Quality Control

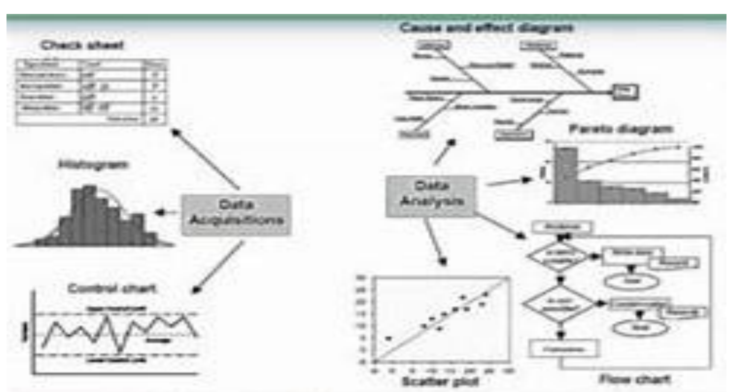
- Quality is fitness for use.
- Quality Control is a system of maintaining standards in manufactured product by testing samples.
- Common goals for quality professionals include
  - reducing defect rates,
  - manufacturing products within specifications, and
  - standardizing delivery time.

ADVANTAGES OF QUALITY CONTROL

- Reduction in production/inspection cost
- Prior fault detection
- Satisfaction of consumers
- Effective utilisation of resources

METHODS OF QUALITY CONTROL

- Cause and effect diagrams
- Control charts
- Check sheet
- Histograms
- Pareto charts
- Scatter diagrams
- Stratification

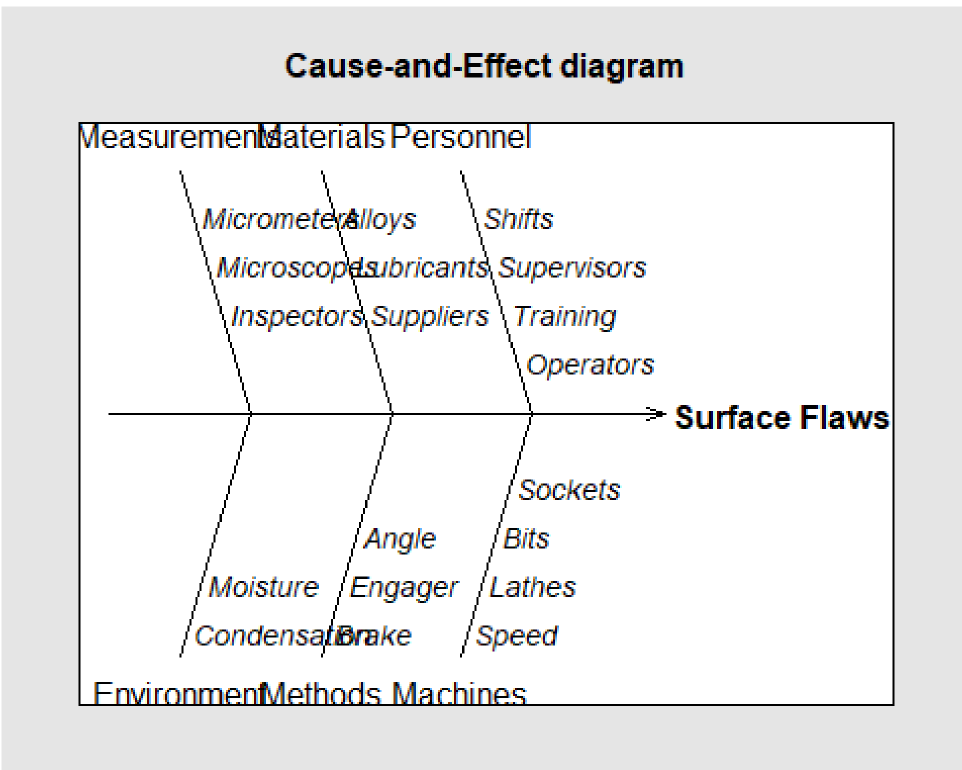


CAUSE AND EFFECT DIAGRAMS

- It is a visualization tool for categorizing the potential causes of a problem.
- It can also be useful for showing relationships between contributing factors.

```r
library(qcc)

cause.and.effect(cause=list(Measurements=c("Micrometers", "Microscopes",
"Inspectors"),
                            Materials=c("Alloys", "Lubricants", "Suppliers"),
                            Personnel=c("Shifts", "Supervisors", "Training",
"Operators"),
                            Environment=c("Condensation", "Moisture"),
                            Methods=c("Brake", "Engager", "Angle"),
                            Machines=c("Speed", "Lathes", "Bits",
"Sockets")),
                 effect="Surface Flaws")
```



