III. The R chart

A. A range chart, which measures variation, shows the confidence interval for the sample range.

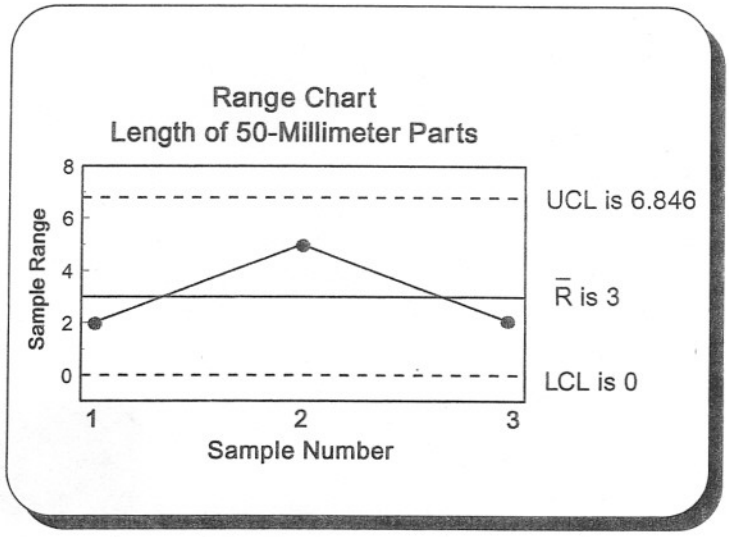
B. Simplified procedures for calculating UCL and LCL have been developed. Again the average range is multiplied by an ASTM factor. (See page 102)

$$UCL = D_4\bar{R} \qquad LCL = D_3\bar{R}$$

C. Three sigma control limits for the page 102 data are determined below.

$$UCL = D_4\bar{R} = 2.282(3) = 6.846$$

$$LCL = D_3\bar{R} = 0(3) = 0$$



D. These limits were determined when the process was in control. Three sigma (99.74%) control limits indicate 9,974 out of 10,000 sample ranges will be within these limits when the process is in control. Customer specifications (tolerances) may call for less variability. Statistics software may result in the more exact, but cumbersome, standard deviation replacing the range as the popular measure for determining variation.

IV. The p chart

A. The p chart measures the proportion of some attribute (defective items) resulting from a process.

B. It measures a qualitative attribute (being defective), rather than a quantitative characteristic (mean weight).

C. Suppose we are interested in tracking the 50-millimeter part defects described on page 102. Daily random samples of 150 parts had the following defects. A 3 sigma p chart is constructed below.

Quality Control Summary Sheet															
Date	1/3	1/4	1/5	1/6	1/7	1/10	1/11	1/12	1/13	1/14	1/17	1/18	1/19	1/20	1/21
Defects	9	0	6	9	12	3	6	12	6	15	0	12	3	9	6
Defect Proportions	.06	.00	.04	.06	.08	.02	.04	.08	.04	.10	.00	.08	.02	.06	.04

$$\bar{p} = \frac{\text{total defects}}{\text{total sampled}}$$

$$\bar{p} = \frac{\text{total defects}}{\text{total sampled}} = \frac{108}{2{,}250} = .048$$

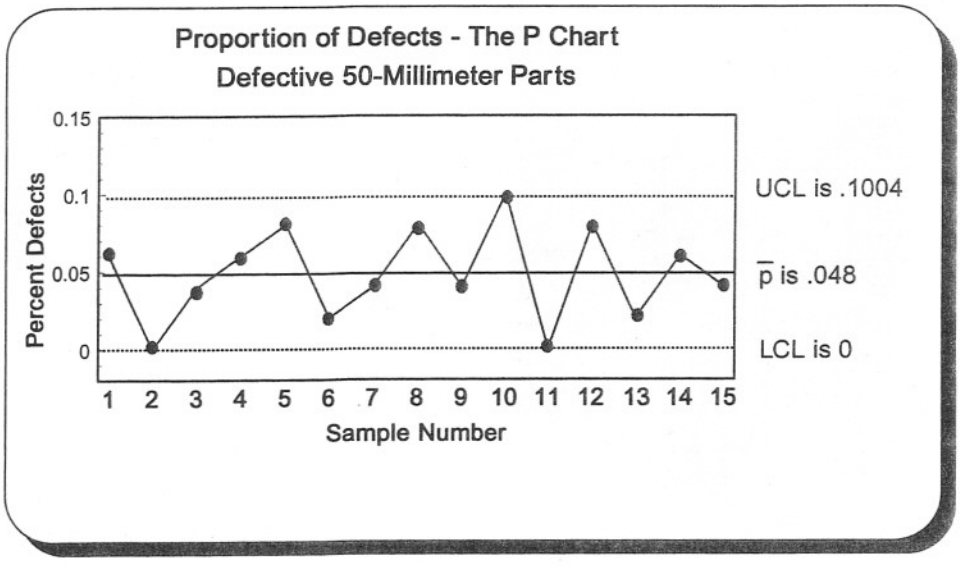
$$\text{UCL and LCL} = \bar{p} \pm 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$\text{UCL and LCL} = \bar{p} \pm 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$.0480 \pm 3\sqrt{\frac{.048(1-.048)}{150}}$$

$$-.0044 \leftrightarrow +.1004$$

$-.0044$ is rounded to zero.



Note: 1) This chart was prepared while the process was in control. An acceptable average proportion of defects is determined by the manufacturer and the customer.
2) The **c chart** is another attribute control chart. It measures counts such as the actual number of defects over time, defects per part, and complaints per period.

$$\text{UCL and LCL} = \bar{c} \pm 3\sqrt{\bar{c}}$$