

# p Charts: Control Charts for Proportions / Percentages

**Data Science for Quality Management:  
Control Charts for Discrete Data  
with Wendy Martin**

## **Learning objectives:**

Calculate Control Limits for the p chart using the normal approximation

Calculate Control Limits for the p chart using the exact calculation

# Control Limits (Normal Approximation)

$$UCL = \bar{p} + 3 \sqrt{\frac{\bar{p}(1 - \bar{p})}{n}} = 0.0678$$

Varies with sample size

$$LCL = \bar{p} - 3 \sqrt{\frac{\bar{p}(1 - \bar{p})}{n}} = \text{none}$$

Varies with sample size

The normal approximation is not terribly useful anymore since we have computers to do the statistics for us, although this is still the default (and frequently only) option in most software.

# Exact Binomial Control Limits

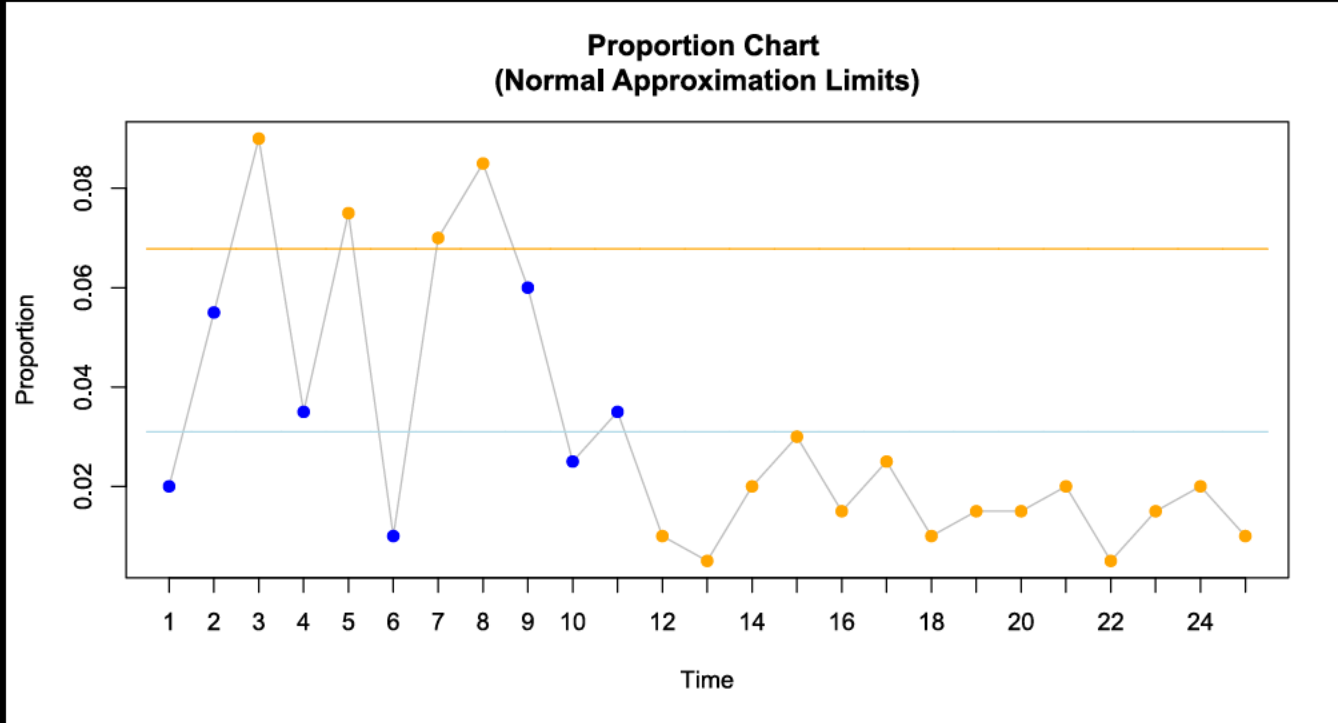
- Using the binomial distribution
  - Find UCL where  $P(r \text{ and above}) \leq 0.00135$  and use  $(r - 0.5)/n$  for the UCL
  - Find LCL where  $P(r \text{ and below}) \leq 0.00135$  and use  $(r + 0.5)/n$  for the LCL
- UCL = 0.0775    LCL = none

