Supplement 6 *Rapid* Review

Main Heading	Review Material	MyOMLab
STATISTICAL PROCESS CONTROL (SPC) (pp. 246–260)	■ **Statistical process control (SPC)**—A process used to monitor standards by taking measurements and corrective action as a product or service is being produced. ■ **Control chart**—A graphical presentation of process data over time. A process is said to be operating *in statistical control* when the only source of variation is common (natural) causes. The process must first be brought into statistical control by detecting and eliminating special (assignable) causes of variation. *The objective of a process control system is to provide a statistical signal when assignable causes of variation are present.* ■ **Natural variations**—The variability that affects every production process to some degree and is to be expected; also known as common cause. When natural variations form a *normal distribution,* they are characterized by two parameters: ■ Mean, μ (the measure of central tendency—in this case, the average value) ■ Standard deviation, σ (the measure of dispersion) As long as the distribution (output measurements) remains within specified limits, the process is said to be "in control," and natural variations are tolerated. ■ **Assignable variation**—Variation in a production process that can be traced to specific causes. Control charts for the mean, $\bar{x}$, and the range, R, are used to monitor *variables* (outputs with continuous dimensions), such as weight, speed, length, or strength. ■ **$\bar{x}$-chart**—A quality control chart for variables that indicates when changes occur in the central tendency of a production process. ■ ***R*-chart**—A control chart that tracks the range within a sample; it indicates that a gain or loss in uniformity has occurred in dispersion of a production process. ■ **Central limit theorem**—The theoretical foundation for $\bar{x}$-charts, which states that regardless of the distribution of the population of all parts or services, the $\bar{x}$ distribution will tend to follow a normal curve as the number of samples increases: $$\bar{\bar{x}} = \mu \quad \text{(S6-1)}$$ $$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \quad \text{(S6-2)}$$ The $\bar{x}$-chart limits, if we know the true standard deviation σ of the process population, are: $$\text{Upper control limit (UCL)} = \bar{\bar{x}} + z\sigma_{\bar{x}} \quad \text{(S6-3)}$$ $$\text{Lower control limit (LCL)} = \bar{\bar{x}} - z\sigma_{\bar{x}} \quad \text{(S6-4)}$$ where z = confidence level selected (e.g., $z = 3$ is 99.73% confidence). The *range*, R, of a sample is defined as the difference between the largest and smallest items. If we do not know the true standard deviation, σ, of the population, the $\bar{x}$-chart limits are: $$\text{UCL}_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R} \quad \text{(S6-5)}$$ $$\text{LCL}_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R} \quad \text{(S6-6)}$$ In addition to being concerned with the process average, operations managers are interested in the process dispersion, or range. The R-chart control limits for the range of a process are: $$\text{UCL}_R = D_4\bar{R} \quad \text{(S6-7)}$$ $$\text{LCL}_R = D_3\bar{R} \quad \text{(S6-8)}$$ Attributes are typically classified as *defective* or *nondefective*. The two attribute charts are (1) *p*-charts (which measure the *percent* defective in a sample), and (2) *c*-charts (which *count* the number of defects in a sample). ■ ***p*-chart**—A quality control chart that is used to control attributes: $$\text{UCL}_p = \bar{p} + z\sigma_p \quad \text{(S6-9)}$$ $$\text{LCL}_p = \bar{p} - z\sigma_p \quad \text{(S6-10)}$$ $$\hat{\sigma}_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \quad \text{(S6-11)}$$ ■ ***c*-chart**—A quality control chart used to control the number of defects per unit of output. The Poisson distribution is the basis for *c*-charts, whose 99.73% limits are computed as: $$\text{Control limits} = \bar{c} \pm 3\sqrt{\bar{c}} \quad \text{(S6-12)}$$ ■ **Run test**—A test used to examine the points in a control chart to determine whether nonrandom variation is present.	Concept Questions: 1.1–1.4 Problems: S6.1–S6.39 **VIDEO S6.1** Farm to Fork: Quality at Darden Restaurants Virtual Office Hours for Solved Problems: S6.1–S6.3 **ACTIVE MODELS S6.1 and S6.2** **VIDEO S6.2** Frito-Lay's Quality-Controlled Potato Chips Virtual Office Hours for Solved Problem: S6.5

