

**QUALITY CONTROL CHARTS, etc. - Chapter 6**  
(use Table XI on page 580 for values of A, B, c, d, and D)

**Monitoring Measures of Central Tendency and Variability**

1. **R Chart** (p. 252) – based on range and  $n$  ( $\bar{R}$  = mean of subgroup ranges)

Centerline is  $\bar{R}$       LCL =  $D_3\bar{R}$       UCL =  $D_4\bar{R}$

NOTE:  $\hat{\mu}$  (estimate of  $\mu$ ) =  $\bar{\bar{x}}$ ,     $\hat{\sigma}$  (estimate of  $\sigma$ ) =  $\frac{\bar{R}}{d_2}$

2.  **$\bar{x}$  Chart** (p. 253)– based on range,  $\bar{\bar{x}}$ , and  $n$   
( $\bar{R}$  = mean of subgroup ranges,  $\bar{\bar{x}}$  = mean of subgroup means)

Centerline is  $\bar{\bar{x}}$       LCL  $\approx \bar{\bar{x}} - A_2\bar{R}$       UCL  $\approx \bar{\bar{x}} + A_2\bar{R}$

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3. **s Chart** (p. 256) – based on  $\bar{s}$  and  $n$  ( $\bar{s}$  = mean of subgroup st. devs)

Centerline is  $\bar{s}$       LCL  $\approx B_3\bar{s}$       UCL  $\approx B_4\bar{s}$

NOTE:  $\hat{\mu}$  (estimate of  $\mu$ ) =  $\bar{\bar{x}}$ ,     $\hat{\sigma}$  (estimate of  $\sigma$ ) =  $\frac{\bar{s}}{c_4}$

4.  **$\bar{x}$  Chart** (p. 256) – based on  $\bar{s}$  and  $n$   
( $\bar{s}$  = mean of subgroup st. dev,  $\bar{\bar{x}}$  = mean of subgroup means)

Centerline is  $\bar{\bar{x}}$       LCL =  $\bar{\bar{x}} - A_3\bar{s}$       UCL =  $\bar{\bar{x}} + A_3\bar{s}$

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**Nonconformance Rates** (p. 261) LSL & USL are given specification limits

Proportion below LSL =  $P(x < LSL) \approx P\left(z < \frac{LSL - \hat{\mu}}{\hat{\sigma}}\right)$

Proportion above USL =  $P(x > USL) \approx P\left(z > \frac{USL - \hat{\mu}}{\hat{\sigma}}\right)$

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**Capability/Conformity Indexes** (p. 263 – 266)

$C_p = \frac{USL - LSL}{6\hat{\sigma}}$        $C_{pl} = \frac{\hat{\mu} - LSL}{3\hat{\sigma}}$        $C_{pu} = \frac{USL - \hat{\mu}}{3\hat{\sigma}}$

$C_{pk} = (1 - k)C_p = \text{minimum}[C_{pu}, C_{pl}]$  where  $k = \frac{|(USL + LSL)/2 - \hat{\mu}|}{(USL - LSL)/2}$

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## Control Charts for Attributes Data (assume equal subgroup sizes)

### 1. p chart (p. 269) – proportions of nonconforming items in successive subgroups

Centerline is  $\bar{p} = \frac{\sum p_i}{k}$  where  $p_i$  = subgroup proportions,  $k$  = number of subgroups

$$\text{LCL} = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \quad \text{UCL} = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \quad n = \text{no. in a subgroup}$$

**NOTE:** for uneven subgroup sizes, see formulas at bottom of pg 269 and top of pg 270

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### 2. np chart (p. 271) – number of nonconforming items in successive subgroups

Centerline is  $n\bar{p}$  using  $\bar{p} = \frac{\sum p_i}{k}$

$$\text{LCL} = n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})} \quad \text{UCL} = n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})} \quad \text{calculated for each subgroup}$$

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### 3. c chart (p. 274) – number of nonconformities per inspection unit

Centerline is  $\bar{c} = \frac{\sum c_i}{k}$  where  $c_i$  = subgroup nonconformities,  $k$  = no. of subgroups

$$\text{LCL} = \bar{c} - 3\sqrt{\bar{c}} \quad \text{UCL} = \bar{c} + 3\sqrt{\bar{c}}$$

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### 4. u chart (p. 276) – like a c chart but with variable numbers of inspection units per subgroup

$$u_i = \frac{c_i}{n_i} \quad \text{for each subgroup}$$

Centerline is  $\bar{u} = \frac{\text{total nonconformities in the } k \text{ subgroups}}{\text{total number of inspection units}} = \frac{c_1 + c_2 + \dots + c_k}{n_1 + n_2 + \dots + n_k}$

$$\text{LCL} = \bar{u} - 3\sqrt{\frac{\bar{u}}{n_i}} \quad \text{UCL} = \bar{u} + 3\sqrt{\frac{\bar{u}}{n_i}} \quad \text{calculated for each subgroup}$$