# Exact Binomial Control Limits

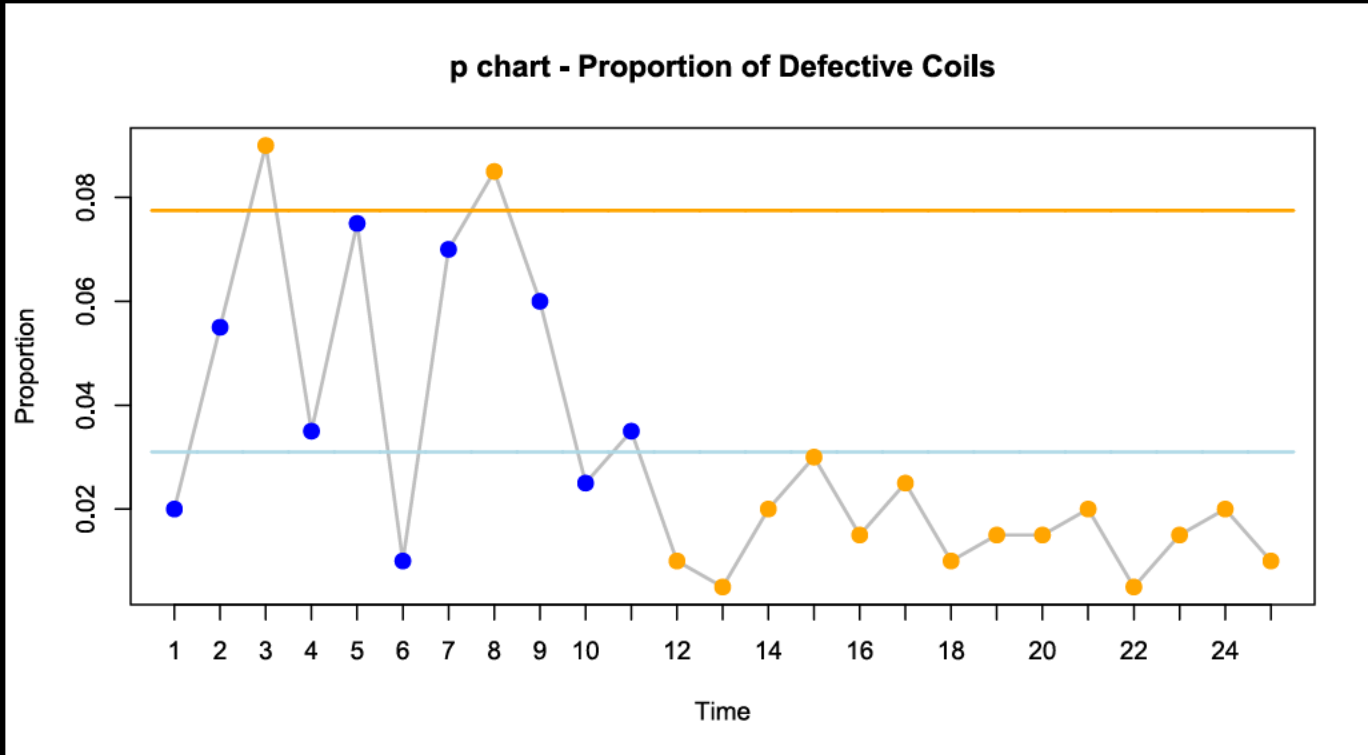
NOTE:

Where  $\{n * \bar{p}\} < 5$ , Exact Control Limits Based on the Binomial Distribution **MUST** be employed!