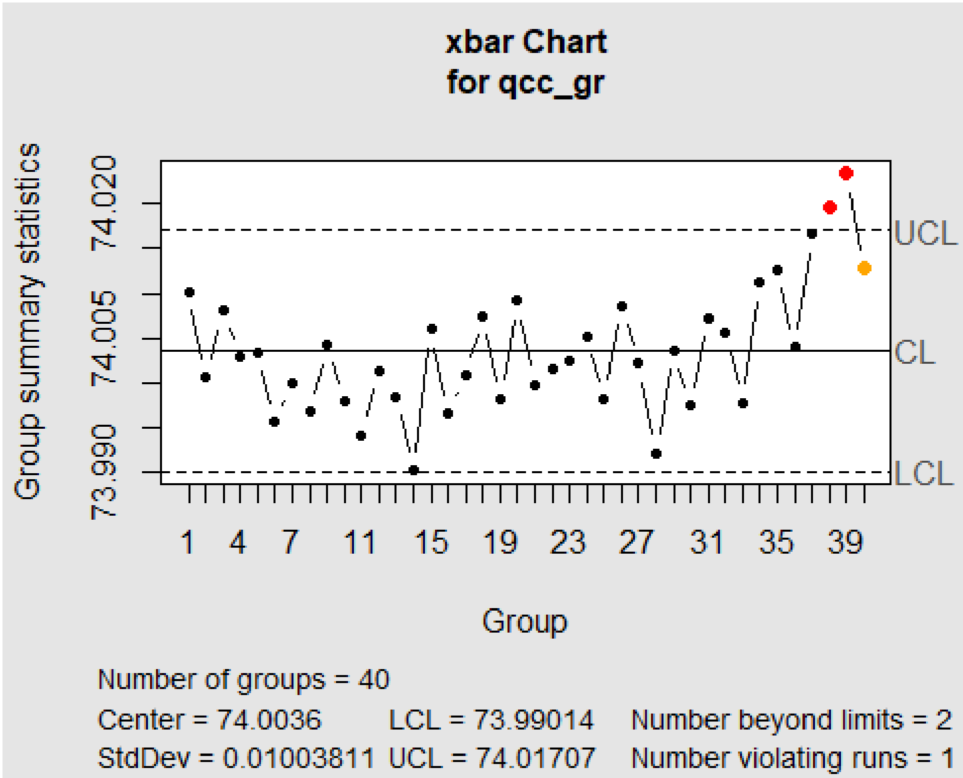
CONTROL CHARTS

- Control charts are powerful statistical tools used in quality control to monitor and visualize process performance over time.
- Use control charts to detect special-cause variation and to assess process stability over time.
- The center line is the average value of the quality statistic that you choose to assess.
- If a process is in control, the points will vary randomly around the center line.
- The upper control limit (UCL) is 3 standard deviations above the center line.
- The lower control limit (LCL) is 3 standard deviations below the center line.
- If a process is in control, all points on the control chart are between the upper and lower control limits.

```r
library(qcc)
data("pistonrings")
attach(pistonrings)
qcc_gr <- qcc.groups(diameter, sample)
head(qcc_gr)
```

```
##     [,1]   [,2]   [,3]   [,4]   [,5]
## 1 74.030 74.002 74.019 73.992 74.008
## 2 73.995 73.992 74.001 74.011 74.004
## 3 73.988 74.024 74.021 74.005 74.002
## 4 74.002 73.996 73.993 74.015 74.009
## 5 73.992 74.007 74.015 73.989 74.014
## 6 74.009 73.994 73.997 73.985 73.993
```

```r
qcc(qcc_gr, type = "xbar",std.dev   = "UWAVE-SD")
```



