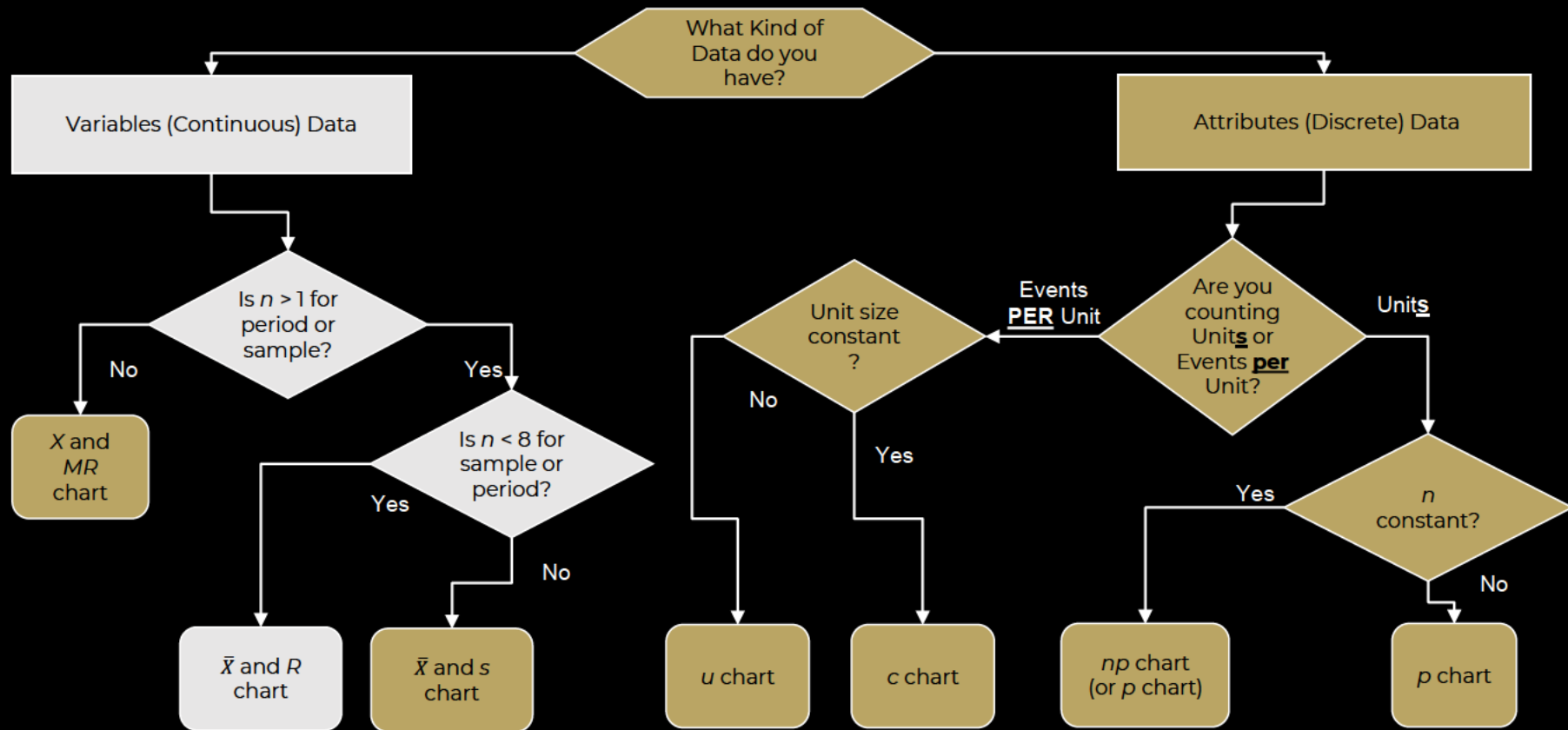
The outside diameter is measured at the center of the cartridge using a 1 to 2 inch snap gauge.



Step 2: Select a Sampling Plan

Five consecutive rings are randomly selected from a single grinding machine and measured per hour ($n = 5$). The samples are drawn at random times within each hour.

Step 3: Select the Chart



Step 4: Collect Data

- 26 samples ($k = 26$) of size 5 ($n = 5$) are collected.
- The data are imported into R Studio for analysis

Control Charts

- Sample statistics are plotted as points
- If time-ordered, the points are connected with straight lines
- If not time-ordered, do not connect the points

Control Charts

- In lolcat, centerlines are drawn as aqua lines
- Control limits are drawn as gold lines
- Typical Control Chart value calculations for an X-Bar & R chart are as follows:

Sample Statistics

$$\bar{X} = \frac{\sum X}{n}$$

$$\begin{aligned} R &= \text{Maximum} - \text{Minimum} \\ &= X_H - X_L \end{aligned}$$

Centerline Calculations

$$\bar{R} = \frac{R_1 + R_2 + \cdots + R_k}{k}$$

$$\bar{\bar{X}} = \frac{\bar{X}_1 + \bar{X}_2 + \cdots + \bar{X}_k}{k}$$

Centerline Calculation Results

$$\bar{\bar{X}} = 1.0410$$

$$\bar{R} = 0.0076$$

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:

- Luftig, J. An Introduction to Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1982
- Luftig, J. Advanced Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1984.
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- Luftig, J. Guidelines for Reporting the Capability of Critical Product Characteristics. Anheuser-Busch Companies, St. Louis, MO. 1994
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- Littlejohn, R., Ouellette, S., & Petrovich, M. Black Belt Business Improvement Specialist Training, Luftig & Warren International, 2000
- Ouellette, S. Six Sigma Champion Training, ROI Alliance, LLC & Luftig & Warren, International, Southfield, MI 2005