# p Chart Limits Calculated Using Normal Approximation



# p Chart Limits Calculated Using Exact Binomial Values



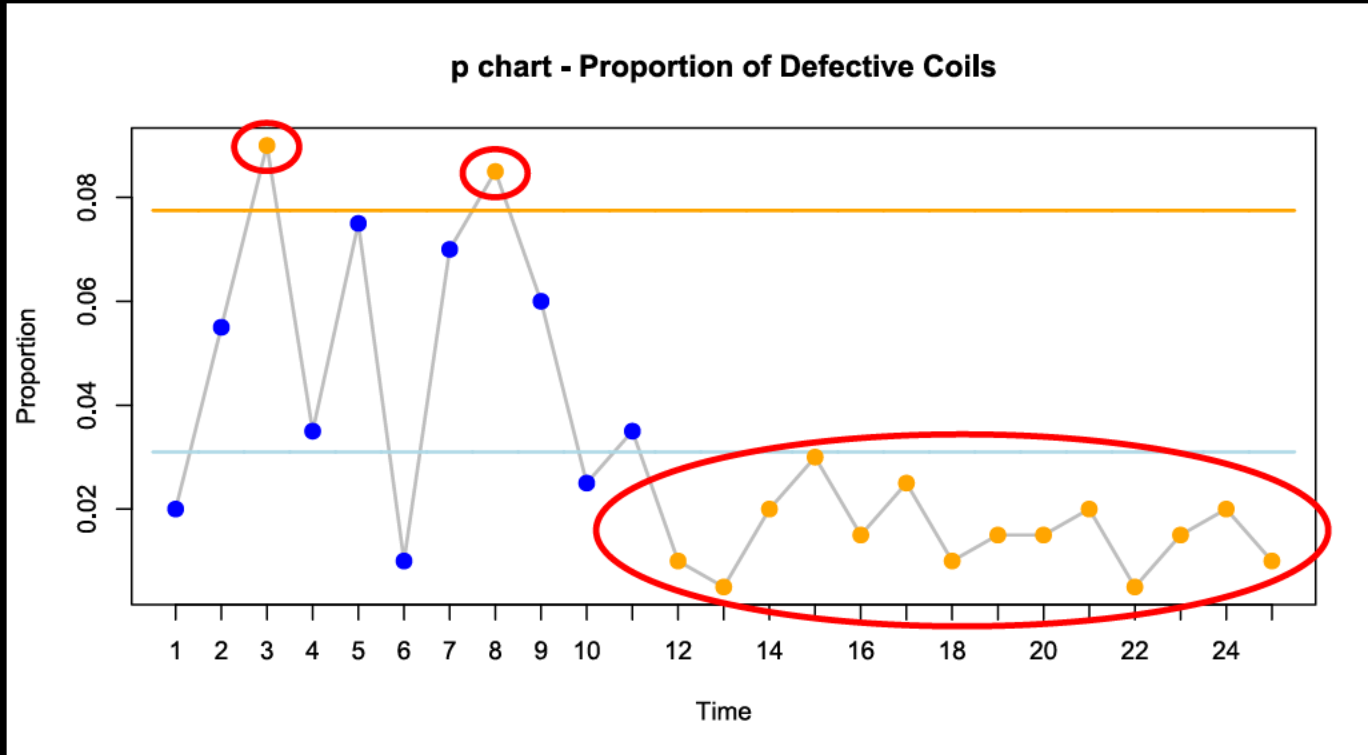
## Step 6: Assess Process Control

- Look for points outside the limits, runs, trends, cycles, and unusual patterns of variation





# Step 6 — Assess Process Control



# 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.
- Luftig, J. A Quality Improvement Strategy for Critical Product and Process Characteristics. Luftig & Associates, Inc. Farmington Hills, MI, 1991
- Luftig, J. Guidelines for Reporting the Capability of Critical Product Characteristics. Anheuser-Busch Companies, St. Louis, MO. 1994
- Spooner-Jordan, V. Understanding Variation. Luftig & Warren International, Southfield, MI 1996
- Luftig, J. and Petrovich, M. Quality with Confidence in Manufacturing. SPSS, Inc. Chicago, IL 1997
- 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