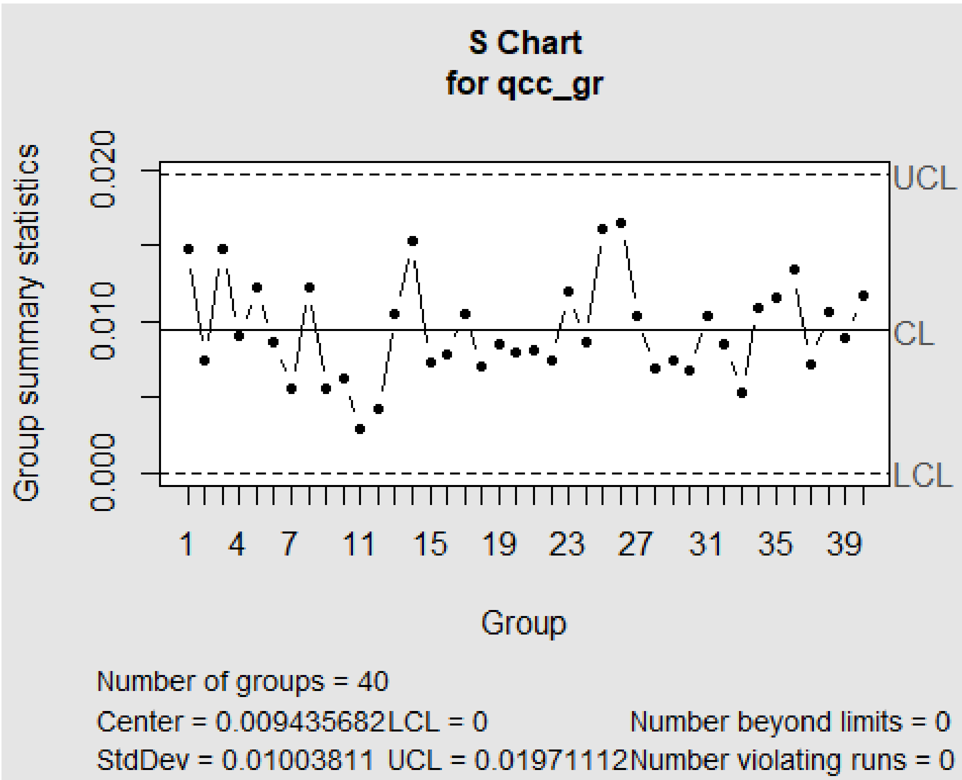
NELSON RULES FOR CONTROL CHARTS

- One point above UCL or below LCL
- Two points above/below 2 sigma
- Four out of five points above/below 1 sigma
- Eight points in a row above/below the center line
- Six points in a row ascending or descending (trend)
- 15 points in a row "hugging" the center line (between -1 and +1 sigma)
- 14 points in a row alternating up and down
- Eight points in a row above 1 sigma or below -1 sigma

S CHART

Use to assess the variability of the process.

