Chapter 17 Statistical Quality Control

I. Introduction

A. Increased competition in manufacturing has made statistical quality control more important than ever.

B. Variation in manufactured parts is natural. It must be measured and controlled to achieve high quality.

1. **Random variation** is due to chance. When it is the primary cause for variation over a period of time (production run), a process is in control.
2. **Assignable variation** is not random and results from an identifiable cause. When it is excessive, a process is statistically out of control. Assignable variation is usually controllable by adjusting equipment, materials, atmospheric conditions, and other environmental factors.

C. Quality control charts

1. A **control chart** measures a process value (statistic) sequentially over a period of time.
2. Whether a statistic such as $\bar{x}$ is within upper and lower limits determines whether a process is in control. These **control limits** are similar to the interval estimates examined on pages 67 and 70.
3. Control charts
   a. An $\bar{x}$ **chart** measures whether the **mean** size, weight, temperature, etc., is getting too high or too low.
   b. A **range chart** measures whether **variation** in size, weight, temperature, etc., is too large.
   c. A $\bar{p}$ **chart** measures whether the **proportion** of some attribute (good or defective parts) is appropriate.

II. The $\bar{x}$ chart

A. Interval estimates based on the central limits theory (chapter 11) provide the theoretical foundation for the $\bar{x}$ chart.

1. Confidence intervals for 99.74%, 95%, and 90% are common. Confidence intervals are called control limits.
2. These formulas are used to determine the 3 sigma or 99.74% confidence interval for the sample mean.

$$UCL = \bar{\bar{x}} + 3\frac{\bar{s}}{\sqrt{n}} \qquad LCL = \bar{\bar{x}} - 3\frac{\bar{s}}{\sqrt{n}}$$

$\bar{\bar{x}}$ is the mean of the sample means.
$\bar{s}$ is an average of the sample standard deviations.

3. Control Factors for calculating UCL and LCL have been developed by the **American Society for Testing and Materials (ASTM)** (See table).

ASTM Control Factors for 99.74%			
Sample Size (n)	A_2	D_3	D_4
2	1.880	0	3.267
3	1.023	0	2.575
4	0.729	0	2.282
5	0.577	0	2.115

$$UCL = \bar{\bar{x}} + A_2\bar{R} \qquad LCL = \bar{\bar{x}} - A_2\bar{R}$$

A_2 is a factor used to relate the mean's confidence interval to the mean of the ranges. (see ASTM table)

$\bar{R}$ is the mean of the sample ranges.

B. Three random samples of four parts designed to be 50 mm long were collected at half hour intervals. Control limits for these parts, using a 99.74% confidence interval, are determined below.

Length of 50-Millimeter Parts (n = 4)						
Sample	Weight of Each Part				$\bar{x}$	Range
1	51	50	50	49	50	2
2	54	49	51	50	51	5
3	49	49	50	48	<u>49</u>	<u>2</u>
Totals for N = 3 samples					150	9

$\bar{\bar{x}} = \frac{\Sigma \bar{x}}{N} = \frac{150}{3} = 50$ $\qquad$ $\bar{R} = \frac{\Sigma R}{N} = \frac{9}{3} = 3$

$$\begin{aligned} UCL &= \bar{\bar{x}} + A_2\bar{R} \\ &= 50 + .729(3) \\ &= 50 + 2.187 \\ &= 52.187 \end{aligned}$$

$$\begin{aligned} LCL &= \bar{\bar{x}} - A_2\bar{R} \\ &= 50 - .729(3) \\ &= 50 - 2.187 \\ &= 47.813 \end{aligned}$$

Note: Control limits should be set when a process is in control. Slight variations from a required tolerance (50 millimeters) are due to chance. With a mean control chart as a guide, future samples trending toward or beyond either control limit would indicate the process may be moving out of control. The answers to this chapter's Quick Questions introduce some of the methods used to judge whether a process is out of control.