19.1 Total Quality Management  356

Inspection vs TQM

<table>
<thead>
<tr>
<th>Inspection:</th>
<th>TQM:</th>
</tr>
</thead>
<tbody>
<tr>
<td>when an inspector (or customer) finds an individual product or service that is defective (&quot;out of the acceptance limits&quot;), either fix it or scrap it and try again. Warn or punish the workers.</td>
<td>when the workers find a sample of products or services beginning to stray out of the control limits, they diagnose the reason and fix the source of the problem before any actually defective products or services are produced.</td>
</tr>
</tbody>
</table>

19.2 Statistical Quality Control 357

Deming's 14 points

19.3 Variation in Processes 358

Common Cause (chance)
Assignable Cause (Special Cause)
The state of "Statistical Control"

<table>
<thead>
<tr>
<th>Stable process:</th>
<th>Unstable process:</th>
</tr>
</thead>
<tbody>
<tr>
<td>only common causes of variation affect the output quality; improvement can only take place by process redesign.</td>
<td>special cause variation is affecting quality and needs to be fixed before it starts producing defects.</td>
</tr>
</tbody>
</table>

2.12 Run Chart 18

19.4 Control Charts 358

Run chart (Time Series Chart)
Sampling by "rational subgroups"
sampling a fixed proportion or "ratio" of products or services at regular time intervals.
Control chart: run chart with upper and lower control lines.
Testing the null hypothesis that the process is stable.

<table>
<thead>
<tr>
<th>3 sigma rule for control limits</th>
<th>6 sigma rule for acceptance limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;sigma&quot; is standard error of the daily sample means</td>
<td>&quot;sigma&quot; is standard deviation of a measurement of the product</td>
</tr>
<tr>
<td>control limits depend on actual variation</td>
<td>acceptable variation depends on acceptance limits</td>
</tr>
</tbody>
</table>
3.9 Use of the Mean in Statistical Process Control 48

9.5 Xbar Charts for Process Mean 359
Each day for k days, measure the value of X for each of a sample of n gizmos produced that day

\[
\bar{X}_i = \frac{\sum_{j=1}^{n}X_{ij}}{n} \quad \bar{X} = \frac{\sum_{i=1}^{k}\bar{X}_i}{k} \quad S_i = \frac{\sum_{j=1}^{n}(X_{ij}-\bar{X}_i)^2}{n-1} \quad \bar{S} = \frac{\sum_{i=1}^{k}s_i}{k}
\]

\(\bar{X}_i\) is in control if \(\bar{X} - 3\frac{\bar{S}}{c_4\sqrt{n}} \leq \bar{X} \leq \bar{X} + 3\frac{\bar{S}}{c_4\sqrt{n}}\) (c4 from table)

10.9 Testing With Respect to the Process Mean in Statistical Process Control 184
Testing Ho: process mean is in control by a simplification of the confidence interval approach to hypothesis testing.

19.6 Interpreting Xbar charts 360
8 signs that process is beginning to run too high or too low
4.10 Use of the Range and Standard Deviation in Statistical Process Control 62

19.7 s Charts for Process Standard Deviation 362
Is the process beginning to show excessive up and down swings?
If we "know" $\sigma$ we can say standard deviation is in control if
$$c_4 \sigma - 3c_5 \sigma \leq s_i \leq c_4 \sigma + 3c_5 \sigma$$
If our estimate of $\sigma$ comes from the data, the formulas get ugly enough to hide them in a black box like Minitab.

19.8 R Charts for Process Range 362
(Crude but simple alternative to s chart; suitable for paper and pencil work)

$$R_1 = \max(X_{i1},...,X_{in}) - \min(X_{i1},...,X_{in})$$

$$R = \frac{\sum R_i}{k}$$

$R_1$ is in control if $D_3 R \leq R_1 \leq D_4 R$

1.9 Testing With Respect to Process Variation in Statistical Process Control 204
Testing $H_0$: process variation is in control by a simplification of the confidence interval approach to hypothesis testing.

19.9 p Charts for Process Proportion
Variables versus attributes.
Used when a few imperfections or defects are considered inevitable

$$\bar{p} = \frac{\sum p_i}{k} \quad p_i \text{ is in control of } \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \leq p_i \leq \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$