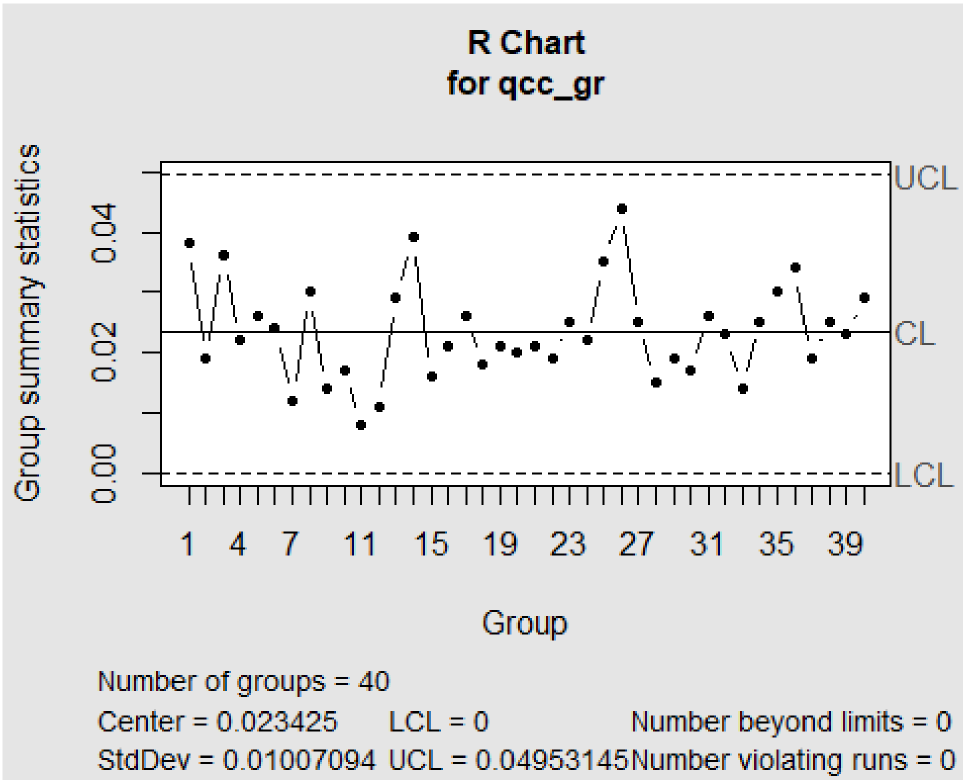
```
qcc(qcc_gr, type = "S",std.dev  = "UWAVE-SD")
```



R CHART

Use to assess the variability of the process with small samples.

```
qcc(qcc_gr, type = "R",std.dev  = "UWAVE-R")
```

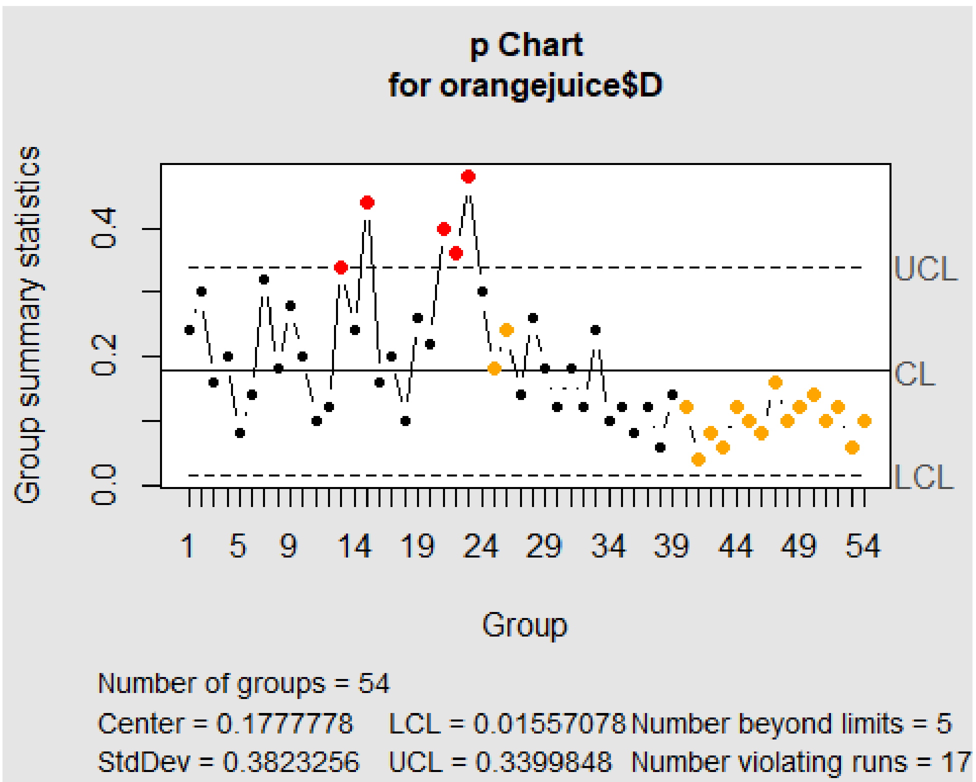


DISCRETE MEASUREMENTS: P AND NP CHARTS

```
data("orangejuice")
head(orangejuice)
```

```
##   sample  D size trial
## 1      1 12   50  TRUE
## 2      2 15   50  TRUE
## 3      3  8   50  TRUE
## 4      4 10   50  TRUE
## 5      5  4   50  TRUE
## 6      6  7   50  TRUE
```

```
qcc(orangejuice$D,orangejuice$size, type = "p")
```