Supplement 6 *Rapid Review* continued

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PROCESS CAPABILITY (pp. 260–262)	■ **Process capability**—The ability to meet design specifications. ■ **C_p**—A ratio for determining whether a process meets design specifications. $C_p = \frac{(\text{Upper specification} - \text{Lower specification})}{6\sigma}$ (S6-13) ■ **C_{pk}**—A proportion of variation (3σ) between the center of the process and the nearest specification limit: $C_{pk} = \text{Minimum of}\left[\frac{\text{Upper spec limit} - \bar{X}}{3\sigma}, \frac{\bar{X} - \text{Lower spec limit}}{3\sigma}\right]$ (S6-14)	Concept Questions: 2.1–2.4 Problems: S6.40-S6.50 Virtual Office Hours for Solved Problems: S6.4 ACTIVE MODEL S6.3
ACCEPTANCE SAMPLING (pp. 262–265)	■ **Acceptance sampling**—A method of measuring random samples of lots or batches of products against predetermined standards. ■ **Operating characteristic (OC) curve**—A graph that describes how well an acceptance plan discriminates between good and bad lots. ■ **Producer's risk**—The mistake of having a producer's good lot rejected through sampling. ■ **Consumer's risk**—The mistake of a customer's acceptance of a bad lot overlooked through sampling. ■ **Acceptable quality level (AQL)**—The quality level of a lot considered good. ■ **Lot tolerance percent defective (LTPD)**—The quality level of a lot considered bad. ■ **Type I error**—Statistically, the probability of rejecting a good lot. ■ **Type II error**—Statistically, the probability of accepting a bad lot. ■ **Average outgoing quality (AOQ)**—The percent defective in an average lot of goods inspected through acceptance sampling: $\text{AOQ} = \frac{(P_d)(P_a)(N - n)}{N}$ (S6-15)	Concept Questions: 3.1–3.4 Problems: S6.51–S6.55

Self Test

■ **Before taking the self-test,** refer to the learning objectives listed at the beginning of the supplement and the key terms listed at the end of the supplement.

LO S6.1 If the mean of a particular sample is within control limits and the range of that sample is not within control limits:
- **a)** the process is in control, with only assignable causes of variation.
- **b)** the process is not producing within the established control limits.
- **c)** the process is producing within the established control limits, with only natural causes of variation.
- **d)** the process has both natural and assignable causes of variation.

LO S6.2 The central limit theorem:
- **a)** is the theoretical foundation of the *c*-chart.
- **b)** states that the average of assignable variations is zero.
- **c)** allows managers to use the normal distribution as the basis for building some control charts.
- **d)** states that the average range can be used as a proxy for the standard deviation.
- **e)** controls the steepness of an operating characteristic curve.

LO S6.3 The type of chart used to control the central tendency of variables with continuous dimensions is:
- **a)** $\bar{x}$-chart.
- **b)** *R*-chart.
- **c)** *p*-chart.
- **d)** *c*-chart.
- **e)** none of the above.

LO S6.4 If parts in a sample are measured and the mean of the sample measurement is outside the control limits:
- **a)** the process is out of control, and the cause should be established.
- **b)** the process is in control but not capable of producing within the established control limits.
- **c)** the process is within the established control limits, with only natural causes of variation.
- **d)** all of the above are true.

LO S6.5 Control charts for attributes are:
- **a)** *p*-charts.
- **b)** *c*-charts.
- **c)** *R*-charts.
- **d)** $\bar{x}$-charts.
- **e)** both a and b.

LO S6.6 The ability of a process to meet design specifications is called:
- **a)** Taguchi.
- **b)** process capability.
- **c)** capability index.
- **d)** acceptance sampling.
- **e)** average outgoing quality.

LO S6.7 The _______ risk is the probability that a lot will be rejected despite the quality level exceeding or meeting the _______.

Answers: LO S6.1. b; LO S6.2. c; LO S6.3. a; LO S6.4. a; LO S6.5. e; LO S6.6. b; LO S6.7. producer's, AQL