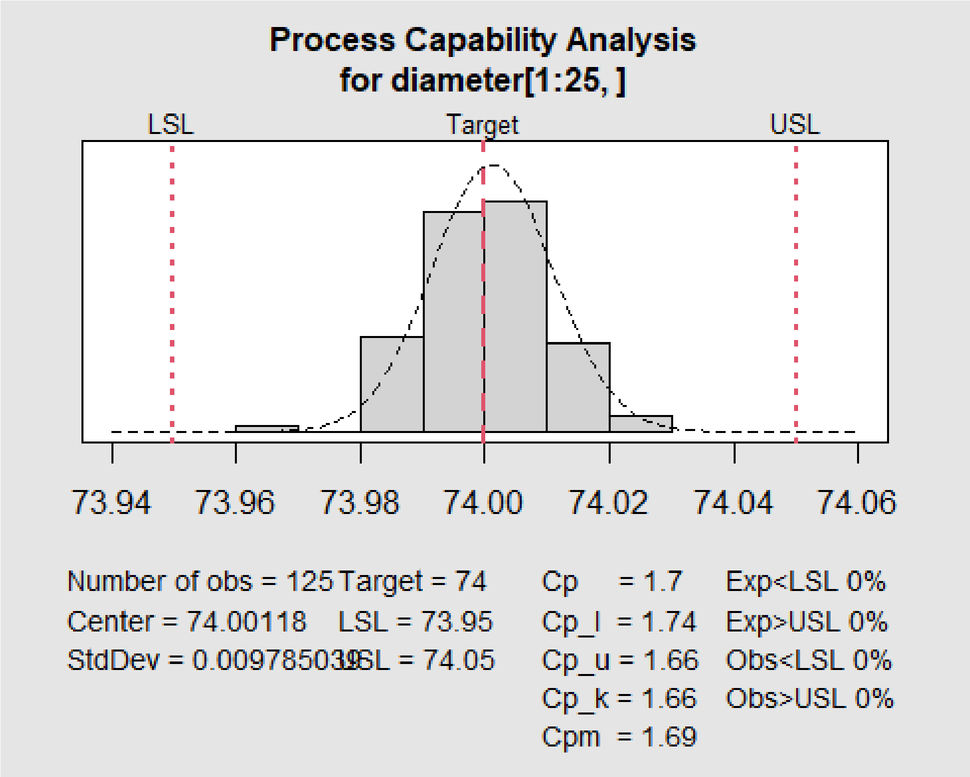
PROCESS CAPABILITY ANALYSIS

Measure whether consumer specified upper and lower specification limits (LSL/USL) are compatible with process control limits (LCL/UCL).

```
data(pistonrings)
attach(pistonrings)

## The following objects are masked from pistonrings (pos = 3):
##
##     diameter, sample, trial

diameter <- qcc.groups(diameter, sample)
q <- qcc(diameter[1:25,], type="xbar", nsigmas=3, plot=FALSE)
process.capability(q, spec.limits=c(73.95,74.05))
```




```
##
## Process Capability Analysis
##
## Call:
```

```
## process.capability(object = q, spec.limits = c(73.95, 74.05))
##
## Number of obs = 125          Target = 74
##        Center = 74              LSL = 73.95
##        StdDev = 0.009785        USL = 74.05
##
## Capability indices:
##
##       Value   2.5%  97.5%
## Cp    1.703  1.491  1.915
## Cp_l  1.743  1.555  1.932
## Cp_u  1.663  1.483  1.844
## Cp_k  1.663  1.448  1.878
## Cpm   1.691  1.480  1.902
##
## Exp<LSL 0%    Obs<LSL 0%
## Exp>USL 0%    Obs>USL 0%
```

CP AND CPK INDICES

- Cp (Process Capability Ratio): measure related to the spread of a process.
- Cpk (Process Capability Index): measure related to the centerness of a process.
- Centered processes are analyzed based on their Cp ratio while non-centered processes are analyzed based on their Cpk index.